Implementation Guidance for FIPS 140-2 and the Cryptographic Module Validation Program

National Institute of Standards and Technology
Canadian Centre for Cyber Security

Initial Release: March 28, 2003

Last Update: October 30, 2023

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Overview

This Implementation Guidance document is issued and maintained by the U.S. Government's National Institute of Standards and Technology (NIST) and the Canadian Centre for Cyber Security (CCCS), which serve as the validation authorities of the Cryptographic Module Validation Program (CMVP) for their respective governments. The CMVP validates the test results of National Voluntary Laboratory Accreditation Program (NVLAP) accredited Cryptographic and Security Testing (CST) Laboratories which test cryptographic modules for conformance to Federal Information Processing Standard Publication (FIPS) 140-2, *Security Requirements for Cryptographic Modules*. The Cryptographic Algorithm Validation Program (CAVP) addresses the testing of *Approved Security Functions*, *Approved Random Number Generators* and *Approved Key Establishment Techniques* which are referenced in the annexes of FIPS 140-2.

This document is intended to provide programmatic guidance of the CMVP, and in particular, clarifications and guidance pertaining to the *Derived Test Requirements for FIPS PUB 140-2* (DTR), which is used by CST Laboratories to test for a cryptographic module's conformance to FIPS 140-2. Guidance presented in this document is based on responses issued by NIST and CCCS to questions posed by the CST Labs, vendors, and other interested parties. *Information in this document is subject to change by NIST and CCCS.*

Each section of this document corresponds with a requirements section of FIPS 140-2, with an additional first section containing general programmatic guidance that is not applicable to any particular requirements section. Within each section, the guidance is listed according to a subject phrase. For those subjects that may be applicable to multiple requirements areas, they are listed in the area that seems most appropriate. Under each subject there is a list, including the date of issue for that guidance, along relevant assertions, test requirements, and vendor requirements from the DTR. *(Note: For each subject, there may be additional test and vendor requirements which apply.)* Next, there is section containing a question or statement of a problem, along with a resolution and any additional comments with related information. This is the implementation guidance for the listed subject.

Cryptographic modules validation listings can be found at:

- Cryptographic Module Validation Lists

Cryptographic algorithm validation listings can be found at:

- Cryptographic Algorithm Validation Lists

General Issues

G.1 Request for Guidance from the CMVP and CAVP

Applicable Levels:	*All*
Original Publishing Date:	*02/25/1997*
Effective Date:	*02/25/1997*
Last Modified Date:	*08/07/2015*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The Cryptographic Module Validation Program (CMVP) and the Cryptographic Algorithm Validation Program (CAVP) defines two types of questions: *Programmatic Questions* and *Test-specific Questions*. The CMVP and CAVP define two types of requests: *Informal Requests* and *Official Requests*.

Question/Problem

What is the difference between *Informal Requests* verses *Official Requests*? To whom should these questions be directed? If an official reply is requested for a question, is there a defined format for these types of requests?

Resolution

Programmatic Questions*:* These are questions pertaining to the general operation of the Cryptographic Module Validation Program or the Cryptographic Algorithm Validation Program. The CMVP and CAVP suggest reviewing the CMVP Management Manual, CMVP Frequently Asked Questions (FAQ), the CAVP Frequently Asked Questions (FAQ), CMVP Announcements and CMVP Notices posted on the CMVP and CAVP web sites first as the answer may be readily available. The information found on the CMVP web site provides the official position of the CMVP and CAVP.

Test-specific Questions*:* These are questions concerning specific test issues of the Cryptographic Module Validation Program or the Cryptographic Algorithm Validation Program. These issues may be technology related or related to areas of the standard that may appear to be open to interpretation.

General Guidance: Programmatic questions regarding the CMVP or the CAVP can be directed to either NIST or CCCS by contacting the appropriate points of contact listed below. The complete list of NIST and CCCS points of contacts **shall** be included on copy for all questions.

Vendors who are under contract with a CST laboratory for FIPS 140-2 or algorithm testing of a particular implementation(s) must contact the contracted CST laboratory for any questions concerning the test requirements and how they affect the testing of the implementation(s).

CST Laboratories must submit all *test-specific questions* in the RFG format described below. These questions must be submitted to all points of contact.

Federal agencies and departments, and vendors not under contract with a CST laboratory who have specific questions about a FIPS 140-2 test requirements or any aspect of the CMVP or CAVP should contact the appropriate NIST and CCCS points of contact listed below.

Questions can either be submitted by e-mail, telephone, and facsimile or written (if electronic document, Microsoft Word document format is preferred).

Informal Request: Informal requests are considered as *ad hoc* questions aimed at clarifying issues about the FIPS 140-2 and other aspects of the CMVP and CAVP. Replies to informal requests by the CMVP are non-binding and subject to change. It is recommended that informal requests be submitted to all points of contact. Every attempt is made to reply to informal request with accurate, consistent, clear replies on a very timely basis.

Official Request: If an official response is requested, then an official request must be submitted to the CMVP and/or CAVP written in the Request for Guidance (RFG) format described below. An official response requires internal review by both NIST and CCCS, as well as with others as necessary, and may require follow-up questions from the CMVP and/or CAVP. Therefore, such requests, while time sensitive, may not be immediate.

Request for Guidance Format: Questions submitted in this format will result in an official response from the CMVP and CAVP that will state current policy or interpretations. This format provides the CMVP and CAVP a clear understanding of the question. An RFG **shall** have the following items:

1. Clear indication of whether the RFG is **PROPRIETARY** or **NON-PROPRIETARY**,
2. A descriptive title,
3. Applicable statement(s) from FIPS 140-2,
4. Applicable assertion(s) from the FIPS 140-2 DTR,
5. Applicable required test procedure(s) from the FIPS 140-2 DTR,
6. Applicable statements from FIPS 140-2 Implementation Guidance,
7. Applicable statements from algorithmic standards,
8. Background information if applicable, including any previous CMVP or CAVP official rulings or guidance,
9. A concise statement of the problem, followed by a clear and unambiguous question regarding the problem, and
10. A suggested statement of the resolution that is being sought.

All questions should be presented in writing. The provided information should include a brief non-proprietary description of the implementation and the FIPS 140-2 target security level. All of this will enable a more efficient and timely resolution of FIPS 140-2 related questions by the CMVP and CAVP. The statement of resolution **shall** be stated in a manner which the CMVP and CAVP can either answer "YES" or "NO". The CMVP may optionally provide rationale if the answer is not in line with the suggested statement of resolution.

When appropriate, the CMVP and CAVP will derive general guidance from the problem and response, and add that guidance to this document. Note that general questions may still be submitted, but these questions should be identified as not being associated with a particular validation effort.

Preferably, questions should be non-proprietary, as their response will be distributed to ALL CST laboratories. Distribution may be restricted on a case-by-case basis.

NIST and CCCS Points of Contact:

- **National Institute of Standards and Technology – CMVP**

  CMVP@nist.gov

- **National Institute of Standards and Technology (NIST) – CAVP**

  CAVPask@nist.gov

- **Canadian Centre for Cyber Security (CCCS) – CMVP**
  CMVP@cyber.gc.ca

G.2 Completion of a test report: Information that must be provided to NIST and CCCS

Applicable Levels:	*All*
Original Publishing Date:	*02/25/1997*
Effective Date:	*02/25/1997*
Last Modified Date:	*11/30/2018*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What information should be submitted to NIST and CCCS upon completion of the CST laboratory conformance testing in order for NIST and CCCS to perform a validation review? Are there any other additional requirements during report COORDINATION?

Resolution

The following test report information **shall** be provided to both NIST and CCCS by the CST laboratory upon report submission. The ZIP file and files within the ZIP file **shall** follow all programmatic naming conventions [1] and be submitted to the CMVP using the specified encryption methods.

1. **Non-proprietary Security Policy** <pdf>

    a. Reference *FIPS 140-2 Appendix C*, *FIPS 140-2 DTR Appendix C* and the CMVP Implementation Guidance for requirements.
    b. The non-proprietary security policy **shall** not be marked as proprietary or copyright without a statement allowing copying or distribution.

2. **CRYPTIK v9.0c (or higher) Reports**

    The validation report submission **shall** be output from the NIST provided CRYPTIK tool.

    a. **Signature page** <insert PDF of signed signature page>

        1. If any of the algorithm validation testing was performed prior to CAVS 17.5, the Algorithm Testing Affirmation on the Report Cover Sheet in CRYPTIK (aka signature page) **shall** be filled out for the algorithms tested with older CAVS versions. If all algorithms were tested on CAVS 17.5 or later, CST labs are not required to fill out and include the Algorithm Testing Affirmation on the Report Cover Sheet in CRYPTIK.

    b. **General Vendor/Module Information** < PDF>

    c. **Full Report with Assessments <** PDF**>**
        1. TE.01.12.01 **shall** state which CAVS version was used to test the algorithms of the module. If multiple versions were used, please indicate which version was used for each algorithm.

    d. **Certificate** <DOC> or <DOCX> or <RTF>

        1. DOC or DOCX file format is preferred but RTF is accepted.
        2. **Shall** include PIV Card Application certificate number reference as applicable.

[1] *CMVP Convention for E-mail Correspondence*

e. **Vendor Text file** <TXT>
Export the validation data and include the _vendor.txt file.

3. **Physical Security Test Report** <pdf – *mandatory* at FIPS 140-2 Section 4.5 Physical Security Levels 2, 3 and 4>

   The laboratory's physical testing report with photos, drawing, etc. as applicable.

   The physical security test evidence **shall** be traceable to the DTR by specifying the appropriate TE for each test described in the physical security test report.

4. **Revalidation Change Summary** <PDF – if applicable>

   Reference IG G.8 for requirements.

5. **Entropy Report** <PDF> as required

   The entropy report **shall** follow the guidelines in IG 7.15.

Note: Separate billing information is no longer required as it is part of the CRYPTIK _vendor.txt output.

The PDF files **shall** not be locked. All PDF submission documents (except Security Policy) **shall** be *merged* into a single PDF document in the following order: Signed Signature Page; General Vendor / Module Information; Executive Overview with Section Summaries or Re-Validation Report with Assessments; Full Report with Assessments; Physical Test Report as applicable; and Other as applicable.

The submission documents **shall** be ZIP'ed into a single file, encrypted (using the CMVP designated application) and sent to the following NIST and CCCS points of contact:

- **NIST:** CMVP@nist.gov
- **CCCS:** CMVP@cyber.gc.ca

Once the electronic report submission document is received by the CMVP it will be placed in the report queue in order received. Those reports marked to be listed, will appear in the weekly published Modules-In-Process listing posted on the CMVP web site. The listing and the definition of the five stages of the Modules-In-Process listing is found at: http://csrc.nist.gov/groups/STM/cmvp/inprocess.html

During the COORDINATION phase the CST laboratory will address each CMVP comment and update any applicable files as necessary in addition to providing a response and additional clarification as necessary in the CMVP comments document. The laboratory will re-submit the report in its entirety as above (i.e. full report submission) including the updated CMVP comments file.

6. **CMVP Comments** <DOC> or <DOCX>

Additional Comments

The naming convention for the submitted ZIP file, e-mail subject line, and files within the ZIP file is provided to the CST Labs in a separate document *CMVP Convention for E-mail Correspondence.* Contact cmvp@nist.gov and cmvp@cyber.gc.ca for the latest version of this document. The CRYPTIK ***File I/O and EMAIL*** function will generate the proper e-mail subject line name depending on the transaction.

An initial or preliminary review will be performed to ensure that the guidelines outlined in the *CMVP Convention for E-mail Correspondence* document have been followed and that required signatures have been included. During the initial review, the submission will not be checked for technical completeness. The report information in the _vendor.txt file will be imported to the CMVP Tracking DataBase and billing information, if applicable, will be sent to NIST billing. The weekly Modules-In-Process listing will be generated based on this provided information.

G.3 Partial Validations and Not Applicable Areas of FIPS 140-2

Applicable Levels:	*All*
Original Publishing Date:	*02/25/1997*
Effective Date:	*02/25/1997*
Last Modified Date:	*01/07/2014*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

Can a cryptographic module be validated only for selected areas of Section 4 of FIPS 140-2? Which areas of Section 4 of FIPS 140-2 can be marked *Not Applicable*?

Resolution

NIST and CCCS will not issue a validation certificate unless the cryptographic module meets at least the Security Level 1 requirements for each area in Section 4 of FIPS 140-2 that cannot be designated as *Not Applicable* according to the following:

- **Section 4.5**, Physical Security may be designated as *Not Applicable* if the cryptographic module is a software-only module and thus has no physical protection mechanisms;

- **Section 4.6**, Operational Environment may be designated as *Not Applicable* depending on the module implementation (e.g. if the operational environment for the cryptographic module is a limited or non-modifiable operational environment); and

- **Section 4.11**, Mitigation of Other Attacks is *Applicable* if the module has been *purposely* designed, built and publicly documented to mitigate one or more specific attacks (RE: IG 11.1). Otherwise this section may be designated as *Not Applicable*.

The CST laboratory **shall** provide in the validation test report the rationale for marking sections as *Not Applicable*.

Additional Comments

If a section is *Not Applicable*, it will be identified as N/A on the module validation certificate entry. If Section 4.6 is N/A, depending on the module implementation, configuration information may still be required on the module validation certificate (e.g. a *firmware* module must provide the tested configuration).

G.4 Design and testing of cryptographic modules

Applicable Levels:	*All*
Original Publishing Date:	*11/12/1997*
Effective Date:	*11/12/1997*
Last Modified Date:	*01/07/2014*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What activities may CST laboratories perform, regarding the design and testing of cryptographic modules?

Resolution

The following information is supplemental to the guidance provided by NVLAP, and further defines the separation of the design, consulting, and testing roles of the laboratories. CMVP policy in this area is as follows:

1. A CST Laboratory *may not* perform validation testing on a module for which the laboratory has:
    a. designed any part of the module,
    b. developed original documentation for any part of the module,
    c. built, coded or implemented any part of the module, or
    d. any ownership or vested interest in the module.
2. Provided that a CST Laboratory has met the above requirements, the laboratory *may* perform validation testing on modules produced by a company when:
    a. the laboratory has no ownership in the company,
    b. the laboratory has a completely separate management from the company, and
    c. business between the CST Laboratory and the company is performed under contractual agreements, as done with other clients.
3. A CST Laboratory may perform consulting services to provide clarification of FIPS 140-2, the Derived Test Requirements, and other associated documents at any time during the life cycle of the module.

Additional Comments

Item 3 in the Resolution references "other associated documents". Included in this reference are:

- Documents developed by the CMVP for the Cryptographic Module testing program (e.g., *CMVP and FIPS 140-2 Implementation Guidance*, *CMVP FAQs*, *CMVP Management Manual*, NVLAP Handbook 150-17:2012, *Cryptographic Module Testing*).

Also, see IG G.9, regarding FSM and Security Policy consolidation and formatting.

G.5 Maintaining validation compliance of software or firmware cryptographic modules

Applicable Levels:	*All*
Original Publishing Date:	*11/21/1997*
Effective Date:	*11/21/1997*
Last Modified Date:	*11/20/2015*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

For a validated software or firmware cryptographic module, how may such a module be implemented so that compliance with the validation is maintained?

Resolution

The tested/validated module version, operational environment upon which it was tested, and the originating vendor are stated on the validation certificate. The certificate serves as the benchmark for the module-compliant configuration.

This guidance addresses two separate scenarios: actions a vendor can affirm or change to maintain a module's validation and actions a user can affirm to maintain a module's validation.

This guidance is *not applicable* for validated modules when FIPS 140-2 Section 4.5 Physical Security has been validated at Levels 2 or higher. Therefore, this guidance is only applicable at Level 1 for *firmware* or *hybrid* modules.

Vendor

1. A vendor may perform post-validation recompilations of a software or firmware module and affirm the modules continued validation compliance provided the following is maintained:

   a) Software modules that do not require any source code modifications (e.g., changes, additions, or deletions of code) to be recompiled and ported to another operational environment must:

      i) For **Level 1 Operational Environment**, a software cryptographic module will remain compliant with the FIPS 140-2 validation when operating on any general-purpose computer (GPC) provided that the GPC uses the specified single user operating system/mode specified on the validation certificate, or another compatible single user operating system, and

      ii) For **Level 2 Operational Environment**, a software cryptographic module will remain compliant with the FIPS 140-2 validation when operating on any GPC provided that the GPC incorporates the specified CC evaluated EAL2 (or equivalent) operating system/mode/operational settings or another compatible CC evaluated EAL2 (or equivalent) operating system with like mode and operational settings.

   b) Firmware modules (i.e. Operational Environment is *not applicable)* that do not require any source code modifications (e.g., changes, additions, or deletions of code) to be recompiled and its identified unchanged tested operating system (i.e. same version or revision number) may be ported together from one GPC or platform to another GPC or platform while maintaining the module's validation.

   c) Hybrid modules (i.e. Operational Environment may or may not be applicable depending if the controlling component is software or firmware) may be ported together from one GPC or platform to another GPC or operating platform while maintaining the module's validation provided that they do not require any of the following:

i) software or firmware source code modifications (e.g., changes, additions, or deletions of code) to be recompiled and its identified unchanged tested operating system (i.e. same version or revision number);

ii) hardware components utilized by the controlling software or firmware is not modified (e.g. changes, additions, or deletions).

The CMVP allows vendor porting and re-compilation of a validated software, firmware or hybrid cryptographic module from the operational environment specified on the validation certificate to an operational environment which was not included as part of the validation testing as long as the porting rules are followed. Vendors may affirm that the module works correctly in the new operational environment. However, the CMVP makes no statement as to the correct operation of the module or the security strengths of the generated keys when so ported if the specific operational environment is not listed on the validation certificate.

The vendor **shall** work with a CST laboratory to update the security policy and submit to the CMVP under one of the available revalidation scenarios (see IG G.8). The update would affirm and include references to the new operational environment(s), GPC(s) or platform(s). The module's Security Policy **shall** include a statement that no claim can be made as to the correct operation of the module or the security strengths of the generated keys when ported to an operational environment which is not listed on the validation certificate.

2. Software or firmware modules that require non-security relevant source code modifications (e.g., changes, additions, or deletions of code) to be recompiled and ported to another hardware or operational environment must be reviewed by a CST laboratory and revalidated per IG G.8 (1) to ensure that the module does not contain any operational environment-specific or hardware environment-specific code dependencies.

3. If the new operational environment and/or platform is requested to be updated on the validation certificate, the CST laboratory **shall** follow the requirements for non-security relevant changes in IG G.8 (1) and in addition, perform the regression test suite of operational tests included in IG G.8 Table G.8.1. Underlying algorithm validations must meet requirements specified in IG 1.4.

   Upon re-testing and validation, the CMVP provides the same assurance as the original operational environment(s) as to the correct operation of the module when ported to the newly listed OS(s) and/or operational environment(s) which would be added to the modules validation web entry.

The vendor must meet all applicable requirements in FIPS 140-2 Section 4.10.

This policy only addresses the operational environment under which a software, firmware or hybrid module executes and does not affect requirements of the other sections of FIPS 140-2. A module must meet all requirements of the level stated.

IG 1.3 describes the difference in terminology between a *software* and a *firmware* module.

IG 1.9 describes the attributes and definition of a hybrid module.

User

A user may not modify a validated module. Any user modifications invalidate a modules validation. [1]

A user may perform post-validation porting of a module and affirm the modules continued validation compliance provided the following is maintained:

[1] A user may post-validation recompile a module if the unmodified source code is available and the module's Security Policy provides specific guidance on acceptable recompilation methods to be followed as a specific exception to this guidance. The methods in the Security Policy must be followed without modification to comply with this guidance.

1. For **Level 1 Operational Environment**, a software, firmware or hybrid cryptographic module will remain compliant with the FIPS 140-2 validation when operating on any general purpose computer (GPC) or platform provided that the GPC for the software module, or software controlling portion of the hybrid module, uses the specified single user operating system/mode specified on the validation certificate, or another compatible single user operating system, or that the GPC or platform for the firmware module or firmware controlling portion of the hybrid module, uses the specified operating system on the validation certificate, and
2. For **Level 2 Operational Environment**, a software cryptographic module will remain compliant with the FIPS 140-2 validation when operating on any GPC provided that the GPC incorporates the specified CC evaluated EAL2 (or equivalent) operating system/mode/operational settings or another compatible CC evaluated EAL2 (or equivalent) operating system with like mode and operational settings.

The CMVP allows user porting of a validated software, firmware or hybrid cryptographic module to an operational environment which was not included as part of the validation testing. The user may affirm that the module works correctly in the new operational environment as long as the porting rules are followed. However, the CMVP makes no statement as to the correct operation of the module or the security strengths of the generated keys when ported and executed in an operational environment not listed on the validation certificate.

Additional Comments

Users include third party integrators or any entity that is not the originating vendor as specified on the validation certificate.

G.6 Modules with both a FIPS mode and a non-FIPS mode

Applicable Levels:	*All*
Original Publishing Date:	*03/11/1998*
Effective Date:	*03/11/1998*
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

How can a module be defined, when it includes both FIPS-approved and non-FIPS approved security methods?

Resolution

A module that contains both FIPS-approved and non-FIPS approved security methods **shall** have at least one "FIPS mode of operation" - which *only* allows for the operation of FIPS-approved security methods. This means that when a module is in the "FIPS mode", a non-FIPS approved method **shall** not be used in lieu of a FIPS-approved method (For example, if a module contains both MD5 and SHA-1, then when hashing is required in the FIPS mode, SHA-1 **shall** be used.). The operator must be made aware of which services are FIPS 140-2 compliant.

The FIPS 140-2 validation certificate will identify the cryptographic module's "FIPS mode" of operation.

For modules that support both FIPS approved and non-approved modes of operation, the certificate **shall** only list what is used in the approved mode of operation (i.e. all approved and allowed algorithms implemented within the module) while the Security Policy **shall** list what is used in both approved and non-approved modes (i.e. all the approved, allowed, and non-approved algorithms implemented within the module).

The selection of "FIPS mode" does not have to be restricted to any particular operator of the module. However, each operator of the module must be able to determine whether or not the "FIPS mode" is selected.

There is no requirement that the selection of a "FIPS mode" be permanent.

G.7 Relationships Among Vendors, Laboratories, and NIST/CCCS

Applicable Levels:	*All*
Original Publishing Date:	*04/14/1998*
Effective Date:	*04/14/1998*
Last Modified Date:	*08/07/2015*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What is the Cryptographic Module Validation Program policy regarding the relationships among vendors, testing laboratories, and NIST/CCCS?

Resolution

The CST laboratories are accredited by NVLAP to perform cryptographic module validation testing to determine compliance with FIPS 140-2. NIST/CCCS rely on the CST laboratories to use their extensive validation testing experience and expertise to make sound, correct, and independent decisions based on 140-2, the Derived Test Requirements, and Implementation Guidance. Once a vendor is under contract with a laboratory, NIST/CCCS will only provide official guidance and clarification for the vendor's module through the point of contact at the laboratory.

In a situation where the vendor and laboratory are at an irresolvable impasse over a testing issue, the vendor may ask for clarification/resolution directly from NIST/CCCS. The vendor should use the format required by Implementation Guidance IG G.1 and the point of contact at the laboratory **shall** be carbon copied. All correspondence from NIST/CCCS to the vendor on the issue will be issued through the laboratory point of contact.

G.8 Revalidation Requirements

Applicable Levels:	*All*
Original Publishing Date:	*08/17/2001*
Effective Date:	*10/30/2023*
Transition End Dates	***11/07/2020*** *– See Below*
Last Modified Date:	*03/17/2023*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What is the Cryptographic Module Validation Program (CMVP) policy regarding revalidation requirements and validation of a new cryptographic module that is significantly based on a previously validated module?

Resolution

An updated version of a previously validated cryptographic module can be considered for a *revalidation* rather than a *full validation* depending on the extent of the modifications from the previously validated version of the module. (Note: the updated version may be, for example, a new version of an existing cryptographic module or a new model based on an existing model.)

The CMVP no longer accepts FIPS 140-2 submissions for new validation certificates unless the vendor is under contract with a CSTL prior to June 15, 2021, the CSTL has submitted an extension request, and the CSTL has received acceptance by the CMVP.

The CMVP continues to accept FIPS 140-2 reports that do not change the validation sunset date, i.e., Scenarios 1, 1A, 1B (combined with a viable revalidation scenario), 3A, 3B, and 4 as defined in this IG.

Also, as of October 1, 2021, Scenario 2 is no longer accepted and Scenario 1B submissions are no longer accepted as a stand-alone submission. The Scenarios 1, 1A, 3A, 3B, and 4 can be submitted by a lab that is not the original lab as long as all requirements of this IG are met for Scenario 1B *and* the combined scenario, including the supporting documentation (e.g., original test report if applicable, design documentation, source code, etc.) and testing performed. The submitting lab is liable for any changes included in the submission.

The Modules In Process (MIP) List will include only scenarios that result in issuing a new certificate (e.g., 3SUB, 5SUB, 1A, 3B, etc.) if the vendor requests the entry to be displayed on the MIP List. The CST lab must check the appropriate box in Cryptik for MIP List inclusion.

There are nine possible submission Scenarios (1, 1A, 1B, 2, 3, 3A, 3B, 4, 5) All Scenarios must be processed and submitted to the CMVP by a CST Laboratory:

Scenario 1:

Scenario 1 includes the following options:

1) Administrative updates (e.g., updating vendor contact information.)
2) Modifications are made to hardware, software or firmware components **that do not affect any FIPS 140-2 security relevant items**. The vendor is responsible for providing the applicable documentation to the CST laboratory, which identifies the modification(s). Documentation may include a previous validation report, design documentation, source code, source code difference evidence, etc.
3) Post validation, approved security relevant functions or services for which testing was not available (or vendor affirming was still permitted per the CMVP/CAVP transition schedule) at the time of submission to the CMVP for validation are now tested and are being submitted for inclusion as a FIPS approved function or service. The CST laboratory is responsible for identifying the documentation that is needed to determine whether a revalidation is sufficient, and the vendor is responsible for submitting the requested documentation to the CST laboratory. Documentation may include a previous validation report and applicable CMVP rulings, design documentation, source code, etc.
4) If a new operational environment and/or platform is added, then the CST laboratory **shall** perform the regression test suite of operational tests included in IG G.8 Table G.8.1.

Modules with certificates on the *Validated FIPS 140-1 and 140-2 Cryptographic Module List* may be submitted under any of the options listed.

Modules with certificates on the *CMVP Historical Validation List* may only be submitted under option 1. The CMVP will not accept options 2, 3 and 4 for modules with certificates on the *CMVP Historical Validation List*.

For options 2 and 3, the CST laboratory **shall**:

- review the vendor-supplied documentation and identify any additional documentation requirements.
- determine additional testing as necessary to confirm that FIPS 140-2 security relevant items have not been affected by the modification.
- identify the assertions affected and **shall** perform the tests associated with those assertions by:
    - reviewing the COMPLETE list of assertions for the module embodiment and security level;
    - identifying from the previous validation report, the assertions that are newly tested;
    - identifying additional assertions that were previously tested but should now be re-tested; and
    - reviewing assertions where specific Implementation Guidance (IG) was provided at the time of the original validation to confirm that the IG is still applicable.

The revalidation submissions made after **November 7, 2020** that claim option 4 in this scenario: If applicable per IG 7.14, entropy assessment reports **shall** be submitted to cover all newly added operational environments and/or platforms. The submitted entropy assessment reports may be similar to those used in the original validation (with compliance claimed either to IG 7.15 or IG 7.18), if the entropy source design warrants it. If the statistical testing was part of the original validation, then the same level of statistical testing **shall** be performed for entropy sources associated with every newly added operational environment and/or platform.

As a reminder, module vendors and users may take advantage of the porting provisions explained in IG G.5. Performing a revalidation and updating a validation certificate is not required.

Upon successful review and applicable testing as required, the CST laboratory **shall** submit a signed explanatory letter that contains a description of the modification(s) and lists the affected TEs and their associated laboratory assessment.

When the certificate is being updated, the CST laboratory **shall** use the following format for listing the modifications to the certificate. Deletions **shall** be marked using strikethrough and additions **shall** be highlighted in yellow. This information **shall** be listed in the change letter.

For example:

Current Cert. #5000	**Change Requested Cert. #5000**
Hardware Version – 3.1	Hardware Versions 3.1, 3.2
Firmware Version – a.1, b.1	Firmware Versions – a.1, b.1, c.1
FIPS Approved Algorithms – AES (Cert. #1); DRBG (Cert. #1); DSA (Cert. #1); ECDSA (Cert. #1); HMAC (Cert. #1); ~~KBKDF (vendor affirmed);~~ RSA (Cert. #1); SHS (Cert. #1); Triple-DES (Cert. #1)	FIPS Approved Algorithms – AES (Cert. #1); DRBG (Cert. #1); DSA (Cert. #1); ECDSA (Cert. #1); HMAC (Cert. #1); KBKDF (Cert. #1); KTS (AES Cert. #1; key establishment methodology provides between 128 and 256 bits of encryption strength); RSA (Cert. #1); SHS (Cert. #1); Triple-DES (Cert. #1)
Allowed Algorithms – ~~AES (Cert #1, key wrapping, key establishment methodology provides between 128 and 256 bits of encryption strength),~~ DES	Allowed Algorithms - DES

When the module's documentation is being updated, the CST laboratory **shall** use the following format for listing the affected TEs and their associated laboratory assessment. This information **shall** be listed in the change letter.

For example:

TE or SP Section	**Related Change**
Module Information	The module name and firmware versions have been updated from version 05 to version 06.

TE.01.03.02 TE.01.08.01	Updated to reflect the updated firmware version, 06.
References	Updated security policy version number and added the vendor provided document listing the differences between the original validation and the revalidation.

The assessment **shall** include the analysis performed by the laboratory that confirms that no security relevant items were affected. The letter **shall** also indicate whether the modified cryptographic module replaces the previously validated module or adds to the latter. If new algorithm certificates were obtained, they **shall** be listed.

A new security policy **shall** be provided for posting if the modifications cause changes to it or updates the new services or functions that are now included in an approved mode of operation as a result of algorithm testing. If the security policy represents multiple versions of a validated module or multiple validated modules, the versioning information **shall** be updated in the security policy with text that clearly distinguishes each module instance with its unique versioning information and the differences between each module instance.

For a Scenario 1 revalidation, the CST laboratory **shall** submit, at a minimum, an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf> and the _vendor.txt file. If the security policy or validation certificate are updated, the CST laboratory **shall** include the updated security policy <pdf> and draft certificate <doc or docx or rtf>. If entropy assessment reports are required, the CST laboratory **shall** include the updated entropy report < _entropyreport.pdf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

The CST laboratory may combine multiple Scenario 1 revalidations into 1 submission provided ALL of the changes are exactly the same for all certificates. If multiple security policies are updated, the submission **shall** include a security policy for each certificate included in the submission.

Please note that if the changes that the lab requests require a higher level of effort to review due either to the number of comments generated or the quantity of Scenario 1 revalidations submitted, a no-points ECR may be levied against the lab.

Upon a satisfactory review by the CMVP, the updated version or release information will be posted on the *Validated FIPS 140-1 and FIPS 140-2 Cryptographic Module List* web site entry associated with the original cryptographic module. A new certificate will not be issued. The sunset date for the certificate will not be changed.

Alternative Scenario 1A:

1. Alternative Scenario 1A applies if there are no modifications to a module and the new module is a re-branding of an already validated Original Equipment Manufacturer (OEM) module. The CST laboratory **shall** include the OEM's written approval for re-branding in the submission package and determine that the re-branded module is identical to the OEM module (n.b. this requirement applies equally to open source and non-open-source modules). Written approval **shall** note the terms of permission (e.g., addition of OEs, possible re-use of CAVP certificates, entropy, remediation of CVEs, non-security relevant changes, whether a rebrand of a rebrand is acceptable, etc.). If these terms do not explicitly allow a vendor to further rebrand the OEM module, then a rebrand of that rebranded module is not permitted unless written permission is granted by the OEM. Please see Additional Comment #8 below on requirements when combining submission scenarios, including Scenario 1A. Additionally, for modules containing any open-source licensed code, the CST laboratory **shall** ensure the open-source licensing requirements are met (e.g., any required notices are contained in the Security Policy). The submission **shall** include a letter requesting the validation of the re-branded module and indicate the applicable documentation changes (e.g., vendor name, address, POC information, versioning information, etc.).

2. Alternative Scenario 1A applies if the module is a ported sub-chip cryptographic subsystem. Please see IG 1.20 for detailed porting guidance.

For options 1 and 2, only modules with certificates on the *Validated FIPS 140-1 and 140-2 Cryptographic Module List* may be used for Scenario 1A modules. Modules with certificates on the *CMVP Historical Validation List* **shall not** be used for Scenario 1A modules.

The CST laboratory **shall** use the following format for listing the information for the new certificate. This information **shall** be listed in the change letter.

For example:

Current Cert. #5000	New Certificate Information
Hardware Version – 3.0	Hardware Version – AA
Firmware Version – 8.3	Firmware Version – XZ
Product Link – www.productA.com	Product Link – www.productB.com
Vendor Name – Vendor A	Vendor Name – Vendor B

The laboratory **shall** provide an updated security policy which is technically identical to the originally validated security policy and describes the re-branded module.

For a Scenario 1A revalidation, the CST laboratory **shall** submit, at a minimum, an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf>, the _vendor.txt file, the security policy <pdf> and draft certificate <doc or docx or rtf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

A new validation certificate will be issued. The new validation certificate will inherit the sunset date of the original certificate.

Alternative Scenario 1B - no longer accepted after September 30, 2021 as a stand-alone submission:

A CST laboratory has been contracted to perform a Scenario 1, 1A, 3A, 3B, or 4 revalidation for a validated module for which the laboratory did not perform the original testing on the base module.

a. The vendor **shall** provide the laboratory with the design documentation and implementation (including source code, HDL, etc.) of the base validated module and of the module that has been updated.

b. The vendor **shall** provide the laboratory with the latest Security Policy as shown on the base module's most recent certificate.

c. The laboratory **shall** determine that the provided base documentation and implementation is identical to the base validated module.

d. The laboratory **shall** examine each modification and confirm that the change is appropriate for the submission type (e.g., non-security relevant for Scenario 1).

e. The laboratory **shall** determine that no other modifications, including unintentional, have been made apart from what is permitted by the revalidation scenario.

f. The laboratory **shall** meet all requirements of the revalidation scenario(s) submitted (i.e., Scenario 1, 1A, 3A, 3B, or 4).

g. The laboratory **shall** indicate which scenario(s) are part of the submission and a summary of associated changes.

The CST laboratory **shall** use the format for listing the information for the certificate as required by each revalidation scenario.

For a Scenario 1B revalidation, the CST laboratory **shall** submit, at a minimum, what is required by the revalidation scenario. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

NIST CR may or may not be applicable depending on the revalidation scenario.

A Scenario 1B combined with another scenario **shall** be submitted as the scenario it was combined with (i.e., Scenario 1, 1A, 3A, 3B, or 4). Any attempt to combine a Scenario 1B with more than one additional scenario **shall** be approved by the CMVP prior to submission per Additional Comment #8 below.

Note: a Scenario 1B submission may or may not be included on the CMVP MIP list depending on the revalidation scenario it is combined with.

Scenario 2 – no longer accepted after September 30, 2021:

Scenario 2 is for extending the module's sunset date when a module has not changed. The module meets all of the latest standards, implementation guidance and algorithm testing in effect at the time the module revalidation package is submitted to the CMVP unless there is an implementation guidance transition that affects reports that have been submitted.

The laboratory **shall** confirm the module has not changed. If there are any changes to the module, it is a new module and must be submitted as a Scenario 3 or 5.

Modules with certificates on both the *Validated FIPS 140-1 and 140-2 Cryptographic Module List* may be used for Scenario 2, as well as modules with certificates on the *CMVP Historical Validation List*.

Upon successful review and applicable testing to confirm the module has not changed and meets the latest standards, implementation guidance and algorithm testing, the CST laboratory **shall** submit a signed explanatory letter that contains a rationale for extending the sunset date, a statement from the vendor that the module is still being supported by the vendor and an implementation guidance summary table which notes the module's original submission date, which implementation guidance was published or modified since that date, whether each applies to the module, and how the module meets the requirements found to be applicable. It is permissible to include vendor contact updates as well as updates to the security policy, where these updates are added to meet documentation requirements in the latest implementation guidance. The security policy may also be modified to reflect the updates needed to comply with the transition rules per **SP 800-131A** and with the new or modified implementation guidance, where the changes are made in documentation only and no changes were made to the module. All changes to the security policy **shall** be listed in the signed explanatory letter.

For a Scenario 2 revalidation, the CST laboratory **shall** submit, at a minimum, an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf>, the _vendor.txt file, security policy <pdf> (even if the security policy has not changed), draft certificate <doc or docx or rtf> and the test report <pdf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

Additional documentation may be required if implementation guidance requiring the additional documentation has been published since the module's original validation.

If applicable per IG 7.14, an up-to-date entropy report **shall** be submitted for all Scenario 2 revalidations.

Upon a satisfactory review by the CMVP, the security policy will be posted on the *Validated FIPS 140-1 and FIPS 140-2 Cryptographic Module List* web site and the sunset date will be extended 5 years from revalidation date.

Scenario 3 – no longer accepted after September 22, 2021 without prior extension request approval by the CMVP:

Modifications are made to hardware, software or firmware components **that affect some of the FIPS 140-2 security relevant items**. An updated cryptographic module can be considered in this scenario if it is similar to the original module with only minor changes in the security policy and FSM, and less than 30% of the modules security relevant features [1].

The CST laboratory is responsible for identifying the documentation that is needed to determine whether a revalidation is sufficient, and the vendor is responsible for submitting the requested documentation to the CST laboratory. Documentation may include a previous validation report and applicable CMVP rulings, design documentation, source code, etc.

Modules with certificates with Validation Status as *Active* or *Historical* are eligible for Scenario 3 revalidation.

The CST laboratory **shall** identify the assertions affected by the modification and **shall** perform the tests associated with those assertions. This will require the CST laboratory to:

a. Review the COMPLETE list of assertions for the module embodiment and security level,

b. Identify, from the previous validation report, the assertions that have been affected by the modification,

c. Identify additional assertions that were NOT previously tested but should now be tested due to the modification, and

d. Review assertions where specific Implementation Guidance (IG) was provided to confirm that the IG is still applicable.

For example, a revision to a firmware component that added security functionality may require a change to assertions in Section 1.

In addition to the tests performed against the affected assertions, the CST laboratory **shall** also perform the regression test suite of operational tests included in Table G.8.1.

The CST laboratory **shall** use the following format for listing the affected TEs and their associated laboratory assessment. This information **shall** be listed in the beginning of the test report.

For example:

TE or SP Section	Assessment
General	The module’s name has been changed from ModuleA to ModuleB
1. Cryptographic Module Specification	01.03.02 and 01.08.05 have been updated for clarification on how to bring the module in the approved mode of operation. 01.06.02, 01.08.03, 01.08.04, 01.08.07, 01.08.10, 01.13.01, 01.14.01 have been updated to reference to the new security policy. 01.06.03 has been updated to mention the new test platforms. 01.08.01 has been updated to reference the updated operating environment. 01.12.01 has been updated to mention the CAVS tool version used for CAVS testing, the new algorithm certificates. 01.12.02 has been updated to clarify which non-FIPS approved algorithms are available to the user of the module. 01.08.02 has been updated to mark some bullets as not applicable.
2. Cryptographic Modules Ports and Interfaces	02.01.01, 02.01.02, 02.01.03, 02.04.01, 02.09.01, 02.11.01, 02.12.01 have been updated to reference to the new security policy. 02.06.01 has been updated to updated the testing approach.

[1] For example, security relevant features may include addition/deletion/change of minor components and their composition, addition/deletion of ports and interfaces, addition/delete/modification of security functions, modification of the physical boundary and protection mechanisms. These changes may affect many TE's yet be considered a minor change (<30%), or affect few TE's yet be a gross change (>30%).

3. Roles, Services, and Authentication	03.02.01, 03.11.01, 03.14.01 have been updated to reference to the new security policy. 03.06.01, 03.06.02 have been updated to better reflect the services available to each role. 03.02.01, 03.02.02 and 03.02.03 have been marked as not applicable.
4. Finite State Model	04.05.01 has been updated to add the state transitions. 04.05.02 has been updated to clarify the differences between the crypto officer and user role.
5. Physical Security	No change
6. Operational Environment	06.04.01, 06.06.01 have been updated to reference to the new security policy. 06.05.01 has been updated to clarify that the module does not support key generation. 06.07.01 has been updated to reference to the new files comprising the module. 06.08.02 has been updated to reference to the new module's file version and naming. 06.05.01 has been updated to replace the DSA algorithm with RSA.
7. Cryptographic Key Management	07.01.01 has been updated to reference to the new security policy. 07.02.01, 07.02.02 has been updated to clarify the RSA signature verification mechanism available by the module replacing the DSA algorithm. 07.03.01 has been updated to clarify that the module does not support key generation. 07.13.01, 07.13.02 have been updated to the address IG 7.15. 07.23.01 has been updated to clarify that the SP800-90A DRBG implementation is automatically seeded by the module.
8. EMI/EMC	08.02.01 has been updated to mention the new test platforms FCC evidence.
9. Self-Tests	09.06.02 has been modified to mention a new testing approach. 09.07.02 has been updated to add the transition from the operational state to the error state. 09.09.02 and 09.22.07 have been updated to replace the term “kernel module” with the term “kernel loadable component”. 09.07.01, 09.18.01, 09.18.02, 09.18.03, 09.22.01, 09.22.02, 09.22.05, 09.22.06, 09.24.01, 09.35.01, 09.35.02, 09.35.03, 09.35.04 have been updated to replace the DSA signature verification with RSA. 09.16.01 has been updated to update the last paragraph regarding the block chaining modes. 09.16.02 has been updated to reflect the new KATs performed by the module. 09.20.01 has been updated for a new source code review. 09.22.03 has been updated to replace the DSA algorithm with RSA. 09.35.05 has been updated to modify the kernel component that was tested. 09.42.01 has been updated to remove ANSI CPRNG from the FIPS approved algorithms.

	09.43.01 has been updated to mention the DRBG which is the only approved RNG for the module.
10. Design Assurance	10.01.01, 10.02.01, 10.02.02, 10.02.03, 10.02.04 have been updated to remove CVS which has been fully replaced by GIT. 10.03.02, 10.23.01 have been updated to reference to the new security policy document.
11. Mitigation of Attacks	No change

The CST laboratory must provide a summary of the changes and rationale of why this meets the <30% guideline. The CMVP upon review, may determine that the changes are >30% and **shall** be submitted as a full report. The CST laboratory **shall** document the test results in the associated assessments and all affected TEs **shall** be annotated as "re-tested." The CST laboratory **shall** submit a test report as specified in IG G.2 describing the modification and highlighting those assertions that have been modified and retested (selecting the re-tested option in CRYPTIK). Upon a satisfactory review by the CMVP, the updated version will be revalidated to FIPS 140-2.

For a Scenario 3 revalidation, the CST laboratory **shall** submit, at a minimum, an encrypted ZIP file containing the _vendor.txt file, the security policy <pdf>, test report <pdf>, and draft certificate <doc or docx or rtf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

If applicable per IG 7.14, an up-to-date entropy report **shall** be submitted for all Scenario 3 revalidations.

Upon a satisfactory review by the CMVP, the updated security policy and information will be posted on the *Validated FIPS 140-1 and FIPS 140-2 Cryptographic Module List*. A new certificate will be issued and will have a sunset date 5 years from the validation date.

Alternative Scenario 3A:

A CST laboratory has been contracted to perform a revalidation for a module on which the vendor has made FIPS 140 security-relevant changes in response to one or more CVEs (Common Vulnerability and Exposure). For more information about CVEs please see https://cve.mitre.org/.

The purpose of the 3A revalidation scenario is to provide the vendor a means to quickly fix, test and revalidate a module that is subject to a *security-relevant CVE*[1], while at the same time providing assurance that the module still meets the FIPS 140-2 standard. If a CVE does not require security relevant changes to address it, then the vendor may pursue a Scenario 1 revalidation.

To complete a Scenario 3A revalidation:

a. The CST laboratory **shall** determine that security relevant changes to the module are only to correct the vulnerability disclosed in the CVE (non-security relevant changes, as defined in Scenario 1, are permissible)

b. The CST laboratory **shall** examine each modification and confirm that the change does not conflict with the requirements of FIPS 140-2.

c. The CST laboratory **shall** determine that no other security relevant modifications have been made.

d. The CST laboratory **shall** identify the assertions affected by the security-relevant modification and **shall** perform the tests associated with those assertions.

e. The vendor is not required to address IGs that have been published since submission of the original module.

f. If the fix to address the CVE is in the scope of an algorithm implementation, then this algorithm **shall** be CAVP tested again to obtain a new CAVP certificate with the new module version.

In addition to the tests performed against the affected assertions, the CST laboratory **shall** also perform the following regression suite of operational tests.

> TE.01.03.02 - The tester shall invoke the Approved mode of operation using the vendor provided instructions found in the non-proprietary security policy.
>
> TE.01.04.02 (levels 3 and 4) - The tester shall use the vendor provided instructions described in the non-proprietary security policy to obtain the Approved mode of operation indicator.
>
> TE.02.06.02 - To the extent that the cryptographic module design and operating procedures allow, the tester shall cause the cryptographic module to enter each specified error state and verify that all data output via the data output interface is inhibited.
>
> TE.02.06.04 - To the extent that the cryptographic module design and operating procedures allow, the tester shall command the module to perform the self-tests and verify that all data output via the data output interface is inhibited.
>
> TE.04.05.08 - The tester shall exercise the cryptographic module, causing it to enter each of its major states of the Finite State Model.
>
> TE.07.41.02 - The tester shall note which keys are present in the module and initiate the zeroize command.
>
> TE.09.09.02 - The tester shall power-up the module and verify that the module performs the power-up self-tests without requiring any operator intervention.

Because the changes to address the CVEs are considered security relevant, the CST lab must submit an updated test report. The CST laboratory **shall** use the Scenario 3 table format for listing the affected TEs and their associated laboratory assessment. This information **shall** be listed in the beginning of the test report.

Modules with certificates on the *140-2 Cryptographic Module List* and on the *CMVP Historical Validation List* may be used for Scenario 3A revalidations.

The laboratory **shall** submit a Scenario 3A revalidation by using the 3SUB process and e-mail transmittal code, but **shall** clearly indicate in the letter that this is a revalidation in response to a CVE, and provide the relevant CVE number(s). The submitted package at a minimum **shall** consist of an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf>, the _vendor.txt file, the updated security policy <pdf>, test report <pdf>, and draft certificate <doc or docx or rtf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail Correspondence* and submitted to the CMVP using the specified encryption methods.

A new validation certificate will not be issued, and the original sunset date will not be extended for modules on the active list. Because the change to the module is to address a security-relevant CVE, the previous version of the module is no longer considered validated and will be removed from the certificate; exceptions may be made if the vendor shows how the CVE can be mitigated by policies included in the Security Policy, while still adhering to the FIPS 140-2 standard.

[1] A *security-relevant CVE* is one that affects how the module meets the requirements of the FIPS 140-2 standard.

Alternative Scenario 3B:

A CST laboratory has been contracted to perform a revalidation for a module on which the vendor has made FIPS 140-2 security relevant changes solely in response to a published CMVP algorithm transition that may cause some previously validated modules to be placed on the Historical list. The examples of the transitions that require security relevant changes to a module are the **SP 800-56Arev3** and **SP 800-56Brev2** transitions, explained in detail in FIPS 140-2 IGs D.8 and D.9, correspondingly.

The purpose of the 3B revalidation scenario is to provide the vendor a means to quickly address algorithm transition requirements, test and revalidate a module in order to meet a CMVP transition, while at the same time providing assurance that the module still meets the FIPS 140-2 standard. Scenario 3B is designed to be similar in process to Scenario 3A in terms of its dedicated purpose (i.e., to address a CVE or to meet a transition requirement), certificate status (i.e. no change in sunset date), and queue length (i.e. much faster review period than a regular 3SUB).

If the module code is *changed* to address an algorithm transition, the following requirements apply:

a. Submitted as a Scenario 3B.

b. The CST laboratory **shall** determine that security relevant changes to the module are only to address a specific CMVP transition (non-security relevant changes, as defined in Scenario 1, are permissible).

c. The CST laboratory **shall** examine each modification and confirm that the change does not conflict with the requirements of FIPS 140-2.

d. The CST laboratory **shall** determine that no other security relevant modifications have been made. The vendor is not required to address IGs or guidance that have been published since submission of the original module, unless directly applicable to the transitioning algorithm (e.g., CAVP testing or self-test requirements).

e. The CST laboratory **shall** identify the assertions affected by the security-relevant modification and **shall** perform the tests associated with those assertions.

f. If the means to meet the transition are in the scope of an algorithm implementation, and the path chosen to meet the requirements necessitates testing, then this algorithm **shall** be CAVP tested to obtain a new CAVP certificate with the new module version.

g. In addition to the tests performed against the affected assertions, the CST laboratory **shall** also perform the regression suite of operational tests outlined in Scenario 3A on all versions listed on the module's certificate and on at least one of the listed Operational Environment (OEs) for software/firmware modules. The lab **shall** provide justification on why testing is not necessary for the untested OEs. With proper justification, these may remain on the module's certificate. If regression testing is not performed on some versions, then those **shall** be removed from the module's certificate. OEs without proper justification or regression testing **shall** be removed from the module's certificate.

If the module code is *unchanged* to address an algorithm transition and the change is purely to documentation, one of the following four options apply. For each option, the lab **shall** include in the change letter/summary that the change to address the transition is purely documentational and indicate which option applies.

Option 1: services or functionality were not moved to or from the approved mode to remain compliant (e.g. non-**SP 800-56Arev3**-compliant services remain in the approved mode but are updated to demonstrate compliance rather than moved into non-approved mode), then the vendor may pursue a Scenario 1 (option 3) revalidation.

Option 2: The vendor moves all non-compliant functionality into the non-approved mode of operation from the approved mode of operation.

a. Requirements 'a' through 'd' above apply.

b. The lab **shall** identify the assertions affected by the security-relevant documentation modification and **shall** perform the tests associated with those assertions.

c. The original validation **shall** be Level 1 or Level 2 for FIPS 140-2 Section 4.1 Cryptographic Module Specification, and implicitly move between approved to non-approved modes.

d. The lab **shall** perform, at minimum, the regression tests required by Scenario 3A <u>minus the test in</u> TE.02.06.02 (error states) on:

i. at least one of the listed Operational Environment (OEs) for software/firmware modules (if the module binary image is identical across all OEs; if not, testing on at least every binary image is required);

ii. all the firmware versions of a hardware module.

As part of testing TE01.03.02 (and in addition to those requirements), the lab **shall** exercise the module in order to provide assurance that the guidance in IG 1.2 is met. Namely, "CSPs defined in an approved mode of operation shall not be accessed or shared while in a non-approved mode of operation. CSPs shall not be generated while in a non-approved mode".

The only exception to this requirement (d.) is if the algorithm being transitioned is part of a standalone service and is not used by any other module service (e.g., cryptographic library where the module only provides the algorithm as an API service to a calling application as a stand-alone service). In this case, the lab **shall** provide justification on why regression testing is not necessary.

e. In the change summary of the Test Report:

i. The lab **shall** provide justification on why testing is not necessary for the untested OEs or hardware versions. With proper justification, these may remain on the module's certificate.

ii. The lab **shall** provide assurance that the non-compliant functionality is not used to meet any FIPS 140-2 requirements (key/CSP establishment, generation, storage, etc.).

iii. The lab **shall** provide assurance, upon module examination, that no service, algorithm or CSP that relied on or used the non-compliant functionality, parameters, keys, etc. remain in the approved mode. The approved mode **shall** only contain approved services.

f. Documentation **shall** be updated to indicate the module does not utilize non-compliant functionality in the approved mode of operation.

Option 3: The vendor recategorizes the non-compliant functionality as claiming no security per IG 1.23, and this functionality remains in the approved mode of operation.

a. The same rules for Option 2 above **shall** be followed except for sub-bullet iii. under "In the change summary of the Test Report".

b. This scenario is intended to be rarely used/accepted and depends on the purpose or use of the service that utilizes the non-approved algorithms. See IG 1.23 (including Additional Comment #2) and IG G.8 Additional Comment #10 for more information.

Option 4: A combination of any of three options above (CAVP testing, moving non-compliant functionality into the non-approved mode, and/or recategorized per IG 1.23), in which case, requirements of each option apply.

a. Submitted as a Scenario 3B.

b. Each option **shall** be listed/indicated in the change letter under Option 4 (e.g. under Option 4, the following are claimed: Options 1 and 2) and note how each of the applicable 'shall' statements for each option are met).

In order to accommodate vendors who are updating their validation to prepare for an algorithm transition, fully compliant 3B or 1sub option 3 revalidations that have addressed the transition and are submitted to the CMVP before the date the transition is to take effect, will remain on the active list through the completion of the revalidation, even if it is not completed until after the transition date, unless the algorithm transition is to address a security concern that is deemed unacceptable by the CMVP. For newly submitted 1sub option 3 submissions that address the transition, the lab **shall** include in the Special Instructions field the text "algorithm_transition" (with or without the underscore) in order for the CMVP not to move this submission to the historical list come the algorithm transition date.

Because the changes to address the transition (whether to the module code or purely to documentation) are considered security relevant, the CST lab **shall** submit an updated test report. The CST laboratory **shall** use the Scenario 3 table format for listing the affected TEs and their associated laboratory assessment. This information **shall** be listed in the beginning of the test report.

When the certificate is being updated, the CST laboratory **shall** use the format specifical in Scenario 1 above for listing the modifications to the certificate. Deletions **shall** be marked using strikethrough and additions **shall** be highlighted in yellow. This information **shall** be listed in the change letter.

Modules with certificates on the 140-2 Cryptographic Module List and on the CMVP Historical Validation List may be used for Scenario 3B revalidations. A new validation certificate will be issued upon completion of the 3B revalidation and will inherit the sunset date of the original certificate. The original certificate will be unmodified and remain either on the Active list (until the transition date arrives) or Historical list.

If a Scenario 3B revalidation addresses an algorithm transition that moved the original certificate to the Historical list, and the sunset date of the certificate has yet to expire, then upon the revalidation of the module under Scenario 3B, a new certificate will be issued on the Active list (inheriting the original sunset date) for the version of the module compliant with the transition requirements. Otherwise, if the original certificate was moved to the Historical list for reasons that are not addressed in the 3B revalidation (e.g. a separate algorithm transition or the sunset date expired), the new certificate will be shown on the Historical list *immediately* after completion of the 3B revalidation.

The laboratory **shall** submit a Scenario 3B revalidation by using the 3SUB process and e-mail transmittal code, but **shall** clearly indicate in the letter that this is a revalidation in response to the specific transition, and provide reference to that transition. The submitted package at a minimum **shall** consist of an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf>, the _vendor.txt file, the updated security policy <pdf>, test report <pdf>, and draft certificate <doc or docx or rtf>. The ZIP file and files within the ZIP file **shall** follow the CMVP Convention for E-mail Correspondence and submitted to the CMVP using the specified encryption methods.

Note: a single Scenario 3B submission may combine multiple algorithm transitions. However, this may increase review time.

Scenario 4:

Modifications are made only **to the physical enclosure of the cryptographic module that provides its protection and involves no operational changes to the module**. The CST laboratory is responsible for ensuring that the change only affects the physical enclosure (integrity) and has no operational impact on the module. The CST laboratory **shall** fully test the physical security features of the new enclosure to ensure its compliance to the relevant requirements of the standard.

Only modules with certificates on the *Validated FIPS 140-1 and 140-2 Cryptographic Module List* may be submitted under Scenario 4. Modules with certificates on the *CMVP Historical Validation List* will not be accepted.

The CST laboratory **shall** submit a letter to the CMVP that:

a. Describes the change (pictures may be required),

b. States that it is a security relevant change,

c. Provides sufficient information supporting that the physical only change has no operational impact,

d. Describes the tests performed by the laboratory that confirm that the modified enclosure still provides the same physical protection attributes as the previously validated module. For physical security levels 2, 3 and 4, the laboratory **shall** submit an updated Physical Security Test Report.

An example of such a change could be the plastic encapsulation of the Level 2 token which has been reformulated or colored. Therefore, the molding or cryptographic boundary has been modified. This change is security relevant as the encapsulation provides the opacity and tamper evidence requirements. But this can be handled as a letter only change with evidence that the new composition has the same physical security relevant attributes as the prior composition.

The CST laboratory **shall** include a new security policy for posting if the modifications cause changes to the areas addressed in FIPS 140-2 Appendix C. If the security policy represents multiple versions of a validated module or multiple validated modules, the versioning information **shall** be updated in the security policy with text that clearly distinguishes each module instance with its unique versioning information and the differences between each module instance.

The CST laboratory **shall** use the following format for listing the modifications to the certificate. Deletions **shall** be marked using strikethrough and additions **shall** be highlighted in yellow. This information **shall** be listed in the change letter.

For example:

Current Cert. #5000	New Certificate Information
Hardware Versions – AX12, AX13, ~~and~~ AX14 with FIPS kit AX00	Hardware Versions – AX12, AX13, AX14 and AX15 with FIPS kit AX00

The CST laboratory **shall** use the following format for listing the affected TEs and their associated laboratory assessment. This information **shall** be listed in the change letter.

For example:

TE or SP Section	Related Change
TE.01.08.02 TE.01.08.03 TE.01.08.12	New version of the hardware. Added to Bill of Materials.
TE.02.09.01 TE.02.09.02	Updated hardware version and power supply added.
TE.10.02.01 TE.10.02.02 TE.10.02.03 TE.10.02.04	Updated version of configuration items.

For a Scenario 4 revalidation, the CST laboratory **shall** submit, at a minimum, an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf>, the _vendor.txt file and physical security test report <pdf>. The ZIP file and files within the ZIP file **shall** follow the *CMVP Convention for E-mail* Correspondence and submitted to the CMVP using the specified encryption methods.

Upon a satisfactory review by the CMVP, the updated security policy and information will be posted on the *Validated FIPS 140-1 and FIPS 140-2 Cryptographic Module List* web site entry associated with the original cryptographic module. A new certificate will not be issued. The sunset date of the certificate will not be changed.

Scenario 5 – no longer accepted after September 22, 2021 without prior extension request approval by the CMVP:

If modifications are made to hardware, software, or firmware components **that do not meet any of the above criteria**, then the cryptographic module **shall** be considered a new module and **shall** undergo a full validation testing by a CST laboratory. The CST laboratory **shall** submit a test report as specified in IG G.2. Scenario 5 is also applicable for a module that is eligible for Scenario 3 but the original laboratory is not performing the revalidation. A new certificate will be issued.

Additional Comments

1. Modules on the *CMVP Historical Validation List* are not eligible for revalidations under Scenarios 1 (options 2, 3 unless only to address an algorithm transition, and 4), 1A, or 4.
2. A cryptographic module that is changed under change Scenarios 1, 1A, 1B, 3A, 3B and 4, must meet ALL standards, implementation guidance and algorithm testing that were met at the time of original validation. For these scenarios, a module does not need to meet requirements that were added since the time of original validation (except for Scenario 3B if guidance is directly applicable to the transitioning algorithm).

3. A cryptographic module that is changed under Scenarios 2, 3 and 5 above, must meet ALL standards, implementation guidance and algorithm testing in effect at the time the module report is submitted to the CMVP unless there is an implementation guidance transition that affects reports that have been submitted. The CST laboratory is responsible for requesting from the vendor all the documentation necessary to determine whether the cryptographic module meets the current standards and implementation guidance. This is particularly important for features/services of the cryptographic module that required a specific ruling from the CMVP.

   For example, a cryptographic module may have been validated with an implementation of KBKDF prior to when KBKDF testing was available. If the same cryptographic module is later submitted for revalidation under Scenarios 3 and 5, this KBKDF implementation to be used in an approved mode of operation **shall** be tested and validated against **SP 800-108**, and the cryptographic module must meet the applicable FIPS 140-2 requirements, e.g., self-tests.

4. This IG makes it clear that revalidation Scenarios 1 (option 4), 2 and 3 require a submission of an entropy report (if applicable per IG 7.14). At the time this IG was last modified, an entropy report is not required for the following Scenarios: 1 (options 1, 2 and 3), 1A, 3A, 3B and 4.

5. If the overall Security Level of the cryptographic module is lowered, the module may be submitted as a 3SUB with full testing on the individual section(s) that is being lowered.

6. If the overall Security Level of the cryptographic module is raised or if the physical embodiment changes, e.g., from multi-chip standalone to multi-chip embedded, then the cryptographic module will be considered a new module and **shall** undergo full validation testing by a CST laboratory.

7. The sunset date for the module is determined based on the scenario:

   - Scenario 1 – sunset date unchanged
   - Scenarios 1A – new certificate issued; sunset date is inherited from the original certificate
   - Scenarios 1B – sunset date depends on submission scenario
   - Scenario 2 – sunset date is extended 5 years from the revalidation date
   - Scenario 3 – new certificate issued; sunset date will be 5 years from the validation date
   - Scenario 3A - sunset date unchanged
   - Scenario 3B - new certificate issued; sunset date is inherited from the original certificate
   - Scenario 4 – sunset date unchanged
   - Scenario 5 – new certificate issued; sunset date will be 5 years from the validation date.

   The NIST CR schedule is available on the CMVP web site.

8. The NIST Cost Recovery (CR) schedule for the above scenarios is available on the CMVP web site: https://csrc.nist.gov/Projects/cryptographic-module-validation-program/nist-cost-recovery-fees

   Please note that ECR may still be applicable as well.

9. Excluding Scenarios 2, 3 and 5, any other two submission scenarios can be combined per the following rules. All requirements of *each* scenario **shall** apply when combining scenarios. If Scenario 1A is combined with another scenario, it must be submitted as Scenario 1A. If Scenario 4 is combined with Scenario 3A or Scenario 3B, then the designation would be Scenario 3A or Scenario 3B respectfully. Otherwise, the higher number submission scenario takes precedent in the submission designation (e.g., a combining Scenario 1B + Scenario 1 + Scenario 3A would be designated as Scenario 3A; combining Scenarios 3A + 3B would be designated as Scenario 3B; and combining Scenario 1 with Scenario 4 would be designated as Scenario 4). In all cases of combining scenarios, the laboratory **shall** indicate in the submission package which scenarios are part of the submission and a summary of associated changes. Any attempt to combine more than two submission scenarios together in a single report **shall** be approved by the CMVP prior to submission.

10. The CMVP has determined that changes made to a module in order to meet either the **SP 800-56Arev3** or the

SP 800-56Brev2 transition are security-relevant, due to their impacts on core and downstream services and the treatment of keys and CSPs, and will therefore require a Scenario 3, 3B or 5 submission regardless of module type or security level. For example, moving allowed Diffie-Hellman or EC Diffie-Hellman key agreement from approved mode to non-approved mode - by either changing the software/firmware or a purely documentation change - is considered security relevant.

In addition, attempts to make use of IG 1.23 *Definition and Use of a non-Approved Security Function* to address transitioning algorithms in approved mode will not be accepted unless all of the requirements of that IG are met, including the clarifications in the Additional Comments. For example, a software library implementing a non-**SP 800-56Arev3** Key Agreement Scheme (KAS) as one of its approved services cannot simply state this KAS does not claim any security (per IG 1.23) and be used in the approved mode, as this does not meet 3) or 4) in IG 1.23 Additional Comment #2.

Table G.8.1 – Regression Test Suite

Regression Testing Table					
AS	**TE**	**Security Level**			
		1	**2**	**3**	**4**
Section 1 - Cryptographic Module Specification					
AS.01.03	TE.01.03.02	x	x	x	x
Section 2 - Cryptographic Module Ports and Interfaces					
AS.02.06	TE.02.06.02	x	x	x	x
	TE.02.06.04	x	x	x	x
AS.02.13	TE.02.13.03	x	x	x	x
AS.02.14	TE.02.14.02	x	x	x	x
AS.02.16	TE.02.16.02			x	x
AS.02.17	TE.02.17.02			x	x
Section 3 - Roles, Services and Authentication					
AS.03.02	TE.03.02.02	x	x	x	x
	TE.03.02.03	x	x	x	x
AS.03.12	TE.03.12.03	x	x	x	x
AS.03.13	TE.03.13.02	x	x	x	x
AS.03.14	TE.03.14.02	x	x	x	x
AS.03.15	TE.03.15.02	x	x	x	x
AS.03.17	TE.03.17.02		x		
AS.03.18	TE.03.18.02		x		
AS.03.19	TE.03.19.02			x	x
	TE.03.19.03			x	x
AS.03.21	TE.03.21.02	x	x	x	x
AS.03.22	TE.03.22.02		x	x	x
AS.03.23	TE.03.23.02	x	x	x	x
Section 4 - Finite State Model					
AS.04.03	TE.04.03.01	x	x	x	x
AS.04.05	TE.04.05.08	x	x	x	x
Section 5 - Physical Security					
	NONE				
Section 6 - Operational Environment					
AS.06.05	TE.06.05.01	x			
AS.06.06	TE.06.06.01	x			
AS.06.07	TE.06.07.01	x	x	x	x
AS.06.08	TE.06.08.02	x	x	x	x
AS.06.11	TE.06.11.02		x	x	x
	TE.06.11.03		x	x	x
AS.06.12	TE.06.12.02		x	x	x
	TE.06.12.03		x	x	x
AS.06.13	TE.06.13.02		x	x	x
	TE.06.13.03		x	x	x
AS.06.14	TE.06.14.02		x	x	x

	TE.06.14.03		x	x	x
AS.06.15	TE.06.15.02		x	x	x
AS.06.16	TE.06.16.02		x	x	x
AS.06.17	TE.06.17.02		x	x	x
AS.06.22	TE.06.22.02			x	x
	TE.06.22.03			x	x
AS.06.24	TE.06.24.02			x	x
	TE.06.24.03			x	x
AS.06.25	TE.06.25.02			x	x
Section 7 - Cryptographic Key Management					
AS.07.01	TE.07.01.02	x	x	x	x
AS.07.02	TE.07.02.02	x	x	x	x
AS.07.15	TE.07.15.02	x	x	x	x
	TE.07.15.03	x	x	x	x
	TE.07.15.04	x	x	x	x
AS.07.25	TE.07.25.02	x	x	x	x
AS.07.27	TE.07.27.02	x	x	x	x
AS.07.28	TE.07.28.02	x	x	x	x
AS.07.29	TE.07.29.02	x	x	x	x
AS.07.31	TE.07.31.04			x	x
AS.07.39	TE.07.39.02	x	x	x	x
AS.07.41	TE.07.41.02	x	x	x	x
Section 8 - EMI / EMC					
	As Required				
Section 9 - Self Tests					
AS.09.04	TE.09.04.03	x	x	x	x
AS.09.05	TE.09.05.03	x	x	x	x
AS.09.09	TE.09.09.02	x	x	x	x
AS.09.10	TE.09.10.02	x	x	x	x
AS.09.12	TE.09.12.02	x	x	x	x
AS.09.22	TE.09.22.07	x	x	x	x
AS.09.35	TE.09.35.05	x	x	x	x
AS.09.40	TE.09.40.03	x	x	x	x
	TE.09.40.04	x	x	x	x
AS.09.45	TE.09.45.03	x	x	x	x
AS.09.46	TE.09.46.03	x	x	x	x
Section 10 - Design Assurance					
AS.10.03	TE.10.03.02	x	x	x	x
Section 11 - Mitigation of Other Attacks					
	NONE				
Appendix C - Cryptographic Module Security Policy					
	As Required				

G.9 FSM, Security Policy, User Guidance and Crypto Officer Guidance Documentation

Applicable Levels:	*All*
Original Publishing Date:	*05/29/2002*
Effective Date:	*05/29/2002*
Last Modified Date:	*08/01/2016*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

May a CST laboratory create original documentation specified in FIPS 140-2? The specific documents in question are the Finite State Model (FSM), Security Policy, User Guidance and Crypto Officer Guidance.

Resolution

FSM and Security Policy:

A CST laboratory may take existing vendor documentation for an existing cryptographic module (post-design and post-development) and consolidate or reformat the existing information (from multiple sources) into a set format. If this occurs, NIST and CCCS **shall** be notified of this when the validation report is submitted. Additional details for the individual documents are provided below.

FSM: The vendor-provided documentation must readily provide a finite set of states, a finite set of inputs, a finite set of outputs, a mapping from the sets of inputs and states into the set of states (i.e., state transitions), and a mapping from the sets of inputs and states onto the set of outputs (i.e., an output function).

Security Policy: The vendor-provided documentation must readily provide a precise specification of the security rules under which a cryptographic module must operate, including the security rules derived from the requirements of FIPS 140-2 and the additional security rules imposed by the vendor.

In addition, a CST laboratory must be able to show a mapping from the consolidated or reformatted FSM and/or Security Policy back the original vendor source documentation. The mapping(s) must be maintained by the CST laboratory as part of the validation records.

Consolidating and reformatting are defined as follows:

- The original source documents were prepared by the vendor (or a subcontractor to the vendor) and submitted to the CST laboratory with the cryptographic module.
- The CST laboratory extracts applicable technical statements from the original source documentation to be used in the FSM and/or Security Policy. The technical statements may **only** be reformatted to improve readability of the FSM and/or Security Policy. The content of the technical statements must not be altered.

- The CST laboratory may develop transitional statements in the FSM and/or Security Policy to improve readability. These transitional statements **shall** be specified as developed by the CST laboratory in the mapping.

User Guidance and Crypto Officer Guidance:

A CST laboratory may create User Guidance, Crypto Officer Guidance and other non-design related documentation for an existing cryptographic module (post-design and post-development). If this occurs, NIST and CCCS **shall** be notified of this when the validation report is submitted.

Additional Comments

Source code information is considered vendor-provided documentation and may be used in the FSM and/or Security Policy.

G.10 Physical Security Testing for Re-validation from FIPS 140-1 to FIPS 140-2

Applicable Levels:	*All*
Original Publishing Date:	*03/29/2004*
Effective Date:	*03/29/2004*
Last Modified Date:	*03/29/2004*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 IG G.2 specifies that all report submissions must include a separate physical security test report section for Levels 2, 3 or 4.

Question/Problem

Questions have been asked regarding re-validation test reports where a previous separate physical security test report may not have existed or evidence such as images, etc. had not been provided with the original validation test report. What should the CST laboratory provide if the physical security requirements have not changed?

Resolution

If a previous *separate* physical security test report did not exist for the module undergoing re-validation testing and the physical security features of the module have not changed, the CST laboratory must compile the physical security test evidence that has been maintained from their records from the original tested module and create and submit a new *separate* physical security test report. If the records no longer exist because they were generated outside the period of the CST laboratories record retention period specified in the quality manual, then re-testing **shall** be required to provide such evidence. It is not required that a CST laboratory perform re-testing simply to create new photographic images that may not have been saved or generated during the original testing

Additional Comments

If the CST laboratory was not the original testing laboratory and therefore does not have access to the previous test records, then the module **shall** be re-tested to be able to provide such evidence. Without the prior records, the new CST laboratory cannot make a determination that the physical security has or has not changed.

G.11 Testing using Emulators and Simulators

Applicable Levels:	*All*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*09/12/2005*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Vendors of cryptographic modules use independent, accredited Cryptographic and Security Testing (CST) laboratories to have their modules tested for conformance to the requirements of FIPS 140-2. Organizations wishing to have testing performed would contract with the laboratories for the required services. The Derived Test Requirements (DTR) document describes the methods that will be used by accredited laboratories to test whether the cryptographic module conforms to the requirements of FIPS 140-2. It includes detailed procedures, inspections, documentation and code reviews, and operational and physical tests that the tester must follow, and the expected results that must be achieved for the cryptographic module to satisfy its conformance to the FIPS PUB 140-2 requirements. These detailed methods are intended to provide a high degree of objectivity during the testing process and to ensure consistency across the accredited testing laboratories.

Definitions:

An **emulator** attempts to “model” or “mimic” the behavior of a cryptographic module. The correctness of the emulators' behavior is dependent on the inputs to the emulator and how the emulator was designed. It is not guaranteed that the actual behavior of the cryptographic module is identical, as many other variables may not be modeled correctly or with certainty.

A **simulator** exercises the actual module source code (e.g., VHDL code) prior to physical entry into the module (e.g., an FPGA or custom ASIC). From a behavioral perspective, the behavior of the source code within the simulator may be logically identical when placed into the module or instantiated into logic gates. However, many other variables exist that may alter the actual behavior (e.g. path delays, transformation errors, noise, environmental, etc.). It is not guaranteed that the actual behavior of the cryptographic module is identical, as many other variables may not be identified with certainty.

Question/Problem

May a CST laboratory tester use module emulation and/or simulation methods to perform cryptographic module testing?

Resolution

There are three broad areas of focus during the testing of a cryptographic module: operational testing of the module at the defined boundary of the module, algorithm testing and operational fault induction error testing.

1. Operational Testing

   Emulation or simulation is prohibited for the operational testing of a cryptographic module. Actual testing of the cryptographic module must be performed utilizing the defined ports and interfaces and services that a module provides.

2. Operational Fault Induction

   An emulator or simulator may be utilized for fault induction to test a cryptographic module's transition to error states as a complement to the already allowed source code review. Rationale must be provided for the applicable TE why a method does not exist to induce the actual module into the error state for testing.

3. Algorithm Testing

   Algorithm testing utilizing the defined ports and interfaces and services that a module provides is the preferred method. This method most clearly meets the requirements of IG 1.4.

   If this preferred method is not possible where the module's defined set of ports and interfaces and services do not allow access to internal algorithmic engines, two alternative methods may be utilized:

   a. A module may be modified by the CST laboratory for testing purposes to allow access to the algorithmic engines (e.g. test jig, test API), or

   b. A module simulator may be utilized.

   When submitting the algorithm test results to the CAVP, the actual operational environment on which the testing was performed must be specified (e.g. including modified module identification or simulation environment). When submitting the module test report to the CMVP, **AS.01.12** must include rationale explaining why the algorithm testing was not conducted on the actual cryptographic module.

   An emulator may not be used for algorithm testing.

G.12 Post-Validation Inquiries

Applicable Levels:	*All*
Original Publishing Date:	*01/26/2007*
Effective Date:	*01/26/2007*
Last Modified Date:	*08/07/2015*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 conformance testing that is performed by the accredited Cryptographic and Security Testing (CST) laboratories and validation of those test results by NIST and CCCS provide a level of assurance that a module conforms to the requirements of FIPS 140-2 and other underlying standards.

Once a module is validated and posted on the NIST CMVP web site, many parties review and scrutinize the merits of the validation. These parties may be potential procurers of the module, competitors, academics or others.

If a party performing a post-validation review believes that a conformance requirement of FIPS 140-2 has not been met and was not determined during testing or subsequent validation review, the party may submit an inquiry to the CMVP for review.

Question/Problem

What is the procedure and process for submitting an inquiry for review and how is the review performed? If a review is determined to have merit, what actions may be taken regarding the module's validation status?

Resolution

An *Official Request* must be submitted to the CMVP in writing with signature following the guidelines in IG G.1. If the requestor represents an organization, the official request must be on the organization's letterhead. The assertions must be objective and not subjective. The module must be identified by reference to the validation certificate number(s). The specific technical details must be identified and the relationship to the specific FIPS 140-2 Derived Test Requirements assertions must be identified. The request must be non-proprietary and not prevent further distribution by the CMVP.

The CMVP will distribute the unmodified official request to the CSTL that performed the conformance testing of the identified module. The CSTL may choose to include participation of the vendor of the identified module during its determination of the merits of the inquiry. Once the CSTL has completed its review, it will provide to the CMVP a response with rationale on the technical validity regarding the merits of the official request. The CSTL will state its position whether its review of the official request regarding the module:

1. is without merit and the validation of the module is unchanged.
2. has merit and the validation of the module is affected. The CSTL will further state its recommendations regarding the impact to the validation.

The CMVP will review the CSTLs position and rationale supporting its conclusion.

If the CMVP concurs that the official request is without merit, no further action is taken.

If the CMVP concurs that the official request has merit, a security risk assessment will be performed regarding the non-conformance issue.

G.13 Instructions for Validation Information Formatting

Applicable Levels:	*All*
Original Publishing Date:	*06/28/2007*
Effective Date:	*06/28/2007*
Last Modified Date:	*03/14/2022*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

How are the various fields in a FIPS 140-2 validation provided to the CMVP for validation?

Resolution

The CST laboratory **shall** use the CMVP supplied CRYPTIK tool to document the module test information. The test report information is presented to the CMVP for review and validation as indicated in IG G.2.

These instructions describe how the information **shall** be formatted to appear on the NIST CMVP validation web page via entry into CRYPTIK.

Laboratory Information

1. **Lab Name** - the name of the CST laboratory. Please include any registration marks or special characters.[1]
2. **NVLAP code** [**nnnnnn-n**] - the code assigned by NVLAP to the CST laboratory

Vendor Information

1. **Vendor Name** - the name of the vendor (including Corp., Inc., Ltd., etc.) that developed the cryptographic module. Please include any registration marks or special characters[1].

   Examples: **AcmeSecurity, Inc.**
   Acmeproducts(R), Ltd.
   AcmeSecurity, Inc. and Acmeproducts(R), Ltd.

   The FIPS 140-1 and FIPS 140-2 Vendor Listing is an alphabetical list of vendors who have implemented validated cryptographic modules. It is desirable that the vendor name be consistent on validation certificates issued for modules from the same vendor. The listing can be found at: http://csrc.nist.gov/groups/STM/cmvp/documents/140-1/1401vend.htm

2. **Address** - the street, building, post office box, suite, etc. components of the vendor's address
3. **City** - the city of the vendor's address
4. **State / Prov** - the state or province of the vendor's address
5. **Postal Code** - the postal code of the vendor's address
6. **Country** - the country of the vendor's address
7. **Web Site** - generally the vendor's main URL. Do not include the prefix http://
8. **Product Link** – a URL that may be specific to the module or products which utilize the module. Do not include the prefix http:// or duplicate the Web Site URL.
9. **POC1** - the primary vendor point of contact which may include phone number, fax number and email
10. **POC2** - the secondary vendor point of contact which may include phone number, fax number and email

Module Information

1. **Module Name(s)** - the complete name of the cryptographic module. Do not include the version number with the name unless by vendor choice. The name of the cryptographic module **shall** be consistent with IG 1.1 and the name found in the security policy and test report. Please include any registration marks or special characters [2].

   Examples: **Crypto Acceleration Token**
   Secure Cryptographic ToolKit™
   Best Crypto©

   If the test report represents multiple modules, list all module names.

   Examples: **Crypto Sensor AM-5000 and AM-5010**
   Crypto 8000 PCI, Crypto 9000 PCI and Crypto Plus++ PCI

2. **Hardware, Software and Firmware Versioning** - the specific versioning information representative of each of the crypto modules elements. This number **shall** be of sufficient level such that updates/upgrades/changes **shall** be reflected in a new version. For example, version 4 may not be sufficient if the releases are numbered 4.0, 4.1, 4.2, etc. The version number may also include letters, for example, 4.0a, 4.0b, 4.0c, etc. This **shall** include the version numbers for each element; hardware, software, and firmware, if applicable. Each elements version number (e.g. hardware, firmware, software)

[1] The special symbols may not translate to the _vendor.txt properly. The special symbol may be indicated as follows: (R) for ®, (C) for ©, (TM) for ™, etc.
[2] The special symbols may not translate to the _vendor.txt properly. The special symbol may be indicated as follows: (R) for ®, (C) for ©, (TM) for ™, etc.

shall be separated by a semi-colon. If a module does not include an element, leave the field blank; do not enter "NA". The version numbers **shall** be the same as the ones found in the security policy. For example, hardware version: 4.2; software version: 4.0a.

If possible, a hardware version of a module **shall** represent all of the components of the module, included (**AS.01.08**) or excluded (**AS.01.09**). If there are any additional components, included (**AS.01.08**) or excluded (**AS.01.09**), that are inside the module boundary but are not within the scope of the hardware version then the module certificate **shall** list these additional components separately in the hardware version field. Brackets **shall** be used to group hardware versions with their corresponding components. If the module is a collection of different hardware components, included (**AS.01.08**) or excluded (**AS.01.09**), and does not contain a hardware version, then the module certificate **shall** list all of the components of the module in the hardware version field without referencing any hardware version.

If there are multiple modules listed on the certificate, or if there are multiple part numbers with different versions of firmware for example, brackets **shall** be used to clearly indicate the pairings between the versioning information and/or the module names.

Examples: **(Hardware Version: 4.2; Software Version: 4.0a; Hardware)**
Hardware module with software embedded within it.

(Hardware Versions [1]: 5.2 and 5.3, Build 3; Firmware Version: 2.45; Hardware)
Two different hardware modules, each with the same embedded firmware. All of the components in these hardware modules must be considered: included (**AS.01.08**) or excluded (**AS.01.09**).

(Hardware Versions: 5.2 [1] and 5.3 [2], Build 3; Firmware Versions: 2.45 [1] and 2.50 [2]; Hardware)
Two different hardware modules each with the specified version of embedded firmware.

(Hardware Version: 88X8868; Software Version: 1.0; Software-Hybrid)
Software hybrid module referencing the hardware and disjoint software components.

(Hardware Version: BN45; Firmware version 1.0; Software Version 2.0; Software-Hybrid)
Software hybrid module referencing the hardware and disjoint software versions. The hardware component also has firmware embedded within it.

(Hardware Version: 88X8686; Firmware Version 1.4; Firmware-Hybrid)
Firmware hybrid module referencing both the hardware and disjoint firmware versions.

Note the use of the commas, semi-colons and colons.

(Hardware Version: [XYZ1, XYZ2, and XYZ3 with components 1234, 1235, 1236] and [ZYX1, ZYX2 and ZYX3 with components 1234, 5123, 6123]; Firmware Version: 1.0; Hardware)
Hardware module contains multiple hardware versions that have additional corresponding components that are included (**AS.01.08**) or excluded (**AS.01.09**).

(Hardware Version: P/N 5432, 7654, and 4321; Firmware Version: 1.0; Hardware)
Hardware module that is a collection of hardware components that are included (**AS.01.08**) or excluded (**AS.01.09**) rather than a versioned hardware module.

3. **PIV Certificate [#nnnn]** - When a module implements a validated PIV application, the application validation certificate type and number **shall** be included. Additional information relating to PIV versioning can be found in IG 1.18.
4. **Certificate Caveat** - This caveat may be modified or expanded by the CMVP during the validation process. Cryptographic modules may not have a caveat if the module only has a single FIPS approved

[1] Version will be changed to plural during the posting by the CMVP

mode of operation.

Examples: <no caveat>
The module can only be installed and operated in an approved mode of operation (i.e. FIPS mode).

When operated in FIPS mode
The module can be installed or operated in either an approved or non-approved mode of operation.

When installed, initialized and configured as specified in Section [section number] of the Security Policy
The module can be installed, initialized and/or configured in order to be considered a FIPS recognized module. Without this configuration, the module is not considered a FIPS-compliant module. After this configuration, a module may run in FIPS mode or non-FIPS mode (if supported by the module) which may require additional configuration and/or procedural guidance to invoke.

The <tamper evident seals> and <security devices> installed as indicated in the security policy
Installation of the referenced components required for the module to operate in an approved mode of operation.

When operated in FIPS mode and initialized to overall level 2 per security policy
The module can be initialized to operate at different overall levels.

Example: A module can be initialized to either support level 2 role-based authentication or initialized to support only level 3 identity-based authentication.

When operated in FIPS mode with module [module name] validated to FIPS 140-2 under Cert. #xxxx operating in FIPS mode
The module's validation is bound to another validated cryptographic module.

Example: A software cryptographic module which requires services from another validated software cryptographic module operating in the same operational environment. Application services are available from either module.

This module contains the embedded module [module name] validated to FIPS 140-2 under Cert. #xxxx operating in FIPS mode
If the module incorporates an embedded validated cryptographic module.

Example: A software cryptographic module which is compiled with a privately linked validated software cryptographic module operating in the same operational environment. Application services are only available from the module indicated on the certificate.

Example: A hardware cryptographic module which has embedded within its physical boundary a validated cryptographic module.

This validation entry is a non-security-relevant modification to Cert. #nnnn
If the lab submits a revalidation under scenario 1B. Please refer to IG G.8.

When operated only on the specific platforms specified on the certificate
For a firmware at overall level 2, 3, or 4 module or where FIPS 140-2 Section 4.5 Physical Security is level 2, 3 or 4. Please refer to IG 1.3.

When utilizing a Trusted Path as specified in the security policy

If the use of the Trusted Path is needed to meet the FIPS 140-2 compliance requirements when Section 4.2 is validated at Security Levels 3 and 4. Please refer to IG 2.1.

The module generates cryptographic keys whose strengths are modified by available entropy
Please refer to IG 7.14.

The module generates random strings whose strengths are modified by available entropy
Please refer to IG 7.14.

The module generates cryptographic keys and random strings whose strengths are modified by available entropy
Please refer to IG 7.14.

No assurance of the minimum strength of generated keys
Please refer to IG 7.14.

When entropy is externally loaded, no assurance of the minimum strength of generated keys
Please refer to IG 7.14.

No assurance of minimum strength or security of keys
If the module receives keys or bit strings from outside of its boundary for use within an approved algorithm (e.g., a key used for AES encryption; or a bit string used for generating the k values of DSA and ECDSA sigGen algorithms).

The output of the DRBG shall not be used to generate keys
If the module implements a DRBG where the module does not meet the requirements for the entropy source explained in IGs IG 7.14, IG 7.15 *and* IG 7.18.

The protocol(s) <TLS, SSH, …> shall not be used when operated in FIPS mode
If the module implements a KDF from NIST SP 800-135rev1 and this KDF has not been validated by the CAVP. Please refer to IG D.11.

5. **Type -** the module type is one of the following: **Hardware, Firmware, Software**, **Software-Hybrid** or **Firmware-Hybrid**. If a module is hardware with embedded software and/or firmware, the module's type is simply labeled Hardware.

6. **Overall Level [n]** – the overall level of the crypto module. This value is the *lowest* value of the individual levels.

7. **Section Level(s) [n]** - for each of the 11 areas, include the specific level. For FIPS 140-2, the Operating System security level, the physical security level and Mitigation of Other Attacks level may not be applicable and if so, **shall** be marked as N/A.

   If a module meets level 3 physical security and also has been tested for EFP and/or EFT, this **shall** be annotated on the certificate as: **Level 3 +EFP** or **+EFT** or **+EFP/EFT**

   Note: If FIPS 140-2 Section 4.5 is level 3 with EFP/EPT, this is selected in CRYPTIK by selecting level 3 for FIPS 140-2 Section 4.5 and selection of the optional EFP/EFT button. CRYPTIK will then present the appropriate set of assessments. However, the generated *draft certificate* and *_vendor.txt* will not reflect the optional EFP/EFT annotation. Currently this must be added manually during validation posting.

8. **Operational Environment** - the specific operational environment(s) or configuration(s) that was employed during testing by the CST laboratory **shall** be specified for all module types. (e.g. software, firmware, hardware and hybrid). This **shall** match the information in the test report in **AS.01.08**. The operational environment includes the operating system(s), the tested platform(s), and the processor(s).

For a *software* cryptographic module at security level 1, the caveat "(single-user mode)" **shall** be included. For Java applets, the Java environment (JRE, JVM) version **shall** be specified for all security levels. For multiple operating environment entries, separate each with a semi-colon; do not use "and".

Examples: **Microsoft Windows XP with SP2 running on a Dell Optiplex Model 4567 with an Intel i7-8550U;**

Sun Solaris Version 2.6SE running on a Sun Ultra SPARC-1 workstation with an Intel Xeon X5670;

Microsoft Windows XP with SP2 running on an HP Pavilon 4.5 with an AMD A8-3850;

HP-UX 11.23 running on an IBM RISC 6000RB2 with an Intel Xeon E3-1230 (single-user mode)

The following example for a *firmware* cryptographic module;

Example: **BlackBerry® 7230 with BlackBerry OS® Versions 3.8, 4.0 and 4.1 with Qualcomm Snapdragon S4 Plus**

If the *firmware* module's physical security meets FIPS 140-2 Section 4.5 levels 2, 3 or 4, the hardware platform **shall** include applicable specific versioning information.

Example: **Little OS® Version 3.7b running on a Crypto Unit (Hardware Version: 1.0) with AMD Duron 800**

The following example for a *software-hybrid* cryptographic module;

Example: **Debian GNU/Linux 4.0 (Linux kernel 2.6.17.13) running on a 4402-A ViPr Desktop Terminal with Intel i7-8550U (single-user mode)**

The following example for a *firmware-hybrid* cryptographic module; the certificate **shall** specify the operating environment (operating system and hardware platform with processor) that was used for testing.

Example: **BlackBerry OS Version 4.2 running on a BlackBerry 8700c with Qualcomm Snapdragon S4 Plus**

The operational environment includes the operating system(s) the tested platform(s) and the processor(s). The operating system may also represent virtual environments. Virtual environments are run by computer software, firmware or hardware called a hypervisor. Native hypervisors run directly on the host computer. Hosted hypervisors run on a conventional operating system.

- For a Type 1 (or native) hypervisor, the OE listing **shall** include the platform, guest OS, hypervisor and processor using the following format:

  Operational Environment: ***<Guest OS>*** on ***<hypervisor>*** running on ***<platform>*** with <***processor***>

  An example is: Windows XP on VMWare ESX 5 running on a Dell Optiplex 5460 with an Intel Core i5

- For a Type 2 (or hosted) hypervisor, the OE listing **shall** include the platform, guest OS, hypervisor, host OS and processor using the following format:

  Operational Environment: ***<Guest OS>*** on ***<hypervisor>*** on ***<Host OS>*** running on ***<platform>*** with <***processor***>

  An example is: Windows 7 on Oracle VM VirtualBox on Oracle Solaris 11 running on a HP Model 20 with Intel Xeon E5-2670v3

The tested platform itself may be procured with a single processor or several different processors. As shown above, the processor(s) on which the module was tested on **shall** be listed on the CMVP certificate, security policy and test report.

Example: **Wind River Linux 6.0 running on a Xerox Explorer 60 with Intel Atom E3800**

SEPOS running on Apple TV 4K with Apple A10X Fusion

Tintri OS 4.5 running on a EC6030 with Intel Xeon E5-2609

If this field is not applicable, mark the field as N/A.

9. **FIPS Approved Algorithms** - the approved security functions included in the cryptographic module and utilized by the module's callable services or internal functions. The security function is listed and then the applicable algorithm Certificate number in parentheses. Do NOT include the modes or key lengths (e.g., ECB, CBC; 128 bits). All algorithm entries must be separated by semi-colons. The security functions **shall** be listed in alphabetical order using the official CAVP security function name.

If a module contains within it or is bound to an already validated cryptographic module, all approved or allowed security functions that are used by the module's callable services and internal functions **shall** be annotated on the certificate (e.g. both those within the embedded/bound module and in addition to the embedding/binding module) and also listed in the security policy with the bound/embedded security functions clearly distinct from the module's implemented security functions.

Algorithms that are never called **shall not** be listed on the certificate. An algorithm that can only be called by a service that performs the self-tests also **shall not** be listed on the certificate; however, the module's security policy **shall** have an entry for the corresponding self-test and explain that this algorithm can only be executed when running a self-test.

The algorithm **shall** meet all three (3) conditions to be listed as FIPS approved:

1. an approved security function as specified in FIPS 140-2 Annexes A, C or D and validated by the CAVP or vendor affirmed per CMVP implementation guidance;
2. meet all requirements of FIPS 140-2 (KAT, etc.); and
3. used in at least one FIPS approved cryptographic function or service for that cryptographic algorithm in a FIPS approved mode of operation. CVL (vendor affirmed)

Examples: **AES (Cert. #1880);**
AES-CBC-CS [1] (vendor affirmed);
CKG [2] (vendor affirmed);
CVL [3] (vendor affirmed);
CVL [4] (Cert. #4);
DRBG [5] (Cert. #12);
DSA [6] (Cert. #200);
ECDSA [7] (Cert. #100);

[1] SP 800-38A Addendum
[2] Cryptographic Key Generation; SP 800-133 and IG 7.8
[3] Vendor affirmed Component Validation List; see IG G.20.
[4] Component Validation List; see CAVP CVL and IG G.20.
[5] Deterministic Random Bit Generator; SP 800-90A
[6] FIPS 186-2 (for Signature Verification only) or FIPS 186-4
[7] FIPS 186-2 (for Signature Verification only) or FIPS 186-4

Either **ENT (P)** or **ENT (NP)** [1];

HMAC [2] **(Cert. #23);**

KAS [3] **(Cert. #33);**

KAS [4] **(SP 800-56Arev2, vendor affirmed);**

KAS [5] **(SP 800-56Arev2 with CVL Certs. #24 and #32, vendor affirmed);**

KAS [6] **(SP 800-56B, vendor affirmed)**

KAS-SSC [7] **(vendor affirmed);**

KAS-SSC [8] **(Cert. #A66);**

KAS (KAS-SSC Cert. #A66, KDA Cert. #A11, CVL Cert. #A43); [9]

KAS (KAS-SSC Cert. #A66, CVL Cert. #153); [10]

KAS-RSA-SSC [11] **(Cert. #A91);**

KAS-RSA (KAS-RSA-SSC Cert. #A91, CVL Certs. #153 and #155, CVL Cert. #A41); [12]

Note. Two different CVL certificates, #153 and #155 demonstrate the KDF validation testing. The CVL certificate #A41 demonstrates the tested key confirmation functionality. There are several possible reasons for obtaining more than one CVL certificate for KDF testing. As with any other algorithm, the vendor might have performed an algorithm testing in multiple operating environments. The vendor could have also chosen to test different key derivation functions separately and to obtain different certificates. Even when testing the same algorithm (or a CVL function) in the same operating environment, the vendor may decide to test various functionalities and different parameter sets (such as key lengths) separately and have multiple certificates issued by the CAVP.

KBKDF [13] **(Cert. #2);**

KDA [14] **(vendor affirmed);**

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[1] The presence of entropy source(s) tested to SP 800-90B. No algorithm certificate number is needed. The letters inside the parentheses indicate if only the physical or both the physical and the non-physical entropy sources tested to SP 800-90B contribute to the computation of the module's entropy, per IG 7.20. Note that at most one ENT () entry may appear in the module's validation certificate.

[2] Includes Truncated HMACs per IG A.8

[3] Key Agreement Scheme; tested to either SP 800-56A or SP 800-56A Rev3 (per IG D.8 Scenario X1 path (2))

[4] Key Agreement Scheme; vendor affirmed to SP 800-56A Rev2

[5] Key Agreement Scheme; vendor affirmed to SP 800-56A Rev2. Two different CVL certificates, #24 and #32 demonstrate the validation testing of the SP 800-135 Rev1-compliant KDFs that can be used with this KAS

[6] Key Agreement Scheme; vendor affirmed to SP 800-56B. See IG D.4.

[7] Shared Secret Computation using the Discrete Logarithm Cryptography; vendor affirmed to SP 800-56A Rev3 per IG D.1-Rev3

[8] Tested for a compliance with one or more shared secret computation schemes in Section 6 of SP 800-56A Rev3. The information about the scheme's security strength is documented in the module's Security Policy.

[9] An SP 800-56A Rev3 compliant key agreement scheme, where testing is performed separately for the shared secret computation, an SP 800-56C Rev1 or Rev2 compliant KDF, and a key confirmation, per IG D.8 Scenario X1 path (2).

[10] An SP 800-56A Rev3 compliant key agreement scheme, where testing is performed separately for the shared secret computation and for a KDF compliant with either SP 800-135 Rev1 or RFC 8446 . No key confirmation. Per IG D.8 Scenario X1 path (2).

[11] Tested for a compliance with the derivation of the shared secret as shown in SP 800-56Br2. The information about the derived shared secret security strength is documented in the module's Security Policy.

[12] An SP 800-56Br2-compliant key agreement scheme, where testing is performed separately for the shared secret computation, for a key derivation function compliant with SP 800-135 Rev1 and/or RFC 8446, and for the key confirmation, per IG D.8 Scenario 2 path (2)

[13] Key Based Key Derivation Function; SP 800-108

[14] Key Derivation Algorithm; vendor affirmed to SP 800-56C Rev1 per IG D.10 as a stand-alone algorithm.

KDA [1] (Cert. #A25);

Note 1. Obtaining a CVL certificate for a tested TLS 1.3 KDF does not lead to granting the vendor a KDA algorithm certificate; in order to receive a KDA certificate, the implementation's compliance to SP 800-56C Rev 1 or Rev2 **shall** be tested separately. This testing may include either a one-step key derivation, or a two-step key derivation (shown in Sections 4 and 5 of SP 800-56C Rev1/2, respectively), or both.

Note 2. A KDA algorithm certificate obtained by the vendor may also be used to claim the correct implementation of the HKDF key derivation function, but only if the KDA certificate has been issued for testing the two-step key derivation documented in Section 5.1 of **SP 800-56C Rev1/2** using HMAC for the randomness extraction in Step 1, as shown in Figure 1 in **SP 800-56C Rev1/2**. The module's Security Policy **shall** provide the justification for claiming a compliant implementation of the HKDF.

The HKDF key derivation function is documented in the IETF RFC 5869 which references the following paper: https://eprint.iacr.org/2010/264.pdf for the algorithm's details.

KMAC [2] (SHA-3 Cert. #33, vendor affirmed)

KTS [3] (vendor affirmed);

PBKDF [4] (Cert. #A25);

PBKDF [5] (vendor affirmed);

RSA [6] (Cert. #133);

RSA [7] (SHA-3 Cert. #55, vendor affirmed);

SHA-3 [8] (Cert. #55);

SHA-3-Customized [9] (SHA-3 Cert. #100, vendor affirmed)

SHS (Cert. #23);

Skipjack [10] (Cert. #45);

Triple-DES (Certs. #78 and #122);

Triple-DES MAC [11] (Triple-DES Cert. #78, vendor affirmed)

For multiple certificate entries, the term "Cert" **shall** be pluralized (i.e., Certs), an "and" **shall** be placed between the last two certificate numbers and there **shall** be a "#" in front of each number.

Examples: **Triple-DES (Certs. #118 and #133);**
SHS (Certs. #103, #115 and #119)

If the module supports symmetric key wrapping, one of the following annotations **shall** be used, depending on the approved wrapping algorithm:

KTS (Triple-DES Cert. #50; key establishment methodology provides 112 bits of encryption strength) – an implementation has been tested for its compliance with three-key

[1] Key Derivation Algorithm compliant to SP 800-56C Rev1 or Rev2.
[2] IG A.15; vendor-affirmed to SP 800-185
[3] Key Transport Scheme; vendor affirmed to SP 800-56B per IG D.4.
[4] Tested Password Based Key Derivation Function; SP 800-132
[5] Vendor-affirmed Password Based Key Derivation Function; SP 800-132. See IG D.6.
[6] FIPS 186-2 (for Signature Verification only) or FIPS 186-4
[7] FIPS 186-4 and FIPS 202. RSA signatures with only the SHA-3 hash functions.
[8] FIPS 202
[9] One or more of the hash functions listed in IG A.15; vendor-affirmed to SP 800-185
[10] Only decryption is approved for Skipjack
[11] **Shall** specify the underlying Triple-DES algorithm certificate number with the "vendor affirmed" caveat.

Triple-DES TKW and this mode of the Triple-DES is used for key wrapping. Triple-DES cert. #50 **shall** be listed separately on the approved line.

KTS (AES Cert. #100) – an implementation has been tested for its compliance with AES KW and/or AES KWP and this mode of AES is used for key wrapping. AES cert. #100 **shall** be listed separately on the approved line.

KTS (AES Cert. #200) - has been tested for its compliance with AES GCM (or any other authenticated encryption mode) and this mode of AES is used for key wrapping. AES cert. #200 **shall** be listed separately on the approved line.

KTS (AES Cert. #300) - has been tested for its compliance with both AES KW and AES GCM and each of these two modes of AES may be used for key wrapping. The AES cert. #300 **shall** be listed separately on the approved line. Each tested AES mode, KW and GCM (and any other) will be shown in the AES algorithm certificate. The security policy **shall** explain how each applicable mode of AES is used for key wrapping.

KTS (AES Cert. #700 and HMAC Cert. #200) - Example of CAVP testing of disjoint AES encryption and HMAC authentication with appropriate strength. AES cert. #700 and HMAC cert. #200 **shall** be listed separately on the approved line.

KTS (AES Cert. #750 and HMAC Cert. #250; key establishment methodology provides 192 bits of encryption strength) - Example of CAVP testing of disjoint AES encryption and HMAC authentication where an AES wrapping key may be of lower length than wrapped key. AES cert. #700 and HMAC cert. #250 **shall** be listed separately on the approved line.

KTS (AES Cert. #300 and HMAC Cert. #355; key establishment methodology provides 128 or 192 bits of encryption strength) – a combination of AES in any mode and message authentication using HMAC is used for key wrapping. There is a range of AES key lengths. AES cert. #300 and HMAC cert. #355 **shall** be listed separately on the approved line.

KTS (AES Cert. #400 and AES [1] Cert. #10; key establishment methodology provides between 128 and 256 bits of encryption strength) - a combination of AES in any mode and message authentication using AES CMAC or GMAC is used for key wrapping. AES certs. #10 and #400 **shall** be listed separately on the approved line.

KTS (AES Certs. #10, #20 and #C55 and AES Certs. #100, #200, #300 and #C66; key establishment methodology provides 128 or 256 bits of encryption strength) - a combination of an AES in any mode (with the AES algorithm certificates #10, #20 and #C55) and message authentication using AES CMAC or GMAC (with the AES algorithm certificates #100, #200, #300 and #C66) is used for key wrapping. An AES algorithm with all certs **shall** be listed separately on the approved line. An AES encryption/decryption may be performed with the AES key sizes of 128 and 256 bits.

NOTE 1: The AES or the Triple-DES algorithm certificate will provide information on the length of the wrapping key. To make a decision if this length is sufficient to avoid adding a strength caveat, one has to know the range of the possible lengths of the wrapped keys. **AS.07.19** requires that the wrapping key used in key transport be equal or of greater strength than the wrapped key. If the strength of the largest key that can be established by a cryptographic module is greater than the comparable strength of the implemented key establishment method, then the module certificate and security policy **shall** be annotated with, in addition to the other required caveats, the caveat "**(key establishment methodology provides xx bits of encryption strength)**" [2] for that key establishment method as allowed in IG 7.5 – *Strength of Key Establishment Methods*. No strength caveat is required

[1] When two algorithm names are included in a symmetric-key-based KTS scheme caveat, the first name shows an algorithm used to perform the encryption and the second one – the message authentication.
[2] While this caveat only has a single encryption strength claimed, other examples included in this IG G.13 indicate that the strength caveat may have a range, depending on the key sizes used for the key establishment methodology.

if the wrapping key used in key transport be equal or of greater strength than the wrapped key. This applies to both an approved KTS, or the allowed key establishment methods (see section 10 of this IG G.13 for allowed key establishment methods). A similar caveat is used when a key is established using a key agreement protocol that might cause the resulting cryptographic strength of the key to be less than the key length in bits.

NOTE 2: The strength of an HMAC key and the size of the hash output are not reflected in the computation of the equivalent encryption strength.

If the module supports an RSA-based key encapsulation/un-encapsulation and the vendor obtains an algorithm certificate of compliance with SP 800-56Br2 then one of the following annotations **shall** be used, depending on the necessity to address the algorithm strength:

KTS-RSA (Cert. #A100)

KTS-RSA (Cert. #A100; key establishment methodology provides 112 bits of encryption strength)

KTS-RSA (Cert. #A100; key establishment methodology provides between 112 and 150 bits of encryption strength)

NOTE: The module's validation certificate will not indicate if the approved RSA-based key establishment algorithm supports the key encapsulation, key un-encapsulation, or both. Neither will the validation certificate indicate the algorithm's support for the key confirmation. This information **shall** be included in the Security Policy.

If the module supports an RSA-based key agreement and the vendor obtains an algorithm certificate of compliance with **SP 800-56Br2** then one of the following annotations **shall** be used, depending on the necessity to address the algorithm strength:

KAS-RSA (Cert. #A25)

KAS-RSA (Cert. #A25; key establishment methodology provides 112 bits of encryption strength)

KAS-RSA (Cert. #A25; key establishment methodology provides 112 or 128 bits of encryption strength)

NOTE: The module's validation certificate will not indicate which approved RSA-based key establishment algorithms (KAS1 or KAS2, or both) are supported. Neither will the module's certificate specify whether the supported schemes include any form of key confirmation. The information about the key confirmation testing will be found in the KAS-RSA algorithm certificate and listed in the module's Security Policy.

If the module implements a key agreement scheme based on the use of the finite field or the elliptic curve technology and the vendor obtains an algorithm certificate of compliance with SP 800-56A Rev3 then one of the following annotations **shall** be used, depending on the necessity to address the algorithm strength:

KAS (Cert. #A72)

KAS (Cert. #A72; key establishment methodology provides 112 bits of encryption strength)

KAS (Cert. #A72; key establishment methodology provides between 112 and 256 bits of encryption strength)

NOTE1: This entry indicates compliance with a key agreement scheme from **SP 800-56A Rev3**. It uses a key derivation function compliant with **SP 800-56C Rev1** or **Rev2**.

NOTE2: The module's validation certificate will not indicate the presence of the CVL certificate for testing of the key confirmation portion of a key agreement scheme. The information about the key confirmation testing will be found in the KAS algorithm certificate and listed in the module's Security Policy.

10. **Allowed algorithms** [1] - cryptographic algorithms that are not approved but are allowed to be used in a FIPS approved mode of operation.

    All allowed algorithms **shall** be identified in the security policy and listed on the validation certificate. Allowed algorithms **shall** be listed in alphabetical order on the certificate.

    Examples: **AES** [2] **(Cert. #300, key unwrapping);**

    Diffie-Hellman [3] **(shared secret computation);**

    Diffie-Hellman [4] **(key agreement);**

    MQV [5] **(CVL Certs. #5 and #6, key agreement);**

    EC Diffie-Hellman [6] **(key agreement);**

    EC Diffie-Hellman [7] **(CVL Cert. #4 with SP 800-56C, vendor affirmed, key agreement);**

    EC MQV (CVL Cert. #12 with SP 800-56C, vendor affirmed, key agreement);

    NDRNG [8]**;**

    RSA [9] **(key unwrapping);**

    RSA [10] **(key wrapping);**

    RSA [11] **(CVL Cert. #10, key wrapping);**

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[1] Through June 30, 2017, section 10 of this IG (Allowed algorithms) will be labelled *Other algorithms* on the certificate and will include allowed and non-approved algorithms. Starting July 1, 2017, section 10 of this IG (Allowed algorithms) will be labelled *Allowed algorithms* and will only include allowed algorithms. Starting July 1, 2017, non-approved and non-allowed algorithms **shall** only be listed in the security policy.
[2] This is an allowed but non-SP-800-38F-compliant key unwrapping, where the key used in key transport is of equal or greater strength than the unwrapped key and therefore the strength caveat is not required.
[3] Only the untested shared secret computation primitive is implemented.
[4] A key agreement scheme with no claim of compliance with SP 800-56A shared secret computation nor with an approved key derivation method (SP 800-56C or SP 800-135).
[5] Composite of two disjoint tested components (DLC and KDF) which forms key agreement. The composite is not tested by the CAVP.
[6] A key agreement scheme with no claim of compliance with SP 800-56A shared secret computation nor with an approved key derivation method (SP 800-56C or SP 800-135). **Shall** use the "EC Diffie-Hellman" annotation not the ECDH notation.
[7] Composite of two disjoint components (tested DLC and vendor-affirmed KDF) which forms key agreement. The CVL **shall** be referenced as shown here if the key agreement scheme utilizes this component. The composite is not tested by the CAVP.
[8] An entropy source that meets the requirements of IG 7.15. No claim of compliance with SP 800-90B.
[9] The module does not support RSA key wrapping but does employ RSA key unwrapping with no claim of compliance with any testable component of SP 800-56B.
[10] No claim of compliance with any testable component of SP 800-56B. If the module supports both RSA key wrapping and unwrapping in this way, or just key wrapping alone, the certificate **shall** only include a "key wrapping" entry without a separate "key unwrapping" entry.
[11] The RSADP component of an RSA-based key transport scheme is tested by CAVP for its compliance with SP 800-56B. The module supports both the wrapping and the unwrapping of the cryptographic keys using RSA, hence the annotation in this example states "key wrapping", even though the listed RSADP CVL certificate applies only to the key unwrapping schemes. This CVL certificate **shall** be referenced as shown here if the implemented key transport scheme does utilize this component. Note: the RSA entry **shall not** reference the KDF CVLs, as these are not directly part of RSA key transport scheme.

Triple-DES [1] (Cert. #200, key unwrapping);

For the non-FIPS approved key establishment schemes refer to IG's D.8 and D.9.

For algorithm implementations that have both approved and non-approved and not allowed (e.g. RSA) components, the approved component **shall** be listed on the FIPS approved line and the non-approved and not allowed component **shall** be listed only in the security policy. The security policy **shall** indicate all uses of the algorithm.

All non-FIPS approved and not allowed algorithms **shall** be listed in the security policy but NOT on the certificate. A non-FIPS approved implementation may exist for what appears to be an approved algorithm where a CAVP validation or the requirements of FIPS 140-2 (e.g. self-test) are not met. These non-FIPS approved implementations are considered non-approved and non-compliant and **shall** be described in the security policy as "*non-compliant*" so that it is clear the algorithm implementation **shall** not be used in an approved mode of operation.

NOTE: Encryption strengths represented on a validation entry are based on algorithm key sizes in bits *only*. As indicated above the calculation of the encryption strength based on key size is performed per IG 7.5. The effective encryption strength may be less depending upon the amount of available entropy. See IG 7.14, IG 7.15, IG 7.18 and this IG for additional guidance and applicable caveats.

In the following key establishment examples, the strength caveat *does* apply (i.e., the security strength of the key establishment scheme implemented by the module **can be** less than that of the agreed or wrapped key).

If the module supports, for a particular key establishment method, a single strength, then the caveat **shall** state the strength provided by the keys.

Examples: **Diffie-Hellman (key agreement; key establishment methodology provides 112 bits of encryption strength)**

RSA (key wrapping; key establishment methodology provides 112 bits of encryption strength)

RSA [2] (key unwrapping; key establishment methodology provides 112 bits of encryption strength)

EC MQV [3] (shared secret computation provides 192 bits of encryption strength)

If a module *only* implements two specific key sizes for Diffie-Hellman, then:

Diffie-Hellman (key agreement; key establishment methodology provides 112 or 128 bits of encryption strength)

If a module implements a key establishment scheme with several key sizes for Diffie-Hellman, MQV, RSA, EC Diffie-Hellman or EC MQV then only the range end points are indicated:

MQV (key agreement; key establishment methodology provides between 112 and 256 bits of encryption strength)

[1] This is an allowed but non-SP-800-38F-compliant key unwrapping, where the key used in key transport is of equal or greater strength than the unwrapped key and therefore the strength caveat is not required.
[2] The module does not support RSA key wrapping but does employ RSA key unwrapping with 2048-bit modulus.
[3] This entry may reflect either Scenario 6 or Scenario X2 of IG D.8.

RSA (key wrapping; key establishment methodology provides between 130 and 180 bits of encryption strength)

EC Diffie-Hellman (key agreement; key establishment methodology provides between 112 and 256 bits of encryption strength)

If a module implements a key establishment scheme of several key sizes and also less than 112 bits of strength, then only the approved range end points are indicated.

Diffie-Hellman (key agreement; key establishment methodology provides between 112 and 256 bits of encryption strength)

If a module supports a key agreement algorithm such that the shared secret computation portion of the key agreement is tested for its compliance with **SP 800-56A** and issued a CVL certificate, then an example of the certificate annotation would be:

EC MQV (CVL Cert. #17, key agreement; key establishment methodology provides between 128 and 256 bits of encryption strength)

If, in addition, the module states compliance with another part of the key agreement protocol, then this also **shall** be caveated in the certificate. For example:

Diffie-Hellman [1] (CVL Cert. #3 with SP 800-56C, vendor affirmed, key agreement; key establishment methodology provides between 112 and 150 bits of encryption strength)

EC MQV [2] (CVL Cert. #17 with CVL Cert. #6, key agreement; key establishment methodology provides between 112 and 192 bits of encryption strength)

If the module supports only a portion of the key establishment scheme and this portion was tested for its compliance with its associated standard (i.e. **SP 800-56A**, **SP 800-56B**, **SP 800-135rev1**, etc.) and issued a CVL certificate, then the FIPS Approved Algorithms line would include the CVL certificate but the *Allowed algorithms* line *would not* include the key establishment scheme, since the CVL certificate covers the implementation. For example, if the module only implements the shared secret computation of the Diffie-Hellman scheme, and this was CVL certified to comply with **SP 800-56A**, then the CVL certificate would be listed on the approved algorithms line but the Diffie-Hellman would *not* be listed on the allowed algorithm line.

If the module supports a key establishment scheme such that part of the scheme has a CVL certificate, but the CVL certificate does not cover all of the curves or key sizes that the scheme implements, then these would be split into separate entries on the certificate - one with the approved CVL reference, and the other without. For example:

EC Diffie-Hellman (CVL Cert. #842, key agreement; key establishment methodology provides 128 or 192 bits of encryption strength); EC Diffie-Hellman (key agreement; key establishment methodology provides 112 or 256 bits of encryption strength)

If the module supports the key unwrapping algorithms that are not compliant with **SP 800-38F** then this **shall** be annotated in the certificate. For example:

AES (Cert. #300, key unwrapping; key establishment methodology provides 128 or 192 bits of encryption strength)

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[1] A key agreement scheme that includes a shared secret computation validated to SP 800-56A and a key derivation function vendor-affirmed to be compliant with either SP 800-56C or SP 800-56C Rev1. The exact revision version of SP 800-56C does not need to be shown in the module's certificate.
[2] A key agreement scheme that includes a shared secret computation validated to SP 800-56A and a key derivation function validated to SP 800-135 Rev1.

Triple-DES (Cert. #114, key unwrapping; key establishment methodology provides 112 bits of encryption strength)

If AES MAC is implemented for OTAR, it **shall** be specified as:

AES MAC (AES Cert. #2, vendor affirmed; P25 AES OTAR)

All other uses of AES MAC are non-compliant and **shall** only be listed in the security policy (as non-compliant).

Note: In all cases, the CMVP report reviewer must ascertain the correctness of the added caveat(s) and the most accurate wording and the best interpretation to give to the Federal users.

If the Allowed algorithms field is not applicable, mark the field as N/A.

For non-FIPS approved algorithms that have names similar to approved security functions, they are considered non-approved and non-compliant and **shall** be listed in the security policy but NOT on the certificate. They **shall** be described as "non-compliant" in the security policy so that it is clear the algorithm implementation **shall not** be used in the approved mode of operation.

11. **Embodiment Type** - the cryptographic module **shall** be specified as one of the three types: **Multi-chip Standalone**, **Multi-chip Embedded**, or **Single-chip**.

G.14 moved to W.14

G.15 moved to W.2

G.16 Requesting an Invoice Before Submitting a Report

Applicable Levels:	*All*
Original Publishing Date:	*05/10/2016*
Effective Date:	*05/10/2016*
Last Modified Date:	*08/15/2022*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

NIST Cost Recovery (CR) is currently levied per the following CMVP webpage: https://csrc.nist.gov/Projects/cryptographic-module-validation-program/nist-cost-recovery-fees. Currently, the CR process is initiated upon receipt of the report submission and typically adds an average of 60 days to the validation process.

Question/Problem

Can the CR process be initiated before the report submission?

Resolution

The following requirements **shall** be met in order to initiate the CR process before the report submission.

- The lab sends an IUTA indicating the correct number of modules, overall security level and submission type. The IUTA can be submitted without requesting that the module be placed on the Implementation Under Test (IUT) list. The IUTA must be successfully processed by the NIST CMVP automated system. (This includes 1A and 1B submission types.) When the submission is successfully processed, the lab will receive an automated response, "*Thank you for your submission*".
- At any time after the lab receives the automated response to the IUTA, the lab has the option to send an IUTB to initiate the CR process before submitting the report. When the IUTB is successfully processed, the lab will receive an automated response, "*Thank you for your request. The cost recovery process for this submission has been initiated*." Changes to the overall security level and submission type will not be accepted.
  - If the lab sends an IUTB for a 1SUB, it is assumed that it is a 1A or 1B and CR applies.
  - If the lab sends an IUTB and then needs to cancel the invoice, the lab must send an IUTC. When the IUTC is successfully processed, the lab will receive the automated response, "*Your request has been received and will be processed. If there are any issues in cancelling the invoice, you will be notified*."
    - Only unpaid invoices can be cancelled.
  - No files are required for an IUTB or IUTC. Only a properly formatted subject line is required.
- When the cost recovery process starts, no changes to the Security Level or Submission Type will be accepted.
- When the invoice is paid, there are no refunds regardless of when the CR process is initiated.
- If a report has not been received by 90 days after the IUTB was accepted, the module will be moved to On Hold and removed from the IUT list. The module can be automatically removed from On Hold and placed on the Modules In Process (MIP) list by sending the report.

If the lab chooses to not send an IUTB, the CR process will initiate upon receiving the report submission.

G.17 Remote Testing for Modules

Applicable Levels:	*1 and 2*
Original Publishing Date:	*08/07/2017*
Effective Date:	*08/07/2017*
Last Modified Date:	*10/30/2023*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The guidance below addresses the need for testing a module remotely while obtaining the equivalent assurance as if the test were performed at the vendor's facility.

Question/Problem

Under what conditions can a cryptographic module be tested on a remote operating environment?

Resolution

All physical security testing except for Environment failure protection/testing **shall** be performed in person by a CSTL tester at either the vendor, the CSTL site and/or remote site as per HB 150-17 requirements.

The CSTL may perform some or all testing remotely. If the testing is performed remotely at the vendor site, the following conditions **shall** be met:

1. a. The hardware, firmware or hybrid IUT is located at the vendor site.

   b. The software IUT is located at the vendor site or 3rd party cloud system.

2. The vendor remotely provides a cryptographic module to the test laboratory and its boundary and version are verified against the Security Policy. The module boundary and version **shall** be verified at the beginning of any new remote testing sessions.

3. a. The network access and/or video conference to a remote test operational environment, in support of actual testing, **shall** be authorized and controlled by the vendor.

   b. A 3rd party cloud system (e.g., Amazon Web Services, Microsoft Azure, and Google Cloud) may be used as a service in support of module validation (e.g. video conference and data storage) if:
   - all HB 150-17 and NVLAP General Criteria Checklist ISO_IEC 17025 requirements are met; and
   - the remote testing requirements are met.

   c. A cloud system (e.g., Amazon Web Services, Microsoft Azure, and Google Cloud) may be used as a testing platform if:
   - all HB 150-17 and NVLAP General Criteria Checklist ISO_IEC 17025 requirements are met;
   - the remote testing requirements are met;
   - the environment provides the same level or additional level of security as the lab would provide for internal testing;
   - the cryptographic module under test **shall** be confirmed to be running on an OE that is well-defined and has a specific OS version, hardware platform and version, and processor (including microprocessor version) as shown on the module's certificate and security policy; and
   - the OS version, hardware platform and version, and processor **shall** be confirmed during the testing session.

   d. As permitted within a signed agreement by the lab and vendor:
   - The tester's network **shall** be connected to the vendor's network via a secure connection (e.g., VPN or SSH) ; and/or
   - A secure video conference **shall** be used and the recording done in a secure manner.

   e. The tester's tools must satisfy the lab's network requirements before connecting to the vendor's network to test the module if applicable.

4. The CSTL **shall** have a procedure for conducting remote testing at the vendor site which includes the following:

   a. All the remote testing sessions that produce the final test results **shall** be recorded and archived at the CSTL as evidence material to demonstrate the tester control and/or oversight (as per bullet 6 below) (e.g. video conference records and/or detailed test plan) and to capture the test results (e.g. video conference records, screenshots and/or log files).

   b. If multiple remote testing sessions are required, a log which includes the date and the test being conducted **shall** be maintained and archived.

c. If during testing, the IUT version or subversion (e.g. pre-release, debug) changes, the final test report being submitted **shall** reflect the final version of the IUT.

d. If there are multiple simultaneous testing activities occurring at the vendor site, a system of separation between the different cryptographic module test activities **shall** be maintained.

e. For all conformance testing and validations, the CSTL **shall** ensure that any file containing iterative, not final, test results are isolated from the final test results.

f. It is the CSTL's responsibility to ensure that any version iteration during the testing doesn't impact any of the final results transmitted to the CMVP.

5. The required operational environment information (e.g., operating system name and version, processor family, hardware platform model) as required by IG G.13 **shall** be obtained and verified against the operational environment information listed on the CAVP algorithm certificates for this module.

6. The tester is accountable and therefore **shall** understand, oversee, direct, and/or assume control of testing operations to initialize, install, and operate the module. The tester is accountable to ensure the proper initialization, installation and operation of the module through the entire testing at the CSTL site and/or vendor site for the multiple testing sessions as applicable.

7. If a test harness is used, it **shall** be reviewed or written by the lab. It **shall** be verified to have been maintained properly with no vendor manipulation prior to its execution. The test results on the remote operating environment **shall** be captured and transmitted back to lab without the risk of being modified. The tester **shall** verify the test harness runs properly on its operating environment. The tester must verify the integrity of the testing session as well as the completeness and accuracy of the test results.

8. The remote testing **shall** cover the same set of FIPS 140-2 requirements including but not limited to the following list, as if the operating environment were local to the tester:

    a. The services listed in the module Security Policy can be invoked and verified by the tester.

    b. For a module to be validated at Level 2 or 3 for FIPS 140-2 Section 4.3, the role-based or identity-based authentication **shall** be performed and verified by the tester.

    c. The failure of self-tests and the subsequent transition to an error state where module data output interfaces are inhibited can be observed and verified by the tester.

    d. The single-user requirements of AS.06.04 can be verified for Level 1 software module.

    e. As applicable per IG 7.14, entropy can be effectively analyzed, and an entropy report can be generated by the lab.

The vendor must provide a signed affirmation letter to the lab describing the remote testing process and access control mechanism that allows the lab to perform the test on the remote operating environment and protects the integrity of the test results. The lab **shall** provide a signed letter to the CMVP stating that the module had been tested remotely, affirming that the vendor provided their affirmation letter, stating what TEs were tested remotely, and explaining how the requirements of this IG were met during the remote testing.

It is the CSTL's responsibility to ensure that the assurance level is maintained when remote testing is being conducted.

Additional Comments

1. It is the responsibility of the tester to determine if a module is eligible to be tested remotely. If the tester cannot demonstrate a test requirement during remote testing, then the module **shall** not be fully tested remotely. If the tester wishes to test a subset of test requirements remotely, the remaining test requirements **shall** be tested onsite.

2. Rule #2 and Lab Bulletin LB-96-2016 are subject to change.
3. The tester must be able to confirm that the operating environment exactly matches the agreed upon test environment, including any virtual environments used. A Virtual Machine may not be used in lieu of an OS, unless the VM has been agreed to be part of the test environment and will be listed on the certificate.

G.18 Limiting the Use of FIPS 186-2

Applicable Levels:	*All*
Original Publishing Date:	*08/16/2019*
Effective Date:	*08/16/2019*
Transition End Date:	***09/01/2020***
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01-02*
Relevant Vendor Requirements:	*VE.01.12.01-02*

Background

FIPS 186-2, *Digital Signature Standard* was replaced by **FIPS 186-3** in June 2009. **FIPS 186-3** was, in turn, replaced by **FIPS 186-4** in July 2013. Nevertheless, algorithm testing to **FIPS 186-2** has continued in the following areas:

- domain parameter validation, public key validation and digital signature verification,
- tested as part of an OEM revalidation (Scenario 1A), and
- RSA signature generation when the modulus length *nlen* is 4096 bits.

The latter provision had been reintroduced because **FIPS 186-4**, as published, does not allow the RSA modulus bit sizes other than 1024 (later disallowed), 2048, and 3072. Hence the CAVP has developed tests only for these lengths of *nlen*. However, later standards, such as SP 800-131Arev1 published in November 2015, allowed the use of any RSA modulus length no smaller than 2048 bits. The existing RSA signature generation test to **FIPS 186-2** with *nlen*=4096 was used to provide at least some testing mechanism for this modulus size.

Question/Problem

Will testing to **FIPS 186-2** continue to be accepted despite having the standard itself retired?

Will the CMVP continue validating and revalidating the cryptographic modules that have the algorithm certificates showing the implementations' compliance to at least some parts of **FIPS 186-2**?

Resolution

Algorithm testing of signature verification implementations for their compliance with **FIPS 186-2** will continue to be allowed (for legacy purposes).

The CAVP will stop validation testing to all other provisions of **FIPS 186-2** on July 1, 2020. On **September 1, 2020**, the CMVP will place on the historical list modules that were CAVP tested for **FIPS 186-2** RSA SigGen with modulus size lower than 4096 or **FIPS 186-2** RSA KeyGen of any modulus size.

If a module falls into this category above and is headed for the historical list, the module may be removed from this list and remain active (or be moved back to the active list from the historical list if the module submission is after September 1, 2020), if at least one of the following submission scenarios are followed:

- 1sub where there are no changes to the module itself. The sunset dates will not be extended. A module may fall into one of the following three 1sub scenarios:
    1. The module does not support any provisions that are unique to **FIPS 186-2** in the FIPS approved mode, except possibly for digital signature verification and SigGen at 4096-bits. Unique, in this context, means that despite the overlap between **FIPS 186-2** and **FIPS 186-4** standards, this module's RSA implementation is compliant to **FIPS 186-4**. Documentation may need to be updated to indicate the module does not utilize **FIPS 186-2** functionality in the approved mode (e.g. the Security Policy approved algorithms table may need to remove references to **FIPS 186-2** or otherwise affirms that while testing against **FIPS 186-2** was performed, the module itself does not make use of those capabilities in the approved mode).
    2. New ACVP testing: During this revalidation, the module RSA implementation that was originally tested against **FIPS 186-2** successfully repasses CAVP (ACVP) testing to **FIPS 186-4** without any modifications. Documentation **shall** be updated to include the new ACVP certificates. A module's implemented **FIPS 186-4** functionality **shall** be tested for all modulus sizes that is supported by the ACVP, including up to 4096-bits.
    3. The vendor moves **FIPS 186-2** functionality (except for digital signature verification) into the non-approved mode of operation from the approved mode of operation. The lab **shall** provide assurances that **FIPS 186-2** functionality is not used to meet any FIPS 140-2 requirements (key generation, key storage, integrity test, firmware/software loading, etc.) or IGs (e.g. IG 1.2 for sharing CSPs between modes). Documentation would need to be updated to indicate the module does not utilize **FIPS 186-2** functionality in the approved mode of operation.
- 3sub where there are security relevant changes to the module. The rules for this 3sub are the same as defined in IG G.8, and a new certificate will be issued upon validation. For this transition, the following two 3sub scenarios may apply:
    1. Changes were made to the module's RSA implementation in order to comply with this transition. ACVP testing to **FIPS 186-4** is required.
    2. Changes were made to the module itself to meet FIPS 140-2 requirements even though the RSA implementation itself may not have been modified. For example, if moving a level 3 hardware module's **FIPS 186-2** functionality into the non-approved mode causes the module to fail to meet AS01.04 requirements (FIPS indicator), then the module must address this requirement and would be submitted as a 3sub, as this is security relevant change.

In the Change Letter, the CST laboratory **shall** indicate which of the above scenario (or a combination of scenarios) the module complies with when submitting the revalidation package to the CMVP.

Additional Comments

1. Modules that support testing to **FIPS 186-2** RSA KeyGen will be moved to the historical list on the date referenced above (even if testing was only conducted at 4096-bit modulus) because it is unclear how the module utilizes this non-approved key generation functionality. However, modules that support testing to **FIPS 186-2** RSA SigGen only at 4096-bit modulus size will *not* be moved to the historical list because **FIPS 186-4** SigGen testing at 4096-bit modulus was not made available until ACVP was later developed and 4096-bit testing was only available in **FIPS 186-2** form via CAVs. So, when a module tested **FIPS 186-4** SigGen for modulus less than 4096 (2048 and/or 3072), but only tested SigGen with **FIPS 186-2** at 4096-bits, it was assumed to be done as an added assurance rather than claiming compliance to **FIPS 186-2**.

G.19 Operational Equivalency Testing for HW Modules

Applicable Levels:	*All*
Original Publishing Date:	*10/23/2019*
Effective Date:	*10/23/2019*
Last Modified Date:	*10/23/2019*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Currently the CMVP requires full testing of any module that the vendor wishes to list on the certificate. This is to provide the CMVP assurance that the module operates as specified in compliance to the FIPS 140-2 standard.

Question/Problem

In the case where a vendor wishes to group multiple hardware modules in the same report, and therefore on the same certificate, under what conditions can the lab perform full operational testing on one module, and limited operational testing on the rest of the modules and still provide the assurance that all of the modules meet the FIPS 140-2 standard? What is the minimum set of "limited testing", if any, that must be performed by the lab?

Resolution

This IG defines the following Equivalency Categories (called Equivalency Category X) based on technology types either of the modules or used by the modules. The technology types listed within each category provide context as opposed to serving as an exhaustive list.

- Memory/Storage Devices
  - HDD, SSD, DRAM, NAND, NOR, ROM, Solid State Memory Device, Optical Disk Drive, Magnetic Tape Drive, USB Flash Drive
- Field Replaceable and Stationary Accessories
  - Power Supplies
  - Fans
- Interfaces (I/O Ports) including:
  - Port Count
  - Line Card Count
  - Serial: RS232, RS422, RS485
  - SAS, SATA, eSATA
  - Fiber Optic, FCoE, Fiber Channel
  - Ethernet, FireWire, DVI, SCSI, USB
- Computational Devices
  - Refer to CAVS equivalency criteria for guidance
- Programmable Logic Devices
  - CPLD, FPGA, PAL

For details on the Equivalency Categories, please see Table G.19.2. This table describes each category, technologies within each category, and their differences as they relate to FIPS 140-2.

For modules that have differences within each of those categories, the level of testing required depends on what the difference actually is. Some differences require analysis only, while others require full or limited regression testing. The following are the general categories of the levels of testing. The actually testing required depends on the Equivalency Category (See Table G.19.1and Table G.19.2):

- Analysis Only (AO) for Equivalency Category X: Once the equivalency evidence/argument is provided and validated for the Equivalency Category X, there is no additional test other than the proof of its physical existence required on a module with the equivalent components in Category X to the module that has been fully tested under the same validation.
- Required Testing (RT) for Equivalency Category X:
    - If a module has some security relevant differences in the Equivalency Category X, the module must be tested against all of the listed TEs for that category in Table G.19.1
    - If a module claims equivalency in multiple categories in comparison to a fully tested module under the same validation, all of the required TEs for each claim equivalency category **shall** be satisfied.
- Focused Testing (FT) for Equivalency Category X:
    - The use of some technologies may introduce Security Relevant differences that cannot be predicted by this IG. For example, Programmable Logic Devices may be used to support the Cryptographic Module in a number of different ways that are security relevant (e.g. authentication). It is up to the lab to determine what section of the standard is affected by this security relevant difference and apply the regression tests of the corresponding section of IG G.8 Table G.8.1 – Regression Test Suite. For other sections not affected by this difference, Regression Testing per Table G.19.1 **shall** be performed.
- Complete Regression Testing (CRT): If an equivalency justification cannot be made, all modules, which lack an equivalency justification must, according to their security level, satisfy each TE listed in IG G.8 Table G.8.1 – Regression Test Suite.

In each report where the vendor wishes to claim equivalency, the lab **shall**:

- List the Equivalency Category, and specific component types being claimed in TE.01.08.01. The lab must justify the component categorizations. The assumption is that the vendor initiated the Equivalency Category argument while the lab performed the analysis.
- List the additional testing performed (if any) between the modules. This list **shall** be provided as an addendum to the test report.

For example:

- 2 devices to be on the same certificate have Hard Drives with different storage capacities, so testing requirement is Analysis Only, e.g. proof that both modules exist as claimed by the vendor.
- 2 devices to be on the same certificate have different types of Solid State Memory: one has NOR Flash and the other has NAND. This will require a small selection of testing, per Table G.19.1 Regression Test Suite Selections.
- 2 devices to be on the same certificate have different types of storage: one has a Hard Disk and the other has a Solid State Drive. This will require complete regression testing per Table G.8.1.

Additional Comments

- The lab **shall** perform full testing on at least one module.
- This IG only applies to Operational testing of Hardware modules
- Physical security testing (section 4.5) is not addressed in this IG for Level 2 and above. In other words, this IG does not exempt the lab from performing physical security testing for modules at Level 2 or above. This is because the lab needs to examine each module for, e.g., opacity and tamper evidence, if there are physical differences between the modules.
- Components considered equivalent may still affect the entropy generated within the modules in different ways. This must be accounted for in the entropy report, if entropy is applicable.
- Equivalency considerations of the main processors/CPUs is out of scope of this IG. If the CPU is different between modules on the same certificate, then the full Regression Test Suite must be run (e.g. Table G.8.1)

Table G.19.1 Regression Test Suite

AS	**TE**	**Memory/Storage Devices**	**I/O Ports**	**Field Replaceable and Stationary Accessories**	**Programmable Logic devices**
Section 1 Cryptographic Module Specification					
AS.01.03	TE.01.03.02	X	X	X	X
Section 2 Cryptographic Module Ports and Interfaces					
AS.02.06	TE.02.06.02	X	X		X
	TE.02.06.04	X	X	X	X
AS.02.13	TE.02.13.03		X		X
AS.02.14	TE.02.14.02				X
AS.02.16	TE.02.16.02 (Level 3 and 4)		X		
AS.02.17	TE.02.17.02 (Level 3 and 4)		X		
Section 3 Role, Services, and Authentication					
AS.03.02	TE.03.02.02				
AS.03.02	TE.03.02.03				
AS.03.12	TE.03.12.03				X
AS.03.13	TE.03.13.02				
AS.03.14	TE.03.14.02				X
AS.03.15	TE.03.15.02				X
AS.03.17	TE.03.17.02 (Level 2)				
AS.03.18	TE.03.18.02 (Level 2)				
AS.03.19	TE.03.19.02 (Level 3 and 4)				
	TE.03.19.03 (Level 3 and 4)				
AS.03.21	TE.03.21.02				
AS.03.22	TE.03.22.02 (Level 2, 3 and 4)	X			
AS.03.23	TE.03.23.02				
Section 4 Finite State Model					
AS.04.03	TE.04.03.01				
AS.04.05	TE.04.05.08	X	X		X
Section 5 Physical Security					
Not Applicable					
Section 6 Operational Environment					
AS.06.05	TE.06.05.01 (Level 1 only)				
AS.06.06	TE.06.06.01 (Level 1 only)				
AS.06.07	TE.06.07.01				

AS	TE	Memory/Storage Devices	I/O Ports	Field Replaceable and Stationary Accessories	Programmable Logic devices
AS.06.08	TE.06.08.02	X			
AS.06.11	TE.06.11.02 (Level 2, 3 and 4)				
	TE.06.11.03 (Level 2, 3 and 4)				
AS.06.12	TE.06.12.02 (Level 2, 3 and 4)				
	TE.06.12.03 (Level 2, 3 and 4)				
AS.06.13	TE.06.13.02 (Level 2, 3 and 4)				
	TE.06.13.03 (Level 2, 3 and 4)				
AS.06.14	TE.06.14.02 (Level 2, 3 and 4)				
	TE.06.14.03 (Level 2, 3 and 4)				
AS.06.15	TE.06.15.02 (Level 2, 3 and 4)				
AS.06.16	TE.06.16.02 (Level 2, 3 and 4)				
AS.06.17	TE.06.17.02 (Level 2, 3 and 4)				
AS.06.22	TE.06.22.02 (Level 3 and 4)				
	TE.06.22.03 (Level 3 and 4)				
AS.06.24	TE.06.24.02 (Level 3 and 4)				
	TE.06.24.03 (Level 3 and 4)				
AS.06.25	TE.06.25.02 (Level 3 and 4)				
Section 7 Cryptographic Key Management					
AS.07.01	TE.07.01.02	X			
AS.07.02	TE.07.02.02	X			
AS.07.15	TE.07.15.02				
	TE.07.15.03				
	TE.07.15.04				
AS.07.25	TE.07.25.02				
AS.07.27	TE.07.27.02				
AS.07.28	TE.07.28.02				
AS.07.29	TE.07.29.02				

AS	TE	Memory/Storage Devices	I/O Ports	Field Replaceable and Stationary Accessories	Programmable Logic devices
AS.07.31	TE.07.31.04 (Level 3 and 4)				
AS.07.39	TE.07.39.02				
AS.07.41	TE.07.41.02	X	X		X
Section 8 EMI/EMC					
Not Applicable					
Section 9 Self Tests					
AS.09.04	TE.09.04.03				
AS.09.05	TE.09.05.03				
AS.09.09	TE.09.09.02	X		X	X
AS.09.10	TE.09.10.02				
AS.09.12	TE.09.12.02				
AS.09.22	TE.09.22.07	X			
AS.09.35	TE.09.35.05				
AS.09.40	TE.09.40.03				
	TE.09.40.04				
AS.09.45	TE.09.45.03				
AS.09.46	TE.09.46.03				
Section 10 Design Assurance					
AS.10.03	TE.10.03.02	X			
Section 11 Mitigation of Other Attacks					
Not Applicable					

G.20 Tracking the Component Validation List

Applicable Levels:	*All*
Original Publishing Date:	*08/12/2020*
Effective Date:	*08/12/2020*
Last Modified Date:	*03/14/2022*
Transition Date	***12/31/2020 – See below*** ***06/30/2022 – See below***
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01-04*
Relevant Vendor Requirements:	*VE01.12.01-04*

Background

In response to vendor and user requirements, the CAVP have identified several components of the approved algorithms that they can test. When these components are successfully tested the vendor is issued the CVL (Component Validation List) certificates.

The reasons for introducing and testing these algorithm components differ. It can be that the module performs only a shared secret computation shown in the original version of **SP 800-56A** or only a key derivation procedure of a key agreement scheme, and the vendor wants to test and receive the credit for the correct implementation of this component. Alternatively, it can be that the module performs both the shared secret computation and the key derivation and each of these two functions is compliant with one of the standards and can be tested but the overall key agreement scheme is not approved and, as the result, is not testable.

In another example, the module may perform a cryptographic signature generation computation without computing the hash of the message as this hash has already been precomputed by another entity. Component testing allows one to verify the correctness of the remaining portion of the signature-generating routine.

Question/Problem

How to find the available testable components of the approved algorithms? Which documents specify the functions that each of these components performs? Can an algorithm component be vendor affirmed?

Resolution

The following components can be tested and documented as CVL in the module's validation certificate.

1. A shared secret computation per Section 6 of the original publication of **SP 800-56A** covering both the FFC and the ECC schemes. The module's Security Policy **shall** state which functionality (such as, the Full Unified Model, C(2, 2, ECC CDH) or a Hybrid One Flow C(1, 2, FFC DH)) is covered by the CVL.
2. An ECC CDH primitive from section 5.7.1.2 of either the original publication of **SP 800-56A** or **SP 800-56A Rev3** (these primitives are identical). The test performs the multiplication of a point on a NIST-recommended elliptic curve by an integer and verifies that the x-coordinate of the resulting point has been computed correctly. The integer in question is defined in **SP 800-56A** and **SP 800-56A Rev3** as the product of the tested party's private key d_A and the curve's co-factor h.
3. An RSA (PKCS1-v1.5 and PSS) or ECDSA signature generation per **FIPS 186-4** without the computation of a hash which is presumed to have already been computed.

For RSA, the test verifies the correctness of the RSA exponentiation when performed as part of the digital signature generation. The test uses the integers *m*, *d* and *n*, where *n* is an RSA modulus, *d* plays the role of the private RSA key and *m* stands for the quantity based on the message to be signed, *M*, the selected approved hash function and the chosen RSA signature scheme (PKCS1-v1.5 or PSS). The primitive computes $s = m^d \bmod n$ and is described in PKCS#1 v2.1: RSA Cryptography Standard, RSA Laboratories, June 14, 2002, Section 5.2.1a. If the *s* value is successfully verified, the test passes.

There is also a test for a signature generation component (no hash computation) using the Chinese Remainder Theorem (CRT). This method of signature generation is described in the same standard, Section 5.2.1b.

For the ECDSA signature generation component, the test is the same as when the full ECDSA signature generation algorithm is tested except that the supplied messages are viewed as being already hashed, therefore no further hashing is performed. A binary string representing the hash is supplied to the test. The length of the supplied string is not tested for being valid. For details, please see the following CAVP publication: https://csrc.nist.gov/CSRC/media/Projects/Cryptographic-Algorithm-Validation-Program/documents/dss2/ecdsa2vs.pdf , Section 6.4.1.

4. An RSA decryption operation using an exponentiation for key encapsulation, as specified in Section 7.1.2 of **SP 800-56B** published in August 2009 and in Section 7.1.2.1 of **SP 800-56B Rev2** published in March 2019.

   As of August 2020, there is no test for the decryption operation using the CRT, as shown in Section 7.1.2.3.

5. The key derivation functions from the following protocols and standards documented in **SP 800-135 Rev1**: IKEv1, IKEv2, TLS 1.0, 1.1 and 1.2, SSHv2, SRTP (using the 32-bit index value in SRTCP), SNMPv3, TPMv1.2, ANSI X9.63-2001 KDF and ANSI X9.42-2001 KDF.

6. The TLS 1.3 key derivation function documented in Section 7.1 of RFC 8446.

7. The key confirmation functionality described in the standards for the key agreement and key transport. The key confirmation can be unilateral or bilateral. See Sections 5.9 and 6.3.3 of **SP 800-56A Rev3** and Sections 5.6, 8.2.3, 8.3.3 and 9.2.4 of **SP 800-56B Rev2**. Key confirmation may be tested as a stand-alone function or as part of an end-to-end testing of a key establishment scheme. In the former case, a tested key confirmation is documented as a CVL.

The Security Policy **shall** individually list the tested components shown in the module's CVL certificates that may be called during the operation of the module.

The following component can be vendor affirmed and documented as CVL (vendor affirmed) in the module's validation certificate.

1. The key derivation function from the following protocol and standard documented in **SP 800-135 Rev1**: SRTP (using the 48-bit index value in SRTCP per the NIST published Informative Note). The Test Report **shall** include documentation demonstrating the module's compliance to **SP 800-135 Rev1** Section 5.3. The CMVP will support a transitional period away from vendor affirming the SRTP KDF using the 48-bit index value in SRTCP once the CAVP has developed a test for it.

The Security Policy **shall** individually list the vendor affirmed components that may be called during the operation of the module.

Additional Comments

1. The testing of compliance to **SP 800-56A Rev3** will consist of testing of each of the shared secret computation schemes defined in Section 6 of this standard and implemented by the module. While **SP 800-56A Rev3** further shows how to apply the key derivation functions defined in **SP 800-56C Rev1**, the computation of a shared secret is viewed as a core functionality defined in **SP 800-56A Rev3**. Therefore, testing of this computation is not viewed as "component testing". If an implementation successfully passes these tests, it will be awarded an algorithm certificate, KAS-SSC, rather than a CVL certificate. This IG does not cover the KAS-SSC testing.

2. The use of the CVL certificates showing an algorithm's compliance with a component of a scheme defined in the original publication of **SP 800-56A** (Resolution 1 above) is subject to the transition rule announced in **SP 800-131A Rev2**. These CVL certificates will become obsolete after **June 30, 2022**. New report submissions (3SUB and 5SUB) with these CVLs will not be accepted past **December 31, 2020**.
3. The details of the CAVP component testing are provided at https://csrc.nist.gov/Projects/cryptographic-algorithm-validation-program/Component-Testing.
4. Refer to IG 9.4 for the applicability of self-tests to the tested components that have been issued the CVL certificates.
5. Refer to IG G.13 FIPS Approved Algorithms bullet number 9 for specific guidance on how to document a tested or vendor affirmed CVL.

Section 1 - Cryptographic Module Specification

1.1 Cryptographic Module Name

Applicable Levels:	*All*
Original Publishing Date:	*02/27/2004*
Effective Date:	*02/27/2004*
Last Modified Date:	*02/27/2004*
Relevant Assertions:	*AS.01.05, AS.01.08 and AS.01.09*
Relevant Test Requirements:	*TE01.08.03,04 and 05 and TE01.09.01 and 02*
Relevant Vendor Requirements:	*VE.01.08.03 and VE.01.09.01*

Question/Problem

How **shall** the name of a cryptographic module relate to the defined cryptographic boundary?

Resolution

The provided name of the cryptographic module (which will be on the validation certificate) **shall** be consistent with the defined cryptographic boundary as defined in the test report.

It is not acceptable to provide a module name that represents a module that has more components than the modules defined boundary. If it is desired to have a name that does represent a larger entity, then the cryptographic boundary must be consistent. All components residing within the cryptographic boundary must either be included (**AS.01.08**) or excluded (**AS.01.09**) in the test report.

Additional Comments

Example: The provided name of a cryptographic module is the *Crypto Card*. However, the defined cryptographic boundary in the test report is a small black encapsulated component placed in one corner of the card. The named card also has additional components that were not referenced (e.g. batteries, connectors). If the defined boundary in the test report specifies *ONLY* the black encapsulated component, it is clearly NOT the *Crypto Card*. A unique different name **shall** be provided to be consistent with the defined boundary. To represent the entire card, the boundary must be redefined and must include all the components and address them properly (include/exclude).

1.2 FIPS Approved Mode of Operation

Applicable Levels:	*All*
Original Publishing Date:	*03/15/2004*
Effective Date:	*03/15/2004*
Last Modified Date:	*05/02/2012*
Relevant Assertions:	*AS.01.02, AS.01.03 and AS.01.04*
Relevant Test Requirements:	*TE01.03.01-02 and TE01.04.01-12*
Relevant Vendor Requirements:	*VE.01.03.01-02 and VE.01.04.01-02*

Definition

Approved mode of operation: a mode of the cryptographic module that employs only approved security functions (not to be confused with a specific mode of an approved security function, e.g., AES CBC mode).

Question/Problem

Are there any operational requirements when switching between modes of operation, either from an approved mode of operation to a non-approved mode of operation, or vice versa?

Resolution

CSPs defined in an approved mode of operation **shall** not be accessed or shared while in a non-approved mode of operation. CSPs **shall** not be generated while in a non-approved mode.

Note: An approved DRBG may be used in a non-approved mode. However, the approved DRBGs seed or seed key **shall** not be accessed or shared in the non-approved mode.

Additional Comments

Preventing the access or sharing of CSPs mitigates the risk of untrusted handling of CSPs generated in an approved mode of operation.

Examples:

- a module may not generate keys in a non-approved mode of operation and then switch to an approved mode of operation and use the generated keys for approved services. The keys may have been generated using non-approved methods and their integrity and protection cannot be assured.
- a module may not electronically import keys in plaintext in a non-approved mode of operation and then switch to an approved mode of operation and use those keys for approved services.
- a module may not generate keys in an approved mode of operation and then switch to a non-approved mode of operation and use the generated keys for non-approved services. The integrity and the protection of the approved keys cannot be assured in the non-approved mode of operation.

1.3 Firmware Designation

Applicable Levels:	*All*
Original Publishing Date:	*04/28/2004*
Effective Date:	*04/28/2004*
Last Modified Date:	*06/12/2010*
Relevant Assertions:	*AS.01.01*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Cryptographic module: the set of hardware, software, and/or firmware that implements approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.

Firmware: the programs and data components of a cryptographic module that are stored in hardware (e.g., ROM, PROM, EPROM, EEPROM or FLASH) within the cryptographic boundary and cannot be dynamically written or modified during execution.

The *operational environment* of a cryptographic module refers to the management of the software, firmware, and/or hardware components required for the module to operate. The operational environment can be non-modifiable (e.g., firmware contained in ROM, or software contained in a computer with I/O devices disabled), or modifiable (e.g., firmware contained in RAM or software executed by a general-purpose computer).

A *limited operational environment* refers to a static non-modifiable virtual operational environment (e.g., JAVA virtual machine on a non-programmable PC card) with no underlying general purpose operating system upon which the operational environment uniquely resides.

If the operational environment is a limited operational environment, the operating system requirements in Section 4.6.1 do not apply.

Question/Problem

How **shall** a *software* cryptographic module running on a limited operational environment be designated as?

Resolution

If the Operational Environment is a limited operational environment, and is indicated as NA on the certificate, then the cryptographic module **shall** be designated as a ***firmware*** module.

Additional Comments

– The reference tested OS must be indicated on the validation certificate for all software and firmware cryptographic modules. It will be referenced on the CMVP validation list web page as follows:

  - If the Operational Environment is applicable: -*Operational Environment: Tested as meeting Level x with …*

  - If the Operational Environment is NA: -*Tested: …*

– For an overall Level 2, 3, or 4 module or where FIPS 140-2 Section 4.5 *Physical Security* is Level 2, 3 or 4, the reference hardware platform with appropriate specific versioning information used during operational testing **shall** also be listed. The certificate caveat **shall** minimally indicate: *When operated only on the specific platforms specified on the certificate*

– For JAVA applets, the tested JAVA environment (JRE, JVM) and operating system need to be specified for all Security Levels.

Per IG G.5, porting of software modules is only applicable to modules operating on a General-Purpose Computer (GPC) and when the Operational Environment is applicable. The module's validation will be maintained if no changes are made to underlying source code.

If the operational environment is not applicable, a firmware module at overall Level 1 (with FIPS 140-2 Section 4.5 *Physical Security* at Level 1) and its identified tested OS together may be ported from one platform to another platform while maintaining the module's validation (IG G.5). For firmware module's that are JAVA applets, the firmware module, its identified tested OS, and the tested JAVA environment (JRE, JVM) must be moved together when porting from one platform to another platform in order to maintain the module's validation.

For all other cases, the validation of the cryptographic module is not maintained if ported.

1.4 Binding of Cryptographic Algorithm Validation Certificates

Applicable Levels:	*All*
Original Publishing Date:	*01/21/2005*
Effective Date:	*01/21/2005*
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

Cryptographic algorithm implementations are tested and validated under the Cryptographic Algorithm Validation Program (CAVP). The cryptographic algorithm validation certificate states the name and version number of the validated algorithm implementation, and the tested operational environment.

Cryptographic modules are tested and validated under the Cryptographic Module Validation Program (CMVP). The cryptographic module validation certificate states the name and version number of the validated cryptographic module, and the tested operational environment.

The validation certificate serves as a benchmark for the configuration and operational environment used during the validation testing.

Question/Problem

What are the configuration control and operational environment requirements for the cryptographic algorithm implementation(s) embedded within a cryptographic module when the latter is undergoing testing for compliance to FIPS 140-2?

Resolution

For a validated cryptographic algorithm implementation to be embedded within a software, firmware or hardware cryptographic module that undergoes testing for compliance to FIPS 140-2, the following requirements must be met:

1. the implementation of the validated cryptographic algorithm has not been modified upon integration into the cryptographic module undergoing testing; and

2. the operational environment under which the validated cryptographic algorithm implementation was tested by CAVP must be identical to the operational environment that the cryptographic module is being tested under by the CST laboratory.

Additional Comments

1. What are examples of an operational environment change?

   If an implementation has been tested on an X-bit processor (e.g. 32-bit, 64-bit), can a claim be made that the implementation also runs on different bit size processors?

   No. An example: An algorithm implementation was tested and validated on a 32-bit platform. This was used in a previous 32-bit version of a software module that was validated for conformance to FIPS 140-2. Now the software module is undergoing testing on a 64-bit platform. This software module cannot operate on a 32-bit platform without change. In this case the operational environments are not the same; therefore, the algorithm implementations must be re-tested on the 64-bit platform. Memory size, processor frequency, etc. are not relevant.

2. If an implementation has been tested on one processor, can a claim be made that the implementation also runs on a different processor when it is submitted for module testing?

   The answer to this question is dependent on the security assurance Level of the module validation and on whether or not the two processors are architecturally compatible or not.

   If the module is being validated as a Level 1 validation and the two processors are architecturally compatible platforms, the answer is Yes. For example, if a Level 1 software module is undergoing testing under Windows 2000 on a DellGatewayPro PC, but the algorithms were tested on Windows 2000 IBMHPClone PC, the algorithm validations do not need to be re-tested as both the DellGatewayPro and IBMHPClone PC's are considered General Purpose Computers (GPC).

   If the two processors are not architecturally compatible, then algorithm validation tests need to be rerun on both processors. For example, a firmware module is undergoing testing on a BlueLiteing processor running Handy OS v5.0. The underlying algorithm implementation was tested on a SlowJoe Processor running Handy OS v0.2. In cases such as this, the algorithm firmware implementations must be re-tested.

   If a Level 2 software module is undergoing testing under an evaluated operating system (OS) and specific platform identified by the evaluation and there is no extensibility provided, the underlying algorithm implementations must be tested under the exact same operational environment (platform and OS).

3. If an algorithm implementation has been tested on one operating system, can a claim be made that the implementation also runs on another operating system when it is considered for module testing?

   No, the algorithm implementation must have been tested on every operating system claimed by the software module at Level 1. The algorithm certificate may include other operating systems as well, but they are not relevant to the module under test. For example, if a Level 1 software module is undergoing testing under Windows 2000, Windows 98 and Linux, the underlying algorithm certificates must indicate at a minimum that the algorithms were tested under Windows 2000, Windows 98 and Linux.

   Another example: A vendor may re-use algorithm implementations between like operational environments. However, if the algorithm implementation testing was only performed on Windows 2000, and the algorithm implementation is to be re-used in a software module undergoing testing under Windows XP, the algorithm implementations must be re-tested under Windows XP.

4. Who is responsible for finding out what operational environment (processor, operating system) the algorithm implementation is tested on if the testing is done by the vendor and not the CST Lab?

   If algorithm testing is not performed directly by the CST Lab (i.e., if test vectors are provided to the vendor), the CST Lab is responsible for asking the vendor to supply the operating environment (processor and/or operating system) on which they ran the algorithm implementation and with which they generated the RESPONSE files. It is the CST Labs' responsibility to verify that the results in the RESPONSE files were generated using the specified operating environment.

5. If an algorithm is implemented in HDL on a Field Programmable Gate Array (FPGA) device and there is no underlying "OS" implemented in the FPGA, can the algorithm implementation be classified as firmware and, when validated, ported as is to other FPGAs and still be considered validated?

   No. We do not validate HDL (which is equivalent to source code). The algorithm implementation would be validated in the FPGA as hardware.

   Once the FPGA device is validated, one could take the HDL on this FPGA and reuse it in creating a new FPGA. If this were done, the algorithm implementations would need to be validated on the new hardware because they would be considered as new hardware implementations.

6. Additional information regarding operational environment can be found in the CAVP FAQ **GEN.12**.

1.5 moved to A.1

1.6 moved to A.2

1.7 Multiple Approved Modes of Operation

Applicable Levels:	*All*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*05/02/2012*
Relevant Assertions:	*AS.01.03 and AS.01.04*
Relevant Test Requirements:	*TE01.03.01-02 and TE01.04.01-02*
Relevant Vendor Requirements:	*VE.01.03.01-02 and VE.01.04.01-02*

Background

FIPS 140-2 Section 4.1 does not preclude a vendor from implementing more than one approved mode of operation in a cryptographic module. An approved mode of operation (IG 1.2) employs the set of approved security functions which are associated with the set of services and CSPs implemented in the module. A module may be designed to employ multiple defined approved modes of operation, where each defined mode employs a subset of the module's approved security functions, services and CSPs. An example of a module with multiple approved modes of operation is one where the module supports a primary mode that employs all of the approved security functions, services and CSPs of the module to personalize or setup the module, as well as a secondary mode which employs only a subset of approved security functions for normal operation and use.

Question/Problem

May a module implement more than one defined approved modes of operation, each employing a defined set or subset of the approved security functions? What are the requirements for a module to implement more than one approved modes of operation?

Resolution

A cryptographic module may be designed to support multiple approved modes of operation. For a cryptographic module to implement more than one approved modes of operation, the following **shall** apply:

- the security policy **shall** contain the following information describing each approved mode of operation implemented in the cryptographic module:
    - the definition of each approved mode of operation;
    - how each approved mode of operation is configured;
    - the services available in each approved mode of operation;
    - the algorithms used in each approved mode of operation;
    - the CSPs used in each approved mode of operation; and
    - the self-tests performed in each approved mode of operation;
- upon re-configuration from one approved mode of operation to another, the cryptographic module **shall** reinitialize and perform all power-up self-tests associated with the new approved mode of operation:
    - at a minimum, power-up self-tests **shall** be performed on the approved security functions used in the new selected approved mode of operation as specified in FIPS 140-2 Section 4.9 including **AS06.08** in FIPS 140-2 Section 4.6.1 (if applicable), and
    - power-up self-tests **shall** be performed in the new selected approved mode of operation regardless if it had been performed in a prior approved mode of operation.

To confirm the correct operation of the several defined approved modes of operation, the tester **shall**:

- verify the documentation describing each approved mode of operation;
- use the vendor provided instructions described in the non-proprietary security policy to invoke each approved mode of operation;
- verify that, for each approved mode of operation, only the security functions employed for that approved mode of operation are accessible and that security functions not implemented for that approved mode of operation are not; and
- verify that the requirements of **AS.01.03** and/or **AS.01.04** are met for each approved mode of operation.

Additional Comments

CSPs may be shared between multiple approved modes of operation

1.8 Moved to W.13

1.9 Definition and Requirements of a Hybrid Cryptographic Module

Applicable Levels:	*Level 1*
Original Publishing Date:	*03/10/2009*
Effective Date:	*03/10/2009*
Last Modified Date:	*03/19/2010*
Relevant Assertions:	*AS.01.01 and AS.01.08*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Cryptographic module: the set of hardware, software, and/or firmware that implements approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.

Software: the programs and data components within the cryptographic boundary, usually stored on erasable media (e.g., disk), that can be dynamically written and modified during execution.

Firmware: the programs and data components of a cryptographic module that are stored in hardware (e.g., ROM, PROM, EPROM, EEPROM or FLASH) within the cryptographic boundary and cannot be dynamically written or modified during execution.

Firmware Designation: IG 1.3:

Question/Problem

Define what a ***hybrid*** cryptographic module is and specify the requirements applicable to this module type?

Resolution

A ***hybrid*** cryptographic module is a special type of software or firmware cryptographic module that, as part of its composition, utilizes disjoint special purpose cryptographic hardware [1] components installed within the physical boundary of the GPC or operating environment. A hybrid cryptographic module implemented as disjoint hardware and software components is defined as a Software-Hybrid. A hybrid cryptographic module implemented as disjoint hardware and firmware components is defined as Firmware-Hybrid.

In addition to the requirements applicable to a software or firmware cryptographic module, the following requirements are also applicable to the additional cryptographic hardware of the ***hybrid*** cryptographic module:

- Cryptographic Module Specification: All the components of the ***hybrid*** cryptographic module must be fully specified by type, part numbers and version numbers;
    - Manufacturer and model of the special purpose hardware component(s) and platform(s) on which testing was performed;
    - Operating system(s) on which testing was performed; and
        - *If Software-Hybrid*: modifiable operating system

[1] e.g. cryptographic hardware accelerator cards, cryptographic hardware chip(s), etc.

        - *If Firmware-Hybrid*: the limited or non-modifiable operating system
    - All additional special purpose hardware and firmware components as applicable

- Cryptographic Module Ports and Interfaces: By policy, all status and control ports and interfaces of the hybrid cryptographic module **shall** be directed through the software component logical interface if a software module (controlling component), and through the firmware interface if a firmware module (controlling component);
- Roles, Services and Authentication: All the services provided by the composite of the ***hybrid*** cryptographic module must be specified;
- Physical Security: FIPS 140-2 Section 5 – *Physical Security* is applicable for a ***hybrid*** module since a hardware component is specified as part of the hybrid composite.
- Cryptographic Key Management: Key exchanged within the boundary of the GPC or operating platform and between two or more components of the ***hybrid*** cryptographic module may be transferred in plaintext;
- Self-Tests: Self-tests requirements are applicable to all components of the ***hybrid*** cryptographic module;
    - A strong integrity test **shall** be performed on the software component,
    - A firmware integrity test (**AS.09.22**) **shall** be performed on any applicable special purpose firmware component, and
    - All other applicable power-up or conditional tests are applicable to all components as required.
- Security Policy: The security policy must specify all the components of the ***hybrid*** cryptographic module by type, part numbers and version numbers. The security policy must contain a picture of the hardware components of the module. The security policy must specify all the services and sub-services provided by each component of the ***hybrid*** cryptographic module.
- Operational Environment: FIPS 140-2 Section 6 – The operating system requirements may be applicable for a ***hybrid*** module.
    - If the module is a Software-Hybrid module; this section is applicable; or
    - If the module is a Firmware-Hybrid module; this section is not applicable.

IG G.13 provides information guidance on how to complete the FIPS certificate for a hybrid module.

Additional Comments

Hybrid cryptographic modules shall be only applicable at FIPS 140-2 Level 1.

The hybrid cryptographic module may be ported to other compatible environments per IG G.5.

Changes to *any* component of the ***hybrid*** cryptographic module require the re-validation of the complete module as per IG G.8 – *Revalidation Requirements*.

The hardware components and applicable firmware components of the ***hybrid*** module are considered an extension of the software or firmware module to perform or accelerate cryptographic operations. In a ***hybrid*** module, the hardware components can only exchange CSPs and control information with the controlling software or firmware component of the module.

1.10 moved to A.3

1.11 moved to D.1

1.12 moved to C.1

1.13 moved to A.4

1.14 moved to A.5

1.15 moved to A.6

1.16 Software Module

Applicable Levels:	*All*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*12/23/2010*
Relevant Assertions:	*AS.01.01, AS.01.06, AS.01.08, AS.01.09, AS.01.14, AS.06.01, AS.06.02, AS.09.22, AS.09.34, AS.09.35 and AS.14.02*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background – FIPS 140-2

Cryptographic module: the set of hardware, software, and/or firmware that implements approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.

Software: the programs and data components within the cryptographic boundary, usually stored on erasable media (e.g., disk), that can be dynamically written and modified during execution.

The *operational environment* of a cryptographic module refers to the management of the software, firmware, and/or hardware components required for the module to operate. The operational environment can be non-modifiable (e.g., firmware contained in ROM, or software contained in a computer with I/O devices disabled), or modifiable (e.g., firmware contained in RAM or software executed by a general-purpose computer).

A *modifiable operational environment* refers to an operating environment that *may* be reconfigured to add/delete/modify functionality, and/or *may* include general purpose operating system capabilities (e.g., use of a computer O/S, configurable smart card O/S, or programmable firmware). Operating systems are considered to be modifiable operational environments if software/firmware components can be modified by the operator and/or the operator can load and execute software or firmware (e.g., a word processor) that was not included as part of the validation of the module.

If the operational environment is a modifiable operational environment, the operating system requirements in FIPS 140-2 Section 4.6.1 **shall** apply.

FIPS 140-2 DTR – Software

AS.01.01: (Levels 1, 2, 3, and 4) The cryptographic module shall be a set of hardware, software, firmware, or some combination thereof that implements cryptographic functions or processes, including cryptographic algorithms and, optionally, key generation, and is contained within a defined cryptographic boundary.

AS.01.06: (Levels 1, 2, 3, and 4) If the cryptographic module consists of software or firmware components, the cryptographic boundary shall contain the processor(s) and other hardware components that store and protect the software and firmware components.

AS.01.08: (Levels 1, 2, 3, and 4) Documentation shall specify the hardware, software, and firmware components of the cryptographic module, specify the cryptographic boundary surrounding these components, and describe the physical configuration of the module.

AS.01.09: (Levels 1, 2, 3, and 4) Documentation shall specify any hardware, software, or firmware components of the cryptographic module that are excluded from the security requirements of this standard and explain the rationale for the exclusion.

AS.01.14: (Levels 1, 2, 3, and 4) Documentation shall specify the design of the hardware, software, and firmware components of the cryptographic module. High-level specification languages for software/firmware or schematics for hardware shall be used to document the design.

AS.06.01: (Levels 1, 2, 3, and 4) If the operational environment is a modifiable operational environment, the operating system requirements in Section 4.6.1 shall apply.

AS.06.02: (Levels 1, 2, 3, and 4) Documentation shall specify the operational environment for the cryptographic module, including, if applicable, the operating system employed by the module, and for Security Levels 2, 3, and 4, the Protection Profile and the CC assurance level.

AS.09.22: (Levels 1, 2, 3, and 4) A software/firmware integrity test using an error detection code (EDC) or Approved authentication technique (e.g., an Approved message authentication code or digital signature algorithm) shall be applied to all validated software and firmware components within the cryptographic module when the module is powered up.

AS.09.34: (Levels 1, 2, 3, and 4) If software or firmware components can be externally loaded into the cryptographic module, then the following software/firmware load tests shall be performed.

AS.09.35: (Levels 1, 2, 3, and 4) An Approved authentication technique (e.g., an Approved message authentication code, digital signature algorithm, or HMAC) shall be applied to all validated software and firmware components when the components are externally loaded into the cryptographic module.

**AS.14.02: (Levels 1, 2, 3, and 4) The cryptographic module security policy shall consist of:
a specification of the security rules, under which the cryptographic module shall operate, including the security rules derived from the requirements of the standard and the additional security rules imposed by the vendor.**

Question/Problem

How is a *software* cryptographic module defined?

Resolution

A *software* module is a cryptographic module implemented entirely in executable or linked code executing in a modifiable operational environment.

- The physical boundary of a software module is the platform which the software and operating system reside per **AS.01.01** and **AS.01.06**.
- The logical boundary of a software module is the defined set of software components that implement the cryptographic mechanisms. The logical boundary is wholly contained within the physical boundary.
- All components of the cryptographic module **shall** be defined per **AS.01.08** or excluded per **AS.01.09**.
- FIPS 140-2 Section 4.2 defines the physical ports and logical interface requirements. A software modules logical interface **shall** be defined. If applicable, physical ports that map to logical interfaces **shall** be defined.
- FIPS 140-2 Section 4.5 may be marked not applicable (NA) for a software module.
- The power-up approved integrity test **shall** be performed over the defined software image(s) within the cryptographic module logical boundary (RE: **AS.01.01** and **AS.01.06**) per **AS.06.08**.
- The loading of software within the defined logical boundary **shall** meet **AS.09.34-35** and guidance in IG 9.7.

1.17 Firmware Module

Applicable Levels:	*All*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*12/23/2010*
Relevant Assertions:	*AS.01.01, AS.01.06, AS.01.08, AS.01.09, AS.01.14, AS.05.01, AS.06.01, AS.06.02, AS.09.22, AS.09.34, AS.09.35 and AS.14.02*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background – FIPS 140-2

Cryptographic module: the set of hardware, software, and/or firmware that implements approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.

Firmware: the programs and data components of a cryptographic module that are stored in hardware (e.g., ROM, PROM, EPROM, EEPROM or FLASH) within the cryptographic boundary and cannot be dynamically written or modified during execution.

The *operational environment* of a cryptographic module refers to the management of the software, firmware, and/or hardware components required for the module to operate. The operational environment can be non-modifiable (e.g., firmware contained in ROM, or software contained in a computer with I/O devices disabled), or modifiable (e.g., firmware contained in RAM or software executed by a general-purpose computer).

A *limited operational environment* refers to a static non-modifiable virtual operational environment (e.g., JAVA virtual machine on a non-programmable PC card) with no underlying general purpose operating system upon which the operational environment uniquely resides.

If the operational environment is a limited operational environment, the operating system requirements in FIPS 140-2 Section 4.6.1 do not apply.

FIPS 140-2 DTR – Firmware

AS.01.01: (Levels 1, 2, 3, and 4) The cryptographic module shall be a set of hardware, software, firmware, or some combination thereof that implements cryptographic functions or processes, including cryptographic algorithms and, optionally, key generation, and is contained within a defined cryptographic boundary.

AS.01.06: (Levels 1, 2, 3, and 4) If the cryptographic module consists of software or firmware components, the cryptographic boundary shall contain the processor(s) and other hardware components that store and protect the software and firmware components.

AS.01.08: (Levels 1, 2, 3, and 4) Documentation shall specify the hardware, software, and firmware components of the cryptographic module, specify the cryptographic boundary surrounding these components, and describe the physical configuration of the module.

AS.01.09: (Levels 1, 2, 3, and 4) Documentation shall specify any hardware, software, or firmware components of the cryptographic module that are excluded from the security requirements of this standard and explain the rationale for the exclusion.

AS.01.14: (Levels 1, 2, 3, and 4) Documentation shall specify the design of the hardware, software, and firmware components of the cryptographic module. High-level specification languages for software/firmware or schematics for hardware shall be used to document the design.

AS.05.01: (Levels 1, 2, 3, and 4) The cryptographic module shall employ physical security mechanisms in order to restrict unauthorized physical access to the contents of the module and to deter unauthorized use or modification of the module (including substitution of the entire module) when installed.

AS.06.01: (Levels 1, 2, 3, and 4) If the operational environment is a modifiable operational environment, the operating system requirements in Section 4.6.1 shall apply.

AS.06.02: (Levels 1, 2, 3, and 4) Documentation shall specify the operational environment for the cryptographic module, including, if applicable, the operating system employed by the module, and for Security Levels 2, 3, and 4, the Protection Profile and the CC assurance level.

AS.09.22: (Levels 1, 2, 3, and 4) A software/firmware integrity test using an error detection code (EDC) or Approved authentication technique (e.g., an Approved message authentication code or digital signature algorithm) shall be applied to all validated software and firmware components within the cryptographic module when the module is powered up.

AS.09.34: (Levels 1, 2, 3, and 4) If software or firmware components can be externally loaded into the cryptographic module, then the following software/firmware load tests shall be performed.

AS.09.35: (Levels 1, 2, 3, and 4) An Approved authentication technique (e.g., an Approved message authentication code, digital signature algorithm, or HMAC) shall be applied to all validated software and firmware components when the components are externally loaded into the cryptographic module.

AS.14.02: (Levels 1, 2, 3, and 4) The cryptographic module security policy shall consist of: a specification of the security rules, under which the cryptographic module shall operate, including the security rules derived from the requirements of the standard and the additional security rules imposed by the vendor.

Question/Problem

How is a *firmware* cryptographic module defined?

Resolution

IG 1.3 defines the *firmware* module designation, referencing, versioning and porting guidance. Additional guidance:

- The physical boundary of a firmware module is the platform which the firmware and operating system reside per **AS.01.01** and **AS.01.06**.
- The logical boundary of a firmware module is the defined set of firmware components that implement the cryptographic mechanisms. The logical boundary is wholly contained within the physical boundary.
- All components of the cryptographic module **shall** be defined per **AS.01.06**, **AS.01.08** or excluded per **AS.01.09**.
- FIPS 140-2 Section 4.2 defines the physical ports and logical interface requirements. A firmware module's logical interface **shall** be defined. If applicable, physical ports that map to logical interfaces **shall** be defined.
- FIPS 140-2 Section 4.5 is applicable for a firmware module.
- For **Level 1** the firmware module **shall** prevent access by other processes to plaintext private and secret keys, CSPs, and intermediate key generation values during the time the firmware module is executing/operational. Processes that are spawned by the firmware module are owned by the module and are not owned by external processes/operators. Non-cryptographic processes **shall** not interrupt the firmware module during execution. The firmware **shall** be installed in a form that protects the software and firmware source and executable code from unauthorized disclosure and modification.

  Note: These requirements cannot be enforced by administrative documentation and procedures, but must be enforced by the firmware module itself.

  Required Vendor Information - Firmware Module (Level 1 only)

  VE.05.01.01: The vendor **shall** provide a description of the mechanism used to ensure that no other process can access private and secret keys, intermediate key generation values, and other CSPs, while the cryptographic process is in use.

  VE.05.01.02: The vendor **shall** provide a description of the mechanism used to ensure that no other process can interrupt the cryptographic module during execution.

  VE.05.01.03: The vendor **shall** provide a list of the cryptographic firmware that are stored on the cryptographic module and **shall** provide a description of the protection mechanisms used to prevent unauthorized disclosure and modification.

  Required Test Procedures – Firmware Module (Level 1 only)

  TE05.01.01: The tester **shall** perform cryptographic functions as described in the crypto officer and user guidance documentation. While the cryptographic functions are executing, the same or another tester **shall** attempt to access secret and private keys, intermediate key generation values, and other CSPs.

TE05.01.02: The tester **shall** perform cryptographic functions as described in the crypto officer and user guidance documentation. While the cryptographic functions are operating, the same or another tester **shall** attempt to execute another process.

TE05.01.03: The tester **shall** attempt to perform unauthorized accesses and unauthorized modifications to software and firmware source and executable code.

- The mechanisms that define, control and manage the non-modifiable or limited operational environment **shall** be identified per **AS.06.02** and are considered security relevant mechanisms.
- The power-up integrity test **shall** be performed over all non-excluded firmware image(s) defined within the cryptographic module boundary (RE: **AS.01.01** and **AS.01.06**) per **AS.09.22**.
- If the Section 4.5 physical security is Level 1, the loading of firmware within the defined logical boundary **shall** meet **AS.09.34-35** and guidance in IG 9.7.
- If the Section 4.5 physical security is Level 2, 3 or 4, the loading of firmware within the defined physical boundary **shall** meet **AS.09.34-35** and guidance in IG 9.7.

1.18 PIV Reference

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	
Last Modified Date:	*04/23/2012*
Relevant Assertions:	*AS01.06 and AS01.08*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background – FIPS 140-2

Cryptographic module: the set of hardware, software, and/or firmware that implements approved security functions (including cryptographic algorithms and key generation) and is contained within the cryptographic boundary.

A hardware cryptographic module may have an embedded PIV card application component that has been validated by the NPIVP. The PIV card application validation is a prerequisite to the module validation. For module validation, the PIV card application **shall** be tested on the module to be validated (i.e. same operational environment).

Question/Problem

How should a PIV card application component that is included as a component of a cryptographic module be referenced on the module validation entry?

Resolution

The cryptographic module validation entry **shall** provide reference to the PIV card application component(s) validation certificate number.

The PIV card application validation entry **shall** include the following information:

1. the name of the PIV card application component,
2. the name of the cryptographic module the PIV component was tested on, and
3. the complete versioning information of the module including the PIV component(s) (IG G.13).

The cryptographic module's versioning information **shall** include the complete versioning information of the module including the PIV component(s). Each PIV component(s) name **shall** be clearly distinguishable as a PIV component.

IG G.13 defines how the PIV Certificate number is referenced on a module validation.

The NPIVP validation entries can be found at:

http://csrc.nist.gov/groups/SNS/piv/npivp/validation_lists/PIVCardApplicationValidationList.htm

Additional Comments

If a PIV card application component will be used on different cryptographic module operating environments, the PIV card application **shall** be tested and validated by the NPIVP on each of the unique operating environments employed.

1.19 non-Approved Mode of Operation

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	
Last Modified Date:	*06/20/2012*
Relevant Assertions:	*AS01.02, AS01.03 and AS01.04*
Relevant Test Requirements:	*TE01.03.01-02 and TE01.04.01-12*
Relevant Vendor Requirements:	*VE01.03.01-02 and VE01.04.01-02*

Background

Approved mode of operation: a mode of the cryptographic module that employs only approved security functions.

A cryptographic module **shall** implement at least one approved security function used in an approved mode of operation. Non-approved security functions may also be included for use in non-approved modes of operation. The operator **shall** be able to determine when an approved mode of operation is selected. For Security Levels 1 and 2, the cryptographic module security policy may specify when a cryptographic module is performing in an approved mode of operation. For Security Levels 3 and 4, a cryptographic module **shall** indicate when an approved mode of operation is selected.

Question/Problem

Are there any operational requirements when switching between an approved mode of operation to a non-approved mode of operation, or vice versa?

Resolution

A cryptographic module may be designed to support both an approved mode of operation (IG 1.2), multiple approved modes of operation (IG 1.7) and a non-approved mode of operation. For a cryptographic module to implement an approved mode of operation (one or more) and a non-approved mode of operation, all applicable requirements of FIPS 140-2 **shall** apply with specific attention to the following areas:

AS.01.03: The operator shall be able to determine when an Approved mode of operation is selected.

AS.01.04: For Security Levels 3 and 4, a cryptographic module shall indicate when an Approved mode of operation is selected.

AS01.12: Documentation shall list all security functions, both Approved and non-Approved, that are employed by the cryptographic module and shall specify all modes of operation, both Approved and non-Approved.

AS03.14: Documentation shall specify the services, operations, or functions provided by the cryptographic module, both Approved and non-Approved, and for each service provided by the module, the service inputs, corresponding service outputs, and the authorized role(s) in which the service can be performed.

AS04.02: The cryptographic module shall include the following operational and error states: *User states*. States in which authorized users obtain security services, perform cryptographic operations, or perform other Approved or non-Approved functions.

AS14.07: The security policy shall specify; all roles and services provided by the cryptographic module.

IG 1.2: Generation and sharing of CSPs.

IG 1.7: Multiple approved Modes of Operation; if applicable.

IG 9.5: Module Initialization during Power-Up.

IG 14.1: Level of Detail when Reporting Cryptographic Services

In summary, the security policy **shall** contain the following information:

- instructions for the operator to determine when the module is in an approved or non-approved mode of operation;
- instructions for the operator for the configuration to an approved or non-approved mode of operation;
  - is the module configured during initialization to operate only in an approved or non-approved mode of operation when in the operational state, or
  - when in the operational state can the module alternate service by service between approved and non-approved modes of operation
- list all security functions employed by the module in both approved and non-approved modes of operation; and
- list all roles and services, operations or functions provided by the cryptographic module in both approved and non-approved modes of operation;
  - for non-approved service names that reference approved terms, references or functions, the caveat "(non-compliant)" **shall** be appended to the service name to alleviate misinterpretation of

approved services; and

- keys or other parameters associated with non-approved services do not need to be provided.

If the module is configured during power-up initialization to operate only in an approved or non-approved mode of operation;

- a power-on reset **shall** be performed to re-configure the module during initialization from a non-approved mode of operation to an approved mode of operation or vice versa; and
- the conditional self-tests in FIPS 140-2 Section 4.2 are not required when in a non-approved mode of operation with the following exception;
  - the module **shall** not allow the loading of software/firmware components as addressed in FIPS 140-2 Section 4.9.2 *Software/Firmware load test* (i.e. **AS.09.34**).

Additional Comments

This implementation guidance is a further clarification of the FIPS 140-2 clauses and of existing implementation guidance.

1.20 Sub-Chip Cryptographic Subsystems

Applicable Levels:	*All*
Original Publishing Date:	*03/02/2015*
Effective Date:	*09/15/2015*
Last Modified Date:	*02/06/2017*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Increased levels of integration in IC design, such as ASIC, FPGA or System-on-Chip (SoC), have been developed with heterogeneous computing characteristics. Heterogeneous computing may include multiple processors or functional engines, with isolated security subsystem designs that may be re-used in multiple configurations or generations of products.

Question/Problem

What is a *sub-chip cryptographic subsystem*, and what are the requirements for *initial* validation? Once validated, how can the sub-chip cryptographic subsystem be re-validated if modified? How can a non-modified sub-chip cryptographic subsystem be ported and reused on other single-chip implementations?

Resolution

The following terminology is used in the context of this IG:

HDL – Hardware Design Language; examples are Verilog and VHDL.
Security relevant – relevant to the requirements of FIPS 140-2.
Soft circuitry core – an uncompiled hardware subsystem of an ASIC, FPGA or SoC.
Hard circuitry core – a fixed or precompiled hardware subsystem of an ASIC, FPGA or SoC.

For a hardware module, the minimum defined physical boundary in FIPS 140-2 is a single-chip. For single-chip hardware modules a sub-chip cryptographic subsystem may be defined as the set of hard and/or soft circuitry cores and associated firmware which represents a sub-chip cryptographic subsystem boundary of a single-chip hardware module. The sub-chip cryptographic subsystem is integrated on the single-chip which may contain other functional subsystems (e.g. processor(s), memory, I/O and internal bus controls, sensors, etc.) and associated firmware. Upon fabrication of the complete physical single-chip, the HDL will be transformed to a gate or physical circuitry representation which may or may not retain a definable internal sub-chip cryptographic subsystem boundary

1. **Initial validation or security relevant re-validations**
   (3SUB or 5SUB)

   - The physical boundary **shall** be defined as the single-chip physical boundary;
     - FIPS 140-2 Section 4.5 requirements **shall** apply at the physical boundary
   - FIPS 140-2 defines the Cryptographic boundary as an explicitly defined continuous perimeter that establishes the physical bounds of a cryptographic module, and contains all the hardware, software, and/or firmware components of a cryptographic module. According to IG 1.16, the physical boundary of a software module is the platform in which the software and operating system reside per AS.01.01 and AS.01.06. The logical boundary of a software module is the defined set of software components that implements the cryptographic mechanisms. The logical boundary is wholly contained within the physical boundary. Similarly, for the sub-chip cryptographic subsystem, the physical boundary is the single-chip physical boundary while its logical boundary (the sub-chip cryptographic subsystem boundary) is defined as the set of hard and/or soft circuitry cores and associated firmware that comprises the sub-chip cryptographic subsystem.
   - If there is any associated firmware externally loaded into the sub-chip cryptographic subsystem, the associated firmware **shall** meet requirements of software/firmware load test (**AS09.29**, **AS09.34**, **AS09.35** and **AS09.36**).
   - Except for externally loaded firmware, the associated firmware **shall** be stored and loaded inside the sub-chip cryptographic subsystem, and **shall** meet software/firmware integrity test (**AS09.13**, **AS09.22**, and **AS09.36**).
   - The ports and interfaces (FIPS 140-2 Section 4.2) **shall** be defined at the sub-chip cryptographic subsystem boundary.
     - For operational testing purposes, access to the sub-chip cryptographic subsystem boundary ports **shall** be required and a mapping **shall** be provided. These may be mapped to physical I/O pins, internal test interfaces (e.g. Level Sensitive Scan Design (LSSD)) or the sub-chip boundary data and control ports. The tester **shall** demonstrate that the ports at sub-chip cryptographic subsystem boundary are accessible via the single-chip's other functional subsystems in a manner such that following four kinds of information are provably unmodifiable and under control of the test program:
       - Data input,
       - Data output,
       - Control input, and
       - Status output,

       even in the presence of intervening other functional subsystems.

       Note 1: Typically, the test program acting on behalf of the tester with direct access to the ports and interfaces defined at the sub-chip cryptographic subsystem boundary provides the required demonstration of port access.

       Note 2: In single-chip embodiments, there may be intervening functional subsystems (or intervening circuitry) other than the sub-chip cryptographic subsystem subject to testing. There is a security concern that such intervening subsystems might act maliciously (e.g. intercept, modify, and store CSPs, or attempt a replay attack and/or man-in-the-middle attack). The tester **shall** provide a rationale in the physical security test report explaining existing risks and mitigations. The CMVP may provide additional guidance in the future on how to analyze and document such potential security risks.

Note 3: If applicable, **VE03.26.01** and **TE03.26.01** **shall** be considered at the level of the tested sub-chip cryptographic subsystem and potential differences between the internal and external with respect to the subsystem boundary single chip clocks **shall** be accounted for properly.

- Depending on the level, the requirements for Cryptographic Key Establishment and Key Entry and Output (FIPS 140-2 Section 4.7.4) **shall** be applicable at the defined sub-chip cryptographic subsystem boundary.
  - If Key establishment and Key Entry and Output occur across the physical boundary of the single-chip embodiment, **AS07.29** and **AS07.30** **shall** apply.
  - Transferring Keys/CSPs including the entropy input between a sub-chip cryptographic subsystem and an intervening functional subsystem for Levels 1 and 2 on the same single chip is considered as not having Key Establishment and Key Entry and Output crossing the boundary of the sub-chip module per IG 7.7. Nevertheless, the above Note 2 for the ports and interfaces is applicable for the transferring of Keys/CSPs as well. That is, the tester **shall** provide a rationale in the physical security test report explaining risks and mitigations to the malicious act by such intervening subsystems.
    - For Level 3 and Level 4 modules, key establishment is ED / EE as stated in IG 7.7.
- Versioning information **shall** be provided for the
  - physical single-chip including any excluded functional subsystem firmware (**shall** be specified in the OE field of the validation),
  - the sub-chip cryptographic subsystem soft and hard circuitry cores, and
  - the associated firmware.
- Processor sub-functions outside the sub-chip cryptographic subsystem boundary but within the physical boundary such as a processor, memory macros, I/O controllers, etc. **may** be excluded under **AS01.09**. However, the data paths used to meet either **AS02.16** and **AS02.18** or **AS02.17** and **AS02.18** **shall not** be excluded.

2. **Non-security relevant re-validations associated with changes within physical boundary** (1SUB and 4SUB): Existing IG G.8 guidance is applicable.

3. **Sub-chip cryptographic subsystem porting**
The sub-chip cryptographic subsystem may be ported to other single-chip implementations which may be different chip technologies, and/or different non-security relevant functional subsystems.

A sub-chip cryptographic subsystem that was previously validated in a single-chip can be ported to other single-chip constructs as a 1SUB/4SUB submission to the CMVP. The following is applicable to validate this new single-chip module as a 1SUB/4SUB:

- The laboratory **shall** verify that there are no security relevant changes in the sub-chip cryptographic subsystem;
- If an entropy source is contained within the sub-chip cryptographic subsystem, a new entropy estimate **shall** be provided;

Note 1: A new entropy estimate may not be required, if the entropy is collected outside the sub-chip cryptographic subsystem, depending on changes to the entropy source or the subsystem housing it. Please refer to IG 7.14 and IG 7.15 for details on entropy estimates and applicable caveats.
Note 2: Single chip embodiments may implement a NDRNG or a DRBG linked to a dedicated entropy source (NDRNG) inside the physical boundary. Such cases may be implemented (a) inside the sub-chip cryptographic subsystem or (b) in two or more sub-chip cryptographic subsystems. The case (b) represents multiple disjoint sub-chip cryptographic subsystems (see 4 of this IG).

- Approved security functions **shall** be retested and validated by the CAVP if implemented in a soft circuitry core recompiled in a different part configuration.

  Note 3: If the original algorithm testing was performed as stated in IG G.11 in a module simulator, and there is no change to the soft-core, no additional algorithm testing is required.

- Operational regression testing (Table G.8.1) **shall** be performed on the new sub-chip cryptographic subsystem after fabrication (transformation of the HDL to a gate or physical circuitry representation);
- FIPS 140-2 Section 4.2 **shall** be addressed for the new single-chip module for all Security Levels within this Section.
- FIPS 140-2 Section 4.5 **shall** be addressed for the new single-chip module at Security Level 1.
- FIPS 140-2 Section 4.8 **shall** be addressed for the new single-chip module for all Security Levels within this Section.
- FIPS 140-2 Sections 4.10.1 and 4.10.4 **shall** be addressed for the new single-chip module for all Security Levels within this Section.
- A new Security Policy **shall** be provided for the new single-chip module.
- A new validation certificate will be issued. Versioning information **shall** be provided for
  - the new physical single-chip
  - non-security relevant single-chip functional subsystem firmware if applicable,
  - the sub-chip cryptographic subsystem soft and hard circuitry cores (which are unchanged from the original validation), and
  - the associated firmware.

The testing laboratory **shall** submit a 1SUB/4SUB test report for the ported updated sub-chip cryptographic subsystem to the CMVP. NIST Cost Recovery fee for Scenario 1A is applicable.

4. Multiple disjoint sub-chip cryptographic subsystems:

Disjoint sub-chip cryptographic subsystems may exist on a single-chip. Each **shall** be separately validated.

Transferring Keys/CSPs including the entropy input between two disjoint sub-chip cryptographic subsystems on the same single chip for Level 1 and Level 2 modules is considered not having Key Establishment and Key Entry and Output crossing their sub-chip cryptographic subsystem boundary per see IG 7.7.

- For Level 3 and Level 4 modules, key establishment is ED / EE as stated in IG 7.7.

Alternatively, plaintext CSPs may be shared directly between two disjoint sub-chip cryptographic subsystems via a Trusted Path (IG 2.1). In this scenario, the following porting rules **shall** apply:

a. If the two sub-chip modules that are connected by a Trusted Path are ported together, it is considered security relevant and the testing lab **shall** submit a 3SUB or a 5SUB.

b. If only one of the sub-chip modules that are connected by a Trusted Path is ported, then the testing lab **shall** verify that the trusted path is no longer functional and may submit a 1SUB/4SUB.

c. If only one of the sub-chip modules that are connected by a Trusted Path are ported and it is connected to a new sub-chip module, then it is considered security relevant and the testing lab **shall** submit a 3SUB or a 5SUB.

Additional Comments

This IG does not apply to single-chip implementations that do not contain sub-chip cryptographic subsystems, i.e. there is only one boundary which is the physical boundary.

If the sub-chip cryptographic subsystem enters an error state, the FIPS 140-2 requirements are applicable at the boundary of the sub-chip cryptographic subsystem; not at the boundary of the single-chip.

1.21 Processor Algorithm Accelerators (PAA) and Processor Algorithm Implementation (PAI)

Applicable Levels:	*All*
Original Publishing Date:	*03/02/2015*
Effective Date:	*03/02/2015*
Last Modified Date:	*10/17/2022*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

As chip fabrication technology advances, additional real estate is becoming available for single-chip processor manufacturers to add acceleration functions to support complex cryptographic algorithms. When these functions are added, the CMVP, the CAVP and the Cryptographic Technology group at NIST will determine if the acceleration function is simply a mathematical construct and not the complete cryptographic algorithm as defined in the NIST standards.

If the function is deemed the complete cryptographic algorithm, then FIPS 140-2 defines the component to be security-specific hardware and complete documentation of the entire component, including HDL, **shall** be submitted to the testing laboratory when under test. This type of implementation is considered a Processor Algorithm Implementation (PAI) function. If the module has been designed to run with and without the security-specific hardware, the resolution below under Software/Firmware Module may apply.

If the function is deemed a mathematical construct and not the complete cryptographic algorithm as defined in the NIST standards, then FIPS 140-2 does not define the component to be security-specific hardware and complete documentation of the entire component, including HDL, is not required. This type of implementation is considered a Processor Algorithm Acceleration (PAA) function.

Question/Problem

What are the currently known processor chips that include Processor Algorithm Acceleration (PAA) and Processor Algorithm Implementation (PAI) functions to support complex cryptographic algorithms and how is it indicated on the validation certificate? What are the testing requirements when a module supports PAA and/or PAI?

Resolution

If a cryptographic module is designed to utilize a processor chip that includes PAA and/or PAI, the part number or version of the processor chip **shall** be included in **TE.01.08.02**. A module that utilizes such processor hardware may or may not be defined as a hybrid module.

Software/Firmware-Hybrid Module: If the software or firmware component of the hybrid can only support a cryptographic algorithm by exclusively utilizing the PAA or PAI capability, then the module **shall** be defined as a Software/Firmware-Hybrid Module Embodiment (IG 1.9).

PAA

- **Module versioning** information **shall** include the part number or version of the processor chip.
- **Operational Environment:** <OS> running on <platform> with <processor> with PAA

PAI

- **Module versioning** information **shall** include the part number or version of the processor chip.
- **Operational Environment:** <OS> running on <platform> with <processor> with PAI

Software/Firmware Module: If the software or firmware component of the module can support a cryptographic algorithm natively or by utilizing the PAA or PAI capability if available, then the module **shall** be defined as a Software/Firmware module Embodiment, unless there are other reasons to designate the module as hybrid.

PAA

- **Algorithm certificates**; the accelerated algorithms **shall** be tested in both native execution and PAA execution.
- **Operational Environments:**
    - <OS> running on <platform> with <processor> with PAA;
    - <OS> running on <platform> with <processor> without PAA

PAI

- **Algorithm certificates**; the algorithms **shall** be tested in both native execution and PAI execution.
- **Operational Environments:**
    - <OS> running on <platform> with <processor> with PAI;
    - <OS> running on <platform> with <processor> without PAI

Testing requirements

A module is considered a hybrid if *all* the Operational Environments (OEs) *only* support *with* PAA/PAI and were tested as such.

A module can support PAA/PAI and be considered a software/firmware module instead of a hybrid if one of the following two options are chosen:

1. Perform module testing *with* and *without* PAA/PAI for all OEs on the certificate.
    a. OEs would either be listed *with* and *without* on the certificate (which is typical), or *with* or *without* (rare) if the algorithm and operational testing is performed on both options and shown in the Test Report. Sometimes a vendor may choose this second option as to encourage a user in using a PAA/PAI or non-PAA/PAI solution (even though both are technically validated).
2. Perform module testing *without* PAA/PAI for at least one OE on the certificate, and *with* PAA/PAI for at least one OE on the certificate. Testing *with* and *without* may be on the same OE or may be on another, “similar”, OE following the rules below.

a. The module **shall** be tested *with* PAA/PAI on *every* OE on the certificate that supports a PAA/PAI. This is to confirm every PAA/PAI implementation/combination is tested, since there may be subtle differences in both the code and the PAA/PAI in the processor.

b. For every OE that is tested *with* PAA/PAI, there **shall** be another "similar" or identical OE tested *without* PAA. Examples of OEs that may or may not be "similar" are provided in IG 1.4 Additional Comment #1 though #3 (e.g., a 64-bit OE is not "similar" to a 32 bit-OE, even if everything else is identical). The testing lab **shall** justify the "similar" claim in the Test Report. It is recommended that "similar" requests be submitted to the CMVP via the existing Request for Guidance process detailed in IG G.1 *Request for Guidance from the CMVP and CAVP*. It is at the discretion of the CMVP to accept this claim.

c. There **shall** be no differences in module binaries executed on any of the OEs that are considered "similar", whether testing *with* or *without* the PAA/PAI (note: the PAA/PAI code is considered outside of the logical boundary of the module). E.g., the module has identical binaries running on all "similar" OEs, and this code was tested in at least one instance of both *with* and *without* PAA/PAI.

d. It is acceptable if some of the OEs only <u>support</u> *without* PAA/PAI and not *with* PAA/PAI – as this is still considered a software/firmware module. E.g., OE1 uses an Intel Xeon E5-2600 and was tested *with* and *without* PAA, while OE2 uses an ARMv5 that does not implement a PAA/PAI and was only tested *without* PAA/PAI.

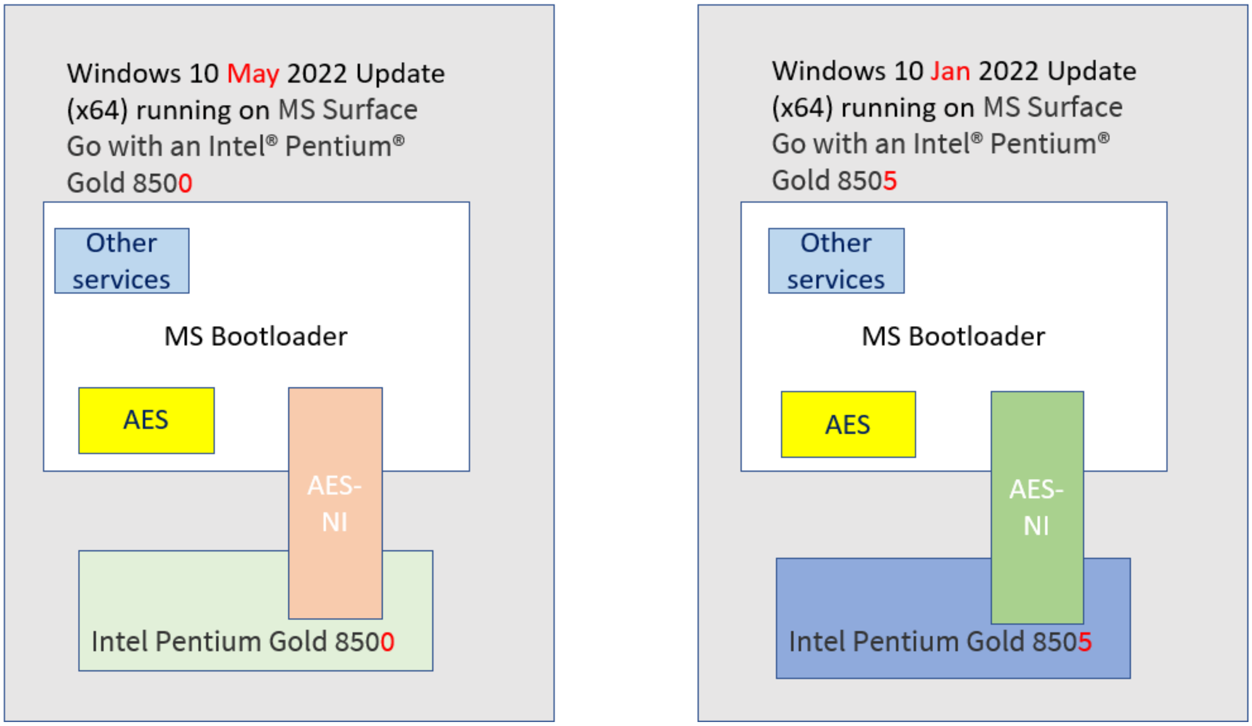
e. It is acceptable if some of the OEs were only <u>tested</u> *with* PAA/PAI and not *without* PAA/PAI – as this is still considered a software module since that code branch (*without* PAA/PAI) has already been tested on a "similar" OE. E.g., OE1 uses OS1 on an Intel Xeon E5-2600 and was only tested *with* PAA, while OE2 uses OS1 on an Intel Xeon E5-2650 that was tested *with* and *without* PAA.

f. The module certificate **shall** never include an OE that was not individually tested by the lab.

g. The Test Report **shall** include evidence demonstrating all module/PAA/PAI code branches used by OEs on the certificate are tested within the combination of the tested OEs.

h. The above rules apply only for MODULE LEVEL testing, and does not address CAVP testing (e.g., see CAVP FAQ AES.2).

Below is a diagram to help explain option 2.



- The diagram shows a module running on two slightly different environments. The module was tested *without* PAA only once, since the module binary that includes the AES implementation without PAA (Yellow box) is exactly the same in both environments. Thus, there is assurance that the AES *without* PAA will function on any "similar" environment.
- However, the module was tested *with* PAA twice, since the processor is different in both environments, and testing on both guarantees that all code is exercised, including *with* the PAA code on the processor itself (peach and green boxes).
- The module certificate can only claim what is tested (i.e., *with* PAA on both environments, and *without* PAA on one).

Known PAAs:

- Intel Processors – Xeon, Core i5, Core i7, Core M and Atom with Westmere, Sandy Bridge, Ivy Bridge, Haswell, Broadwell, Skylake, Kaby Lake, Coffee Lake, Goldmont Plus, Whiskey Lake, Amber Lake, Cascade Lake, Comet Lake or Sunny Cove micro-architectures: PAA = AES-NI
    - Accelerator sub-functions for AES implementations
- Intel Processors – Atom, Celeron, and Pentium with Goldmont, Goldmont Plus, Sunny Cove micro-architectures: PAA = Intel SHA Extensions
    - Accelerator sub-functions for SHA implementations
- AMD Processors - Opteron, Athlon, Sempron, FX, and A series with Bulldozer, Piledriver, Steamroller, Jaguar, Puma micro-architectures: PAA = AES-NI
    - Accelerator sub-functions for AES implementations
- AMD Processors – Ryzen series with Zen micro-architectures: PAA = SHA Extensions
    - Accelerator sub-functions for SHA implementations

- ARM Cortex A series, R series, Qualcomm Snapdragon, Apple A series processors, Samsung Exynos with ARMv7-A and ARMv8-A micro-architectures: PAA = NEON or Cryptography Extensions
  - Accelerator sub-functions for AES and SHA implementations
- IBM Power Processors 8, 9: PAA = Power ISA
  - Accelerator sub-functions for AES and SHA implementations
- Oracle: Oracle SPARC T series, M series: PAA = SPARC
  - Accelerator sub-functions for AES, DES, and SHA implementations

Known PAIs:

- IBM CP Assist for Cryptographic Functions (CPACF)
  - Full implementations of AES (ECB, CBC), TDES, SHA-1, SHA-2

Additional Comments

NOTE1: AES.2 in the CAVP FAQ gives requirements for both types of implementations.

NOTE2: Please reference IG 1.9 regarding hybrid definition and requirements.

NOTE3: The processor manufacturer may provide a device driver to support use of the processor algorithm accelerator. The device driver **shall** not provide any additional functionality to the PAA.

NOTE4: The implementation of complete algorithms, partial cryptographic modules, or full cryptographic modules as a component of a single-chip, or multiple of any of the above as components of a single-chip, is addressed in the Sub-Chip Cryptographic Subsystems IG.

NOTE 5: Please contact the CMVP to address new PAA or PAI implementations to make a determination whether they are full cryptographic functions or not.

NOTE 6: If the PAI security function appears on the list of known PAIs, its HDL is not required for validation of software modules using it.

1.22 Module Count Definition

Applicable Levels:	*All*
Original Publishing Date:	*11/15/2016*
Effective Date:	*11/15/2016*
Last Modified Date:	
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The CMVP allows multiple modules to be validated on a single certificate. However, the separation of these modules in the report is not always clear.

Question/Problem

How does the vendor or lab determine what the module count is for a particular validation?

Resolution

Determining the module count for a validation depends on the type of report; that is, if it is Software, Hardware, Firmware, or a Hybrid.

Software:

- For a software module, its binary package(s) compiled from its source code is the Implementation Under Test (IUT). The same source code may result in different sets of binaries when it's compiled for the different target platforms. The module count **shall** be the number of distinct sets of binaries.

  Examples:

  - If a software module was validated on software version 1.0, and this source code package was compiled on three operating environments of the same family (e.g. *iOS 8.0 running on iPhone5*, *iOS 9.0 running on iPhone5, and iOS 9.1 running on iPhone5)* resulting in a single binary set, the module count is "1".
  - If a software module was validated on software version 1.0, and this source code package was compiled on two operating environments (e.g. *iOS 9.0 running on iPhone5* and *Android 4.0 running on a Galaxy Nexus)* resulting in two separate sets of binaries (each set forming the logical boundary of the module), the module count is "2".
  - If a software module was validated on software version 1.0 and software version 2.0, and these source code packages were compiled on four operating environments (e.g. *iOS 9.0 running on iPhone5*, *iOS 9.1 running on iPhone5, Microsoft Windows Phone 8.1 running on Windows Phone 8.1,* and *Android 4.0 running on a Galaxy Nexus)*, where two of the environments are of the same family (*iOS 9.0 and iOS 9.1)* resulting in six separate sets of binaries (software versions 1.0 and 2.0 each map to three distinct sets of binaries), the module count is "6". In this case, a single iOS binary maps to both *iOS 9.0 and 9.1*, a single Microsoft Windows Phone binary maps to *Microsoft Windows Phone 8.1*, and a single Android binary maps to the *Android 4.0*, resulting in three distinct binaries for each software version (1.0 and 2.0), for a total of 6.

Hardware:

- For a hardware module report, the module count can be determined by the physical boundary of the module and understanding the components that are either tested individually and have their own boundary, or the boundary encompasses multiple components and these are tested collectively.
  - If the boundary of the module consists of one hardware component with other hardware components within it, with each having its own hardware version number listed in the certificate (such as tamper seals, service processing cards, switch fabric, core switch blades, control processor blade, power supplies, fan kits, filler panels, management modules, network modules), then the module count **shall** be the number of 'base' modules which support the components within it.

    Examples:

    - If a hardware module report contains a switch (Series 1500, P/N 1010) which can optionally support four additional network modules for uplink ports (P/Ns 10, 20, 30, 40), then the module count is "1" (the switch being the 'base' component).
    - If a hardware module report contains a router with three separately tested part numbers (Series 2000, P/Ns 10, 20, 30), and each router can be configured to use service processing card *A* (P/N 100) or service processing card *B* (P/N 101), along with tamper seal *TAMP1* (P/N 500), then the module count is "3" (the routers, each part number – 10, 20 and 30 - being a 'base' component).

        - If a hardware module report contains a series of four switches and two chassis-based switches (all running either the same firmware, or firmware with non-security relevant differences), and within the boundary of each of the chassis-based switches is a common control processor blade, four different core blades, fiber channel (FC) port blades, an optional extender blade, a power-supply and a tamper seal, then the module count is "6" (the switches being the 'base' component: four switches and two chassis-based switches).

    - If the report has several hardware modules that are individually tested and independent from one another, each having their own cryptographic boundary (flash drives, hard drives, single chips, multi-chips, etc.), but have slight hardware differences (shape, capacity storage, number or type of ports, etc.), then each of the independent hardware pieces **shall** contribute to the module count.

      Examples:

        - If a hardware module report contains two hard drive series with five separately tested configurations [Series SSD1 (P/Ns 128, 256, 500) and SSD2 (P/Ns 1000, 2000)], each with their own cryptographic boundary, the module count is "5".
        - If a hardware module report contains three switch series with eight separately tested configurations [Series 6000 (P/Ns 100, 101, 102), 7000 (P/Ns 200, 201) and 8000 (P/Ns 300, 301, 302)], each with their own cryptographic boundary, the module count is "8".

    - If the hardware module report contains multiple firmware versions tested (with non-security relevant differences) on the same hardware platform, then the module count **shall** reflect the number of hardware modules only, not the number of firmware versions that are running on it.

        - For example, if a hardware module includes two hard-drives (one being a 250GB drive and the other being a 500GB drive), and each of these drives map to four firmware versions (with non-security relevant differences), the module count is "2" to reflect the hardware platforms.

<u>Firmware</u>:

- For a firmware module, the firmware package itself **shall** be considered a separate module, regardless of the number of hardware platforms it was tested on.

  Examples:

    - If a firmware package was validated as firmware version 1.0, and this package was tested on two hardware platforms (e.g. *hardwareX* version 1.0 and *hardwareY* version 2.0), the module count is "1".
    - If a report includes firmware version 1.0 and firmware version 2.0, then the module count is "2", regardless of the number of hardware platforms these packages were tested on.

<u>Hybrid</u>:

- Since hybrid modules (firmware-hybrid or software-hybrid) are dependent on both the software/firmware and the hardware components, the module count **shall** be the total number of configurations that are possible that map to a single module boundary.

  Examples:

    - If a firmware-hybrid includes hardware version 1.0 and firmware version 3.1, the module count is "1", since there is only a single combination of these two components.

- If a firmware-hybrid includes hardware versions 1.0, 1.1, and 1.2, and firmware versions 1.1 and 1.2, and each of the hardware version can map to either of the firmware versions, then the total combination is equal to “6” (3 hardware versions times 2 firmware versions).

1.23 Definition and Use of a non-Approved Security Function

Applicable Levels:	*All*
Original Publishing Date:	*8/07/2017*
Effective Date:	*8/07/2017*
Last Modified Date:	*02/14/2022*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 Glossary:

Approved: *FIPS-Approved and/or NIST-recommended.*

Approved mode of operation: *a mode of the cryptographic module that employs only approved security functions (not to be confused with a specific mode of an approved security function, e.g., DES CBC mode).*

Approved security function: *for this standard, a security function (e.g., cryptographic algorithm, cryptographic key management technique, or authentication technique) that is either*

a) specified in an approved standard,

b) adopted in an approved standard and specified either in an appendix of the approved standard or in a document referenced by the approved standard, or

c) specified in the list of approved security functions.

FIPS 140-2 Section 3 Functional Security Objectives:

The security requirements specified in this standard relate to the secure design and implementation of a cryptographic module. The requirements are derived from the following high-level functional security objectives for a cryptographic module:

- *To employ and correctly implement the approved security functions for the protection of sensitive information.*
- *To protect a cryptographic module from unauthorized operation or use.*
- *To prevent the unauthorized disclosure of the contents of the cryptographic module, including plaintext cryptographic keys and CSPs.*
- *To prevent the unauthorized and undetected modification of the cryptographic module and cryptographic algorithms, including the unauthorized modification, substitution, insertion, and deletion of cryptographic keys and CSPs.*
- *To provide indications of the operational state of the cryptographic module.*
- *To ensure that the cryptographic module performs properly when operating in an approved mode of operation.*

- *To detect errors in the operation of the cryptographic module and to prevent the compromise of sensitive data and CSPs resulting from these errors.*

FIPS 140-2 Section 4.7 Cryptographic Key management:

Encrypted cryptographic keys and CSPs refer to keys and CSPs that are encrypted using an Approved algorithm or Approved security function. Cryptographic keys and CSPs encrypted using a non-Approved algorithm or proprietary algorithm or method are considered in plaintext form, within the scope of this standard.

IG 3.5 Documentation Requirements for Cryptographic Module Services:

FIPS 140-2 Section 2.1 Glossary of Terms does not provide a definition of service. However, the standard does give a few examples to illustrate the intended use of the term Service. Encryption, authentication, digital signature and key management are mentioned as examples of cryptographic services on page iv. Origin authentication, data integrity and signer non-repudiation are listed as the services provided by a digital signature. Show status and self-tests are mentioned in Section 4.3 as examples of services that do not affect the security of the module.

A service is any externally operator-invoked operation and/or function that can be performed by a cryptographic module.

Question/Problem

The term *non-approved security function* is not defined in the FIPS 140-2 Glossary of Terms, but is cited in multiple places in the standard, DTR and IG. It is central to the correct interpretation of IG 1.2 and IG 1.19. How is *non-approved security function* defined, and how is it interpreted in relation to IG 1.2 "FIPS Approved Mode of Operation" and IG 1.19 "Non-Approved Mode of Operation"?

Resolution

Definition of *non-approved security function*

FIPS 140-2 is concerned specifically with approved and non-approved security functions: the term *non-approved security function* must be defined relative to functions that claim security, rather than all functionality outside the set of *approved security functions*. The term *security* is not defined in the Glossary of Terms, but, within the scope of FIPS 140-2, is determined based on the Section 3 Functional Security Objectives, and the specific Section 4 Security Requirements derived from those objectives.

Security Function: A cryptographic algorithm, cryptographic key management technique, or authentication technique that supports a claim of security and meets the objectives stated in FIPS 140-2 Section 3.

FIPS 140-2 also uses the term *Cryptographic Algorithm*, defined next for consistency with FIPS 140-2 and for convenience in this IG.

Cryptographic Algorithm: An algorithm whose intended function is encryption/decryption, key establishment (inclusive of key generation), message authentication, message digest generation, digital signature generation/verification, or random number generation.

Annexes A, C and D provide the definitive current set of approved cryptographic algorithms. A cryptographic algorithm that is not listed in one of the FIPS 140-2 Annexes (A, C or D) is non-approved.

A *non-approved security function* is any function within the scope of the module that relies on a non-approved cryptographic algorithm to support a claim of security.

Notes

Primitive computational and logical operations (e.g. addition, subtraction, multiplication, division, AND, NOT, OR, and XOR) are used in cryptographic algorithms but are not themselves cryptographic algorithms.

A non-approved cryptographic algorithm or proprietary cryptographic algorithm is not a security function if processed data can be treated as plaintext without violating the Objectives stated in FIPS 140-2 Section 3, the applicable requirements in FIPS 140-2 Section 4, or the security rules specified in the module's Security Policy.

Relationship of non-approved cryptographic algorithms and the modes of operation

Non-approved security functions **shall not** be used in the approved mode of operation; however, non-approved cryptographic algorithms may be used in the approved mode of operation if the non-approved algorithms are not a security function. If a non-approved cryptographic algorithm is used by the module in the approved mode but is not a security function, the algorithm **shall** be included as a separate list of non-approved but allowed algorithms with no security claimed in the Security Policy. However, the module's certificate **shall not** include these algorithms as they do not claim any security and are not used to meet any requirement of FIPS 140-2.

A non-approved cryptographic algorithm **shall not** share the same keys or CSPs that are used by an approved or allowed algorithm for any cryptographic operation in either the approved, or non-approved mode, as this counters Section 3 Security Objectives by potentially releasing sensitive data and/or CSP(s). A non-approved cryptographic algorithm may still access or modify a CSP in the approved mode (under strict conditions laid out in this IG), as long as the CSP is not used as part of the non-approved cryptographic operation, such encryption/decryption, key establishment (inclusive of key generation), message authentication, message digest generation or digital signature generation/verification. The only exception to the rule explained in the first sentence of this paragraph, is the use of a non-approved cryptographic algorithm that utilizes an *approved DRBG* for any purpose such as key establishment, stand-alone random number generation, hashing, data obfuscation, etc. Despite access and modification of the state of the DRBG CSP(s) by a non-approved algorithm, this is allowed in both the approved and non-approved modes of operation. See the examples below for more information.

Possible example scenarios of non-approved cryptographic algorithms in various modes of operation

Example scenarios of non-approved cryptographic algorithms allowed in FIPS mode with no security claimed

1. Use of a non-approved cryptographic algorithm to "obfuscate" a CSP

   For purposes of storage or certificate formatting (e.g. PFX), a module might:

   - XOR a CSP with a secret value (note, the XOR itself is not a cryptographic algorithm but rather a part of a cryptographic algorithm that may include the establishment of the secret value for example)
   - Encrypt or decrypt a CSP using a proprietary or non-approved cryptographic algorithm.
   - Store authentication data using MD5 or using HMAC-SHA-1 with a weak HMAC key
   - Format certificate data using a non-approved PKCS #12

   As noted in Section 4.7, "Cryptographic keys and CSPs encrypted using a non-approved algorithm or proprietary algorithm or method are considered in plaintext form, within the scope of this standard."

   All Section 4 requirements must be satisfied when considering the CSP in plaintext form:

   - The report description of CSPs must correctly describe the form of the CSP.
   - The module must support zeroization of any CSPs stored internally in the forms described above.
   - If the obfuscated CSP is imported or exported, the module must meet the requirements for plaintext CSP import or export.

   This conclusion is consistent with IG 7.16 *Acceptable Algorithms for Protecting Stored Keys and CSPs*.

2. Use of an approved, non-approved or proprietary algorithm for a purpose that is not security relevant or is redundant to an approved cryptographic algorithm

a. Use of MD5 [1] in the TLS 1.0 / 1.1 KDF

SP 800-135 Rev1 Section 4.2.1 describes the use of MD5 in conjunction with SHA-1 in the key derivation function, concluding that the TLS 1.0/1.1 KDF may be used within the context of the TLS protocol (with provisions for validation of the companion approved functions, SHA-1 and HMAC).

This use of MD5 does not conflict with the security of the approved security functions.

b. Storage device use of a PRF (e.g. XTS AES) for memory wear leveling (a technique for prolonging the service life of some kinds of erasable computer storage media). For best results, a method with good statistical properties (i.e. a PRF) may be used for wear leveling, redundant to any other encryption or decryption performed by the module. This use of an algorithm is not for a security purpose; it is to prolong memory life.

c. A secure channel operated over an insecure communications channel

Consider a module whose purpose is to provide end-to-end secure communications over an insecure communications channel. That channel may be plaintext or some method which provides insufficient security, assumed to provide no greater security than plaintext.

Specifically, assume the module communicates over a normal, unprotected Ethernet, provides approved end to end encryption, decryption and message authentication, as well as initial authentication of the peer node, and meets all FIPS 140-2 Section 4 requirements. This module can be validated.

Consider the same scenario but with wireless communications over WEP, WPA, WPA2 or similar, where the purpose of the module is a ***remedy*** for insecure communications media. The module must communicate with a WAP using the communications protocols the WAP provides. If the channel is treated as plaintext, and the module provides secure channel services that meet all FIPS 140-2 Section 4 requirements, to deny validation to such a module because the communications media uses non-approved functions defeats the purpose of the module, and is contrary to the intent of the CMVP as a program.

d. Non-approved cryptographic algorithm that uses an approved DRBG for cryptographic purposes

The module uses a non-approved cryptographic algorithm to “obfuscate” a CSP for RAM storage. The key used for “obfuscation” is derived via an approved DRBG. By doing this, the DRBG changes its state, and therefore the DRBG CSPs are modified. Despite the modification and use of the DRBG CSPs within a cryptographic operation, this is allowed because the DRBG is the exception to the rule laid out in this IG.

3. Use of a non-approved cryptographic algorithm as part of an approved algorithm that claims security

a. Use of GHASH within AES GCM

Although GHASH, alone, is a non-approved hashing function, it is used within an approved AES GCM algorithm, and is therefore permitted, even if the vendor claims security on this algorithm. However, if the vendor claims security on this function, then it **shall not** be used in the approved mode for any independent operation outside of the approved algorithm.

Example scenarios of non-approved cryptographic algorithms <u>*not allowed in any mode*</u>

1. Non-approved cryptographic algorithm that share the same key or CSP as an approved algorithm

a. A DES algorithm is encrypting data using a DES key K1. This key is a part of a Triple-DES key K = (K1, K2, K3) which is a CSP, as it may be used by an approved Triple-DES algorithm. The value E = DES_{K1} (data) is sent outside the module’s boundary. An attacker

[1] May be allowed in an approved mode of operation when used as part of an approved key transport scheme (e.g. SSL v3.1) where no security is provided by the algorithm.

can easily break the single-DES encryption and recover K1, which will lead to the disclosure of the Triple-DES key K.

b. Suppose a module generates, in full compliance with **FIPS 186-4**, a key pair for an approved RSA signature algorithm. However, the module also has a non-approved RSA signature algorithm not claiming any security. This non-approved RSA signature algorithm could use the same RSA key to generate its "signatures". These non-approved signatures may be broken by an attacker and the signing key may be recovered, allowing the attacker to use this key to sign what *they* want.

   The reason the above two examples are prohibited is because they do not follow the above rule which states: "A non-approved cryptographic algorithm **shall not** share the same keys or CSPs that is used by an approved or allowed algorithm for any cryptographic operation in either the approved, or non-approved mode". Even if the vendor claims no security on these non-approved algorithms, they are still not allowed.

Additional Comments

1. The vendor must provide clear documentation and reasoning as to why the non-approved cryptographic algorithms can be used in an Approved Mode, i.e., not being used to meet the requirements of FIPS 140-2 sections 3 and 4. It is at the discretion of the CMVP to determine if such usage of an algorithm fits within the guidance laid out in this IG.

2. In addition, attempts to make use of this IG to include algorithms in the approved mode will not be accepted unless all of the following are met: 1) the algorithm is not used whatsoever to meet any FIPS 140-2 requirements; 2) the algorithm does not access or share CSPs in a way that counters the requirements of this IG; 3) the algorithm is either: i) not intended to be used as a security function (e.g. interoperability or for memory wear leveling); ii) redundant to an approved algorithm (e.g. double encryption); iii) a cryptographic or mathematical operation applied for "good measure" but not for providing sound security (e.g. XORing a CSP with a secret value, using a proprietary algorithm, or using non-approved algorithms to obfuscate stored CSPs which are considered plaintext); 4) the algorithm's non-approved use and purpose (from 3) above) is unambiguous to the operator and can't be easily confused for a security function.

   A key point to consider for 4) above is the *purpose* or *use* of the service that utilizes the non-approved algorithms. For example, if the purpose is solely to provide cryptographic functionality to a calling application, then the service is easily confused for a security function (e.g., a software library that provides non-approved key agreement, key transport, or general encryption/decryption services) and the algorithm(s) within this service *cannot* claim no security per this IG. But if it is clear that the purpose of a service does not include providing any security functionality recognized in FIPS 140-2 then the service can use non-approved algorithms in the approved mode if provisions of this IG are met. Examples of such services are status output (possibly, using the non-security provisions of the SNMP protocol) and obfuscating CSPs for internal storage that is considered plaintext.

Section 2 – Cryptographic Module Ports and Interfaces

2.1 Trusted Path

Applicable Levels:	*Levels 3 and 4*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*02/05/2019*
Relevant Assertions:	*AS.02.16, AS.02.17, AS.02.18 and AS.07.33*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 specifies the use of a Trusted Path as a means to protect plaintext CSPs during their input or output from a cryptographic module.

The following requirements of FIPS 140-2 may apply:

- **AS.02.16: (Levels 3 and 4) The physical port(s) used for the input and output of plaintext cryptographic key components, authentication data, and CSPs shall be physically separated from all other ports of the cryptographic module or AS.02.17 must be satisfied.**

- **AS.02.17: (Levels 3 and 4) The logical interfaces used for the input and output of plaintext cryptographic key components, authentication data, and CSPs shall be logically separated from all other interfaces using a *trusted path* or AS.02.16 must be satisfied.**

- **AS.02.18**: **(Levels 3 and 4) Plaintext cryptographic key components, authentication data, and other CSPs shall be directly entered into the cryptographic module (e.g., via a *trusted path* or directly attached cable).**

- **AS.07.33: (Levels 3 and 4) If split knowledge procedures are used, plaintext cryptographic key components shall be directly entered into or output from the cryptographic module (e.g., via a *trusted path* or directly attached cable) without traveling through any enclosing or intervening systems where the key components may inadvertently be stored, combined, or otherwise processed (see Section 4.2).**

FIPS 140-2 defines the Trusted Path only in the Glossary section. The definition appears to be very general and hard to interpret in practical cases. Furthermore, it is not obvious whether using the Trusted Path to meet the applicable requirements of Sections 4.2 and 4.7 of FIPS 140-2 applies to all CSPs, only to keys, or only to those CSPs that are not the cryptographic keys.

Question/Problem

What is the scope of Sections 4.2 and 4.7 of FIPS 140-2 when addressing the input and output of plaintext cryptographic keys and other CSPs?

What is the definition of the "Trusted Path" for the purposes of the FIPS 140-2 compliance and what are the applicable documentation requirements?

Resolution

Sections 4.7, or, specifically, Section 4.7.4 of FIPS 140-2 contains the requirements relative to the input and output of the plaintext cryptographic keys. The requirements of this section do not apply to other CSPs. The entry and output requirements of Section 4.2 apply to all CSPs.

Therefore, the input and output of keys must satisfy the applicable rules stated in both Section 4.2 and Section 4.7.4, while the input and output of the CSPs, such as passwords, the key components and the secret IVs are only subject to the requirements of Section 4.2. An intermediate computational parameter, such as a shared secret in a key agreement scheme, is considered a key for the purposes of this Implementation Guidance if an actual key can be derived from this intermediate value without the knowledge of any other CSPs. Otherwise, this parameter is considered a non-key CSP.

The input and output requirements at Security Levels 1 and 2 are quite straightforward in both Section 4.2 and Section 4.7.4 and will not be further discussed in this Guidance. The requirements of Section 4.2 at Security Levels 3 and 4 are more complicated and involve the use of a Trusted Path.

A notion of the Trusted Path needs to be defined when the source or destination of the path is not under the direct control of the cryptographic module. A Wikipedia article: https://en.wikipedia.org/wiki/Trusted_path defines the Trusted Path as "a mechanism that provides confidence that the user is communicating with what the user intended to communicate with, ensuring that attackers can't intercept or modify whatever information is being communicated." The article also makes a reference to the Common Criteria standards which define the trusted path in a similar generic way.

For the purposes of the FIPS 140-2 compliance, the mechanism mentioned in the above definition of a Trusted Path is a strong physical or cryptographic protection. Here "strong" means that

- if this is a physical protection then the operator stays in control over the physical path and is able to prevent any unauthorized tampering,
- if this is a cryptographic/logical protection, then the CSPs that are sent in plaintext over the Trusted Path are protected using the approved or allowed cryptographic techniques employed by the Trusted Path. These techniques include a symmetric-key-based encryption using any AES or Triple-DES mode approved for data encryption, or an RSA key wrapping, and the strength of these techniques is sufficient to meet the user's security objectives. If a symmetric encryption is used to protect the CSPs that are keys, then the encryption scheme **shall** be compliant with the requirements of **SP 800-38F**.

If the Trusted Path relies on the physical protection of the CSPs, the Security Policy **shall** specify the following:

- the physical characteristics of the Trusted Path, with an explanation of how the Trusted Path will protect the plaintext CSPs,
- the controls that are used to maintain the Trusted Path, including the list of any physical tools (wires, cables, etc.) needed to establish the Trusted Path,
- operator instructions for setup and operation of the Trusted Path,
- the specific characteristics and specification of the source or target of the Trusted Path relative to the cryptographic module.

If the Trusted Path uses the cryptographic protection of the CSPs, the Security Policy **shall** specify the following:

- the algorithms used to provide the cryptographic protection,
- the strength of the cryptographic protection of the CSPs,
- operator instructions for setup and operation of the Trusted Path,
- the User Guidance for identifying the source or target of the Trusted Path relative to the cryptographic module.

Please refer to IG G.13 Module Information bullet number 4 for specific guidance on how to document a Trusted Path on the certificate.

Additional Comments

1. Two other IGs apply to the input and output of cryptographic keys, in addition to this one. IG 7.7 provides various scenarios that apply to both physical and cryptographic protection of keys when they are either entered into or output out of the module's boundary, with several examples of physical devices that can be used in key entry. IG D.9 states which algorithms and key sizes are approved or allowed when the input and output of keys is protected by the cryptographic methods. The requirements stated in IGs 7.7 and D.9 do not apply to the protection of the CSPs that are not keys. It is, however, strongly recommended that if a module performs a symmetric-key-based encryption (AES or Triple-DES) to protect the input or output of non-key CSPs, then an authentication encryption method is used, similar to the SP 800-38F requirements for the cryptographic key wrapping.
2. The AS.07.33 Derived Test Requirement, shown above, addresses the input and output of plaintext cryptographic key *components*. As these components are not keys, the remaining (not covered by AS.07.33) key entry and output requirements of Section 4.7.4 of FIPS 140-2 do not apply to them. The protection of these components relies on the Trusted Path which is defined in this Guidance.
3. It is possible for a module to get validated at different security levels in Sections 4.2 and 4.7 of FIPS 140-2, as these sections are addressing the different sets of requirements. For example, a module can meet the Security Level 3 requirements of Section 4.2 by inputting the plaintext cryptographic keys using the Trusted Path provided by a directly attached cable. However, this module will only be validated at Security Levels 1 or 2 in Section 4.7, as the imported keys are neither encrypted nor entered in plaintext using the split knowledge procedures. This example is consistent with the fact that the requirements of Section 4.7 are stricter than those of Section 4.2, hence, potentially, the lower validation level in Section 4.7.

Section 3 – Roles, Services, and Authentication

3.1 Authorized Roles

Applicable Levels:	*2, 3, and 4*
Original Publishing Date:	*05/29/2002*
Effective Date:	*05/29/2002*
Last Modified Date:	*03/17/2023*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

From FIPS 140-2 Section 4.3:

An operator is not required to assume an authorized role to perform services where cryptographic keys and CSPs are not modified, disclosed, or substituted (e.g., show status, self-tests, or other services that do not affect the security of the module).

From FIPS 140-2 Section 4.3.3:

Authentication mechanisms may be required within a cryptographic module to authenticate an operator accessing the module, and to verify that the operator is authorized to assume the requested role and perform the services within the role.

Question/Problem

What are the services that do not require an operator, in the approved mode, to assume an authorized role and, therefore, not be authenticated, as required if Security Level 2, 3, or 4 is claimed for Section 4.3?

Resolution

If a Security Level 2 or above is claimed for Section 4.3, an operator in the approved mode **shall** be authenticated when assuming a role for all services utilizing approved security functions, with the following exceptions:

(a) The hash algorithms that are specified in FIPS 180-4 and FIPS 202;

(b) The deterministic random number generators and entropy sources that are specified in SP 800-90A rev1 and SP 800-90B.

(c) Digital signature verification, as specified in "Digital Signature Standard", FIPS 186-2 and FIPS 186-4.

(d) Authentication procedures used for authenticating the operator and/or initialization procedures to setup the operator's authentication credentials; and

(e) Show status and self-tests.

Exceptions for other services that do not affect the security of the module may be claimed; however, in this case a justification, subject to CMVP approval, **shall** demonstrate the rationale in Additional Comment 1 below is met. It is recommended that requests for exception should be submitted to the CMVP via the existing Request for Guidance process detailed in G.1 Request for Guidance from the CMVP and CAVP. Approval obtained prior to report submission can be referenced therein.

Additional Comments

1. The rationale for the stated exceptions is either:

   a. that the referenced algorithms and services do not create, disclose, modify, substitute, access or make use of the module's CSPs; or

   b. that the referenced algorithms and services do not affect the security of the module or the security of the information being protected by the module.

2. FIPS 140-2 Section 4.3 talks about "authorized" roles. For the purposes of this IG, an authorized role is any defined role. Some of these defined roles may require an operator to get authenticated before the operator is authorized to assume the role.

3. Performing any service requires an assumption of a role. This IG clarifies under what conditions some of the roles may remain unauthenticated. When the FIPS 140-2 standard states (see the **Background** section above) that an operator is not required to assume an authorized role to perform certain services, this means that while the module may be validated at Security Level 2 or above in Section 4.3, a defined role may not require an authentication of an operator for the role to perform these services.

4. Please note the following rationale for the inclusion of the DRBG in the resolution exceptions above: An approved DRBG may be called from an unauthenticated role, or even from a role that includes the non-approved services. Each execution of a DRBG may result in a modification of the DRBG's secret state parameters, which are the module's CSPs (see IG 14.5). This indirect modification of the CSPs is permissible because it does not result in the weakening of the CSPs or in a loss of their secrecy.

5. The zeroization of all of the module's unprotected keys and CSPs performed as required in Section 4.7.6 of FIPS 140-2 is not viewed as a "modification" of these parameters. Therefore, the corresponding zeroization service may be called from an unauthenticated role.

6. For services that can update module code and only use cryptographic algorithms falling under an exception above (in c.), the operator is still required to be authenticated (at Security Level 2+). Loading and running new or additional code into the module, even if the code succeeds the required load test, has security implications. Services providing such capability are not granted an exception under this IG.

7. A module may establish a secure connection (e.g., TLS utilizing approved security functions) for protecting data exchanges with the operator before this operator is authenticated to an authorized role. This way, when authentication data is sent to the module, it benefits from the secure connection protection. Establishing a secure connection for the purpose of protecting authentication data and other data in-transit can be considered "authentication procedures used for authenticating the operator". As described in exception d. above, no operator authentication is required prior to executing such procedures. When a module establishes a secure connection without having authenticated the operator and claims Security Level 2, 3, or 4 for Section 4.3 (as allowed by this IG, exception d.), the module **shall** authenticate the operator with authentication data received under this same secure connection prior to executing any service that requires authentication.

3.2 Bypass Capability in Routers

Applicable Levels:	*ALL*
Original Publishing Date:	*04/01/2009*
Effective Date:	*04/01/2009*
Last Modified Date:	*04/01/2009*
Relevant Assertions:	*AS.03.12 and AS.03.13*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

A router is a particular type of cryptographic module where bypass is typically applicable but has some unique attributes. Typically, a router has an internal IP address table that contains entries for known addresses as well as instructions specifying routing destinations and whether the packets are to be encrypted or passed in plaintext. In addition, if an unknown IP address is found, a router may "drop" the incoming packet or pass it to a predetermined address unchanged (e.g. default gateway).

Question/Problem

Is the cryptographic module subject to the bypass requirements of FIPS 140-2 if packets with an unknown IP address are either dropped or re-directed to a predetermined address (e.g. default gateway)?

Resolution:

The bypass requirements of FIPS 140-2 are not applicable if packets with an unknown IP address are dropped unprocessed.

Packets with an unknown IP address that are re-directed to a predetermined address (e.g. default gateway) are bypassing the module's encryption and the bypass requirements of FIPS 140-2 are applicable.

This IG is also applicable to cryptographic modules that are offering an exclusive bypass capability or no bypass capability at all.

3.3 Authentication Mechanisms for Software Modules

Applicable Levels:	*Levels 2, 3, or 4*
Original Publishing Date:	*05/02/2012*
Effective Date:	
Last Modified Date:	*05/02/2012*
Relevant Assertions:	*AS03.31 and AS03.32*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

A cryptographic module may implement authentication mechanisms to authenticate an operator accessing the module and to verify that the operator is authorized to assume the requested role and perform services within that role. Depending on the security level, a cryptographic module may support role-based or identity-based authentication.

Question/Problem

Can a software module (IG 1.16) rely on the authentication mechanisms employed in the operating environment rather than implemented explicitly by the software module within the software modules logical boundary?

Resolution

If a software cryptographic module supports either role-based or identity-based authentication, the authentication mechanisms **shall** be implemented within the logical boundary of the module with the following *exception*:

- If FIPS 140-2 Section 4.6 *Operating Environment* is validated at Level 2, 3, or 4, the authentication mechanisms employed in the operating environment may be used to meet the FIPS 140-2 Section 4.3 authentication requirements. If role-based authentication is claimed in FIPS 140-2 Section 4.3, then the operating environment **shall** satisfy either the role-based or identity-based requirements in FIPS 140-2 Section 4.3. If identity-based authentication is claimed in FIPS 140-2 Section 4.3, then the operating environment **shall** satisfy identity-based requirements in FIPS 140-2 Section 4.3.

    - If the operating environment requires special configuration settings to satisfy the selected authentication method in FIPS 140-2 Section 4.3, the configuration settings **shall** be defined in the Security Policy, and the Security Policy **shall** indicate that the Crypto Officer Role is responsible for ensuring the configuration settings are properly set for the module to operate in an approved mode of operation.

3.4 Multi-Operator Authentication

Applicable Levels:	*Levels 2, 3 and 4*
Original Publishing Date:	*05/02/2012*
Effective Date:	
Last Modified Date:	*05/10/2017*
Relevant Assertions:	*AS03.16, AS03.17, AS03.18, AS03.19 and AS03.20*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

AS03.16: (Levels 2, 3, and 4) Depending on the security level, the cryptographic module shall perform at least one of the following mechanisms to control access to the module: *role-based authentication* or *identity-based authentication*.

AS03.17: (Level 2) If role-based authentication mechanisms are supported by the cryptographic module, the module shall require that one or more roles either be implicitly or explicitly selected by the operator and shall authenticate the assumption of the selected role (or set of roles).

AS03.19: (Level 3 and 4) If identity-based authentication mechanisms are supported by the cryptographic module, the module shall require that the operator be individually identified, shall require that one or more roles either be implicitly or explicitly selected by the operator, and shall authenticate the identity of the operator and the authorization of the operator to assume the selected role (or set of roles).

Question/Problem

A module may implement separately defined operator roles which have different authentication claims. For example, the Crypto Officer (CO) role implements *identity-based authentication* while the User role implements *role-based authentication* (Case 1). In another example, the CO role implements *role-based authentication* while the User role does not implement any *authentication* (Case 2). There is also a possibility of the CO and User roles each supporting role-based as well as the identity-based authentication (Case 3): some of the operators who are assuming a given role are authenticated using the role-based credentials, while others, who will also assume this role, pass an identity-based authentication. Are these implementations compliant with the requirements of Section 4.3 of FIPS 140-2, and, if so, at what security level?

For the above scenarios, it is assumed that approved security services are included in each assumed role. Should there be an exception to the operator authentication requirement when the approved security functions do not affect the security of the module?

Resolution:

Following are the resolutions for the three scenarios from the Question/Problem section above.

1. The first case (Case 1) is compliant to FIPS 140-2 Section 4.3 because for the purposes of the FIPS 140-2 validation, *identity-based authentication* is considered to be meeting the *role-based authentication* requirement. Both the CO and the User operators get authenticated to access the approved security services. The section security level is 2 because it is the lower of the two authentication methods described.

   The security policy **shall** identify all roles, and for each role, the authentication method (i.e. either *role-based* or *identity-based*).

2. In the second case (Case 2) the module is compliant to FIPS 140-2 Section 4.3 level 2 only if the unauthenticated User role does not call any services that affect the module's security. See IG 3.1 for the

definition of such services. Otherwise, FIPS 140-2 Section 4.3 is annotated at level 1 and only the level 1 assertions are addressed.

3. The Case 3 scenario is also compliant with FIPS 140-2. The vendor can claim compliance with Section 4.3 only at security level 2. The test report addresses each role at security level 2. The security policy **shall** explain how the authentication may be performed for each role.

Additional Comments

1. IG 3.1 addresses authenticated roles for approved security services and non-authenticated services.
2. In Case 3, the module can only be validated at level 2 in Section 4.3 because the role-based authentication is also available to the module.
3. Other mixed cases are also possible. There is sufficient information in this Implementation Guidance to determine how to treat each of these cases and what will be the overall security level of the module's validation in Section 4.3. For example, the User role can have both a role-based and an identity-based authentication, while the Crypto Officer role always requires an identity-based authentication. As shown above, such module is validated at security level 2 in Section 4.3, unless the User role only calls the services that are exceptions identified in IG 3.1 as not affecting the module's security. If the latter case, the module's Section 4.3 may be validated at security level 3.
4. When the module supports both the role-based and the identity-based authentication, either within the same role (as in Case 3 above) or by the different roles (as in Case 1), the testing laboratory, when writing the Test Report, **shall** select the "Identity Auth." option in the Module Information form. This will require the testing laboratory to address in the Test Report both the level 2 (role-based) and the level 3 (identity-based) assertions.

3.5 Documentation Requirements for Cryptographic Module Services

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*11/15/2016*
Relevant Assertions:	*AS.03.14, AS.14.07*
Relevant Test Requirements:	*TE.03.14.01, TE.14.07.01*
Relevant Vendor Requirements:	

Background

From FIPS 140-2 Section 4.3.2 and Appendix C:

AS03.07: (Levels 1, 2, 3, and 4) Services shall refer to all of the services, operations, or functions that can be performed by the cryptographic module.

AS03.08: (Levels 1, 2, 3, and 4) Service inputs shall consist of all data or control inputs to the cryptographic module that initiate or obtain specific services, operations, or functions.

AS03.09: (Levels 1, 2, 3, and 4) Service outputs shall consist of all data and status outputs that result from services, operations, or functions initiated or obtained by service inputs.

AS03.10: (Levels 1, 2, 3, and 4) Each service input shall result in a service output.

AS03.14: (Levels 1, 2, 3, and 4) Documentation shall specify:

- **the services, operations, or functions provided by the cryptographic module, both Approved and non-Approved, and**
- **for each service provided by the module, the service inputs, corresponding service outputs, and the authorized role(s) in which the service can be performed.**

AS14.07: (Levels 1, 2, 3, and 4) The security policy shall specify: all services provided by the cryptographic module.

Question/Problem

FIPS 140-2 Section 4.3.2 Roles, Services, and Authentication lays out requirements for service inputs, service outputs, correlation between inputs and outputs, and access control on the services by authorized roles as stated in the Background section above. Nevertheless, it does not specify what operations or functions that can be performed by the cryptographic module are considered as services. The statement that services **shall** refer to all of the services does not answer the question what is considered as a service and must be documented in a security policy.

FIPS 140-2 Section 2.1 Glossary of Terms does not provide a definition of service. However, the standard does give a few examples to illustrate the intended use of the term Service. *Encryption, authentication, digital signature* and *key management* are mentioned as examples of cryptographic services on page iv. *Origin authentication, data integrity* and *signer non-repudiation* are listed as the services provided by a digital signature. *Show status* and *self-tests* are mentioned in Section 4.3 as examples of services that do not affect the security of the module.

What is the definition of service in the context of FIPS 140-2? What is the expected level of granularity to specify a service in order to meet the referenced requirements? Do all services need to be documented in the security policy, including the services that are not security-relevant or not specified in FIPS 140-2 Section 4.3.2?

Resolution

Services of a cryptographic module are the top-level operations and/or functions that represent the module's main functionality provided through its external interface. The services that are commonly provided by a cryptographic module are among Encryption, Digital Signature operations, Key Derivation Functions, Key Establishment Schemes, Message Authentication, Random Number generation, Secure Hashing, User Authentication, Self-tests, key Zeroization, Show Status, Protocol Handshake, Signature Operations, etc.

FIPS 140-2 states unambiguously that *all* services need to be documented in the module's Security Policy. This applies to the following groups:

1. services that use approved (i.e. including allowed) security functions and mechanisms that are available for use in an approved mode of operation,
2. services that do not use any security functions (i.e. approved or non-approved), but are described in FIPS 140-2 Section 4.3.2 (e.g. Show Status service),
3. services that use non-approved security functions or mechanisms and therefore not available for use in an approved mode of operation,
4. services that may perform actions that are not addressed in the above bullets. An example of such service would be "image manipulation."

The security policy **shall** list each service individually that belongs to groups 1 to 3, as per **AS14.07**. When reporting cryptographic services in group 1, IG 14.1 provides the guidance for level of detail.

For services that belong to group 4, the security policy **shall** either list them individually in the same manner as all other services, or provide a reference to separate external document where these services are documented.

A reference **shall** include the document name, version number, release date and how the document can be publicly acquired (e.g. a provided URL).

The description of each service **shall** address the requirements in FIPS 140-2 Appendix C.3.2.

All module security functions listed in **AS01.12** **shall** map to at least one defined security service.

Additional Comments

A service is any externally operator invoked operation and/or function that can be performed by a cryptographic module. A service **shall** correspond to a specific task or callable function to be performed by the module.

Services provided by a software module are not required to have one-to-one correspondence to the API functions implemented by the module. A service (e.g. Random Number Generation) may invoke a group of API functions. On the other hand, an API function may provide different services (e.g. symmetric encryption vs. asymmetric encryption) depending on the different values of some or all of its input parameters. A vendor may choose to document services in terms of API functions if appropriate. Nevertheless, API functions are not required to be the only way to specify services.

Section 4 - Finite State Model

Section 5 - Physical Security

5.1 Opacity and Probing of Cryptographic Modules with Fans, Ventilation Holes or Slits at Level 2

Applicable Levels:	*Level 2*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*02/10/2004*
Relevant Assertions:	*AS.05.49*
Relevant Test Requirements:	*TE05.49.01*
Relevant Vendor Requirements:	*VE.05.49.01*

Background

Cryptographic modules typically require the use of heat dissipation techniques that can include the use of fans, ventilation holes or slits. The size of these openings in the modules' enclosure, or the spacing between fan blades, may allow the viewing or possible probing of internal components and structures within the cryptographic module.

Question/Problem

How do the opacity requirements of FIPS 140-2 affect the design of the heat dissipation techniques on those cryptographic modules at Security Level 2? Should the cryptographic module prevent probing through the ventilation holes or slits at Security Level 2?

Resolution

The following are the physical security requirements for multi-chip stand-alone module at Security Level 2 pertaining to opacity and probing:

- the embodiments that are entirely contained within a metal or hard plastic production-grade enclosure that may include doors or removable covers (Security Level 1 requirement); and
- the enclosure of the cryptographic module **shall** be opaque within the visible spectrum.

Probing Requirements

Probing is not addressed at Security Level 2. Probing through ventilation holes or slits is addressed at Security Level 3 (**AS.05.21**).

Opacity Requirements

The purpose of the opacity requirement is to deter direct observation of the cryptographic module's internal components and design information to prevent a determination of the composition or implementation of the module.

A module is considered "opaque" only if it cannot be determined by visual inspection within the visible spectrum using artificial light sources shining through the enclosure openings or translucent surfaces, the manufacturer and/or model numbers of internal components (such as specific IC types) and/or design and composition information (such as wire traces and interconnections).

Component outlines may be visible from the enclosure openings or translucent surfaces as long as the component's manufacturer and/or model numbers, and/or composition and information about the module's design cannot be determined.

All components within the boundary of the cryptographic module must meet the opacity requirements of the standard. Excluded non-security relevant components do not have to meet these requirements.

Additional Comments

Note: Visible light is defined as light within a wavelength range of 400nm to 750nm.

5.2 Testing Tamper Evident Seals

Applicable Levels:	*Levels 2, 3 and 4*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*09/12/2005*
Relevant Assertions:	*AS.05.16, AS.05.35, AS.05.36, AS.05.37, AS.05.48, AS.05.50*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What level of testing and scope of testing should be applied when testing tamper evident seals?

Resolution

If a module uses tamper evident labels, it **shall** not be possible to remove or reapply a label without tamper evidence. For example, if the label can be removed without tamper evidence, and the same label can be re-applied without tamper evidence, the assertion fails.

Conversely, if any attempt to remove the label leaves evidence, or removal and re-application leaves evidence, or the label is destroyed during removal, the assertion passes. This means that the CST laboratory **shall** have to use creative ways (e.g. chemically, mechanically, thermally) to remove a label without evidence and without destroying the original label, and be able to re-apply the removed label in a manner that does not leave evidence.

Additional Comments

It is out-of-scope for an attacker to introduce new materials to cover up evidence of the attack.

5.3 Physical Security Assumptions

Applicable Levels:	*ALL*
Original Publishing Date:	*03/10/2009*
Effective Date:	*03/10/2009*
Last Modified Date:	*03/10/2009*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Extracted from FIPS 140-2 Section 1 – OVERVIEW:

FIPS 140-1 was developed by a government and industry working group composed of both operators and vendors. The working group identified requirements for four security levels for cryptographic modules to provide for a wide spectrum of data sensitivity (e.g., low value administrative data, million dollar funds *transfers, and life protecting data) and a diversity of application environments (e.g., a guarded facility, an office, and a completely unprotected location). Four security levels are specified for each of 11 requirement areas. Each security level offers an increase in security over the preceding level. These four increasing levels of security allow cost-effective solutions that are appropriate for different degrees of data sensitivity and different application environments. FIPS 140-2 incorporates changes in applicable standards and technology since the development of FIPS 140-1 as well as changes that are based on comments received from the vendor, laboratory, and user communities.*

The use of a validated cryptographic module in a computer or telecommunications system is not sufficient to ensure the security of the overall system. The overall security level of a cryptographic module must be chosen to provide a level of security appropriate for the security requirements of the application and environment in which the module is to be utilized and for the security services that the module is to provide. The responsible authority in each organization should ensure that their computer and telecommunication systems that utilize cryptographic modules provide an acceptable level of security for the given application and environment.

The importance of security awareness and of making information security a management priority should be communicated to all users. Since information security requirements vary for different applications, organizations should identify their information resources and determine the sensitivity to and the potential impact of losses. Controls should be based on the potential risks and should be selected from available controls, including administrative policies and procedures, physical and environmental controls, information and data controls, software development and acquisition controls, and backup and contingency planning.

FIPS 140-2 does not specify the required strength of the approved security functions that may be implemented within a cryptographic module at each security level. Allowable strengths are addressed in IG 7.5. Therefore, a Level 1 module may implement the same security strength of an encryption function as a Level 4 module.

The four physical security levels of FIPS 140-2 are focused on the protection of the modules CSPs by the module itself independent of the environment the module is deployed. Therefore, selection of a security level is greatly influenced by the environment the module is to be deployed. At a Level 1 security level, which does not itself provide physical security protection, in the right environment, may be an acceptable solution because the environment provides the required physical security protection features.

A software cryptographic module is not subject to the physical security requirements of this standard. The following resolution assumes the host platform is not subject to the physical security requirements of FIPS 140-2.

Question/Problem

What are the assumptions that have defined the protection, attack types and operator roles in the FIPS 140-2 physical security requirements for which a cryptographic module itself provides at each security level?

Resolution:

Level 1

Protection Provided:
No physical protection of CSPs; access assumed

Hardware: probing and observation of components assumed.
Software: access to operating environment, applications and data assumed.

User Assumptions:

Correct operation of the *approved* cryptographic services and security functions.
All attacks result in access to CSPs and data (plaintext and ciphertext) held within the module.
Operator is responsible for the physical protection of the module.

*Value or sensitivity of data protected by the module is assumed negligible in an unprotected environment.

Attack Type:

Passive attack to gain immediate access to CSPs and data held by the module.

Attack Characterization/Testing Assumptions:

No prior access to the module is assumed.
No tools and materials are assumed needed.

Value:

The module provides correct operation of security functions and services. Protection of the plaintext CSPs and data held within the module is provided by the operator of the module (e.g. the environment the module may be used). If the module is used in an unprotected environment, then the module should not hold or maintain unprotected plaintext CSPs or data.

Level 2

Protection Provided:

Observable evidence of tampering.
Physical boundary of the module is opaque to prevent direct observation of internal security components.
Hardware: probing is assumed.
Software: logical access protection of the cryptographic modules unprotected CSPs and data is provided by the evaluated operating system at EAL2.

User Assumptions:

Correct operation of the *approved* cryptographic services and security functions.
All attacks result in access to CSPs and data (plaintext and ciphertext) held within the module.
Operator is responsible for the physical protection of the module.

*Value or sensitivity of data protected by the module is assumed low in an unprotected environment.

Attack Type:

Active attack to gain immediate access to CSPs and data held by the module.

Attack Characterization/Testing Assumptions:

No prior access to the module is assumed.
Readily available low cost tools and materials which are on hand at time of attack.
Attack time is assumed to be low.

Value:

The module provides correct operation of security functions and services. Protection of the plaintext CSPs and data held within the module is provided by the operator of the module (e.g. the environment the module may be used). The operator of the module is aware by tamper evidence that internal information may be compromised. If the module is used in an unprotected environment, then the module should not hold or maintain unprotected plain-text CSPs or data which have a moderate or high value.

Level 3

Protection Provided:

Observable evidence of tampering.
Physical boundary of the module is opaque to prevent direct observation of internal security components.
Direct entry/probing attacks prevented.
Strong tamper resistant enclosure or encapsulation material.
If applicable, active zeroization if covers or doors opened.
Software: logical access protection of the cryptographic modules unprotected CSPs and data is provided by the evaluated operating system at EAL3.

User Assumptions:

Correct operation of the *approved* cryptographic services and security functions.
Non-direct attacks result in access to CSPs and data (plaintext and ciphertext) held within the module.

*Value of data protected by the module is assumed moderate in an unprotected environment.

Attack Type:

Moderately aggressive attack to gain immediate access to CSPs and data held by the module.

Attack Characterization/Testing Assumptions:

Prior access to or basic knowledge of the module is assumed.
Readily available tools and materials.
Actual attack time is assumed to be moderate (this does not include time spend gaining prior access or basic knowledge of module).

Value:

The module provides correct operation of security functions and services. Protection of the plaintext CSPs and data held within the module is provided by the operator of the module (e.g. the environment the module may be used) and by the physical protection mechanisms of the module (e.g. strong enclosure, tamper response for covers and doors, deterrent of probing). The operator of the module is aware by tamper evidence that internal information may be compromised. An attack is pre-meditated but will be of moderate difficulty. If the module is used in an unprotected environment, then the module should not hold or maintain unprotected plain-text CSPs or data which have a high value.

Level 4

Protection Provided:

Observable evidence of tampering.
Physical boundary of the module is opaque to prevent direct observation of internal security components.
Direct entry/probing attacks prevented.
Strong tamper resistant enclosure or encapsulation material.
If applicable, active zeroization if covers or doors opened.
A complete envelope of protection around the module preventing unauthorized attempts at physical access.

Penetration of the module's enclosure from any direction had a very high probability of being detected resulting in immediate zeroization of plaintext CSPs or severe damage to the module rendering it inoperable.
Non-direct attacks prevented.
Software: logical access protection of the cryptographic modules unprotected CSPs and data is provided by the evaluated operating system at EAL4.

User Assumptions:

Correct operation of the *approved* cryptographic services and security functions.
Module is tamper resistant against all physical attacks defined in the standard.

*Value of data protected by the module is assumed high in an unprotected environment.

Attack Type:

Aggressive attack to gain immediate access to CSPs and data held by the module.

Attack Characterization/Testing Assumptions:

Prior access to or advanced knowledge of the module is assumed.
Specialized tools and materials.
Temperature and voltage attacks.
No time restriction on attack.

Value:

The module provides correct operation of security functions and services. Protection of the plaintext CSPs and data held within the module is provided by the operator of the module (e.g. the environment the module may be used) and by the physical protection mechanisms of the module (e.g. strong enclosure, tamper response for covers and doors, complete envelope of protection and penetration detection resulting in immediate zeroization of plaintext CSPs, voltage and temperature assurance). The operator of the module is aware by tamper evidence that the module was attacked. The module **shall** zeroize all unprotected CSPs before an attacker can compromise the module. An attack is pre-meditated, well-funded, organized and determined.

Additional Comments

*Discussion of the value of the data protected by the module does not consider physical protection provided by the operator to supplement the minimum physical security requirements of each level in FIPS 140-2. As an example, a user of Level 1 module may add "guards, guns, vaults and gates" surrounding the module and therefore may be comfortable in protecting more valuable information.

Attack times of low and moderate are subjective and depend on the experience and skill of an attacker and techniques employed. FIPS 140-2 Derived Test Requirements and FIPS 140-1 and FIPS 140-2 Implementation Guidance provide further guidance for the tester for each security level.

5.4 Level 3: Hard Coating Test Methods

Applicable Levels:	*Level 3*
Original Publishing Date:	*01/27/2010*
Effective Date:	
Last Modified Date:	*06/15/2010*
Relevant Assertions:	*AS.05.28, AS.05.39 and AS.05.52*
Relevant Test Requirements:	*TE05.28.02, TE05.39.06 and TE05.52.02*
Relevant Vendor Requirements:	

Background

AS.05.28: (Single-Chip - Levels 3 and 4) Either the cryptographic module shall be covered with a hard opaque tamper-evident coating (e.g., a hard opaque epoxy covering the passivation).

TE05.28.02: The tester shall verify that the coating cannot be easily penetrated to the depth of the underlying circuitry, and that it leaves tamper evidence. The inspection must verify that the coating completely covers the module, is visibly opaque, and deters direct observation, probing, or manipulation.

AS.05.39: (Multiple-Chip Embedded - Levels 3 and 4) the multiple-chip embodiment of the circuitry within the cryptographic module shall be covered with a hard coating or potting material (e.g., a hard epoxy material) that is opaque within the visible spectrum.

TE05.39.06: (Option 1 - Utilize a hard opaque material) The tester shall verify by inspection and from vendor documentation that the module is covered with a hard opaque material. The documentation shall specify the material that is used. The tester shall verify that it cannot be easily penetrated to the depth of the underlying circuitry. The tester shall verify that the material completely covers the module and is visibly opaque within the visible spectrum.

AS.05.52: (Multiple-Chip Standalone – Levels 3 and 4) the multiple-chip embodiment of the circuitry within the cryptographic module shall be covered with a hard potting material (e.g., a hard epoxy material) that is opaque within the visible spectrum.

TE05.52.02: (Option 1 – Covered with a hard opaque potting material) Encapsulate within a hard, opaque potting material. The tester shall verify from vendor documentation and by inspection, if internal access is possible, that the circuitry within the module is covered with a hard opaque potting material. The documentation shall specify which potting material is used and its hardness characteristics.

Question/Problem

What kind of testing is expected to be performed at Level 3 to verify that the hard coating or potting material that encapsulates the circuitry is *hard*?

Resolution

Within the scope of FIPS 140-2, the term *hard* is defined as:

Hard / hardness: the relative resistance of a metal or other material to denting, scratching, or bending; physically toughened; rugged, and durable. The relative resistances of the material to be penetrated by another object.

Test methods **shall** be consistent with IG 5.3 that addresses a *moderately aggressive attack* at Level 3.

The test methods **shall** at a minimum address the hardness characteristics of the epoxy or potting material as follows:

1. Attempts to penetrate the material by an instrument (e.g. awl, pointed handheld tool, etc.) using a *moderately aggressive* amount of force to the depth of the underlying circuitry. The use of a drilling or grinding motion is out-of-scope.

2. The use of an instrument with a *moderately aggressive* amount of force to pry or break the material away from the underlying circuitry (e.g. insert a pry instrument at the boundary of the epoxy or potting material and another material/component (e.g. PCB board)).

3. The use of a *moderately aggressive* amount of flexing or bending force to crack or break the material away from or expose the underlying circuitry.

During testing the module should be consistently assessed to determine if serious damage has occurred (i.e. the module will either cease to function or the module is unable to function).

The manufacturing method which is used to apply the epoxy or potting material **shall** be reviewed to determine if voids or pockets may exist that could create an exposure or weakness. The above testing **shall** exploit those areas.

Module hardness testing **shall** be performed at the vendors specified nominal operating temperature for the module and at the vendors specified lowest and highest temperature that the module will not be damaged (e.g. during storage, transportation/shipping, etc.). If no specification is provided, hardness testing **shall** be performed by the laboratory at ambient temperature.

The Security Policy **shall** (**AS.14.05**) specify the nominal and high/low temperature range that the module hardness testing was performed. If the module hardness testing was only performed at a single temperature (e.g. vendor provided only a nominal temperature or the vendor did not provide a specification), the Security Policy **shall** clearly state that the module hardness testing was only performed at a single temperature and no assurance is provided for Level 3 hardness conformance at any other temperature.

At Level 3, testing methods at all embodiments (single-chip, multi-chip embedded and multi-chip standalone) shall not **consist of drilling, milling, cutting, burning, melting, grinding or dissolving the epoxy or potting material, in order to gain access to the underlying circuitry. These types of "attacks" are addressed by Level 4 physical security and are consistent with *FIPS 140-1 Implementation Guidance* IG 5.7.**

Additional Comments

While the above test methods may be applicable at *Physical Security* Level 3 for a module which is protected by a strong enclosure or includes doors or removable covers, this IG does not specifically address those test methods.

5.5 Physical Security Level 3 Augmented with EFP/EFT

Applicable Levels:	*Level 3*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*12/23/2010*
Relevant Assertions:	*AS.05.60*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

AS.05.60: (Level 4) The cryptographic module shall either employ environmental failure protection (EFP) features or undergo environmental failure testing (EFT).

Question/Problem

EFP/EFT is a Level 4 Physical Security requirement. Can a module that only claims Level 3 physical security also claim EFP/EFT?

Resolution

A module that has been designed only to meet Level 3 physical security in FIPS 140-2 Section 4.5 can augment the Level 3 requirements with the Section 4.5 EFP/EFT requirements.

The CMVP provided test reporting tool (CRYPTIK) was modified to allow this scenario where FIPS 140-2 Section 4.5 is claimed at Level 3 and the “EFP/EFT” option is selected in the Module Information panel. This requires the testing laboratory to address both the Level 3 physical security requirements and the Level 4 EFP/EFT assertions while keeping the overall section annotated as Level 3.

As indicated in IG G.13, the validation certificate will be annotated as either:

-Physical Security: Level 3 +EFP
-Physical Security: Level 3 +EFT
-Physical Security: Level 3 +EFP/EFT

Section 6 – Operational Environment

6.1 Single Operator Mode and Concurrent Operators

Applicable Levels:	*All*
Original Publishing Date:	*03/10/2003*
Effective Date:	*03/10/2003*
Last Modified Date:	*04/24/2003*
Relevant Assertions:	*AS.06.04*
Relevant Test Requirements:	*TE06.04*
Relevant Vendor Requirements:	*VE.06.04*

Background

Historically, for a FIPS 140-1 and FIPS 140-2 validated software cryptographic module on a server to meet the single user requirement of Security Level 1, the server had to be configured so that only *one* user at a time could access the server. This meant configuring the server Operating System (OS) so that only a single user at a time could execute processes (including cryptographic processes) on the server. Consequently, servers were not being used as intended.

Question/Problem

AS.06.04 states: "(Level 1 Only) The operating system **shall** be restricted to a single operator mode of operation (i.e., concurrent operators are explicitly excluded)". What is the definition of concurrent operators in this context? Specifically, may Level 1 software modules be implemented on a server and achieve FIPS 140-2 validation? (Note: this question is also applicable to VPN, firewalls, etc.)

Resolution

Software cryptographic modules implemented in client/server architecture are intended to be used on both the client and the server. The cryptographic module will be used to provide cryptographic functions to the client and server applications. When a crypto module is implemented in a server environment, the server application is the user of the cryptographic module. The server application makes the calls to the cryptographic module. Therefore, the server application is the single user of the cryptographic module, even when the server application is serving multiple clients

Additional Comments

This information must be included in the non-proprietary security policy.

6.2 Applicability of Operational Environment Requirements to JAVA Smart Cards

Applicable Levels:	*All*
Original Publishing Date:	*04/08/2003*
Effective Date:	*04/08/2003*
Last Modified Date:	*09/11/2003*
Relevant Assertions:	*AS.06.01*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 states (Section 4.6 Operational Environment) "A limited operational environment refers to a static non-modifiable virtual environment (e.g., a JAVA virtual machine on a non-programmable PC card) with no underlying general purpose operating system upon which the operational environment uniquely resides."

Question/Problem

Does the FIPS 140-2 statement mean that a smart card implementing a non-modifiable operating system (e.g., like the ones currently used today in most smart cards) that accept and run JAVA applets (whether validated or not) is a limited operational environment?

Resolution

The CMVP cannot issue a general statement that applies to all JAVA card modules since functionality and design can vary greatly from module to module. The determination is left to the CST laboratories, which have the complete module documentation available to them. In general**,** however, a JAVA smart card module with the ability to load unvalidated applets post-validation is considered to have a *modifiable* operational environment and the Operational Environment requirements of FIPS 140-2 are applicable.

A JAVA smart card module having a modifiable operational environment which either:

a) is configured such that the loading of any applets is not possible, or

b) loads only applets that have been tested and validated to either FIPS 140-1 or FIPS 140-2,

could be considered to have a *limited* operational environment and have the FIPS 140-2 Operational Environment requirements section of the module test report marked as *Not Applicable*.

The validated JAVA smart card cryptographic module must use an approved authentication technique on all loaded applets. The module **shall** also meet, at a minimum, the requirements of **AS.09.34**, **AS.09.35**, **AS.10.03** and **AS.10.04**, as well as any other applicable assertions. Validation of the cryptographic module is maintained through the loading of applets that have either been tested and validated during the validation effort of the smart card itself or through an independent validation effort (i.e., the applet itself has its own validation certificate number).

The security policy of the validated smart card module must state whether:

- The module can load applets post-validation, validated or not (Note: if the module can load non-validated applets post-validation, the security policy must clearly indicate that the module's validation to FIPS 140-1 or FIPS 140-2 is no longer valid once a non-validated applet is loaded);

- Any applets are contained within the validated cryptographic module and, if so, must list their name(s) and version number(s).

Additional Comments

The name(s) and version number(s) of all applets contained within a validated cryptographic module **shall** be listed on the module's certificate and CMVP website entry.

6.3 Correction to Common Criteria Requirements on Operating System

Applicable Levels:	*All*
Original Publishing Date:	*03/29/2004*
Effective Date:	*03/29/2004*
Last Modified Date:	*03/29/2004*
Relevant Assertions:	*AS.06.10, AS.06.21 and AS.06.27*
Relevant Test Requirements:	*TE06.10, TE06.21 and TE06.27*
Relevant Vendor Requirements:	*VE.06.10, VE.06.21 and VE.06.27*

Background

Depending on how assertions **AS.06.10**, **AS.06.21** and **AS.06.27** are read, they could be interpreted as the OS upon which the module is running on has to meet ALL of the listed PPs in Annex B at EAL2, EAL3 and EAL4 respectively. This is because of the plural at the end of the "Protection Profile**s**".

Question/Problem

Must the OS upon which the module is running on has to meet ALL of the listed PPs in Annex B at EAL2, EAL3 and EAL4 respectively?

Resolution

No, the requirements should be interpreted to read as follows:

- For **AS.06.10**:

  an operating system that meets the functional requirements specified in **a** Protection Profile listed in Annex B and is evaluated at the CC evaluation assurance level EAL2

- For **AS.06.21**, the first sentence:

  an operating system that meets the functional requirements specified in **a** Protection Profile listed in Annex B.

- For **AS.06.27**, the first sentence:

  an operating system that meets the functional requirements specified in **a** Protection Profile listed in Annex B.

6.4 Approved Integrity Techniques

Applicable Levels:	*All*
Original Publishing Date:	*01/21/2005*
Effective Date:	*01/21/2005*
Last Modified Date:	*01/21/2005*
Relevant Assertions:	*AS.06.08*
Relevant Test Requirements:	*TE06.01.01-02*
Relevant Vendor Requirements:	*VE.06.08.01*

Background

FIPS 140-2 Section 4.6.1 states that "A cryptographic mechanism using an approved integrity technique (e.g. approved message authentication code or digital signature algorithm) **shall** be applied to all cryptographic software and firmware components within the cryptographic module."

Question/Problem

What is an *approved integrity technique*, as specified in **AS.06.08**, and when must be it performed?

Resolution

An *approved integrity technique* is a keyed cryptographic mechanism that uses an approved and validated cryptographic security function. This includes a digital signature scheme, an HMAC or a MAC. Approved security functions are listed in FIPS 140-2 Annex A.

The approved integrity technique is considered a *Power-Up Test* and **shall** meet all power-up test requirements.

Section 7 – Cryptographic Key Management

7.1 moved to D.2

7.2 Use of IEEE 802.11i Key Derivation Protocols

Applicable Levels:	*All*
Original Publishing Date:	*01/21/2005*
Effective Date:	*01/21/2005*
Expiration Date:	
Last Modified Date:	*01/27/2010*
Relevant Assertions:	*AS.07.17*
Relevant Test Requirements:	*TE07.17.01-02*
Relevant Vendor Requirements:	*VE.07.17.01*

Background

FIPS 140-2 Annex D provides a list of the FIPS approved key establishment techniques applicable to FIPS PUB 140-2.

The commercially available schemes referred to in FIPS 140-2 Annex D are concerned with the derivation of a shared secret, or, as it is sometimes called, “the keying material.” The IEEE 802.11i standard describes how to derive keys from a secret shared between two parties. It does not specify how to establish this commonly shared secret.

Question/Problem

Assuming that the shared secret is established using a key establishment technique specified in Annex D, can a cryptographic module use the 802.11i key derivation techniques to derive a data protection key, a key wrapping key and other keys for use in a FIPS approved mode of operation?

Resolution

Implementations of the IEEE 802.11i protocol operating in a FIPS approved mode of operation must meet the following requirements:

1. To derive a data protection key, a key wrapping key and other keys for use in a FIPS approved mode of operation, the following requirements **shall** be met:
   a) the shared secret (the keying material) **shall** be established using a FIPS approved method specified in FIPS 140-2 Annex D; and
   b) the key derivation function **shall** be implemented as defined IG 7.10.
2. The data protection method defined in the 802.11i protocol **shall** be AES CCM, which is an approved security function for use in a FIPS approved mode of operation as specified in FIPS 140-2 Annex A.
3. The keying material may be established via manual methods as specified in FIPS 140-2. The key derivation function as defined in IG 7.10 may then be applied.

References

Amendment 6: IEEE 802.11Medium Access Control (MAC) Security Enhancements, IEEE P802.11i/D10.0, April 2004. Section 8.5.1.2. Pairwise Key Hierarchy.

7.3 moved to C.2

7.4 Zeroization of Power-Up Test Keys

Applicable Levels:	*All*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*02/23/2007*
Relevant Assertions:	*AS.07.41*
Relevant Test Requirements:	*TE07.41.01-04*
Relevant Vendor Requirements:	*VE.07.41.01*

Background

FIPS 140-2 Section 4.7.6 states that "The cryptographic module **shall** provide methods to zeroize all Plaintext secret and private cryptographic keys and CSPs within the module."

Question/Problem

Are cryptographic keys used by a module ONLY to perform FIPS 140-2 Section 4.9.1 Power-Up Tests (e.g. cryptographic algorithm Known Answer Tests (KAT) or software/firmware integrity tests) considered CSPs and is zeroization required under FIPS 140-2 Section 4.7.6?

Resolution

Cryptographic keys used by a cryptographic module ONLY to perform FIPS 140-2 Section 4.9.1 Power-Up Tests are not considered CSPs and therefore do not need to meet the FIPS 140-2 Section 4.7.6 zeroization requirements.

7.5 Strength of Key Establishment Methods

Applicable Levels:	*All*
Original Publishing Date:	*11/23/2005*
Effective Date:	*06/29/2005*
Last Modified Date:	*05/10/2017*
Relevant Assertions:	*AS.07.19*
Relevant Test Requirements:	*TE07.19.01-02*
Relevant Vendor Requirements:	*VE.07.19.01*

Background

FIPS 140-2 **AS.07.19** states that "Compromising the security of the key establishment method (e.g., compromising the security of the algorithm used for key establishment) **shall** require as many operations as determining the value of the cryptographic key being transported or agreed upon."

SP 800-57, *Recommendation for Key Management – Part 1: General (Revised)* (March 2007), Section 5, Sub-Section 5.6.1, Comparable Algorithm Strength, contains Table 1, which provides comparable security strengths for the approved algorithms.

Table 1: Comparable Strengths				
Bits of security	**Symmetric key algorithms**	**FFC (e.g., DSA, D-H)**	**IFC (e.g., RSA)**	**ECC (e.g., ECDSA)**
112	3TDEA	$L = 2048$ $N = 224$	$k = 2048$	$f = 224\text{-}255$
128	AES-128	$L = 3072$ $N = 256$	$k = 3072$	$f = 256\text{-}383$
192	AES-192	$L = 7680$ $N = 384$	$k = 7680$	$f = 384\text{-}511$
256	AES-256	$L = 15{,}360$ $N = 512$	$k = 15{,}360$	$f = 512+$

1. Column 1 indicates the number of bits of security provided by the algorithms and key sizes in a particular row. Note that the bits of security are not necessarily the same as the key sizes for the algorithms in the other columns, due to attacks on those algorithms that provide computational advantages.
2. Column 2 identifies the symmetric key algorithms that provide the indicated level of security (at a minimum), where 3TDEA is specified in **SP 800-67**, and AES is specified in **FIPS 197**. 3TDEA is TDEA with three different keys.
3. Column 3 indicates the minimum size of the parameters associated with the standards that use finite field cryptography (FFC). Examples of such algorithms include DSA as defined in **FIPS 186-4** for digital signatures, and Diffie-Hellman (DH) and MQV key agreement as defined in **SP 800-56A**, where L is the size of the public key, and N is the size of the private key.
4. Column 4 indicates the value for k (the size of the modulus n) for algorithms based on integer factorization cryptography (IFC). The predominant algorithm of this type is the RSA algorithm. RSA is specified in ANSI X9.31 and the PKCS#1 document. These specifications are referenced in **FIPS 186-4** for digital signatures. The value of k is commonly considered to be the key size.
5. Column 5 indicates the range of f (the size of n, where n is the order of the base point G) for algorithms based on elliptic curve cryptography (ECC) that are specified for digital signatures in ANSI X9.62 and adopted in FIPS186-4, and for key establishment as specified in ANSI X9.63 and **SP 800-56A**. The value of f is commonly considered to be the key size.

For example, if a 256 bit AES is to be transported utilizing RSA, then k=15360 for the RSA key pair. A 256 bit AES key transport key could be used to wrap a 256 bit AES key.

For key strengths not listed in Table 2 above, the correspondence between the length of an RSA or a Diffie-Hellman key and the length of a symmetric key of an identical strength can be computed as:

If the length of an RSA key L (this is the value of k in the fourth column of Table 2 above), then the length x of a symmetric key of approximately the same strength can be computed as:

$$x = \frac{1.923 \times \sqrt[3]{L \times \ln(2)} \times \sqrt[3]{[\ln\,(L \times \ln(2))]^2} - 4.69}{\ln(2)} \qquad (1)$$

If the lengths of the Diffie-Hellman public and private keys are L and N, correspondingly, then the length y of a symmetric key of approximately the same strength can be computed as:

$$y = \min(x, N/2), \qquad (2)$$

where x is computed as in formula (1) above.

Question/Problem

What does FIPS 140-2 assertion **AS.07.19** mean in the context of **SP 800-57**?

Resolution

The requirement applies to the key establishment methods found in FIPS 140-2 Section 4.7.

If a key is established via a key agreement or key transport method, the transport key or key agreement method **shall** be of equal or greater strength than the key being transported or established. For example, it is acceptable to have a 2048-bit RSA key (112-bit strength) transported using an AES key.

If the apparent strength of the largest key (taken at face value) that can be established by a cryptographic module is greater or equal than the largest comparable strength of the implemented key establishment method, then the module certificate and security policy will be annotated with, in addition to the other required caveats, the caveat "(Key establishment methodology provides xx bits of encryption strength)" for that key establishment method. For example, if a 256 bit AES is to be transported utilizing RSA with a value of k=2048 for the RSA key pair, the caveat would state "RSA (key wrapping, key establishment methodology provides 112 bits of encryption strength)".

Furthermore, if the module supports, for a particular key establishment method, several key strengths, then the caveat will state either the choice of strengths provided by the keys while operated in FIPS mode, if there are only two possible effective strengths, or a range of strengths if there are more than two possible strengths. For example, if a module implements 2048 and 3072-bit public key Diffie-Hellman with the private keys of 224 and 256 bits then the caveat would state "Diffie-Hellman (key agreement; key establishment methodology provides 112 and 128 bits of encryption strength)". The security policy **shall** provide details about the non-compliant key sizes. If, on the other hand, a module implements, in support of a key wrapping protocol, the RSA encryption/decryption with the RSA keys of 2048, 4096 and 15360 bits, then the caveat would say "RSA (key wrapping; key establishment methodology provides between 112 and 256 bits of encryption strength)". These caveats provide clarification to Federal users on the actual strength the module is providing even though Table 2 below states that the strength is sufficient.

Additional Comments

SP 800-57, *Recommendation for Key Management – Part 1: General (Revised)* (March 2007) also provides the following information in Section 5.6.2:

Table 2 provides recommendations that may be used to select an appropriate suite of algorithms and key sizes for Federal government unclassified applications. Between 2011 and 2030, a minimum of 112 bits of security **shall** be provided. Thereafter, at least 128 bits of security **shall** be provided.

1. Column 1 indicates the estimated time periods during which data protected by specific cryptographic algorithms remains secure. (i.e., the algorithm security lifetimes).

2. Column 2 identifies appropriate symmetric key algorithms and key sizes: 3TDEA are specified in **SP 800-67**, the AES algorithm is specified in **FIPS 197**, and the computation of Message Authentication Codes (MACs) using block ciphers is specified in **SP 800-38**.

3. Column 3 indicates the minimum size of the parameters associated with FFC, such as DSA as defined in **FIPS 186-4**.

4. Column 4 indicates the minimum size of the modulus for IFC, such as the RSA algorithm specified in **ANSI X9.31** and **PKCS#1** and adopted in **FIPS 186-4** for digital signatures.

5. Column 5 indicates the value of f (the size of n, where n is the order of the base point G) for algorithms based on elliptic curve cryptography (ECC) that are specified for digital signatures in ANSI X9.62 and adopted in **FIPS 186-4**, and for key establishment as specified in **ANSI X9.63** and **SP 800-56A**. The value of f is commonly considered to be the key size.

Table 2: Recommended algorithms and minimum key sizes				
Algorithm security lifetimes	**Symmetric key Algorithms (Encryption & MAC)**	**FFC (e.g., DSA, D-H)**	**IFC (e.g., RSA)**	**ECC (e.g., ECDSA)**
Through 2030 (min. of 112 bits of strength)	3TDEA AES-128 AES-192 AES-256	Min.: $L = 2048$ $N = 224$	Min.: k=2048	Min.: f=224
Beyond 2030 (min. of 128 bits of strength)	AES-128 AES-192 AES-256	Min.: $L = 3072$ $N = 256$	Min.: k=3072	Min.: f=256

The algorithms and key sizes in the table are considered appropriate for the protection of data during the given time periods. Algorithms or key sizes not indicated for a given range of years **shall** not be used to protect information during that time period. If the security life of information extends beyond one time period specified in the table into the next time period (the later time period), the algorithms and key sizes specified for the later time **shall** be used. The following examples are provided to clarify the use of the table:

a. If information is encrypted in 2005 and the maximum expected security life of that data is only five years, any of the algorithms or key sizes in the table may be used. But if the information is protected in 2005 and the expected security life of the data is six years, then 2TDEA would not be appropriate.

b. If a CA signature key and all certificates issued under that key will expire in 2005, then the signature and hash algorithm used to sign the certificate needs to be secure for at least five years. A certificate issued in 2005 using 1024 bit DSA and SHA-1 would be acceptable.

c. If information is initially signed in 2009 and needs to remain secure for a maximum of ten years (i.e., from 2009 to 2019), a 1024 bit RSA key would not provide sufficient protection between 2011 and 2019 and, therefore, it is not recommended that 1024 bit RSA be used in this case. It is recommended that the algorithms and key sizes in the "Through 2030" row (e.g., 2048 bit RSA) should be used to provide the cryptographic protection. In addition, the signature must be generated using a hash algorithm of comparable or greater strength, such as SHA-224 or SHA-256.

7.6 moved to W.5

7.7 Key Establishment and Key Entry and Output

Applicable Levels:	*All*
Original Publishing Date:	*01/24/2008*
Effective Date:	*01/24/2008*
Last Modified Date:	*02/06/2017*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

Given different configurations of cryptographic modules, how can a module's key establishment and key entry and output states be easily mapped to the FIPS 140-2 Section 4.2 *Cryptographic Module Ports and Interfaces*, Section 4.7.3 *Key Establishment* and Section 4.7.4 *Key Entry and Output*? Are there any special considerations for S*ub-Chip Cryptographic Subsystems* (IG 1.20)?

Resolution

Using the following guidelines, first determine how keys are established to a module. Once the establishment method is determined, the Key Entry format table will indicate the requirements on how keys **shall** be entered or output. The following is based on the requirements found in FIPS 140-2 in Sections 4.2 and 4.7.

CM: a FIPS 140-2 *validated* Cryptographic Module

GPC: General Purpose Computer

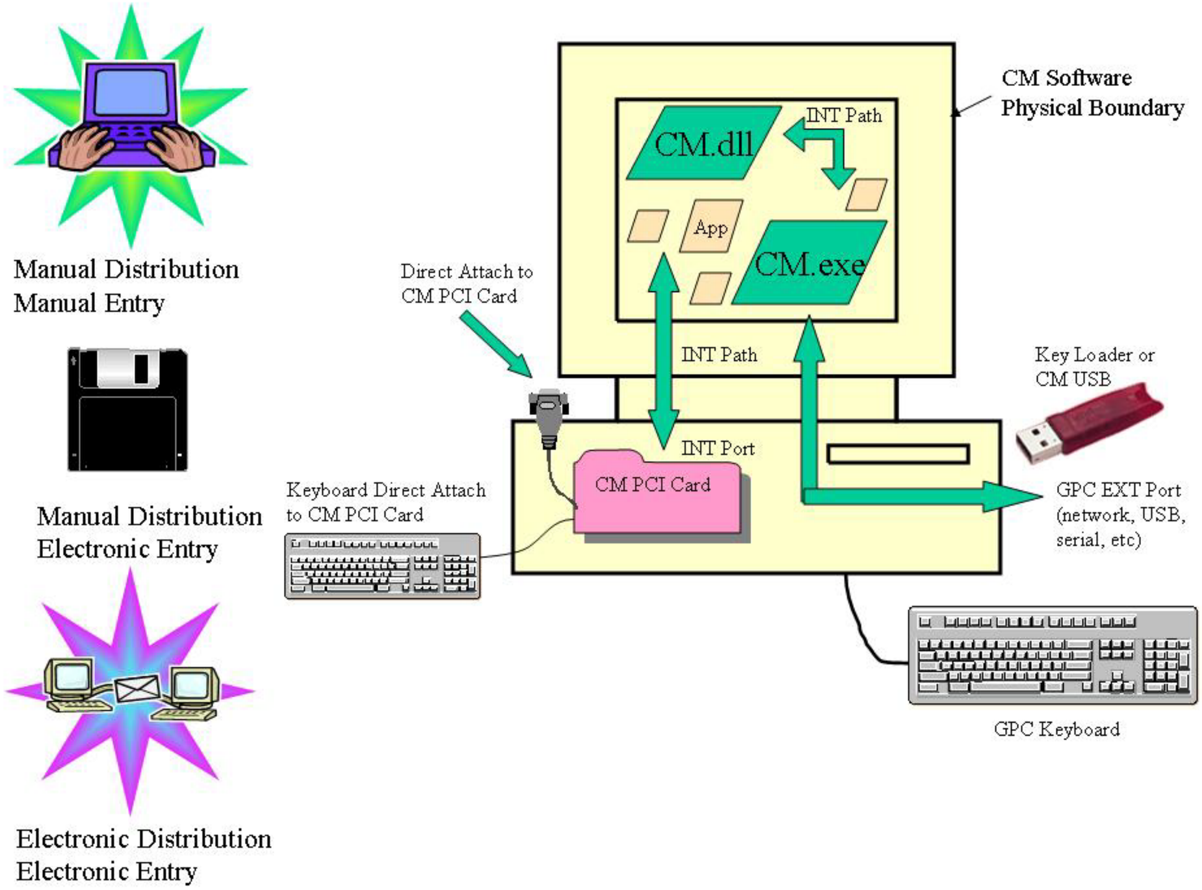
EXT: a validated Cryptographic Module which lies external or outside of the physical boundary. See the CM software physical boundary diagram for an example.

INT: a validated Cryptographic Module which lies internal or inside of the physical boundary. See the CM software physical boundary diagram for an example.

App: a non-validated non-crypto general purpose software application operating inside of the boundary in regard to the reference diagrams CM software physical boundary.

Key Establishment – Table 1		
MD: Manual Distribution	**ME: Manual Entry (Input / Output)**	
ED: Electronic Distribution	**EE: Electronic Entry (Input / Output)**	
CM Software[1] from GPC Keyboard		**MD / ME**
CM Software[1] to/from GPC Key Loader (e.g., diskette, USB token, etc.)		**MD / EE**
CM Software[1] to/from GPC EXT Ports (e.g., network port)		**ED / EE**
CM Software[1] to/from CM Software[1] via GPC INT Path		**N/A**
CM Software[1] to/from App Software via GPC INT Path		**N/A**
CM Software[1] to/from INT CM Hardware via GPC INT Path		**N/A**
CM Software[1] to/from EXT CM Hardware running on a non-networked GPC (key loader)		**MD / EE**
CM Software[1] to/from EXT CM Hardware running on a networked GPC		**ED / EE**
INT CM Hardware to/from App Software via GPC INT Path		**ED / EE**
INT CM Hardware (Sub-Chip Cryptographic Subsystem) to/from INT CM Hardware (Sub-Chip Cryptographic Subsystem) via Single-Chip INT Path at Levels 1 and 2		**N/A**
INT CM Hardware (Sub-Chip Cryptographic Subsystem) to/from INT CM Hardware (Sub-Chip Cryptographic Subsystem) via Single-Chip INT Path at Levels 3 and 4		**ED / EE**
INT CM Hardware from GPC Keyboard via GPC INT Path		**MD / EE**
INT CM Hardware to/from direct attach key loader		**MD / EE**
INT CM Hardware from direct attach keyboard		**MD / ME**
EXT CM Hardware to/from networked GPC		**ED / EE**
EXT CM Hardware to/from directly attached key loader (a non-networked GPC could be considered and used as a key loader)		**MD / EE**
EXT CM Hardware from direct attach keyboard		**MD / ME**
[1] Must meet requirements of AS.06.04, AS.06.05 and AS.06.06 - These requirements cannot be enforced by administrative documentation and procedures, but must be enforced by the cryptographic module itself.		

The following illustration provides reference to the above Key Establishment table.



Key Entry Format – Table 2

		Distribution (Establishment)							
		Manual				**Electronic**			
Entry (Input / Output)	**Manual**	Keyboard, Thumbwheel, Switch, Dial							
		1	**2**	**3**	**4**				
		P/KT	P/KT	KT/SK	KT/SK				
	Electronic	Smart Cards, Token, Diskettes and Key Loaders				**Key Establishment** Key Transport or Key Agreement			
		1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
		P/KT	P/KT	KT/SK	KT/SK	KE	KE	KE	KE

<u>**Legend**</u>:
P/KT: May be Plaintext or by Key Transport
KE: Key Establishment
KT/SK: Key Transport or Plaintext Split Knowledge (via separated physical ports or via trusted path)

At Levels 3 and 4, plaintext key components may be entered either via separate physical ports or logically separated ports using a trusted path. Manual entry of plaintext keys must be entered using split knowledge procedures. Keys may also be entered manually using a key transport method. If automated methods, a key establishment method **shall** be used.

Additional Comments

This IG reaffirms that keys established using *manual transport methods* and *electronically input or output* to a cryptographic module may be input or output in <u>plaintext</u> at Levels 1 and 2.

<u>Level 1 Software – General Purpose Operational Environment</u>

AS.06.04: (Level 1 Only) The operating system shall be restricted to a single operator mode of operation (i.e., concurrent operators are explicitly excluded).

AS.06.05: (Level 1 Only) The cryptographic module shall prevent access by other processes to plaintext private and secret keys, CSPs, and intermediate key generation values during the time the cryptographic module is executing/operational. Processes that are spawned by the cryptographic module are owned by the module and are not owned by external processes/operators.

AS.06.06: (Leve.1 1 Only) Non-cryptographic processes shall not interrupt the cryptographic module during execution.

A Software Cryptographic Module (SCM) requires the use of an underlying General Purpose Computer (GPC) and Operational Environment (OE) to execute/operate. A SCM is conceptually comprised of two sub-elements: a Physical Cryptographic Module (PCM) and the Logical Cryptographic Module (LCM) boundary. The LCM is executes/operates within the PCM. The LCM is the collection of executable code that encompasses the cryptographic functionality of the SCM (e.g., dll's,. exe's). Other general-purpose application software (App) (e.g., word processors, network interfaces, etc.) may reside within the PCM. Therefore, the PCM encompasses the following elements: GPC, OE, LCM and App. The LCM relies on the OE and GPC for memory management, access to ports and interfaces, and other services such as the requirements of AS.06.04, AS.06.05 and AS.06.06. The LCM has no operational control over other App elements within the PCM of the SCM. The SCM, which is comprised of all the various sub-elements (GPC, OE, LCM and App), is restricted to a single operator mode of operation, such that the single operator has a level of confidence in the SCM environment as a whole. The CMVP views the non-LCM elements (GPC, OE and App) as implicitly excluded.

Example: If the LCM generates keys, it must use a FIPS approved RNG. That key may be stored within the PCM but must meet **AS.06.05** unless the LCM wishes the key to be exported. If exported, refer to Table 1 for the key establishment and key entry requirements. If a key is generated outside of the LCM, then the generation method is out-of-scope but the key must be imported per Table 1 requirements.

It is the burden of the operator of the SCM to understand the environment the SCM is running. If that environment is not acceptable, then there are alternative solutions (hardware cryptographic modules and/or Level 2, 3 or 4 software cryptographic modules) that should be considered.

If the operating system requirements of **AS.06.04**, **AS.06.05** and **AS.06.06** cannot be met, then the SCM cannot be validated at Level 1. The vendor provided documentation **shall** indicate how these requirements are met (**AS.14.02**). These requirements cannot be enforced by administrative documentation and procedures, but must be enforced by the cryptographic module itself.

7.8 The Use of Post-Processing in Key Generation Methods

Applicable Levels:	*All*
Original Publishing Date:	*03/10/2009*
Effective Date:	*03/10/2009*
Last Modified Date:	*08/12/2020*
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 Section 4.7.2 states that "… approved key generation methods are listed in Annex C to this standard. If an approved key generation method requires input from an RNG, then an approved RNG that meets the requirements specified in FIPS 140-2 Section 4.7.1 **shall** be used."

Question/Problem

There exists a NIST standard for key generation, **SP 800-133**. This standard, however, does not include the so-called post-processing, which, instead, has been documented in the FIPS 140-2 IG 7.8. The post-processing has been used very infrequently by the vendors. The remaining key generation methodology is adequately addressed in **SP 800-133**.

Why have two separate documents (IG 7.8 and **SP 800-133**) to illustrate an almost identical functionality?

Resolution

The vendor has an option to perform a qualified post-processing that would apply to U, an output of an approved DRBG, before the updated value of U is passed to the **SP 800-133**-compliant portion of the key generation process. The post-processing methodology is not shown in **SP 800-133** and, therefore, not addressed in IG D.12.

Qualified Post-Processing Algorithms

The value of U in the **SP 800-133** key generation mechanism is the output of an approved DRBG. As explained earlier, this DRBG output may be further modified by applying a qualified post-processing algorithm *before* it is used to compute the secret value B (from Section 4). When post-processing is performed on DRBG output, the output of the post-processing operation **shall** be used in place of any use of the DRBG output. This output from the post-processing operation becomes the new U.

Let M be the length of the output requested from the DRBG by a consuming application, and let R_M be the set of all bit strings of length M. When the output is to be used for keys, M is typically a multiple of 64; however, these algorithms are flexible enough to cover any output size. Let R_N be the set of all bit strings of length N, and let F: $R_N \rightarrow \{0,1, \ldots, k\text{-}1\}$ be a function on N-bit strings with integer output in the range 1 to k, where k is an arbitrary positive integer. Let $\{P_1, P_2, \ldots, P_k\}$ be a set of permutations (one-to-one functions) from R_M back to R_M. The P_j's may be fixed, or they may be generated using a random seed or secret value. Examples of F and P_i are given below.

Let r_1 be randomly selected from the set R_N (i.e., r_1 is a random N-bit value), and let r_2 be randomly selected from the set R_M (i.e., r_2 is a random M-bit value). Both r_1 and r_2 **shall** be outputs from an approved DRBG, such that $N \leq M$. (The case r_1=r_2 is permissible.) The post processor's output is the M-bit string $P_{F(r_1)}(r_2)$.

The apparent complexity of this post-processing should not be of any concern to vendors and testing laboratories. The post-processing step is optional. Vendors are not encouraged to design the post-processing into the cryptographic modules.

Examples of F(r_1) used for Post Processing

The function F may be simple or fairly complex.

Let *k* be the number of desired permutations, and let r_1 represent an *N*-bit output of an approved DRBG. Two examples are provided:

1. A very simple example of a suitable F is the following, where *k* is assumed to be an integer in the range 1 to 2^N .

   $$F(r_1) = r_1 \bmod k.$$

   Here, r_1 is interpreted as an integer represented by the bit string r_1.

2. A more complex example is:

   $$F(r_1) = \mathrm{HMAC}(key, r_1) \bmod k ,$$

   using a hashing algorithm and a fixed key in the HMAC computation. In this case, *k* could be as large as 2^{outlen}, or as small as 1, where *outlen* is the length of the hash function output in bits. (Having a single permutation, while permitted, would certainly not require the use of a keyed hash to "choose" it. On the other hand, $k = 2$ might make sense in the right application.)

Note that in both of these examples, the *k* permutations are selected with (nearly) equal probability, but this is not a requirement imposed by this post-processing algorithm.

Examples of P_i used for Post-Processing.

Depending on the requirements of the application, the P_i may be very simple or quite complex. The security of the key generation method depends on the P_i being *permutations*.

1. An example of a very simple permutation P_i is bitwise XOR with a fixed mask A_i: $P_i(r_2) = (r_2 \text{ XOR } A_i)$, where r_2 and A_i are *M*-bit vectors. Continuing this example, if there are four such masks ($k = 4$), the simple function $F(r_1)$ that maps r_1 into an integer represented by the two rightmost bits of r_1 (say, '01' corresponds to 1, '10' corresponds to 2, '11' corresponds to 3, and '00' corresponds to 4) could be used to choose among them. Then the post-processor's output $P_{F(r_1)}(r_2)$ would be r_2 XOR $A_{F(r_1)}$. Note that in this example, $2 \le N \le M$, where *N* is the length of r_1, and *M* is the length of r_2.

   [This should not be confused with the XORing defined in equation (1) above. The equation in (1) is applied after each of the U and V values is calculated, including any qualified post-processing, if applicable.]

2. A more complex example would be the use of a codebook to affect a permutation. For example, $P_i(r_2)$ = Triple-DES(key_i, r_2) could be used on a DRBG whose outputs were 64-bit strings. Similarly, $P_i(r_2)$ = AES(key_i, r_2) could be used to effect permutations on a DRBG with 128-bit outputs.

   Suppose that there are ten 256-bit AES keys ($k = 10$). Let $F(r_1) = \mathrm{SHA256}(r_1) \bmod 10$. Then the post-processed output $P_{F(r_1)}(r_2)$ would be AES($key_{\mathrm{SHA256}(r1) \bmod 10}$, r_2) . Note that in this case, $4 \le N \le M$, where *N* is the length of r_1, and *M* is the length of r_2 (the minimum length of r_1 is determined by the modulus value 10, which is represented in binary as 4 bits).

   A similar example, but one with a *much* larger value for *k*, (e.g., $k = 2^{128}$), might use key_i = SHA256(128-bit representation of *i*). Let $F(r_1) = \mathrm{SHA256}(r_1)$. The output $P_{F(r_1)}(r_2)$ of the post-processor would be AES(SHA256(r_1), r_2). Note that is this case, $N = M = 128$.

3. An example of a permutation somewhere between these extremes of complexity is a byte-permutation '$SBOX_i$', which will be applied to each byte of input, with the final output being the concatenation of the individually permuted bytes:

   $$P_i(B_1 \| B_2 \| \ldots \| B_{M/8}) = SBOX_i(B_1) \| SBOX_i(B_2) \| \ldots \| SBOX_i(B_{M/8})$$

   For specificity, suppose that $M = 128$; there are just 2 byte permutations to choose from, $SBOX_0$ and $SBOX_1$; and F maps 8-bit strings to their parity: $F(r_1) = 0$ if r_1 has an even number of 1's, and $F(r_1) = 1$ if r_1 has an odd number of 1's. Note that in this case, $N = 8$.

The post-processor's output $P_{F(r_1)}(r_2)$, on the input pair r_1 and $r_2 = B_1 \| B_2 \| \ldots \| B_{16}$ would be $SBOX_{parity(r1)}(B_1) \| SBOX_{parity(r1)}(B_2) \| \ldots \| SBOX_{parity(r1)}(B_{16})$. To complete the example, suppose that the two byte permutations are specified as: $SBOX_0$ = the AES SBOX, and $SBOX_1$ is the inverse permutation to the same AES SBOX.

Additional Comments

1. If the vendor chooses to perform the post-processing, the vendor **shall** explain the details of how it works. If possible, the vendor should map their method into one of the examples shown in this Implementation Guidance.
2. Although some security strength may be lost during post-processing, the loss is small enough to be ignored for the purposes of FIPS 140-2 validation.
3. The post-processing may apply whenever the module generates either a symmetric cryptographic key or a seed to be used when generating the asymmetric keys.

Test Requirements

Code review, vendor documentation review, and mapping of the module's post-processing procedures into the methods described in this Implementation Guidance.

7.9 Procedural CSP Zeroization

Applicable Levels:	*All*
Original Publishing Date:	*03/24/2009*
Effective Date:	*03/24/2009*
Last Modified Date:	*03/24/2009*
Relevant Assertions:	*AS.07.41, AS.07.42*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 Section 4.7.6 states "A cryptographic module **shall** provide methods to zeroize all plaintext secret and private cryptographic keys and CSPs within the module."

Question/Problem

A module **shall** provide methods to zeroize all plaintext permanent, temporary and ephemeral CSPs within the module. These methods may be operational (i.e. a callable service invoked by the operator of a module), or methods commonly referred to as *procedural zeroization* methods. What are acceptable methods?

Resolution

The zeroization methods required in AS.07.41 are operational or procedural methods that will provide an operator of a module a method to zeroize all permanent, temporary and ephemeral plaintext CSPs. This **shall** be done with a level of assurance that the CSPs cannot be easily recovered. However, this **shall** not include methods of recovery that require substantial skill and methods that may be employed by governmental or other well-funded institutions. As an operational or procedural method, the time necessary to perform the zeroization **shall** be reasonable based on the method employed.

- For software modules, a procedural method may include the uninstallation of the cryptographic module application, *and* reformatting of and overwriting, at least once, the platform's hard drive or other permanent storage media. Only performing the procedural uninstallation of the cryptographic module application is not an acceptable method.

- For space-based modules, a procedural method that relies on the de-orbit destruction is acceptable *only if* the vendor of the module provides analysis that indicates the components where plaintext CSPs may reside have a high probability of destruction and non-recovery.

- All procedural or operational zeroization methods **shall** be performed by the operator of the module while the operator is in control of the module (i.e. present to observe the method has completed successfully or controlled via a remote management session). If the method is not under the direct control of the operator, then rationale **shall** be provided on how the zeroization method(s) are employed such that the secret and private cryptographic keys and other CSPs within the module cannot be obtained by an attacker.

- Except for space-based modules, physical destruction of the module is not considered an acceptable zeroization method.

Additional Comments

TE07.41.03: is revised as follows:

TE07.41.03: The tester **shall** initiate zeroization and verify the key destruction method is performed in a sufficient time that an attacker cannot access plaintext secret and private cryptographic keys and other plaintext CSPs while under the direct control of the operator of the module (i.e. present to observe the method has completed successfully or controlled via a remote management session). If the method is not under the direct control of the operator, then rationale **shall** be provided on how the zeroization method(s) are employed such that the secret and private cryptographic keys and other CSPs within the module cannot be obtained by an attacker.

7.10 Using the SP 800-108 KDFs in FIPS Mode

Applicable Levels:	*All*
Original Publishing Date:	*10/22/2009*
Effective Date:	*10/22/2009*
Last Modified Date:	*10/22/2009*
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

When a key is shared between two entities, it may be necessary to derive additional keying material using the shared key. **SP 800-108** provides Key Derivation Functions (KDFs) for deriving keys from a shared key; in **SP 800-108**, the shared key is called a pre-shared key. The shared key may have been generated, entered or established using any method approved or allowed in FIPS mode.

Note that IG D.2 contains key establishment methods, and includes KDFs that are used during key agreement to derive keying material from a shared secret, which is the result of applying a Diffie-Hellman or MQV primitive. The keying material may be used as a key directly or to derive further keying material.

IG 7.2 defines IEEE 802.11i KDFs that may be used to derive further keying material.

Question/Problem

Where do the KDFs from **SP 800-108** fit in the key establishment process, and under what conditions can these KDFs be used in FIPS mode? Are there any other allowed methods for deriving additional keys from a pre-shared key?

Resolution

All key derivation methods listed in **SP 800-108** will be allowed in FIPS mode if the Key Derivation Key K_I, as introduced in Section 5 of **SP 800-108** has been generated, entered or established using any method approved or allowed in FIPS mode.

Note that the KDFs described IG 7.2 are included in **SP 800-108**, thus making IG 7.2 obsolete.

Other KDFs that are allowed for key derivation from shared keying material are:

1. The KDF specified in the Secure Real-time Transport Protocol (SRTP) defined in RFC 3711.

Additional Comments

A key hierarchy as specified in Section 6 of **SP 800-108** may be used.

7.11 Moved to W.6

7.12 Key Generation for RSA Signature Algorithm

Applicable Levels:	*All*
Original Publishing Date:	*05/02/2012*
Effective Date:	
Transition End Date:	***12/31/2013***
Last Modified Date:	*01/11/2016*
Relevant Assertions:	*AS07.16*
Relevant Test Requirements:	*TE07.16.01-02*
Relevant Vendor Requirements:	*VE07.16.01-02*

Background

FIPS 140-2 Annex A lists the approved security functions for FIPS 140-2. For asymmetric key digital signature standards, references address RSA signature generation, verification and key generation. Some of these referenced RSA standards include the specification of the RSA key generation procedure while others, such as RSASSA-PKCS1-v1_5 and RSASSA-PSS only define the requirements for signature generation and verification. These latter references do not address the generation of keys used in signature generation and verification.

Question/Problem

What methods for RSA key generation may be used when the module claims compliance with the RSA signature standards that do not explicitly address an RSA key generation method?

Resolution

If the module performs signature verification only, then the module does not need to possess a private RSA key and therefore does not need to generate it. The RSA public key parameters might be entered into the module or loaded at the time of manufacturing.

If the module performs an RSA Signature generation then the RSA private and public keys may either be loaded into the module (externally or pre-loaded at the time the module is manufactured) or generated by the module. If the module generates RSA signature keys then this key generation procedure **shall** be an approved method. The approved methods are described in **FIPS 186-4** or **ANSI X9.31**. The module's RSA Signature

CAVP algorithm certificate **shall** indicate that the RSA key generating algorithm has been tested and validated for conformance to the methods in **FIPS 186-4** or **ANSI X9.31**.

Additional Comments

The Transition End Date is based on IG G.15 ***FIPS 186-2*** *to* ***FIPS 186-4*** *Validation Transition Plan* Clause 2.2.b: *Conformance to* ***FIPS 186-2*** after December 31, 2013.

This Implementation Guidance does not address RSA key generation for use in the approved key establishment protocols. The user should follow the requirements of **SP 800-56B**.

7.13 Moved to W.1

7.14 Entropy Caveats

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2015*
Effective Date:	*08/07/2015*
Last Modified Date:	*10/07/2022*
Relevant Assertions:	*AS.07.13*
Relevant Test Requirements:	*TE.07.13.01 and TE.07.13.02*
Relevant Vendor Requirements:	

Background

Section 4.7 of FIPS 140-2 states that **"***compromising the security of the key generation method (e.g., guessing the seed value to initialize the deterministic RNG)* ***shall*** *require as least as many operations as determining the value of the generated key.***"** **TE.07.13.02** further states that "*The tester* ***shall*** *determine the accuracy of any rationale provided by the vendor. The burden of proof is on the vendor; if there is any uncertainty or ambiguity, the tester* ***shall*** *require the vendor to produce additional information as needed.*"

There are some module designs where it may be impossible to know how much entropy has been supplied for key generation. For example, a module designed as a software library with an API allowing the caller to supply random buffer to use as a seed for random number generation, the module would be passively accepting the entropy "infusions" from third-party applications. From such module's perspective, it is only possible to talk about the number of bytes/bits size of the received random field, not of the amount entropy in it. Does it mean that the requirement in AS.07.13 cannot be tested and therefore the module cannot be validated?

To be fair, in this case the module is not necessarily non-compliant with AS.07.13; it is just impossible to determine within the scope of the CST lab testing that the module would be compliant in all possible deployments. This Implementation Guidance weighs this and similar issues and shows how to identify the cases when compliance with that entropy requirements of FIPS 140-2 cannot be directly verified by the testing labs and how to inform the user of potential weakness or lack of assurance for the true strengths of the cryptographic keys generated by such modules.

Question/Problem

When is it necessary for the module to provide the evidence of the amount of generated entropy?

How to handle the case when the amount of generated entropy is sufficient to meet the minimum key strength requirement (112 bit) but not necessarily sufficient to account for an *apparent* strength of the generated keys?

What information **shall** the testing laboratory provide in the test report submitted to the CMVP? What information **shall** be included in the module's certificate and the Security Policy to indicate the various forms of compliance with the AS.07.13 requirement?

Resolution

We identify the main "logical" cases and for each case indicate whether the module can be validated and what certificate caveat, if any, **shall** be used.

1. The module is either generating the entropy itself or it is making a call to request the entropy from a well-defined source.

   Examples include

   (a) A hardware module with an entropy source inside the module's cryptographic boundary.

   What is required: (i) the testing lab **shall** corroborate the entropy strength estimate as provided by the vendor, (ii) the Security Policy **shall** state the minimum number of bits of entropy generated by the module for use in key generation.

   If the amount of entropy used to generate the module's cryptographic keys employed in an approved mode is less than 112 bits, then this module **cannot** be validated.

   If the amount of entropy used to generate the module's cryptographic keys is at least 112 bits while the module generates keys with an apparent cryptographic strength greater than the amount of the available entropy, the following caveat **shall** be included in the module's certificate: *The module generates cryptographic keys whose strengths are modified by available entropy*. The apparent cryptographic strength of a key is addressed under the Additional Comments below.

   (b) A software module that contains an approved DRBG that is seeded exclusively from one or more known entropy sources located within the operational environment inside the module's physical boundary but possibly outside the logical boundary. For instance, a software library on a Linux platform making a call to /dev/random for seeding its DRBG.

   What is required: (i) the testing lab **shall** corroborate the entropy strength estimate of the sources as provided by the vendor, (ii) the Security Policy **shall** state the minimum number of bits of entropy requested per each GET function call.

   If the amount of entropy used to generate the module's cryptographic keys employed in an approved mode is less than 112 bits, then this module cannot be validated.

   If the amount of entropy used to generate the module's cryptographic keys is at least 112 bits while the module generates keys longer than the amount of available entropy, the following caveat **shall** be included in the module's certificate: *The module generates cryptographic keys whose strengths are modified by available entropy*.

   (c) A software module that contains an approved DRBG that issues a GET command to obtain the entropy from a source located outside the module's physical boundary.

   What is required: (i) the testing lab **shall** corroborate – to the extent it is possible, given that the entropy source is not subject to this module's testing and validation – the entropy strength estimate as provided by vendor, (ii) the Security Policy **shall** state the minimum number of bits of entropy requested per each GET function call, (iii) the following caveat **shall** be added to the module's certificate: *No assurance of the minimum strength of generated keys*.

If the claimed amount of obtained entropy used to generate the module's cryptographic keys employed in an approved mode is known to be less than 112 bits, then this module cannot be validated.

2. The module is passively receiving the entropy while exercising no control over the amount or the quality of the obtained entropy.

   Examples include:

   (a) A hardware module with an approved DRBG inside the module's cryptographic boundary. The approved DRBG is either seeded via a seed loader from outside the module's cryptographic boundary or the seed is pre-loaded at factory.

   What is required: (i) the Security Policy **shall** state the minimum number of bits of entropy believed to have been loaded and justify the stated amount (from the length of the entropy field and from any other factors known to the vendor), (ii) the following caveat **shall** be added to the module's certificate: *No assurance of the minimum strength of generated keys*.

   If the amount of claimed entropy used to generate the module's cryptographic keys employed in an approved mode is known to be less than 112 bits, then this module cannot be validated.

   (b) A software module that contains an approved RNG/DRBG that receives a LOAD command (or its logical equivalent) with entropy obtained from either inside the operational environment within the physical boundary of the module or, via an I/O port, from an external source that is outside the physical boundary.

   What is required: (i) the Security Policy **shall** state the minimum number of bits of entropy believed to have been loaded and justify the stated amount (from the length of the entropy field and from any other factors known to the vendor), (ii) the following caveat **shall** be added to the module's certificate: *No assurance of the minimum strength of generated keys*.

   If the amount of entropy used to generate the module's cryptographic keys employed in an approved mode is *known to be* less than 112 bits, then this module cannot be validated.

3. The module uses a *hybrid* approach to obtaining entropy for key generation. Some entropy is passively received while the module is exercising no control over the amount or the quality of the obtained entropy. Another portion of the entropy is obtained when the module is either generating the entropy by itself or is making a GET call to request the entropy from a well-defined source inside the module's physical boundary. For instance, a software library on a Linux platform may be making a call to /dev/random for seeding its DRBG while it is also providing an API allowing the calling application to supply an additional random buffer to use in seeding its DRBG.

   What is required: The testing lab **shall** examine the design of seeding the DRBG from multiple sources and corroborate an entropy strength estimate as provided by vendor; the lab will need to understand the work of the sources within the operational environment and be able to verify vendor's claim about the amount of entropy loaded into the software cryptographic module.

   If the review of the design of seeding the DRBG reveals that the entropy data obtained passively can **only** add to the entropy obtained actively and the module will block the seeding until a minimal threshold amount of actively obtained entropy is reached, then

   The Security Policy **shall** state the minimum number of bits of entropy that can be guaranteed to be actively obtained and, in addition, it **shall** state the number of bits believed to have been loaded and justify the stated amounts (from the lengths of the entropy fields and from any other factors known to the vendor).

If between the active and passive entropy calls the module cannot possibly accumulate at least 112 bits of entropy when generating cryptographic keys, then this module cannot be validated.

If the amount of entropy obtained actively *may be* less than 112 bits, then the following caveat **shall** be added to the module's certificate: *No assurance of the minimum strength of generated keys*.

If the review of the design of the DRBG seeding reveals that the entropy data obtained passively can preempt the seeding of the DRBG in a way that causes the module to unblock the seeding even when the minimal threshold amount of entropy obtained actively has not been reached at any time when the caller uses the API for supplying the passive data, then

The Security Policy **shall** state the minimum number of bits of entropy believed to have been loaded and justify the stated amount (from the length of the entropy field and from any other factors known to the vendor).

If the module cannot possibly accumulate at least 112 bits of entropy when generating cryptographic keys, then this module cannot be validated.

The following caveat **shall** be added to the module's certificate: *When entropy is externally loaded, no assurance of the minimum strength of generated keys.*

Additional Comments

1. Unless the design of the module falls under the case for which a specific caveat is explicitly allowed under a particular scenario described in this Implementation Guidance, the vendor may not use the caveat. In particular, the vendor cannot use the "*No assurance of the minimum strength of generated keys*" caveat and get their module validated if the scenario that applies to this module requires an explicit estimation of the generated entropy.
2. If a software module's design requires entropy estimation then the module's Security Policy **shall** contain a statement that if porting to an untested platform is allowed then when running a module on such an untested platform the "*No assurance of the minimum strength of generated keys*" caveat applies regardless of what caveat, if any, is applicable to the original validation.
3. This implementation guidance only covers the applicability of entropy estimation and the way to document the amount of the available entropy. The actual methodology for entropy estimation is addressed in IGs 7.15 and 7.18.
4. The "apparent" key strength referenced in this Implementation Guidance refers to the key strength corresponding to the length of the key alone, without taking into the consideration any other factors such the amount of the available entropy or the methodology used when generating or establishing this key.

   Thus an AES key has the apparent strength equal to its length; a three-key Triple-DES key has the apparent strength of 168 bits (even though there exist the man-in-the middle attacks that reduce the strength of this key to 112 bits); an RSA 2048 and 3072 private keys have the apparent strengths of 112 and 128 bits, correspondingly; a DSA or a Diffie-Hellman private key has the apparent strength of half of its bit length (even though the overall algorithm strength is largely determined by the size of the public key); an ECDSA or an EC Diffie-Hellman private key has the apparent strength of half of its bit length; an HMAC key has the apparent strength equal to its bit length.
5. If the module generates random strings that are not keys and the security strength of a generated string is less than the bit length of the string due to limited entropy, then the strength caveats shown in this IG are applicable, but they **shall** reference random strings rather than keys. For example, in Scenario 1(b) above, the caveat would say: *The module generates random strings whose strengths are modified by available entropy.*

If the module generates both keys and random strings that have security strengths smaller that the presumed strengths of the keys and strings, then the caveat **shall** address the potential loss of strength in both keys and the random strings: *The module generates cryptographic keys and random strings whose strengths are modified by available entropy.*

The module's Security Policy **shall** state the guaranteed amount of entropy for both the cryptographic keys and the random strings generated by the module using the available entropy source(s).

6. There exist situations where it could be reasonable to place two different entropy caveats in the module's validation certificate for a single scenario in this IG. For example, a software module receives a LOAD command that carries an externally-generated entropy (Scenario 2(b) above). The module uses this entropy to generate the 256-bit AES keys, yet the length of the received entropy string is, say, 192 bits. As shown above, this module may be validated. Since the entropy is generated externally, the *No assurance of the minimum strength of generated keys* caveat is required. In addition, the user can be certain that the obtained entropy is not sufficient to generate an AES key with the 256-bit strength. Should the module's certificate also include another available caveat: *The module generates cryptographic keys whose strengths are modified by available entropy*?

   The approach taken in this IG is that when more than one caveat might be needed for a single scenario in this IG, the module's certificate **shall** document only the strongest caveat. In the above example, it is *No assurance of the minimum strength of generated keys*. The scenarios of this IG are written following this single-caveat approach. The module's Security Policy **shall** inform the reader about the length of a random string loaded into the module and explain, if applicable, the effect of the random string length on the strengths of the generated keys.

7. The hybrid Scenario 3 above applies when two or more entropy sources are used together to seed a DRBG. If a module uses two or more entropy sources that independently seed the DRBG (i.e., the DRBG is seeded entirely from a single source per instantiation or re-seed), two or more of the scenarios described in the Resolution of this IG can apply separately. In this case, the module **shall** meet the requirements of each scenario independently and the certificate **shall** document the unique caveats that apply to each scenario. For example, one source may require the caveat "*No assurance of the minimum strength of generated keys*" while the other source requires the caveat "*The module generates cryptographic keys whose strengths are modified by available entropy*", so both will be shown on the certificate. As another example, both entropy sources require the same caveat "*The module generates cryptographic keys whose strengths are modified by available entropy*", so this caveat will only be shown once on the certificate. The module's Security Policy **shall** inform the reader how many scenarios are applicable and include the appropriate documentation requirements for each scenario.

8. The following scenarios of this IG require an entropy assessment report and meet the applicable entropy requirements (i.e., IG 7.15 or IG 7.18): 1(a), 1(b), 3 (for the source obtained actively).

Test Requirements

The vendor and tester evidence **shall** be provided under **TE.07.13.01** and **TE.07.13.02**.

7.15 Entropy Assessment

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2015*

Effective Date:	*08/07/2015* [1]
Last Modified Date:	*05/07/2019*
Relevant Assertions:	*AS.07.13*
Relevant Test Requirements:	*TE.07.13.01 and TE.07.13.02*
Relevant Vendor Requirements:	

Background

Section 4.7 of FIPS 140-2 states that **"***compromising the security of the key generation method (e.g., guessing the seed value to initialize the deterministic RNG)* ***shall*** *require as least as many operations as determining the value of the generated key*.**"** **TE.07.13.02** further states that "*The tester* ***shall*** *determine the accuracy of any rationale provided by the vendor. The burden of proof is on the vendor; if there is any uncertainty or ambiguity, the tester* ***shall*** *require the vendor to produce additional information as needed.*"

Note that the FIPS 140-2 standard is not asking to compare the length of the seed of a random number generator to the length of a generated key. The question is about comparing the *numbers of operations* that are required to guess the seed and to determine the key. These numbers depend on the amount of entropy produced by the source that generated the seed.

Question/Problem

As of the last modified date of this **IG**, standards do not yet exist for the embodiment or construction of an entropy source or the mechanisms to gather entropy.

As of the last modified date of this **IG**, test methods do not yet exist for determining the conformance of an entropy embodiment, construction or a gathering mechanism.

As of the last modified date of this **IG**, statistical methods to determine the conformance of an entropy embodiment, construction or a gathering mechanism have not been standardized.

The FIPS 140-2 DTR states the tester **shall** verify that the vendor provided documentation that provides rationale stating how compromising the security of the key generation method (e.g., guessing the seed value to initialize the deterministic RNG) **shall** require as least as many operations as determining the value of the generated key. The tester **shall** determine the accuracy of any rationale provided by the vendor.

What information **shall** the testing laboratory provide in the test report submitted to the CMVP? How should the tester determine the accuracy of any rationale provided by the vendor?

[1] There are some cases of modules incorporating third-party hardware entropy sources that may not meet all documentation and test requirements set forth in this IG due to a lack of cooperation from the third-party vendor or other legal constraints. To allow adequate time to adapt to the documentation and test requirements in this IG to vendors that use third-party hardware sources, until December 31, 2016 the CMVP allows vendor-affirmation by the vendor of the module in lieu of full testing of the entropy source. The vendor-affirmation statement must be signed by a corporate officer of the company sponsoring the validation and contain an estimate of the assumed amount of entropy from the third-party and a stated assumption of residual security risks that may result from the incomplete testing of the third-party entropy source. The laboratory must include this vendor affirmation in the entropy report for the tested module. Note that the CMVP expects all laboratories and vendors to work in good faith to test the entropy sources fully and resort to this provision only in extreme cases. The CMVP reserves the right to consider a limited number of special cases by vendors who may be able to substantiate a hardship case as the result of the December 31, 2016 deadline. The CMVP will work with them on a case-by-case basis to minimize the negative impact.

Resolution

This IG must be used together with IG 7.14 Entropy Caveats that shows various scenarios for reporting the relationship between the amount of gathered entropy and the apparent (that is, length-based) strength of the cryptographic keys established by the module. Depending on the applicable scenario, as explained in IG 7.14 Entropy Caveats, an entropy estimate may or may not be required. If entropy estimation is required, the testing laboratory and the vendor **shall** follow the directions given in this IG.

The IG shows how to perform entropy estimation when the vendor cannot claim that the source is compliant with **SP 800-90B**. Upon the expiration of the transition period defined in IG 7.18, all sources in the newly-validated modules would need to be compliant with **SP 800-90B**.

The testing laboratory **shall** provide the following documentation as a **PDF** addendum to the submitted test report to meet the requirements of **AS.07.13** and **AS.07.16**:

1. A detailed logical diagram **shall** illustrate all of the components, sources and mechanisms that constitute an entropy source. These components may include the Linear Feedback Shift Registers LFSRs, noisy diodes, thermal sampling, entropy service calls from other FIPS 140-2 validated modules, clock readings, memory cache hits, as well as various human-induced measurements, such as the time intervals between the keystrokes, mouse movements, etc.

2. Tester's arguments in support of the accuracy of vendor-provided rationale.

3. (Optional but *strongly* recommended) Results of statistical testing using an appropriate set of tests. The statistical testing may either be performed by the testing laboratory or by the vendor. The explanation of the test results **shall** include the assumptions that have been made, how many bits of data have been collected, what the p-value (or an equivalent parameter) of the test is, and what numerical values were obtained to demonstrate that the test results supported the vendor provided rationale. Typically, it takes several statistical tests to obtain a reasonable estimate of entropy. Some tests establish the degree of confidence in the independence of the observed values. Other tests may examine the short and long runs of bits and again, check the behaviors of these runs for their consistency with the claimed properties of the tested source. NIST SP 800-22-rev1a and the current draft of NIST **SP 800-90B** *may* be used as informative guidance. The rationale **shall** be mathematically sound and consistent with vendor claims of the strengths of the generated cryptographic keys.

The CMVP will determine during the report review if the information provided in the testing laboratory's test report is acceptable. During the report review coordination process the testing laboratory may follow up with additional details to support the previously provided rationale.

This **IG** may be rescinded or modified when standards are published, and conformance testing developed for entropy security strength testing. A suitable transition period will be granted to vendors.

Additional Comments

1. If the module is using a non-deterministic RNG approved for use in classified applications as allowed in Section 4.7.1 of FIPS 140-2 then provided entropy is assumed to provide N bits of entropy based on the length N of the entropy field (unless the vendor chooses to state that a smaller amount of entropy has been received).

2. Following are some examples of the heuristic analysis of entropy that the testing laboratory may perform:

   The vendor may say that 6 bits of entropy are gathered by measuring the time intervals between the human touches of the keyboard; 10 bits of entropy come from the decimal fraction in the value of the time of day when a certain event took place, another 10 bits come from the timing or frequency or another property of software interruptions measured by the module. These are all reasonable estimates for a wide range of devices although their validity can only be accepted by the CMVP in the context of the particular module being validated. If the time of day is measured, for example, every 3 seconds or less frequently, it can be argued that if this time is represented as hh:mm:ss.zzz, where zzz is the decimal fraction of a second measured up to the third decimal point (thus three "z" in the above expression), then the zzz values of different measurements are nearly independent and each can take 1,000 different values, thus yielding approximately 10 bits of entropy. The independence of clock measurements at different frequency is very important. The best case is when the module has different time sources, entirely independent down to the hardware. If the time measurements were taken every 0.5 seconds or so, then the three-digit zzz values would not be independent and therefore the 10-bit entropy value could not be claimed. In this case, the CMVP would accept a claim of 7 bits of entropy. The reason is that if the time measurements are taken every 500 milliseconds as in this example, then the values made out of the second and third "z" after the decimal point are 'almost' independent (and there are 100 of them) and the first z has some randomness in it as well, so the resulting variability of the zzz values is somewhat similar to having 128 equally likely scenarios (100 plus a little more thanks to the first z) and this is leading to the 7 bits of entropy. The CMVP may even accept a claim of 8 bits of entropy in this case if a slightly more sophisticated argument is made to support such a claim.

If the entropy is generated by a physical device, again a heuristic argument should be made. If this device is a radioactive isotope such that the average decay rate is known and the random value is the number of atoms that have decayed in a particular time period, the lab should state some known facts about the mean rate of the decay and also about either the distribution or at least about the variance of the number of the decaying atoms and give a rough estimate of the generated entropy. Note that in this scenario, not all outcomes (numbers of the decayed atoms) are equally likely, the values around the mean come with the highest probability, an IID claim (that the random variables are Independent and Identically Distributed) most likely cannot be made and therefore the vendor should either use the "min-entropy" estimate for the non-IID sources or come up with another reasonable and statistically sound estimate of generated uncertainty.

If the entropy is generated by oscillating rings, the vendor will need to explain the design of the random noise generator. The design description in http://csrc.nist.gov/groups/ST/rbg_workshop_2012/shankar.pdf may serve as an example. However, to complete the description of the entropy source from the referenced presentation, the vendor still needs to explain, at least heuristically, how the jitters are measured, how these measurements are used to generate the seed value for an approved RNG or DRBG and how much entropy the seed value carries. A special consideration **shall** be given to the speed of generating bits and the frequency of recording the results in claiming their independence.

If the RNG is reseeded frequently, the overall entropy increases if the lab can make a reasonable heuristic claim of the independence of the individual entropy values. Obviously, if the entropy comes from the minute value in the time of day and the module measures this time value every second, there is not much uncertainty in the minute field after the first measurement. The decaying isotope is, however, going to continue to decay independently (in some sense, and after adjusting by the number of the remaining atoms) of its history and therefore in this case the entropy values can be added without providing any further justification.

If the entropy is coming from an operational environment of the module, then again, some analysis should be made of the source of entropy. If this source is the /dev/random or the /dev/urandom function in one of the common operating system (OS), the justification of the generated entropy (possibly, provided by the vendor of the OS) will be required. In addition, the lab may refer to an independently published analysis of dev/random and dev/urandom. See, for example, "The Linux Pseudorandom Number Generator Revisited," Lacharme at al. 2012, (https://eprint.iacr.org/2012/251.pdf) .

The /dev/random justification is the easier of the two. This OS entropy source will satisfy a request for a random value only when it believes it has collected "enough" entropy; that is, when its own estimate of the collected entropy is such that a module's request can be met. For example, if the module needs to generate a 128-bit AES key and therefore the module requests 128-bits of entropy then the dev/random call would block until it is able to generate this much entropy. This, the module cannot generate the aforementioned AES key until enough entropy is gathered and the call to /dev/random returns.

In case of the /dev/urandom request, the call to this OS entropy generator is non-blocking. The data obtained from the non-blocking call is not guaranteed to possess the desired amount of entropy. How can the vendor provide the assurance that the requirements of the FIPS 140-2 AS.07.13 assertion are satisfied?

To meet these requirements, the vendor must first demonstrate that the initial call (that is, the first call after the module has been powered up or instantiated) to /dev/urandom returns the claimed amount of entropy. A possible way to achieve this is to analyze the sequence of events that precedes this initial call. If, for example, this sequence includes several restarts of the module and if each of these restarts includes several events that are measured and that provide the desired uncertainty, then a heuristic claim about the entropy in the initial call can be made. These events may include the times between the restarts, the measurements of an operator activity during the restarts (mouse clicks, etc.), the values stored in certain memory locations that are known to be unpredictable during the restarts. The events accumulated in one restart are accumulated to the events from previous restarts and persisted on the system for later use. This argument has a good chance of succeeding for the stand-alone modules; the embedded modules normally do not require multiple restarts so the use of dev/urandom in such modules is harder to justify.

If the vendor can justify having the desired amount of entropy returned on the first call to /dev/urandom, then the vendor can continue to claim that at least this much entropy (not necessarily independent of the initial entropy of the first call) is generated on each subsequent call. To see this, suppose that the OS collects a pool A with 256 bits of entropy prior to returning the first /dev/urandom request. Suppose that the request is returned in the form of E1 = SHA256(A). The module can then claim that the keys generated using the entropy received from the /dev/urandom call possess 256 bits of entropy. If, however the request is returned in the form of E1 = SHA1(A), then E1 possesses only 160-bits of entropy.

Suppose now that the OS generates the entropy pool B between the first and the second /dev/urandom calls. The field returned by /dev/urandom to the module is E2 = SHA256(B||SHA256(A)). (A particular implementation may use a different formula for E2, but again with a dependency on both B and SHA256(A).) As long as B is not an empty field and is not a function of SHA256(A) then regardless of the amount of entropy in B this returned field E2 contains at least 256 bits of entropy. Therefore, keys generated from the randomness in the second /dev/urandom call also possess at least 256 bits of entropy (not necessarily an independent entropy from the first call.) Similarly, if E2 = SHA1(B||SHA1(A)) would result in E2 containing 160-bits of entropy.

Note that the entropy estimates in the above example cannot be added automatically. That is, because B and A are not necessarily independent, one cannot claim that E1 || E2 contains more entropy than either E1 or E2 alone. if, A could only be shown to possess 128 bits of entropy and B could not be demonstrated to have any specific new entropy amount independent of A (a typical scenario when running /dev/urandom multiple times) then the entropy collected from E1 and E2 (that is, from the first and second calls to /dev/urandom) would only amount to 128 bits, not 256 bits.

3. Here is a possible way to estimate the generated min entropy that the CMVP will allow until a further notice. This is a dramatic simplification of one of the methods proposed in the current draft of **SP 800-90B**. This method of entropy estimation, if shown by the lab or the vendor to be applicable to a given module, would be allowed prior to the publication of **SP 800-90B** and during the transition period that would follow. At some point in the future, the CMVP would expect all vendors to comply with **SP 800-90B**.

   This method would only apply if unprocessed (non-whitened) noise sources (and any conditioning components, if applicable) are IID (independent and identically distributed random variables). See Section 9.1.1 of the August 2012 draft of **SP 800-90B** or any Statistics textbook for an explanation of this notion. The sources do not have to produce the uniform distribution of the outcomes: the probabilities of different outcomes may be different. However, the probability distributions are identical between the sources (or between the different consecutive readings of each source's random output) and these probabilities do not depend on the outcomes of other events generated by these sources.

The August 2012 draft of **SP 800-90B** shows the sequence of statistical tests that would allow the vendor to test if the noise sources are indeed IID. These tests are quite complicated. Furthermore, if the tests support the IID assumption the draft **SP 800-90B** standard presents a complicated and, arguably, a very conservative method of estimating the min entropy.

The alternative this IG offers is for the vendor to present the heuristic arguments in favor of the IID assumption. Any reasonable argument will be considered by the CMVP and if the sources are truly IID it should not be difficult for the vendor and the lab to make such arguments.

Once the IID assumption has been accepted (or, in a more formal way, the IID hypothesis has not been rejected) the vendor may estimate the min entropy as follows (compare this to the algorithm in Section 9.2 of the August 2012 draft of **SP 800-90B**.)

Find the probability p_{max} of the most common outcome among all the possible events generated by the noise source. If this probability is already known, then use it. (Give the justification to why this probability is what it is claimed to be.) If p_{max} is not known, then, following the draft of **SP 800-90B**, take a dataset with *N* samples and count the occurrences of the most common value in the dataset. Again, following the draft of **SP 800-90B**, count the number of occurrences of this most common value in the dataset and denote the result C_{max}. Set $p_{max} = C_{max} / N$.

The **SP 800-90B** draft then tells how to establish the 99% confidence interval for $p_{\max}$ and then compute the min entropy estimate based on the upper bound of this confidence interval. However, at this time the CMVP will accept a far less conservative and simpler-to-compute estimate of min entropy from the value of p_{max} itself. Simply set $H = -log_2(p_{max})$ and use this value H as the entropy. For example, if the most common event happens with the probability $1/2^{128}$, the estimated min entropy is 128 bits regardless of the probabilities of the occurrences of other less frequent events generated by the same source.

4. This IG applies to the generation of both symmetric cryptographic keys and seeds that serve as the starting points for the asymmetric algorithm key generation (such as the RSA keys). Once the analysis of the generated entropy has been made according to this IG, the TE.07.16.01 and TE.07.16.02 assessments, using **SP 800-133** or IG 7.8, **shall** show how the generated keys can be assured of possessing sufficient entropy to account for the target key strength.

Test Requirements

The vendor and tester evidence **shall** be provided under **TE.07.13.01** and **TE.07.13.02**.

7.16 Acceptable Algorithms for Protecting Stored Keys and CSPs

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2015*
Effective Date:	*08/07/2015*
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS07.21*
Relevant Test Requirements:	*TE07.21.01*
Relevant Vendor Requirements:	*VE07.21.01-02*

Background

Rules for key storage are described in some general terms in FIPS 140-2. The standard, however, does not list **any approved or allowed methods for encrypting keys or CSPs stored within the cryptographic module.**

Question/Problem

In Section 4.7.5 of FIPS 140-2 it is stated that "cryptographic keys stored within a cryptographic module **shall** be stored either in plaintext form or encrypted form." What does this mean? The above statement may appear to indicate that there are no requirements on key storage inside the module. However, the zeroization requirement does apply to "all plaintext secret and private cryptographic keys and CSPs within the module." Keys and CSPs that are cryptographically protected are not plaintext and are exempt from this requirement. Therefore, it is necessary to know what constitutes, in this context, an acceptable "protection" of stored keys and CSPs.

In particular, it should be made clear whether the encryption of a stored key or a CSP using a symmetric-key-encryption algorithm such as AES or the Triple-DES needs to satisfy the same requirements that apply to the protection of the cryptographic keys that are transported in and out of the module. The latter requirements and methods of meeting them are described in **SP 800-38F**.

Resolution

Keys and CSPs may be stored within a module in any form – encrypted or unencrypted. To make a claim that keys and CSPs are stored encrypted, or, more precisely, "protected", the module **shall** protect them using one of the following algorithms:

- An AES or a Triple-DES encryption using any approved mode of AES or the Triple-DES as defined in Annex A of FIPS 140-2
- An RSA-based key encapsulation that may either comply with the requirements of **SP 800-56B** or be allowed by IG D.9.
- An approved hash algorithm for a CSP such as a password that does not need to be recovered but is used to check if it matches any other values.

The requirements of **SP 800-131A** for the encryption and key encapsulation key sizes apply if a stored key or CSP is claimed to be protected.

Additional Comments

1. Even though this guidance does not mandate the use of authenticated encryption algorithms from **SP 800-38F** it is *highly* recommended vendors adopt them because these algorithms are specifically designed to protect the confidentiality and the authenticity/integrity of cryptographic keys.

2. The AES and Triple-DES algorithm implementations used to protect stored keys and CSPs **shall** be tested by the CAVP.

3. It follows from this IG and IG D.9 that if the AES or the Triple-DES encryption is used then the requirements for encrypting stored keys and CSPs are different from those when keys are transported in and out of the module. It is, however, strongly recommended that the rules of IG D.9 are followed in this case as well.

   If an RSA-based key encryption (encapsulation) is used to protect keys and CSPs the requirements are the same regardless of whether or not the protected key or CSP leaves the module's boundary.

4. If the AES or the Triple-DES encryption is used to protect a stored key, the key encryption key may be established as shown in **SP 800-132**.
5. The **SP 800-131A** notation in this Implementation Guidance refers to the latest published revision of this standard.

7.17 Zeroization of One Time Programmable (OTP) Memory

Applicable Levels:	*All*
Original Publishing Date:	*11/15/2016*
Effective Date:	*11/15/2016*
Last Modified Date:	
Relevant Assertions:	*AS.07.41*
Relevant Test Requirements:	*TE07.41.01-04*
Relevant Vendor Requirements:	*VE.07.41.01*

Background

The One Time Programmable (OTP) memory is a form of digital memory where the setting of each bit is locked by a fuse or antifuse. It provides a flexible, field-programmable alternative to Read Only Memory (ROM).

Question/Problem

If OTP is used within a module, how can the module meet FIPS 140-2 zeroization requirements? Are there specific zeroization requirements for OTP implementations?

Resolution

OTP can be used for storing plaintext secret and private cryptographic keys and CSPs within the module. However, the module **shall** be implemented in the following way in order to meet FIPS 140-2 zeroization requirements:

1. Given that the OTP should be writable during module operation, the module **shall** provide the operator with the ability to zeroize all of the keys and CSPs stored in OTP by overwriting the memory with 0s or 1s. This will likely decommission the module but will prevent attackers from gaining knowledge of secret data stored within the OTP.

2. After OTP keys have been zeroized, the module **shall** recognize the zeroized value as invalid and restrict the use to this value. This might be by using an additional bit that is flipped, or else code that knows the zeroization value is invalid such as an integrity value that is not correct after zeroization.

3. OTP storage of data is more likely than other types of data storage to have integrity values associated with the information. Therefore, any integrity value on the OTP **shall** be treated as a CSP (and thus subject to zeroization) unless the vendor demonstrates that it does not leak information about the original key. This follows the definition of a CSP in that a key is considered a CSP if disclosing or modifying it could compromise the security of the module. Therefore, if integrity values are stored on the OTP, the tester or vendor **shall** either have the ability to zeroize these values, or provide evidence to the CMVP that disclosure or modification of these values would not compromise the security of the module or the values in which the integrity values are protecting.

Additional Comments

Once data is fused onto the OTP, the process is irreversible. Therefore, keys and CSPs that are stored on the OTP are unlikely to be modified, written to, or stored during module operation. This makes the data that is on the OTP prior to module operation likely intended for long time term use and unchanged throughout the lifetime of the module. Regardless, the zeroization requirements explained in this IG applies.

7.18 Entropy Estimation and Compliance with SP 800-90B

Applicable Levels:	*All*
Original Publishing Date:	*05/07/2019*
Effective Date:	*05/07/2019*
Transition End Dates	***11/07/2020***
Last Modified Date:	*11/05/2021*
Relevant Assertions:	*AS.01.12, AS.07.13, AS.07.16*
Relevant Test Requirements:	*TE.01.12.01, TE.07.13.01, TE.07.13.02, TE.07.16.01, TE.07.16.02*
Relevant Vendor Requirements:	*VE's associated with the TE's above*

Background

Section 4.7 of FIPS 140-2 states that "*compromising the security of the key generation method (e.g., guessing the seed value to initialize the deterministic RNG)* ***shall*** *require at least as many operations as determining the value of the generated key*." TE.07.13.02 further states that "*The tester* ***shall*** *determine the accuracy of any rationale provided by the vendor.*"

There was no NIST standard for entropy estimation prior to January 2018. When entropy estimation is required (according to an applicable scenario of IG 7.14), testers have used the rather loose guidelines of IG 7.15 to review the properties of an entropy source and to estimate the amount of generated entropy. IG 7.15 allows various kinds of entropy measurements (Shannon entropy, min-entropy, collision entropy, and others).

With the publication of **SP 800-90B**, which uses the min-entropy measurement of entropy, vendors and testers have received a standard against which they can design, build and test their entropy sources. Since the amount of the generated entropy is the most critical component of an estimate of the overall security of the module's cryptographic operations, it is necessary to transition to full compliance with the **SP 800-90B** standard.

Question/Problem

What does the vendor need to do to claim compliance with **SP 800-90B**?

When will the **SP 800-90B** compliance become mandatory?

What will be the status of the cryptographic modules validated to FIPS 140-2 before the **SP 800-90B** compliance became mandatory?

How **shall** the compliance with the entropy-generation requirements be documented in the module's validation certificate?

When establishing the source's compliance with **SP 800-90B**, how **shall** a laboratory test it and verify the vendor's claims?

Resolution

If the test report for a cryptographic module is submitted for validation after November 7, 2020 (that is, more than eighteen months after the original publication date of this Implementation Guidance) and if this module falls under one of the scenarios of IG 7.14 that require entropy estimation, then the module **shall** be tested for its compliance with **SP 800-90B** and IG 7.19. The requirements represented by the "**shall**" statements in **SP 800-90B** apply and must be tested by the lab, with the possible exceptions as stated below in this Implementation Guidance and in IG 7.19. These requirements include running statistical tests on the raw entropy data, as explained in **SP 800-90B**. Statistical testing **shall** be performed using a software tool available at https://github.com/usnistgov/SP800-90B_EntropyAssessment. Besides the statistical testing, a CST laboratory is still responsible for performing a heuristic analysis of the entropy source, as this is required in Section 3.2.2, item 3, of **SP 800-90B**.

When claiming compliance with **SP 800-90B** to meet the requirements of **AS.07.13** and **AS.07.16**, the testing laboratory **shall** provide a **PDF** addendum to the submitted test report. This addendum **shall** include a detailed logical diagram showing all components of an entropy source and the numerical results of various tests required by **SP 800-90B**. The addendum **shall** contain both a rationale for why the final entropy assessment is consistent with both the **SP 800-90B** statistical tests and the required heuristic analysis of the entropy source, and a description of how the entropy source satisfies all of the **SP 800-90B** 'shall' statements.

When a cryptographic module is validated for its compliance with **SP 800-90B**, the module's validation certificate **shall** include one of the following entries on the approved algorithm line: **ENT (P)** or **ENT (NP)** where P stands for physical and NP for non-physical. See IG 7.20 for the precise definition of each entry.

Modules submitted for validation no later than November 7, 2020 may choose between compliance with **SP 800-90B**, as explained in this Implementation Guidance and in IG 7.19, and compliance with IG 7.15. If compliance with IG 7.15 is selected during this transition period, this will be annotated by an NDRNG entry on the 'non-FIPS approved algorithms' line of the module's validation certificate.

Any revalidation submission received after November 7, 2020 that extends the life of a validated module will need to demonstrate its compliance with **SP 800-90B**.

Additional Comments

1. In compliance with **SP 800-90B**, vendors **shall** provide access to the raw outputs of the entropy source. The vendor may use special methods (or devices, such as an oscilloscope) that require detailed knowledge of the source to collect raw data. The testing laboratory is required to include a section in the Entropy Test Report to present a rationale why the data collections methods will not alter the statistical properties of the noise source or explain how to account for any change in the source's statistical characteristics and its entropy yield.

2. The requirement 2 of Section 3.2.2 of **SP 800-90B** about the entropy source being stationary does not have to be met, as long as it can be guaranteed that the source is generating the sufficient amount of entropy even when operating at the lowest entropy yield. If the source may deteriorate to the point when the generation of the sufficient amount of entropy (sufficient to support the claims about the strengths of the generated cryptographic keys) can no longer be guaranteed, the module's Security Policy **shall** explain what action is to be taken.

3. The approved algorithms used in the vetted conditioning components **shall** be tested by the CAVP (if testing is available for them). This is a reiteration of a requirement from Section 3.1.5.1.2 of **SP 800-90B**.

   It is recommended that these algorithms undergo the power-up tests as specified in Section 4.9.1 of FIPS 140-2. However, these tests are not mandatory if an algorithm implementation is used solely in a conditional component of an entropy generation process.

4. A restart test requirement from Section 3.1.4.3 of **SP 800-90B** needs to be addressed. A failure of a restart test does not automatically disqualify the module from being validated. Should this failure occur, the lab

shall analyze the reason for a failure of the test and explain how the entropy requirement can be met in light of this failure.

5. For the applicability of entropy testing and for the specific validation certificate caveats, see IG 7.14.

6. When entropy source testing to **SP 800-90B** is applicable, the module's Security Policy **shall** document the overall amount of generated entropy and the estimated amount of entropy per the source's output bit.

7. The **SP 800-90B** testing tool's version number will be made available to users of the tool. This version number **shall** be included in the lab's Entropy Test Report.

8. The new entries, ENT (P) and ENT (NP), on the approved algorithm line do not include the algorithm certificate numbers. This makes them look different from other entries on the same line. As the process of testing to **SP 800-90B** matures, the CAVP/CMVP will consider issuing the numbered algorithm certificates for the **SP 800-90B**-compliant entropy sources and maintaining a webpage where the details of the test results for the sources that provide entropy to validated modules will be shown.

9. Should the vendor decide to claim an IID assumption of the samples generated by the noise sources, they will need to provide a rigorous proof in support of this claim. As the majority of the noise sources do not produce the IID events, any IID claim by the vendor will be thoroughly vetted by the validation body. A claim of independence and that of an identical distribution **shall** be substantiated separately. For an independence claim, a deep understanding of the underlying operation of the noise source is required. A claim of an identical distribution of the samples **shall** consider a possible deterioration of the source's entropy generation pattern due to the mechanical or the environmental changes or to the timing variations in human behavior.

   Further instructions can be found in Section 3.1.2 of **SP 800-90B**.

10. Note that even if an IID claim is accepted, the Most Common Value entropy estimate for the IID sources in Section 6.3.1 of **SP 800-90B** is more conservative than that offered in IG 7.15. Once the transition to **SP 800-90B** is completed, the IG 7.15 formula for entropy estimation for the IID sources will no longer be acceptable.

11. A module submitted for validation no later than on **November 7, 2020** can be validated to IG 7.15 requirements. This validation will not be affected by the transition. In addition, a new module (any validation or revalidation scenario) submitted *after* November 7, 2020 may use entropy from a previously validated embedded or bound module as long as it is on the active list. The new module's sunset date will be that of the embedded or bound module and the new module will move to the historical list if the embedded or bound module moves to the historical list for any reason. The CMVP will provide future guidance if an embedded/bound module became historical because of an algorithm transition, and the binding/embedding module does not use the embedded/bound module's historical functionality.

12. The CMVP allows other parties, such as the vendor or a third-party consultant, to contribute to or to write the labs' entropy source description and its heuristic entropy analysis if the following conditions are met:

    a. The lab **shall** be responsible for the content submitted. The lab **shall** perform a thorough review of the submission, be accountable for the content of the Entropy Test report and respond to any CMVP comments. As a result, if the report contains serious shortcomings the CMVP will hold the lab responsible (e.g. by assigning an ECR in accordance with the CMVP FIPS 140-2 Management Manual).

    b. The lab **shall** communicate with the CMVP. The CMVP will communicate with the lab and not the vendor or a third-party since it is the lab that the CMVP and the NVLAP have accredited to perform an independent review and testing. The lab **shall not** act solely as an intermediary by passing comments from the CMVP to the vendor or a third party as the lab **shall** possess a full understanding of the content of the Entropy Test report. In some rare cases, the vendor or a third-party may be invited to a meeting between the CMVP and the lab.

    c. The lab **shall** explain how the collected entropy is used by the module. Specifics regarding how the module makes use of the entropy generated **shall** be the responsibility of the lab (e.g., the full entropy requirement for a CTR_DRBG without a derivation function or internal entropy generation to justify the properties of various algorithm parameters, including IVs).

7.19 Interpretation of SP 800-90B Requirements

Applicable Levels:	*All*
Original Publishing Date:	*08/28/2020*
Effective Date:	*08/28/2020*
Transition End Date:	***11/07/2020***
Last Modified Date:	*03/17/2023*
Relevant Assertions:	*AS.01.12, AS.07.13, AS.07.16*
Relevant Test Requirements:	*TE.01.12.01, TE.07.13.01, TE.07.13.02, TE.07.16.01, TE.07.16.02*
Relevant Vendor Requirements:	*VE's associated with the TE's above*

Background

SP 800-90B was originally added to FIPS 140-2 Annex C on June 10, 2019. This was preceded by a release of IG 7.18 on May 7, 2019, an IG that specified how entropy sources with claims of compliance to **SP 800-90B** would be evaluated and tested within the CMVP program. As of **November 7, 2020**, all newly submitted modules requiring an entropy evaluation must demonstrate compliance to **SP 800-90B**.

Question/Problem

Some ambiguities in the **SP 800-90B** document have been publicly documented. Vendors and testing laboratories would like to know the CMVP's interpretation of the requirements in **SP 800-90B** so that evaluations against these requirements are consistent between laboratories. In addition, vendors producing designs intended to meet these requirements would prefer to experience less risk of eventual non-compliance due to differing interpretations of this document within the FIPS 140-2 validation program.

Resolution

Digitization

1. For Section 2.2.1, the vendor **shall** justify why all processing occurring within the digitization process does not conceal noise source failures from the health tests or obscure the statistical properties of the underlying raw noise output from this digitization process.

   Note: This resolution may impact designs that combine the outputs of multiple copies of the same type of physical noise source (see also Resolution #10). For example, in some designs the XOR of the output of noise source copies may pass most statistical tests, even when the noise source copies are in a failure mode where their outputs are wholly deterministic (and thus entropy free). Designs that include such a digitization step require thorough arguments that the included health tests detect degraded and failure modes of the noise source, and that the statistical assessment of the identified raw data is meaningful. One possible approach for such designs is to designate the raw data sample as the outputs of all the noise source copies present concatenated as a string, and then describe the XOR tree as a first stage of non-vetted conditioning. The tester **shall** provide a detailed description of all digitization processes used within the noise source and describe the format of the raw data that was tested. (See **SP 800-90B** Section 3.2.2 Requirement #3, and Section 4.3 Requirements #1, #6, #7, #8, and #9).

IID Claim

2. For Section 3.1.2, use of the IID-track requires that

> "The submitter makes an IID claim on the noise source, based on the submitter's analysis of the design. The submitter shall provide rationale for the IID claim."

IG 7.18 states that

> "Should the vendor decide to claim an IID assumption of the samples generated by the noise sources, they will need to provide a rigorous proof in support of this claim. As most noise sources do not produce the IID events, any IID claim by the vendor will be thoroughly vetted by the validation body. A claim of independence and that of an identical distribution **shall** be substantiated separately. For an independence claim, a deep understanding of the underlying operation of the noise source is required. A claim of an identical distribution of the samples **shall** consider a possible deterioration of the source's entropy generation pattern due to the mechanical or the environmental changes or to the timing variations in human behavior."

The testing laboratory **shall** evaluate the technical accuracy and completeness of any IID rationale made by the vendor. If it is not possible for the vendor to produce such a rigorous proof and/or is not possible for the laboratory to verify the correctness and completeness of the vendor's rationale, then the vendor **shall not** make an IID claim for the noise source. (See **SP 800-90B** Section 3.1.2, Section 3.2.2 Requirement #5, IG 7.18).

Conditioning Components

3. For Section 3.1.5, any processing of the raw data output from the noise sources that happens before it is ultimately output from the entropy source **shall** occur within a *conditioning chain*: a finite sequence of one or more conditioning components where each conditioning component in the chain receives any input data that is claimed to contain entropy from either the primary noise source (for the first conditioning component in the conditioning chain), or from the previous conditioning component in the conditioning chain (for all other conditioning components). An entropy estimate for the output of each conditioning component making up the conditioning chain **shall** be provided. For each non-vetted conditional component within a chain, an entropy estimate h', defined in Section 3.1.5.2, **shall** be computed using the statistical tests on the conditioned sequential data set for this component, as specified in Section 3.1.5.2. The entropy source's entropy rate is the entropy rate output from the final conditioning component in the conditioning chain.

   Note 1. As stated in Resolution #9 below, if the conditioning function is bijective then the vendor may claim that the entropy of the conditioned output, h_{out}, is equal to the entropy of the input, h_{in}. If claiming this property, it is the responsibility of the vendor and the testing lab to demonstrate that the mapping performed by the conditioning function is indeed bijective. They **shall** describe the set A of random data samples before conditioning [1], the set B of samples after the conditioning, and then show that the mapping of A to B performed by the conditioning function is both injective (the different elements of A map into the different elements of B) and surjective (every element of B has an element of A that maps into it.)

   Note 2. In view of the **SP 800-90B**, Section 3.1.5.2, requirements, the output of a non-vetted conditioning component that was not shown by the vendor to be a bijective mapping, cannot be considered as having "full entropy", so the output of any entropy source whose conditioning chain ends with a non-vetted non-bijective conditioning component cannot be considered as having "full

[1] If the conditioning component is the first (or only) component in the chain of conditioning components in an entropy source, then set A is the alphabet, as defined in Section 1.3 of SP 800-90B.

entropy".

Note 3. If the bijection property can be demonstrated for a non-vetted conditioning component, then the statistical testing *for this conditioning component* described in Section 3.1.5.2 of **SP 800-90B** does not need to be performed. Note that the vendor may choose not to claim the conditioning component's bijective property (even if they can prove that the component possesses this property), and instead perform an analysis of the conditional component's output entropy as specified in Section 3.1.5.2 of **SP 800-90B**.

Note 4. This Resolution does not preclude the inclusion of input data from additional noise sources (see **SP 800-90B** Section 3.1.6) or of supplemental data (see Resolution #6) into vetted conditioning components, as such data is not credited as containing entropy in **SP 800-90B**.

4. For Section 3.1.5, for each conditioning component within the conditioning chain, the vendor **shall** specify:

    a. the parameter n_{in}, a lower bound for input data obtained from the primary noise source (for the first conditioning component) or the prior conditioning component in the chain (for all other conditioning components), and

    b. the parameter h_{in}, a lower bound for the assessed entropy supplied within this data.

    Note 1. While the above definition of n_{in} may appear to be different from that in **SP 800-90B**, the definition of n_{in} in this IG reflects the intended meaning of this parameter: the size of the input data string from the primary noise source that is credited with the generation of entropy. Any data input into a conditioning component that is not credited with the generation of entropy does not affect the value of n_{in}.The actual amount of data and entropy provided to each conditioning component per-output may vary, so long as the specified lower bounds are consistently satisfied (See **SP 800-90B** Sections 3.1.5, 3.1.5.1.2, 3.1.6, and Section 3.2.3 Requirements #1 and #4).

    Note 2. The output of any conditioning component in a conditioning chain may be used as a source of supplemental information for any vetted conditioning component at the same stage of that conditioning chain or earlier (see also Resolution #6).

5. Conditioning components (described in Section 3.1.5 and its subsections, and in Section 3.2.3) are permitted to retain state between invocations.

    Resolution #9 allows the vendor to argue that a conditioning function is bijective, and thus preserves entropy. For non-bijective conditioning functions, this is not in general true.

    When a non-vetted conditioning component is used, **SP 800-90B** Section 3.2.3 Requirement #5 obliges the vendor to justify the appropriateness of any non-vetted conditioning function. In the case that the conditioning component retains state, interactions between this retained state and the input data can additionally reduce the output entropy, as the retained state may allow for interactions between the conditioning component's inputs across different invocations.

    If a non-vetted conditioning component retains state and the primary noise source is non-independent, then the vendor **shall** provide mathematical evidence that the conditioning component's entropy output is not below its assessed value (h_{out}). (See **SP 800-90B** Section 3.2.3 Requirement #5). This mathematical evidence **may** provide and justify an upper bound for the reduction of the conditioning component's output entropy due to the cancellation of mutual information present in both the data input to the conditioning component and the retained state (for example, if a conditioning component updates its internal state by XORing the prior state with the input data, then inputting the same value into the conditioning component twice, even in different invocations, will cancel the entropy contributed by this value). This mathematical evidence **shall** justify why the reduction of the conditioning component's output entropy due to the cancellation of mutual information present in both the data input to the conditioning component and the retained state does not result in the output entropy of the conditioning component being below its assessed value (h_{out}).

There are additional considerations when the stateful conditioning component is a DRBG. For every request to GetEntropy from the entropy source, at least n_{in} bits must be provided to the stateful conditioning component (where n_{in} is defined for the conditioning component and provides h_{in} bits of entropy). If the conditioning component is a DRBG, the conditioning component **shall** have prediction resistance enabled, or **shall** be reseeded before requesting an output using at least n_{in} bits from the noise source, or the previous conditioning component. A stateful conditioning component **shall not** output any bits without obtaining at least n_{in} bits from the primary noise source or the previous conditioning component. A DRBG is not a bijective conditioning function. The length of the output of the DRBG **shall** be at most equal to the security strength of the DRBG. If the DRBG is used in other contexts than as a conditioning component for the entropy source, the DRBG **shall** be reseeded both before and after bits are requested in the other context. This may occur when one DRBG instance has been instantiated to serve multiple applications such as within an operating system. The submitter **shall** describe how the DRBG is initialized, the security strength, and if applicable, how the DRBG is rekeyed.

Note 1. All non-vetted conditioning components (including the bijective ones) are required to meet **SP 800-90B** Section 3.2.3 Requirement #5. None of the "shall" requirements specified in **SP 800-90B** Section 3.2.3 Requirement #5 apply to vetted conditioning components.

Note 2. The maximum number of bits per request from a DRBG used as a conditioning component stated in this resolution is smaller than the specified max_number_of_bits_per_request provided in **SP 800-90A**. The maximum set in this resolution takes precedence only in this use case of a DRBG.

6. For Section 3.1.5 and its subsections, a vetted conditioning component may optionally take a finite amount of supplemental data (e.g., data from additional noise sources, a prior output of this conditioning component or any conditioning component later in the conditioning chain, an input counter, a time stamp, etc.) in addition to the data from the primary noise source (for the first conditioning component in the conditioning chain) or from the previous conditioning component in the conditioning chain (for all other conditioning components in the conditioning chain). The presence of supplemental data **shall not** be credited for the purpose of computing h_{in} or n_{in}. (See **SP 800-90B** Sections 3.1.5.1.2 and 3.1.6).

7. For Section 3.1.5.1.1, for a conditioning function to qualify as "vetted", it **shall** consist solely of one of the listed vetted functions in this section or this IG. A conditioning function that integrates a vetted conditioning function as a subcomponent is not a vetted conditioning function unless the entire conditioning function is equivalent to one of the vetted conditioning functions listed in Section 3.1.5.1.1. A conditioning chain may be made up of a mix of vetted and non-vetted conditioning components (see also Resolutions #3 and #6).

   Note 1. A CAVP-validated **SP 800-90A** DRBG may be considered a vetted conditioning component. A CTR-DRBG, to be considered vetted, **shall** utilize the derivation function, or **shall** be provided with at least $seedlen$ bits of entropy as input, per request to GenerateBits where $seedlen$ is defined in Table 3 from **SP 800-90A**. The DRBG **shall** be seeded with h_{in} greater than or equal to the claimed security strength of the DRBG, in accordance with **SP 800-90A**. The DRBG **shall** also meet the criteria mentioned in Resolution #5. DRBGs that do not meet the listed criteria in this note may be submitted as non-vetted conditioning components.

8. For Section 3.1.5 and its subsections, nw **shall not** be greater than n_{in}. The narrowest width for non-vetted conditioning components **shall** be established by analysis of their designs. The tester **shall** describe how the application of Appendix E resulted in the reported narrowest internal width values. (See **SP 800-90B** Appendix E).

9. For Section 3.1.5, if the conditioning function can be shown to be bijective, then the vendor may claim that $h_{\text{out}} = h_{\text{in}}$. If this bijective conditioning function is non-vetted, then its output **shall not** be truncated, as per Section 3.1.5.2. None of the vetted conditioning components are bijective in their anticipated use. Any transform that is reversible is bijective, and the tester **shall** specify a detailed procedure for reversing any conditioning function that is claimed to be bijective. For example, encrypting the output of the noise source and outputting all the resulting ciphertext is clearly bijective, as one could decrypt the ciphertext and recover the original data. An example of a non- bijective conditioning function is any function that has a compression ratio greater than 1 for all input data, such as repeated XORing of raw data samples together to produce a single output the same width as the raw data.

Primary and Additional Noise Sources

10. Section 3.1.6 specifies that multiple copies of the same physical noise source are considered as a single noise source. Combining the outputs of the noise source copies under this provision **shall** be considered part of the digitization process, and so Resolution #1 **shall** apply. (See **SP 800-90B** Section 2.2.1 and Appendix B).

11. For Section 3.1.6, multiple ring oscillators may be treated as "copies", even in the instance where the design and layout of the ring oscillators vary.

12. The **SP 800-90B** document (including Section 3.2.2) and this IG specify requirements for noise sources. Only the "primary noise source" needs to fulfill the requirements that apply to a"noise source" where the term is unqualified by either "primary" or "additional".

13. In Section 3.2.2, Requirement #1 states

    > "The operation of the noise source shall be documented; this documentation shall include a description of how the noise source works, where the unpredictability comes from, and rationale for why the noise source provides acceptable entropy output."

    Requirement #3 describes how the estimate $H_{\text{submitter}}$ must be created:

    > "Documentation shall provide an explicit statement of the expected entropy provided by the noise source outputs and provide a technical argument for why the noise source can support that entropy rate."

    The technical argument supporting the expected $H_{\text{submitter}}$ value **shall** be based on the vendor's description of the source of unpredictability within the noise source and how the noise source outputs vary depending on this identified unpredictability. Statistical testing may be used to establish parameters referenced within this argument, but the $H_{\text{submitter}}$ value **shall not** be the result of some general statistical testing process that does not account for the design of the noise source.

Health Tests

14. Section 4.3 requires that

    > "The submitter shall provide documentation of any known or suspected noise source failure modes (e.g., the noise source starts producing periodic outputs like 101…01) **and shall include developer-defined continuous tests to detect those failures.**"

If the design integrates the described RCT and APT tests and these tests are shown to not detect the vendor-identified known or suspected noise source failure modes, then the developer **shall** include additional developer-defined continuous testing that does detect the vendor-identified noise source failure modes (irrespective of Section 4.4's statement that the RCT and APT are the only tests required). The tester **shall** verify that all the vendor-identified known or suspected noise source failure modes are detected by the continuous health tests included within the entropy source. (See **SP 800-90B** Section 4.3, Requirements #1, #7, #8 and #9).

15. For Section 4.3, Requirement #3, when stating the false positive rate (alpha) to satisfy the requirement, the false positive rate may be either the alpha used to generate the cutoffs for the APT/RCT tests or the actual observed false positive rate experienced by this health test when supplied with raw data from the noise source in use. The developer **shall** describe the exact meaning of the specified false positive rate and what the relation is between this false positive rate and any cutoff values used with the health tests.

16. For Section 4.4.2, the cutoff value C for the APT **shall** be no larger than the window size (i.e., $C \leq W$).

17. Many types of noise sources do not produce a constant min entropy per output, but instead produce a min entropy per output that is dependent on some internal state. For such noise sources, $H_{\text{submitter}}$ and $H = \min(H_r, H_c, H_I)$ in Sections 3.1.3 and 3.1.4.2 **shall** reflect an entropy bound that can be justified in the average case and/or on a per-symbol basis with high probability. When producing the arguments to meet the requirements of Section 4.5 for developer-defined health tests, it is acceptable to assume that the noise source produces raw data samples whose per-sample min entropy is equal to the assessed min entropy. (This is consistent with the assumptions used in the analysis of the **SP 800- 90B** Adaptive Proportion Test (APT) and the Repetition Count Test (RCT).)

18. For Section 4.5, when using simulation to argue that the developer-provided health test satisfies the requirements of Section 4.5, the developer **shall** specify how the data used within this simulation was created. Possible approaches include using:

    - the output data of simulated noise sources experiencing the anticipated failure modes,
    - the output data of an actual noise source that is forced into failure modes,
    - the output of an actual noise source interleaved with generated data that is statistically similar to the anticipated data output by the noise source in a failure mode, and
    - generated data that is expected to be statistically similar to the noise source output combined with generated data consistent with the failure mode being simulated.

    To fulfill the Section 4.5 requirements using simulation, at least 1 million rounds of simulation **shall** be used for each simulated health test, and there **shall** be sufficient simulation rounds so that at least five health test failures are observed for each health test. (See **SP 800-90B** Section 4.3, Requirement #1 and Section 4.5).

Full Entropy

19. To receive full entropy from the output of a conditioning component, the following criteria must be met:
    a. The conditioning component **shall** be vetted,
    b. h_{in} **shall** be greater than or equal to $n_{\text{out}} + 64$ bits,
    c. n_{out} **shall** be less than or equal to the security strength of the cryptographic function used

as the conditioning component.

Note 1. If n_{in} bits of full entropy are provided to a vetted conditioning component, then the output of the conditioning component will maintain full entropy.

Additional Comments

1. This Implementing Guidance does not address any issues that may arise when running the statistical tests defined in Sections 5 and 6 of **SP 800-90B** or interpreting their results. The CMVP has published an implementation of these tests [1] that includes many small corrections and enhancements to these tests described in **SP 800-90B**. This site also includes a mechanism for reporting errors in the tool, and to provide proposed fixes.

   Some further guidance helping the implementers and the testing laboratories interpret the **SP 800-90B** requirements can be found in IG 7.18.

2. **SP 800-90B** uses the term "submitter" for the party that presents an entropy source to the CMVP for their review of compliance within the scope of the cryptographic module's validation to FIPS 140-2. To be consistent with previously written Implementation Guidance, this term is substituted here for "vendor", except in places where the text quotes directly from **SP 800-90B**.

3. The tester **shall** verify that each conditioning component's implementation is fully consistent with the component's design. This verification **shall** be performed by means of either running a computerized test developed for testing just the conditioning component (separate from the statistical testing of the noise source) or by the code review. The Entropy Assessment Report submitted by the lab **shall** describe the chosen method for verifying the correctness of each conditioning component's implementation.

   The requirements in this Additional Comment apply to all conditioning components. While the design of the vetted components and of the non-vetted ones whose bijective properties have been demonstrated may guarantee that a certain amount of entropy will be output, the correctness of the components' implementations has not been established, thus requiring a separate testing or a code review by the CST labs.

   The CAVP testing of the approved cryptographic algorithms used in vetted conditioning components is required per Section 3.1.5.1.2 of **SP 800-90B**. Per IG 7.18, while it is recommended that the module performs the self-tests for these algorithms, this is not mandatory if an algorithm implementation is used solely in a conditional component of an entropy generation process. Note that a vetted conditioning component may include more than an approved cryptographic algorithm. For example, buffering may be performed before a cryptographic algorithm is executed. The requirement for the tester to verify the correctness of a conditioning component's implementation includes the testing or a code review of the functionality of the component that may not be addressed by the CAVP testing of the approved algorithms.

4. The decision of how the conditioning processing is partitioned into discrete conditioning components in a conditioning chain is established by the vendor. The vendor always retains an option to define the multiple conditioning components as a single function, in which case separate testing of components is not required.

   In many circumstances, it may be helpful to identify portions of conditioning that are performed by vetted conditioning functions as discrete conditioning components, as the assessed entropy for non-vetted conditioning components is limited by **SP 800-90B**'s required statistical assessment

[1] The CMVP implementation of the **SP 800-90B** test tool is available at the URL https://github.com/usnistgov/SP800-90B_EntropyAssessment

of the output of non-vetted conditioning components (see **SP 800-90B** Section 3.1.5.2 for details), truncation of the output of non-vetted conditioning components is disallowed (see **SP 800-90B** Section 3.1.5.2), and only vetted conditioning components can integrate input from additional noise sources (see **SP 800-90B** Section 3.1.6) or supplemental data (see Resolution #6).

5. This Implementation Guidance **does not** impose any *technical* requirements not currently stated in **SP 800-90B**. The purpose of this IG is to highlight some of the **SP 800-90B** requirements, show how the highlighted requirements can be satisfied, add certain requirements (such as those in Resolution #1) to avoid implementation mistakes, and provide some optional flexibility to vendors and testing laboratories.

7.20 Combining Entropy from Multiple Sources

Applicable Levels:	*All*
Original Publishing Date:	*05/04/2021*
Effective Date:	*05/04/2021*
Last Modified Date:	*05/04/2021*
Relevant Assertions:	*AS.01.12, AS.07.13*
Relevant Test Requirements:	*TE.01.12.01, TE.07.13.01, TE.07.13.02*
Relevant Vendor Requirements:	*VE.01.12.01, VE.07.13.01, VE.07.13.02*

Background

SP 800-90B, published in January 2018, specifies that entropy from only one *noise* source may be credited when estimating the output entropy of an *entropy* source. See Figure 1 and Section 3.1.6 in **SP 800-90B**. Multiple copies of the same physical noise source are viewed as a single noise source. An output from different noise sources may be concatenated together before invoking the conditional component(s) of an entropy source, but only one, primary, noise source produces entropy creditable towards the estimated entropy yield of the source. Again, see Section 3.1.6 of **SP 800-90B** for details.

The scope of **SP 800-90B** is limited to showing the requirements for a single entropy source. It does not say anything about combining entropy from multiple sources. This will be addressed in **SP 800-90C** when this standard, now in the draft form, gets published.

Question/Problem

Prior to the publication of **SP 800-90C**, can a cryptographic module combine entropy from various sources? If so, how to estimate the total amount of entropy generated by these sources?

Resolution

Entropy outputs from the multiple independent **SP 800-90B**-compliant entropy sources may be concatenated together to provide a DRBG seed.

Each entropy source is identified as either physical or non-physical. The definitions of the physical and non-physical noise sources are given in Section 2.2.1 of **SP 800-90B**. An entropy source is called physical or non-physical following the classification of the entropy-providing noise source within the entropy source.

Section 3.3 of the current (January 2021) draft of **SP 800-90C** offers two methods for counting entropy collected from multiple entropy sources. Each method allows concatenating the outputs of any number of both physical and non-physical sources. Method 1 counts only the entropy in the physical sources while Method 2 allows counting the entropy from both physical and non-physical sources. A valid min entropy claim for the concatenation of the output of multiple entropy sources is a sum of the individual entropies produced by a subset of those sources whose credited random behavior is independent of all other random behavior credited as providing entropy in that concatenation. If the vendor demonstrates the independence of all entropy sources contributing to the concatenated bitstring, then the total entropy is the sum of the individual entropies produced by the sources. If sources S1, S2 and S3 contribute entropy to the module, with S1 and S3 being the physical sources and S2 being non-physical, and the amounts of entropy generated by the sources are, correspondently, E1, E2 and E3, then Method 1 estimates the total entropy as E1 + E3, while the Method 2's estimate is E1 + E2 + E3.

While it appears that Method 2 is more advantageous as it produces, in the presence of non-physical sources, a higher entropy estimate, the vendor and the user **shall** be aware that, as pointed out in the draft of **SP 800-90C**, the entropy produced by a validated physical source is generally more reliable than the entropy produced by a validated non-physical source. Certain constructions described in the draft of **SP 800-90C** will only count entropy using Method 1. See, for example, the rules in Section 5 of that standard's draft for an RBG1 construction instantiation.

Prior to the publication of **SP 800-90C**, the CMVP will accept both Method 1 and Method 2 of entropy estimation.

It has become necessary to distinguish between the all-physical and not-all-physical validated entropy sources in the modules' certificates. IG G.13 shows how to annotate this differentiation by using the ENT (P) and ENT (NP) entries for the validated entropy sources. In line with the logic and the requirements of the current draft of **SP 800-56C**, the ENT (P) notation in the certificate indicates that all validated entropy sources creditable toward the module's total entropy estimate are physical; ENT (NP), that at least some of the creditable sources are non-physical. The Security Policy **shall** further explain the nature of the module's entropy sources, specify which of them are creditable, and indicate if Method 1 or Method 2 is used for entropy calculation.

Additional Comments

1. If the multiple entropy sources contributing to the concatenated string are mutually dependent then at most one of these mutually dependent sources may be credited; in this instance, the vendor may select which entropy source should be credited.
2. The current draft **of SP 800-90C** (Section 4.3) allows external conditioning of entropy sources: the conditioning that is performed outside an entropy source. An external conditioning might be useful when it is necessary to obtain a full entropy bitstring. At this time, the Implementation Guidance does not allow this form of conditioning.
3. When full entropy is required, such as when generating a seed for a CTR_DRBG without a derivation function, each of the contributing entropy sources **shall** be shown to generate the full-entropy bitstrings.
4. Entropy sources can be combined only by having their output strings concatenated, as shown in the draft of **SP 800-90C**. This holds true even if the vendor credits the entropy from only one of these sources.
5. In Section 3.5 of the current draft of **SP 800-90C** (January 2021) an entropy source is considered independent of another entropy source if their entropy source security boundaries do not overlap. This is a sufficient but not a necessary condition for an independence. While a true independence of entropy sources located within the same entropy source security boundary is difficult to achieve, if the sources are very different in nature (e.g., one is physical while another one is driven by certain software actions) then it may be possible to make a natural convincing heuristic argument for independence. In all cases, the vendor's arguments supporting their independence will be considered by the CMVP. More on the RBG security boundaries can be found in Section 3.6 of the draft of **SP 800-90C**.

Section 8 – Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC)

Section 9 – Self-Tests

9.1 Known Answer Test for Keyed Hashing Algorithm

Applicable Levels:	*All*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*03/27/2018*
Relevant Assertions:	*AS.09.07*
Relevant Test Requirements:	*TE09.07.01*
Relevant Vendor Requirements:	*VE.09.07.01*

Background

Several keyed hashing algorithms are FIPS-approved (e.g. HMAC-SHA-1, HMAC-SHA2, HMAC-SHA3, KMAC) and have different levels of complexity that determine the power-on Know-Answer-Test (KAT) requirements.

Question/Problem

What are the KAT requirements when implementing keyed hashing algorithms in FIPS mode?

Resolution

IG 9.11 has been published on August 7, 2017. This Implementation Guidance allows the user not to perform, under the conditions stated in IG 9.11, any of the KATs for the approved algorithms implemented by the module. When the KATs are required by IG 9.11 then, to use any HMAC in the approved mode, the module **shall** perform at least one KAT of any approved HMAC implemented in the module to self-test all other approved forms of HMAC used by that module (this includes, HMAC-SHA-1, HMAC-SHA2 and HMAC-SHA3 with all approved SHA2 and SHA3 hash functions).

Even if the module is not taking advantage of the IG 9.11 provision allowing it not to perform the known-answer tests, the vendor may still consider the information in IG 9.1 when deciding if only one HMAC self-test needs to be performed. We show in the Additional Comments below that under our assumptions the HMAC known answer tests with different hash functions only help verify the correct padding in the HMAC and that the padding strings are not very different from each other, thus the additional HMAC self-tests add very little information about the health of the module.

The decision to perform only one HMAC KAT does not absolve the module from the requirement to self-test the different hash functions, as applicable. Please see IG 9.4 and the text in the Additional Comments below.

Additional Comments

1. As stated in IG 9.3, if an HMAC is used as the approved integrity technique to verify the software or firmware components as specified in **AS.06.08**, a KAT is not required for either the HMAC-*hash* or the underlying *hash*, where *hash* stands for any approved hashing algorithm.

2. The reason for requiring only one HMAC self-test when various approved forms of HMAC (that is, the HMACs using the different hash functions including SHA3) are employed by the module is that one HMAC KAT tests everything except for some details of the padding mechanisms pertaining to the HMACs using the other approved hash functions. For example, consider the module implementing both HMAC-SHA-256 and HMAC-SHA-1. Suppose the module performs an HMAC-

SHA-256(K,m) self-test. If this test passes, this assures (per IG 9.2) the health of the SHA-256 implementation. SHA-1 needs to be self-tested separately. If the module does not have an HMAC-SHA-1 self-test, then SHA-1 will need to be self-tested either directly or by means of self-testing another approved high-level algorithm that employs SHA-1. We assume that SHA-1 has been self-tested and explain why it is not necessary to further perform an HMAC-SHA-1 self-test.

The successful KAT for HMAC-SHA-256 checks the correctness of the following value: $H(K_1||H(K_2||m))$, where K_1 is the HMAC key K (padded with the zero bits on the right to get to the SHA-256 block size (512 bits)) XORed with the 512-bit value (written here in the hexadecimal format) Hex(5c5c…5c), K_2 is the similarly padded value of K XORed with the 512-bit value Hex(3636…36) and H is SHA-256. For HMAC-SHA-1, a KAT would have tested $H(K_1||H(K_2||m))$ with SHA-1 as H. As we are assuming that SHA-1 has been self-tested separately, the only error that may possibly occur when computing HMAC-SHA-1 is in the padding being different due to the different output lengths of SHA-256 and SHA-1.

The following figure shows the formats of both versions of HMAC.

SHA-256{|___________K_1___________|_SHA-256(K_2||m)_|100…..000|00…..00100000000|}
512 bits 256 bits 191 zeros 8 zeros at the end
64 bits total

SHA-1{|___________K_1___________|__SHA-1(K_2||m)__|100……….000|00…..00010100000|}
512 bits 160 bits 287 zeros 5 zeros at the end

The first expression is self-tested successfully. In the second expression, K_1 and K_2 are the same as in the first one, while SHA-1 is self-tested separately and hence can be trusted to operate as designed. The paddings in the two expressions are slightly different. However, the module has been tested by a CST lab and has undergone an integrity test upon a power-on. It is safe to assume that as the module passes the applicable self-tests and correctly perform the HMAC-SHA-256 padding, it is also very likely to continue to properly perform the HMAC-SHA-1 padding. The last block in each of the above bit strings consists of 64 bits and is used to represent an output length of the hash function in the HMAC. For example, the output length of SHA-1 is 160 = 128 + 32, thus requiring two binary 1's separated by a 0.

3. The difference in the padding mechanism would be more significant when comparing the HMAC-SHA-256 and HMAC-SHA-512, due to the different length of the Blocks (512 and 1024 bits, correspondingly). However, again, when one HMAC is self-tested, performing a KAT for the other one only results in testing the correctness of the padding mechanism.

4. The KMAC self-test requirements are addressed in IG A.15.

5. It is not required to perform a KAT for the Triple-DES MAC, as long as the underlying Triple-DES algorithm is self-tested.

9.2 Known Answer Test for Embedded Cryptographic Algorithms

Applicable Levels:	*All*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*03/27/2018*
Relevant Assertions:	*AS.09.19*
Relevant Test Requirements:	*TE09.19.01-03*
Relevant Vendor Requirements:	*VE.09.19.01-02*

Background

Core cryptographic algorithms are often embedded into other higher cryptographic algorithms for their operation in FIPS mode (e.g. SHA-1 algorithm embedded into HMAC-SHA-1 and DSA). IG 9.11 lists the conditions when a cryptographic module that implement FIPS-approved algorithms performs the Known-Answer-Tests (KATs) as part of their power-up self-tests. However, when the cryptographic module performs a KAT on the higher cryptographic algorithm, the embedded core cryptographic algorithm may also be self-tested.

Question/Problem

If an embedded core cryptographic algorithm is self-tested during the higher cryptographic algorithm KAT, is it necessary for the cryptographic module to implement a KAT for the already self-tested core cryptographic algorithm implementation?

Resolution

It is acceptable for the cryptographic module not to perform a KAT on the embedded core cryptographic algorithm implementation if;

1. the higher cryptographic algorithm uses that implementation,
2. the higher cryptographic algorithm performs a KAT at power-up and,
3. all cryptographic functions within the core cryptographic algorithm are tested (e.g. encryption and decryption for AES).

Additional Comments

If the cryptographic module contains several core cryptographic algorithm implementations (e.g., several different implementations of SHA-1 algorithm) and some are not used by other higher FIPS-approved cryptographic algorithms (and are therefore not self-tested), then the cryptographic module must perform a KAT at power-up for each of those implementations.

9.3 KAT for Algorithms used in an Integrity Test Technique

Applicable Levels:	*All*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*02/10/2004*
Relevant Assertions:	*AS.06.08 and AS.09.16*

Relevant Test Requirements:	*TE06.08.01-02 and TE09.16.01-02*
Relevant Vendor Requirements:	*VE.06.08.01 and VE.09.16.01*

Background

AS.06.08 requires that a cryptographic mechanism using an approved integrity technique **shall** be applied to all cryptographic software and firmware components within the cryptographic module. **AS.09.16** requires that a cryptographic algorithm test using a Known-Answer-Test (KAT) **shall** be conducted for all cryptographic functions of each approved cryptographic algorithm implemented by the cryptographic module and used in FIPS mode of operation.

Question/Problem

Must a cryptographic module implement a separate KAT for the underlying cryptographic algorithm used in the approved integrity technique?

Resolution

A cryptographic module may not implement a separate KAT for the underlying cryptographic algorithm used for the approved integrity technique if all the cryptographic functions of the underlying cryptographic algorithm are tested (e.g. encryption and decryption for Triple-DES).

Rationale

The software/firmware integrity check using an approved integrity technique is considered a KAT since the cryptographic module uses itself as an input to the algorithm and a known answer as the expected output.

EX: If HMAC-SHA-1 is used as the approved integrity technique to verify the software or firmware components, a KAT is not required for either the HMAC-SHA-1 or the underlying SHA-1 algorithm.

EX: If Triple-DES MAC is used as the approved integrity technique to verify the software or firmware components, a KAT is still required for the underlying Triple-DES as the integrity checking may not use both the Triple-DES encrypt and decrypt functions.

EX: If RSA is used to verify the signature of the software or firmware components, a KAT is still required for the underlying RSA as the integrity checking would not use the RSA signature generation function. However, a KAT for the underlying SHA-1 hashing function is not required.

9.4 Known Answer Tests for Cryptographic Algorithms

Applicable Levels:	*All*
Original Publishing Date:	*08/19/2004*
Effective Date:	*08/19/2004*
Transition End Dates	***05/30/2019*** *– KBKDF* ***11/30/2019*** *– Cipher Functions* ***11/30/2019*** *– Authenticated Mode* ***09/01/2020*** *– SHA-3 and SHA-3 derived functions* ***12/31/2020*** *– for select algorithms*
Last Modified Date:	*11/05/2021*
Relevant Assertions:	*AS.09.08-09, 12-13, 16 and 18*
Relevant Test Requirements:	*TE's associated with AS's above*
Relevant Vendor Requirements:	*VE's associated with AS's above*

Background

The cryptographic module **shall** perform the following power-up tests: cryptographic algorithm test, software/firmware integrity test, and critical functions test.

Cryptographic algorithm test. A cryptographic algorithm test using a known answer **shall** be conducted for all cryptographic functions (e.g., encryption, decryption, authentication, and random number generation) of each approved cryptographic algorithm implemented by a cryptographic module. A known-answer test involves operating the cryptographic algorithm on data for which the correct output is already known and comparing the calculated output with the previously generated output (the known answer). If the calculated output does not equal the known answer, the known-answer test **shall** fail.

Cryptographic algorithms whose outputs vary for a given set of inputs (e.g., the Digital Signature Algorithm) **shall** be tested using a known-answer test or **shall** be tested using a pair-wise consistency test (specified below).

Each approved cryptographic function implementation to be used in a FIPS approved mode of operation **shall** implement a cryptographic algorithm test. The cryptographic algorithm test is a *health check* of the algorithm implementation performed at power-up or on demand.

Question/Problem

What Known Answer Tests (KATs) are required for approved:

- symmetric-key algorithms (**FIPS 197**, **SP 800-38** series, **SP 800-67rev2**)?
- hash algorithms that are not keyed (**FIPS 180-4**)?
- SHA-3 permutation-based and extendable-output functions (**FIPS 202**)?
- SHA-3 derived functions (**SP 800-185**)?
- hash algorithms that are keyed (**FIPS 198-1**)?
- deterministic random number generators (**SP 800-90A**)?
- entropy sources used for random bit generation (**SP 800-90B**)?
- key derivation functions, such as: KBKDF (**SP 800-108**), PBKDF (**SP 800-132)** and KDA (**SP 800-56C Rev1** or **Rev2**)?
- algorithms that are tested as a Component Validation List (see CVL listing and IG G.20)?
- RSA, ECDSA, or DSA signature algorithms (**FIPS 186-4**)?

- key agreement schemes (**SP 800-56Arev3** or **SP 800-56Brev2**)?
- asymmetric key transport schemes (**SP 800-56Brev2**)?
- vendor affirmed algorithms (IG A.3)?

FIPS 140-2 allows performing a pair-wise consistency test in lieu of a KAT for an algorithm that may have varying output for a given set of inputs. How is this applied to the set of approved algorithms? What are the minimum requirements placed on a pair-wise consistency test (for public and private keys) if performed at power-up or on demand?

Please note that the requirements of this IG apply when it is necessary to perform the power-up self-tests; that is, where the IG 9.11 provisions do not make them optional.

Resolution

The FIPS 140-2 standard requires that a self-test be performed for each mode of each approved algorithm within each implementation of the algorithm. However, the following is a subset of algorithm self-test specific implementation guidance which provides additional clarity and/or leniency for this requirement:

- for symmetric-key algorithms, such as SKIPJACK, Triple-DES or AES,

    1. if the module implements the encryption function, the module **shall** have an encrypted value pre-computed, perform the encryption using known data and key, and then compare the result to the pre-computed value;

    2. if the module implements the decryption function, the module **shall** have a decrypted value pre-computed, perform the decryption using known data and key (the data could be the encrypted value computed during the encryption test), and then compare the result to a value that was pre-computed value.

    3. in addition, and applying only to the AES algorithm, if the module implements the forward cipher function, then this forward cipher function **shall** be self-tested at least once by either performing a KAT on any encryption mode that supports the forward cipher function (typically all encryption modes support the forward cipher), or by selecting a decryption mode that supports the forward cipher function (e.g. CFB, OFB, CTR, CMAC, CCM, GCM, FF1). Similarly, if the inverse cipher function is implemented, then it **shall** be self-tested at least once by performing a KAT on any mode that supports the inverse function. Typically, the following modes support the inverse function within the decryption mode: ECB, CBC, XTS, KW, KWP.

        The Encrypt KAT and Decrypt KAT do not need to be performed for each mode(s) that is selected to meet this cipher function requirement, as long the forward and inverse cipher functions (if implemented) are self-tested at least one time within any implemented mode(s). For example, if the module only implements AES GCM (Encrypt/Decrypt) and AES ECB (Encrypt/Decrypt), then the following KATs would suffice: AES GCM Encrypt (to cover the forward cipher function), AES ECB Decrypt (to cover the inverse cipher function). KATs on AES GCM Decrypt and AES ECB Encrypt would not be necessary. Or, in this example, the following KATs would also suffice: AES ECB Encrypt (to cover the forward cipher function), AES ECB Decrypt (to cover the inverse cipher function). KATs on AES GCM would not be necessary to meet this cipher function requirement.

        The reason the above two paragraphs only apply to AES and not Triple-DES is because every approved Triple-DES mode involves running both a forward and an inverse application of the underlying DES algorithm.

        All module submissions (2SUB, 3SUB or 5SUB) after **November 30, 2019** **shall** comply with this requirement.

    4. Furthermore, since modes that provide authentication (i.e. AES KW, KWP, GCM, CCM, CMAC, GMAC or Triple-DES CMAC and KW) are significantly more complex than those that perform only encryption/decryption (i.e. AES and Triple-DES ECB, CBC, OFB, CFB, CTR, and AES XTS), a module **shall** perform a KAT on at least one authenticated encryption mode for

each underlying algorithm implementation (i.e. AES and Triple-DES) that is contained in the module.

Moreover, some authenticated encryption modes are more complex than others (e.g. AES GCM requires a hash while AES KW only appends a known block to the plaintext to be encrypted as the authentication method). Therefore, below is the hierarchy for which mode(s) require a KAT, and which are covered by the higher-level self-test. If item (a) is self-tested, then this covers the requirements for items (b) and (c); if item (b) is self-tested, it covers items (c), and so on.

(a) A KAT for one of the following AES authenticated encryption modes is required if implemented: GCM, CCM, CMAC or GMAC. A KAT for Triple-DES CMAC is required if this mode is implemented;

(b) A KAT for AES KW or KWP is required if no other AES authenticated encryption modes are implemented and self-tested; and a KAT for Triple-DES KW is required if no other Triple-DES authenticated encryption modes are implemented and self-tested;

(c) A KAT for one of the non-authenticated encryption mode (ECB, CBC, OFB, CFB, CTR, or AES FF1 or XTS) is required if no other modes of the corresponding encryption algorithm (AES or the Triple-DES) are implemented and self-tested.

Please note that this hierarchy does not overrule the requirement above (item #3) to test at least one of each of the forward and inverse cipher functions (if implemented by the module), as that rule still applies regardless of which mode is selected to meet the authenticated encryption requirement. However, it is possible to use these rules in conjunction with each other (e.g. an encryption and decryption KAT on AES KW would cover the KAT requirements for all other non-authenticated AES modes implemented in a module, since AES KW is higher on the hierarchy list and also implements both the forward and inverse cipher functions).

Please also note that the above requirements to self-test a mode using separate encryption and decryption KATs (items #1 and #2) apply only to modes that are required by this authentication encryption mode hierarchy. The encrypt/decrypt requirement does not apply to KATs that are used to meet the cipher function requirement (item #3).

All module submissions (2SUB, 3SUB or 5SUB) after **November 30, 2019** **shall** comply with this requirement.

Note1: The SKIPJACK algorithm can only be used for decryption in FIPS approved mode so only a known-answer test for decryption is required.

- if the module implements a SHS function (**FIPS 180-4**), the following **shall** be the minimal requirements for SHS algorithms:
  - a KAT for SHA-1 is required;
  - a KAT for SHA-256 is required;
  - a KAT for SHA-224 is required if SHA-224 is implemented without SHA-256;
  - a KAT for SHA-512 is required;
  - a KAT for SHA-512/224 or SHA-512/256 is required if the SHA-512 KAT is not performed;
  - a KAT for SHA-384 is required if SHA-384 is implemented without SHA-512.
- if the module implements SHA-3 permutation-based and/or extendable-output functions (see IG A.11 and **FIPS 202**):
  - At the minimum, the cryptographic module **shall** perform a KAT for one of the functions defined in **FIPS 202**: SHA3-224, SHA3-256, SHA3-384, SHA3-512, SHAKE128 and SHAKE256, no matter how many of these functions the module may be designed to use.
  - If a SHA-3 hash function is used as part of a higher-level approved algorithm that is tested by the CAVP, then the module **shall** either perform a self-test for this higher-level algorithm that uses

SHA-3, or perform a self-test for this higher-level algorithm using a different hash function (if this configuration is implemented in the module) and have the SHA-3 implementation self-tested separately (either as a stand-alone algorithm or as part of another higher-level algorithm's self-test). No additional KATs for any of the **FIPS 202**-compliant functions implemented by this module are required.

  - If the module contains several Keccak-p permutation implementations, a self-test **shall** be performed for more than one implementation of the **FIPS 202**-defined functions so that each permutation implementation is self-tested separately.
  - All module submissions (2SUB, 3SUB or 5SUB) after **September 1, 2020** **shall** comply with this requirement.

  Note2: The reason for requiring a self-test for only one of the **FIPS 202**-compliant hash functions is that all of these functions, including SHAKE128 and SHAKE256, rely on the same underlying Keccak-p permutation. Note that this is different from the SHA-1 and SHA-2 self-test requirements where separate self-tests are needed for SHA-1, SHA-256 and SHA-512, if the module is designed to use these hash functions.

  Note3: Higher-level algorithms, in this context, are the algorithms such as digital signatures and the key establishment, but not the **SP 800-185** algorithms.

- if the module implements SHA-3 derived functions (see IG A.15 and **SP 800-185**):
  - One KAT for one of the functions defined in **SP 800-185**: cSHAKE-128, cSHAKE-256, KMAC128, KMAC256, TupleHash and ParallelHash, is sufficient to meet the self-test requirements for all **SP 800-185** functions implemented in the module, as long as all use the same underlying implementation of the Keccak-p permutation.
  - If the module contains several Keccak-p permutation implementations, a self-test **shall** be performed for more than one implementation of the **FIPS 202** or **SP 800-185**-defined functions so that each permutation implementation is self-tested separately.
  - If a module supports both **FIPS 202** and **SP 800-185** functions and they share the same SHAKE implementation (either SHAKE128 or SHAKE256), then one KAT on a function defined in either **SP 800-185** or **FIPS 202** is sufficient to meet the KAT requirement for **SP 800-185** functions.
  - All module submissions (2SUB, 3SUB or 5SUB) after **September 1, 2020** **shall** comply with this requirement.

  Note4: The reason for allowing a KAT for either the **SP 800-185** or SHAKE-based **FIPS 202** hash functions is because all of these functions rely on the same SHAKE128 or SHAKE256 function, and the **SP 800-185** functions do not add significant complexity to this underlying function.

- if the module implements a HMAC function (**FIPS 198-1**), a KAT for HMAC is required and **shall** be performed with the HMAC function using at least one of the implemented underlying SHA-1, SHA-2 or SHA-3 algorithms.

  Note5: See IG 9.1 for the justification for self-testing only one HMAC function.

- if the module implements an approved DRBG (**SP 800-90A**) algorithm then KATs are required and **shall** be performed as specified in **SP 800-90A** Section 11.3. This requires separate KATs for each implemented DRBG algorithm (e.g. separate tests for HMAC_DRBG, CTR_DRBG and HASH_DRBG) for the instantiate (11.3.2), generate (11.3.3), and reseed (11.3.4) functions of the DRBG. The values, such as seed that normally contribute to the "randomness" of a DRBG, **shall** be preset and used in the calculation of an output of the DRBG, which **shall** then be compared to the pre-computed result.
  - The module may be optimized by combining the testing of Instantiate()-Generate() instead of testing each function separately. Similarly, the testing of Instantiate(), Reseed() and Generate() may be optimized in one sweep, since the new working state created by Reseed() is

cryptographically chained to the state created by Instantiate(). A KAT of a DRBG **shall** be performed by: Instantiate with known data, Reseed with other known data, Generate and then compare the result to a pre-computed value.

- if the module implements an approved ENT (**SP 800-90B**), then the health-tests specified in **SP 800-90B** Section 4.2 are required, including the start-up tests, the on-demand tests, and the continuous tests. No KATs are required. See IG 7.18 Additional Comment 3 for specific requirements on vetted conditioning components used within an ENT.

- if the module implements an approved KBKDF (**SP 800-108**), the module **shall** perform a KAT for this algorithm covering at least one KDF option, even if the module supports multiple KBKDF options. That is, at least one mode (Counter, Feedback, or Double Pipeline) with at least one PRF **shall** be self-tested to cover a single KDF option.

  All module submissions (2SUB, 3SUB or 5SUB) after **May 30, 2019** **shall** comply with this requirement.

- if the module implements an approved PBKDF (**SP 800-132**), the module **shall** perform a KAT, at minimum, on the derivation of the Master Key (MK) as specified in Section 5.3 of **SP 800-132**. In addition to performing a KAT on the MK derivation, the module **shall** self-test all underlying prerequisite algorithms (the key derivation functions and the authenticated encryption/decryptions, as applicable) implemented in the module that are used in the derivation or the protection of the Data Protection Key (DPK), if the same implementations of the underlying algorithms are not already self-tested either on their own or as part of higher level algorithm self-tests.

  In addition, the lengths and the properties of the Password and Salt parameters, as well as the desired length of the Master Key used in a KAT **shall** be among those supported by the module in the approved mode. The Iteration Count parameter does not need to be among those supported by the module in the approved mode but **shall** be at least two. The reason is the Iteration Count is only used to repeat the same pseudorandom function calculation, and a large Iteration Count can greatly affect the performance of the self-test. There is enough assurance that the Iteration Count will perform correctly for any number if it runs successfully for at least two iterations.

  All module submissions (2SUB, 3SUB or 5SUB) after **December 31, 2020** **shall** comply with this requirement.

- if the module implements an approved KDA (**SP 800-56C Rev1** or **Rev2**), the module **shall** perform at least one KAT covering a **SP 800-56C (Rev1** or **Rev2**) Section 4 one-step KDF (if implemented) and another KAT covering a **SP 800-56C (Rev1** or **Rev2**) Section 5 two-step KDF (if implemented), including at least one auxiliary function for each. For example, if a module implements both a two-step KDF using either the HMAC or AES-CMAC auxiliary function, and one-step KDF using either the hash or HMAC auxiliary function, then at least two KATs are required: one for the two-step KDF (with either HMAC or AES-CMAC), and the other for the one-step KDF (with either the hash or HMAC). The implementations of the auxiliary functions used in the KDA KATs do not require separate self-tests.

  In addition, the module **shall** self-test all underlying prerequisite algorithms used in the remaining **SP 800-56C** (**Rev1** or **Rev2**) schemes implemented in the module, if the same implementations of the underlying algorithms are not already self-tested either on their own or as part of other higher-level algorithm self-tests.

  All module submissions (2SUB, 3SUB or 5SUB) after **December 31, 2020** **shall** comply with this requirement.

- if the module implements an approved CVL, this function is considered an algorithm "component" (and therefore part of a larger crypto system), and no KAT is required for the approved CVL. The only time a KAT is required for a CVL is when this Implementation Guidance document specifically requires it (for example, IGs 9.6, D.8 and D.9).

- for each public key digital signature algorithm (RSA, DSA and ECDSA), a KAT **shall** be performed using at least one of the schemes approved for use in the FIPS mode. For example, if an RSA signature algorithm is self-tested using an X9.31-compliant scheme, it is not necessary to perform any additional known-answer tests for the implementations of the digital signature compliant with RSASSA-PSS or RSASSA-PKCS1-v1_5, even if these schemes are also supported by the module.

- for the RSA algorithm,

  1. if the module implements digital signature generation, the module **shall** have an RSA digital signature pre-computed, generate an RSA digital signature using known data and key, and then compare the result to the pre-computed value;

  2. if the module implements digital signature verification, the module **shall** have an RSA digital signature pre-computed (which could be the output of the RSA digital signature generate test), and using a known key, verify the signature by comparing the recovered message digest with its target value.

  3. if the module does not implement RSA signature generation or RSA signature verification, but only implements RSA key encapsulation and un-encapsulation schemes for key transport described in **SP 800-56Br2** and IG D.9, the module is required to perform the **SP 800-56Br2** KATs as described in IG D.9.

  The only exception to the above requirement is when the module implements the RSA Probabilistic Signature Scheme (PSS) *only*. In this case, per the provision of Section 4.9.1 of FIPS 140-2, the RSA digital signature algorithm may be tested using a pair-wise consistency test, since the algorithm's output may vary for a given set of inputs. If the module implements at least one approved RSA digital signature algorithm that has a fixed output value for a given input, an RSA KAT using the pre-computed values **shall** be performed.

  Note6: an RSA KAT **shall** be performed using both the public and private exponents (e and d) and the two exponents **shall** correspond [that is, $d * e = 1$ (mod (LCM (p-1, q-1)))]. The public exponent e used in this RSA KAT **shall** be chosen from the public exponent values supported by the module.

  Note7: an RSA KAT **shall** be performed at a minimum on any one approved modulus size that is supported by the module.

  Note8: The CMVP will not validate RSA digital signature algorithms as approved in modules that implement a pair-wise consistency test in lieu of a KAT at power-up (other than the above exception for PSS only).

- for algorithms whose output vary for a given set of inputs such as DSA and ECDSA, they **shall** be tested either,

  1. as a KAT similar to RSA for signature generation or verification if the randomization parameter is fixed, or

  2. as a *pair-wise consistency test*. This test does not require the comparison of the intermediate result (the generated signature) to a known value.

  Note9: a KAT or pair-wise consistency test for DSA **shall** be performed at a minimum on any one approved modulus size that is supported by the module.

  Note10: a KAT or pair-wise consistency for ECDSA **shall** be performed at a minimum, on any one of the implemented curves in each of the implemented two types of fields (i.e., prime field *GF(p)*, and binary field $GF(2^m)$).

- key agreement schemes (see IG D.8, **SP 800-56Arev3** and **SP 800-56Brev2**):

  - self-test requirements for approved key agreement and shared secret computation schemes are shown in IG D.8.

  - all module submissions (2SUB, 3SUB or 5SUB) after **December 31, 2020** **shall** comply with these self-test requirements.

- key transport schemes (see IG D.9 and **SP 800-56Brev2**):

- self-test requirements for approved key transport schemes are shown in IG D.9.
- all module submissions (2SUB, 3SUB or 5SUB) after **December 31, 2020** **shall** comply with these self-test requirements.

If the module contains different implementations of a single algorithm, each implementation of this algorithm within a specified approved mode of operation **shall** be self-tested separately.

All other approved algorithms that have been issued a CAVP certificate **shall** be self-tested unless an IG specifically reduces the requirement.

If an algorithm's implementation in the module is vendor-affirmed, then there is no self-test requirement unless an IG specifically requires it (for example IG D.4).

Additional Comments

If the module implements asymmetric key pair generation, the conditional (FIPS 140-2 Section 4.9.2) *pair-wise consistency test* is applicable only if the key generation is used as part of an approved key transport scheme (**AS09.31**), or if the key generation is used as part of an approved digital signature computation (**AS09.33**). No conditional tests are required for the asymmetric key pairs used in the key agreement schemes, beyond the tests that are already made mandatory by the standards where these schemes are defined and to which the vendor has either tested the module or is claiming the vendor affirmation. These standards are: **SP 800-56A**, **SP 800-56B** and their published revisions. Also, no power-up self-test is required to test the key generation function even if such function is implemented by the DSA, ECDSA, or the RSA Digital Signature algorithm(s) supported by the module.

9.5 Module Initialization during Power-Up

Applicable Levels:	*ALL*
Original Publishing Date:	*04/01/2009*
Effective Date:	*04/01/2009*
Last Modified Date:	*04/01/2009*
Relevant Assertions:	*AS.09.08, AS.09.09, AS.09.10, AS.09.11*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

Power-up tests **shall** be performed by a cryptographic module when the module is powered up. All data output via the data output interface **shall** be inhibited when the power-up tests are performed.

Question/Problem

What is the *initialization period* and what module activities are allowed to occur during that period?

Resolution

The *initialization period* is the period between the time power is applied to the module (after being powered off, reset, rebooted, instantiated, etc.), and the time the module completes the power-up tests and outputs status (success or failure) indicating that the module is ready or not to perform operational cryptographic functions and services. The module may perform many activities during this period (i.e. before, during or after the power-up tests are performed) prior to the output of status and the module becoming operational. The cryptographic module is not considered to be in a FIPS approved mode of operation during the *initialization period*.

During the initialization period, the module:

- **shall** perform all the power-up tests required by FIPS 140-2 Section 4.9 including **AS.06.08** in FIPS 140-2 Section 4.6.1 (if applicable). When completed, the results (i.e. indications of success or failure) **shall** be output via the "status output" interface; (status output may be implicit or explicit);
- **shall** perform all the necessary internal services required to properly initialize or instantiate the module in conjunction with performing the power up self-tests;
- may receive data and control input via the *data input interface* or *control input interface* (e.g. may receive data and control requests for approved services that the module may act upon once the initialization period is completed);
- **shall** inhibit all data output via the data output interface *except*:
  - the module is allowed to output, when requested, non-security relevant module identification information, or module identification information. The module **shall** prevent the output of any plaintext secret and private cryptographic keys or CSPs that are contained within the module.

If applicable, the security policy **shall** describe the outputted information and the services performed during the *initialization period*.

Once the initialization period is completed (which includes the power-up tests), the module would transition to the operational state and may start providing approved cryptographic functions and services (if operating in an approved mode of operation).

Additional Comments

Rationale: One can consider the services performed to properly initialize or instantiate the module and the exchange of non-security relevant information in conjunction with the power-up tests to be part of the power-up initialization sequence (e.g. a modules handshake during the powering sequence).

9.6 Self-Tests When Implementing the SP 800-56A Schemes

Applicable Levels:	*All*
Original Publishing Date:	*10/21/2009*
Effective Date:	*10/21/2009*
Last Modified Date:	*04/23/2012*
Relevant Assertions:	*AS.09.01*
Relevant Test Requirements:	*AS.09.27*
Relevant Vendor Requirements:	*AS.09.27*

Background

FIPS 140-2 Section 4.9 states that "… *A cryptographic module **shall** perform power-up self-tests and conditional self-tests to ensure that the module is functioning properly. Power-up self-tests **shall** be performed when the cryptographic module is powered up. Conditional self-tests **shall** be performed when an applicable security function or operation is invoked (i.e., security functions for which self-tests are required)*."

SP 800-56A is different from other cryptographic algorithm standards in regard to the cryptographic algorithm test because the standard does not describe an algorithm but instead describes a scheme consisting of steps utilizing existing algorithms (i.e., DSA, ECDSA, SHA, RNG, etc.). Therefore, defining the self-test requirement is different. The self-test requirement does not directly address the correct implementation of the scheme as this is addressed by CAVP validation testing. The self-test defined in **SP 800-56A** instead addresses the major underlying mathematical functions.

Question/Problem

What power-up or conditional self-tests are required when a cryptographic module implements an approved **SP 800-56A**-compliant scheme?

Resolution

The following **SP 800-56A** power-up self-tests **shall** be performed:

1. ***Primitive "Z" Computation KAT***. A Known Answer Test (KAT) **shall** be performed on the underlying mathematical function(s) which use modular exponentiation for an FFC-based key establishment protocol (per **SP 800-56A**, Section 5.7.1.1) or point multiplication for ECC-based protocol (per **SP 800-56A**, Section 5.7.1.2).

   The mathematical function can be either the computation of $g^x \pmod{p}$ for an FFC scheme or the point multiplication hxP on an elliptic curve in the usual notation. The value of p used in a self-test **shall** be in the range supported by the module. The elliptic curve point multiplication **shall** be performed on one of the NIST-recommended curves supported by the module.

   The value of x in the self-test **shall** be chosen to make the computations non-trivial. In the FFC case, x **shall** be chosen such that $g^x > p$. In the case of the elliptic-curve-based computations, the value of x **shall** be greater than 1.

   The self-tests **shall** consist of performing the calculations and comparing their result to a pre-computed value. In the case of an elliptic curve self-test, it is sufficient to compare the x-coordinate of the computed point to its expected value.

   The actual computation of a Z value is not required.

2. ***Key Derivation Function (KDF) KAT***. A KAT **shall** be performed on the SHS function which is used for the KDF function(s) used (per **SP 800-56A**, Sections 5.8.1 and/or 5.8.2).

3. ***KATs on Prerequisite Algorithms***. KATs **shall** be performed on all underlying prerequisite algorithms used in a given **SP 800-56A** scheme. Depending on which **SP 800-56A** scheme, this may include DSA, ECDSA, SHS, and/or RNG/DRBG. If these KATs are already performed as required by their underlying prerequisite algorithms, they should not need to be repeated for **SP 800-56A** if the same implementation is used.

The following **SP 800-56A** conditional self-tests **shall** be performed:

1. ***Conditional Tests for Assurances***. Necessary conditional tests **shall** be performed on Assurances used in a given **SP 800-56A** scheme. Assurances are specified in **SP 800-56A** Sections 5.5.2, 5.6.2 and 5.6.3 and will vary based on the implementation.

2. ***Conditional Tests on Prerequisite Algorithms***. A pair-wise conditional test **shall** be performed for every key pair generated by the module for use in an **SP 800-56A**-compliant protocol. If a key pair already passed a pair-wise consistency test because the pair could be used in another algorithm implemented by the cryptographic module, the key pair does not have to be retested for the purposes of being used in the **SP 800-56A** protocols.

If the module's validation certificate claims, by referencing a CVL algorithm certificate on the approved algorithms line, a partial compliance with the requirements of **SP 800-56A** by only implementing either one or more of the **SP 800-56A** primitive(s) or by computing a shared secret Z, then only a power-up test that is named above '***Primitive "Z" Computation KAT***' is required. No conditional self-tests are necessary.

Additional Comments

Separate guidance may be provided in the future for implementations that do not claim conformance to **SP 800-56A**.

Test Requirements

The vendor and tester evidence **shall** be provided under **AS.09.27**.

9.7 Software/Firmware Load Test

Applicable Levels:	*All*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*12/23/2010*
Relevant Assertions:	*AS.09.34 and AS.09.35*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background – FIPS 140-2

FIPS 140-2 DTR

AS.09.34: (Levels 1, 2, 3, and 4) If software or firmware components can be externally loaded into the cryptographic module, then the following software/firmware load tests shall be performed.

AS.09.35: (Levels 1, 2, 3, and 4) An Approved authentication technique (e.g., an Approved message authentication code, digital signature algorithm, or HMAC) shall be applied to all validated software and firmware components when the components are externally loaded into the cryptographic module.

Question/Problem

How is this conditional test applicable for a hardware, software or firmware module?

Resolution

- For a hardware module, this requirement is applicable if software or firmware can be loaded within the defined physical boundary of the module.

The logical boundary of a software or firmware module includes all software and/or firmware that is associated, bound, modifies or is an executable requisite of the validated software or firmware module.

- For a software module, this requirement is applicable if software can be loaded within the defined logical boundary of the module.

- For a firmware module, this requirement is applicable if
  - firmware can be loaded within the defined logical boundary of the module (FIPS 140-2 Section 4.5 Level 1 only) or,
  - firmware can be loaded within the defined physical boundary of the module (FIPS 140-2 Section 4.5 Levels 2, 3, or 4.)

For a software module or a firmware module where FIPS 140-2 Section 4.5 physical security is Level 1, if the loaded software or firmware image is a complete replacement or overlay of the validated module image, this requirement is not applicable (NA) as the replacement or overlay constitutes a new module. The new module requires validation for conformance to FIPS 140-2 and is addressed as a **3SUB** (IG G.8 (3)) or **5SUB** (IG G.8 (5)) validation.

Note: The operator should zeroize the validated modules CSPs prior to the complete replacement or overlay of the validated module image.

The loading of non-security relevant software or firmware is addressed as a **1SUB** (IG G.8 (1)) validation submission and the loading of security relevant software or firmware is addressed as a **2SUB**, **3SUB** or **5SUB** (IG G.8) for validation. At a minimum, FIPS 140-2 Sections 4.10.1, 4.10.2 and Appendix C **shall** be addressed.

Additional Comments

Procedural or policy methods or statements can-not substitute for the FIPS 140-2 requirement for a software/firmware load test if the module has the capability to load software or firmware whether in an approved or non-approved mode of operation.

This requirement is not applicable if a module

1. has the capability to only load software or firmware during the pre-operational initialization (IG 9.5) of the module,
2. is configured to operate only in a FIPS approved mode of operation when operational,
3. the loading of software or firmware is inhibited while operational. (i.e. non-functional without transitioning through a new power-off, power-on re-initialization cycle), and
4. all CSPs are zeroized prior to loading the software or firmware during the pre-operational initialization.

9.8 Continuous Random Number Generator Tests

Applicable Levels:	*All*
Original Publishing Date:	*05/02/2012*
Effective Date:	*12/22/2015*
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS09.41*
Relevant Test Requirements:	*TE09.41.01*
Relevant Vendor Requirements:	*VE09.41.01*

Background

AS.07.04: (Levels 1, 2, 3, and 4) If a cryptographic module employs Approved or non-Approved RNGs in an Approved mode of operation, the data output from the RNG shall pass the continuous random number generator test as specified in Section 4.9.2.

AS.09.29: (Levels 1, 2, 3, and 4) Conditional tests shall be performed by the cryptographic module when the conditions specified for the following tests occur: pair-wise consistency test, software/firmware load test, manual key entry test, continuous random number generator test, and bypass test.

AS.09.41: (Levels 1, 2, 3, and 4) If a cryptographic module employs Approved or non-Approved RNGs in an Approved mode of operation, the module shall perform the following continuous random number generator test on each RNG that tests for failure to a constant value.

Question/Problem

The FIPS 140-2 standard includes a requirement that all random number generators **shall** pass the continuous random number generator test (CRNGT). This requirement needs to be further explained in view of the existence of new technology such as the **SP 800-90A** Deterministic Random Bit Generators (DRBGs). In particular, the following questions need to be answered.

Does an **SP 800-90A**-compliant DRBG have to satisfy the Continuous Random Number Generator Test (CRNGT) requirement specified in **AS.07.04** and **AS.09.41**?

How should the CRNGT requirement be interpreted for all other RNGs?

Resolution

While **AS.07.04** and **AS.09.41** state that RNGs employed in an approved mode of operation **shall** perform a CRNGT as specified in Section 4.9.2 of FIPS 140-2, there are alternative ways in which this requirement to "perform a CRNGT" can be interpreted.

The simplest way to meet this requirement is to implement, for each RNG used in an approved mode, an explicit test as described in Section 4.9.2 of FIPS 140-2, AS.09.42 and AS.09.43. However, the same or the generally equivalent assurance of the RNG "not being stuck" can be achieved when performing different tests and taking into account other evidence. There are several considerations that lead to an alternative interpretation.

1. Before any random numbers are generated the module must successfully pass an integrity test. While this requirement was always present and had to be supplemented by the CRNGT, the advancement in the reliability of modern technology makes it extremely unlikely that an RNG/DRBG, tested by an accredited lab, will fail (get stuck on one output value); especially, after an integrity test was passed at module's power-up.
2. The DRBGs are particularly safe as they must pass certain health tests independent of the FIPS 140-2 CRNGT requirement. While it is possible to construct a scenario when a DRBG passes its health tests but fails a CRNGT, the **SP 800-90A** health test requirements provide an additional, strong assurance that the DRBG does not have a catastrophic failure. Conversely, just because a DRBG passes the CRNGT it is not a guarantee this generator is working properly – see item 3 below. At the time of the publication of FIPS 140-2, there was no **SP 800-90A** standard and no DRBG mechanisms available, so the assurances these advancements offer could not have benefited the introduction of a different CRNGT in the standard. The state of technology is different now.
3. It can be argued that if the CRNGT on a tested DRBG is performed according to the *method* described in Section 4.9.2 of FIPS 140-2, this test would do more harm than good. Indeed, a true random number generator will, with certain probability, generate two identical outputs one after another. FIPS 140-2 treats this as an error condition. When correcting this condition, the module introduces an unnecessary bias among the DBRG outputs. At the same time, the CRNGT does not guard against other possible symptoms of a random number/bit generator getting stuck: for example, the DRBG can be generating the string ABABABABAB…, and this condition would not be identified by the CRNGT.
4. Similar concerns do apply if the CRNGT from Section 4.9.2 of FIPS 140-2 is performed on the output from non-deterministic RNG (NDRNG). The statistical properties of the NDRNG output depend on the amount of entropy in the noise sources incorporated by the NDRNG. Therefore, a test that takes into account this dependency can adapt better to the characteristics of a particular NDRNG and avoid altering the bias in the output than the inflexible CRNGT. The Repetition Count Test (RCT) has the capability to take into account the statistical properties of the NDRNG while protecting against

catastrophic failures that cause the NDRNG to become "stuck" on single output value for a significant period. The RCT is defined as follows:

Given assessed min-entropy H of a noise source, the probability that the source generating n identical samples consecutively is at most $2^{-H(n-1)}$. (See a proof in the Additional Comments area below.) The test raises a trigger, if a sample is repeated more than the cutoff value C, which is determined by the acceptable false-positive probability $\alpha > 0$ (that is, the probability that the entropy source is functioning normally, but at a certain time would produce a string of C consecutive identical samples) and the min-entropy estimate H. The cutoff value of the repetition count test is given in **SP 800-90B** as:

$$C = \left\lceil 1 + \frac{-\log_2 \alpha}{H} \right\rceil \qquad (1).$$

This value of C is the smallest integer satisfying the inequality $\alpha \geq 2^{-H(C-1)}$, which ensures that the probability of obtaining a sequence of identical values from C consecutive noise source samples is no greater than α. For example, for $\alpha = 2^{-30}$, an entropy source with H = 7.3 bits per sample would have a repetition count test cutoff value of $\lceil 1+30/7.3 \rceil = 6$.

The *recommended* value of α is 2^{-30}.

Given a dataset of noise source observations, and the cutoff value C, the test is performed as follows:

1. Let A be the current sample value.
2. Initialize the counter B to 1.
3. If the next sample value is A, increment B by one.
   a. If B is equal to C, return error.

   Else:
   a. Let A be the next sample value.
   b. Initialize the counter B to 1.
   c. Repeat Step 3.

Running the repetition count test requires enough memory to store:

A : the most recently observed sample value,
B : the number of consecutive times that the sample A has been observed, and
C : the cutoff value at which the test fails.

This test's cutoff values can be applied to any min-entropy estimate, H, including very small and very large estimates.

In view of the considerations stated above, the requirement to pass the CRNGT is interpreted as follows.

The SP-800-90A-compliant DRBGs are not required to perform the test as described in AS.09.42 and AS.09.43.

The NDRNGs **shall** perform either the RCT as described above or the CRNGT as described in AS.09.42 and AS.09.43.

All other random number generators approved for use in an approved mode **shall** perform the CRNGT precisely as described in AS.09.42 and AS.09.43.

The cryptographic module's Security Policy **shall** say, for each random number/bit generator that can be used in an approved mode whether the CRNGT, as described in Section 4.9.2 of FIPS 140-2, is performed.

Additional Comments

1. If the design of the cryptographic module is such that the approved RNG or DRBG is only seeded (seed and seed key) once from an NDRNG after cryptographic module power-on and never re-seeded (seed and seed key) until the module is powered-off, and the NDRNG is not used for any other function or purposes, then the module does not need to implement the CRNGT on the output of the NDRNG.
2. The RCT test may only be used if a min-entropy estimate exists for the output from the NDRNG.
3. One may think of the RCT as a generalization of the CRNGT, which can be viewed as a RCT with a cutoff value *C=2*.

   From formula (1) it is clear that *C*=2 if and only if

   $\frac{-\log_2 \alpha}{H} \leq 1$, or $\alpha \geq 2^{-H} = p_1$, where p_1 is the highest probability (given the entropy estimate *H*) of an occurrence of a given sample value amount the outputs of the NDRNG. If a vendor decides to use a smaller false positive probability α in the RCT then the test will not report an error until there are more than 2 consecutive sample repetitions (6 in the example in this IG.)

   To further demonstrate that the RCT test is compliant with the requirements of Section 4.9.2 of FIPS 140-2, one can note that the requirements in AS.09.42 and AS.09.43 do not address the maximum sample size generated by a NDRNG. A vendor who chooses to implement the RCT test may, after selecting the parameter α and estimating the rate of min-entropy per bit, demonstrate the module's compliance with FIPS 140-2 by combining the outputs from that generator into longer samples that become the effective sample size of the outputs from the new "NDRNG". The resulting new "NDRNG" would have the larger samples, say 64 bits or larger, and the vendor may claim that this "NDRNG" produces more than 30 bits or entropy per sample. Then, taking into account the recommended value of $\alpha = 2^{-30}$, formula (1) yields *C=2*, which is precisely equivalent to performing a CRNGT. A vendor who would want to pursue this approach for complying with Section 4.9.2 of FIPS 140-2 would just need to determine the parameters α and H and define the new NDRNG with the corresponding sample size.

4. To show how the *C* from formula (1) relates to the characteristics of a particular NDRNG, consider a noise source with assessed min-entropy *H*. Let $p_1, p_2, \ldots, p_k$ be the probabilities of the possible outcomes from sampling the NDRNG, with $p_1 \geq p_2 \geq \cdots \geq p_k$. Note that the probability of producing *C* consecutive samples of outcome *i* is p_i^C. Then the probability *P* of producing any *C* consecutive identical samples is

   $$P = p_1^C + p_2^C + \cdots + p_k^C = p_1 p_1^{C-1} + p_2 p_2^{C-1} + \cdots + p_k p_k^{C-1}$$

   $$\leq p_1 p_1^{C-1} + p_2 p_1^{C-1} + \cdots p_k p_1^{C-1} = (p_1 + p_2 + \cdots p_k) p_1^{C-1} = p_1^{C-1} = (2^{-H})^{C-1} = 2^{-H(C-1)}, \qquad (2)$$

   by the definition of min-entropy. From (1), one can see that $C = \left\lceil 1 + \frac{-\log_2 \alpha}{H} \right\rceil \geq 1 + \frac{-\log_2 \alpha}{H}$, hence $H(C\text{-}1) \geq -\log_2 \alpha$, or $-H(C\text{-}1) \leq \log_2 \alpha$, thus $2^{-H(C-1)} \leq \alpha$. (3)

   From (2) and (3), we obtain: $P \leq \alpha$, and from the above derivation it is clear that this is a tight inequality.

5. It is very important to use the same entropy estimate *H* in determining the cutoff value *C* for the RCT as the estimated entropy for determining the size of output buffer from the NDRNG to use in seeding a DRBG with the strength sufficient for generating the cryptographic keys. In other words, it is not acceptable to use a low entropy estimate H_1 in order to compute a large *C* for the RCT applied to the NDRNG but use a different larger estimate H_2 to determine how many samples of the NDRNG output would be needed to derive a seed for a DRBG.

9.9 Pair-Wise Consistency Self-Test When Generating a Key Pair

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS09.30-33*
Relevant Test Requirements:	*TE09.31.01 and TE09.33.01*
Relevant Vendor Requirements:	*VE09.31.01 and VE09.33.01*

Background

AS09.30: (Levels 1, 2, 3 and 4) If a cryptographic module generates public or private keys, then the following pair-wise consistency tests for public and private keys shall be performed.

AS09.31: (Levels 1, 2, 3 and 4) If the keys are used to perform an approved key transport method, then the public key shall encrypt a plaintext value. The resulting ciphertext value shall be compared to the original plaintext value. If the two values are equal, then the test shall fail. If the two values differ, then the private key shall be used to decrypt the ciphertext and the resulting value shall be compared to the original plaintext value. If the two values are not equal, the test shall fail.

AS09.33: (Levels 1, 2, 3 and 4) If the keys are used to perform the calculation and verification of digital signatures, then the consistency of the keys shall be tested by the calculation and verification of a digital signature. If the digital signature cannot be verified, the test shall fail.

Question/Problem

1. When does the pair-wise consistency self-test need to be performed upon the generation of a (private, public) key pair?
2. Which of the two self-tests listed in the **AS09.31** and **AS09.33** needs to be implemented if, at the time of a key pair generation, it is not yet known if the newly-generated keys will be used in the digital signature or key establishment applications?

Resolution

There is no explicit requirement in FIPS 140-2 for the pair-wise consistency tests for keys used in the key-agreement schemes. AS.09.30 talks about performing the pair-wise consistency tests if the module generates public or private keys, but when this requirement is spelled out in detail, in AS.09.31 and AS.09.33, the requirement applies only to the key transport schemes and to the signature algorithms, not to the key agreement schemes. The versions of **SP 800-56A** include the applicable pair-wise consistency tests for generated keys. No additional tests (that is, not listed in the **SP 800-56A** documents) are required by FIPS 140-2 for the key pairs used in the discrete-logarithm-based key agreement schemes.

The provisions of this Implementation Guidance apply only to the RSA-based key schemes, where the requirements of AS.09.31 and AS.09.33 are applicable. These include the RSA signature and the **SP 800-56B**-compliant key transport (encapsulation) schemes.

1. **Timing of the Pair-Wise Consistency Self-Test**

   The pair-wise consistency self-test **shall** be performed after the generation of a pair (private and public) of keys and before the intended use in the RSA-based asymmetric-key cryptography.

2. **Choice of the Pair-Wise Consistency Self-Test**

   If it is known at the time when the (private, public) RSA key pair is generated whether the keys will be used in a digital signature algorithm or to perform a key transport, then the choice of a pair-wise consistency test **shall** be consistent with the intended use of the keys. That is, if a key pair has been generated for use in the computation and the verification of a digital signature then the pair-wise consistency of the keys **shall** be tested by the calculation and verification of a digital signature on a message as described in **AS09.33**. If a key pair has been generated for use in an approved RSA-based key transport scheme, then the test **shall** be performed as described in **AS09.31**.

   If at the time when a key pair is generated, it is not known whether this pair of keys will be used in the RSA digital signature or the key establishment applications then a pair-wise consistency self-test described either in **AS09.31** or **AS09.33** may be performed on this key pair.

Additional Comments

This Implementation Guidance does not introduce any new requirements not already present in FIPS 140-2. It allows a more relaxed interpretation of the self-test requirement by saying that in one specific case there is a choice how a pair-wise consistency test can be performed.

9.10 Power-Up Tests for Software Module Libraries

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*04/25/2014*
Relevant Assertions:	*AS.09.08, AS.09.09, AS.09.13*
Relevant Test Requirements:	*TE.09.09.01, TE.09.09.02*
Relevant Vendor Requirements:	*VE.09.09.01, VE.09.13.01*

Background

FIPS 140-2 sets the following power-up test requirements for cryptographic modules:

AS09.08: (Levels 1, 2, 3 and 4) Power-up tests shall be performed by a cryptographic module when the module is powered up (after being powered off, reset, rebooted, etc.).

AS09.09: (Levels 1, 2, 3 and 4) The power-up tests shall be initiated automatically and shall not require operator intervention.

TE.09.09.02: The tester shall power-up the module and verify that the module performs the power-up self-tests without requiring any operator intervention.

Software modules may be implemented as applications or libraries. Applications and libraries are fundamentally different from each other with respect to the way the Operating System (OS) loader manages the operational control once the corresponding software module is loaded into memory. The OS loader automatically transfers control over to the application but does not do this in the case of a library unless the library is specifically instrumented to request a transfer. Therefore, an application naturally starts to execute its instructions automatically and without intervention after it is loaded but a library cannot unless it is specifically designed for this. This means that applications may easily satisfy the power-up test requirements for cryptographic modules but libraries need special care.

There are different types of software libraries with respect to the way they are intended to be linked and used by an application: static, shared and dynamically loaded (dynamic). This guidance is applicable to all library types.

Question/Problem

How can modules implemented as software libraries meet the power-up test requirements in **AS09.09**?

Resolution

FIPS 140-2 treats software applications used by an operator on a computing platform as acting on behalf of that operator. An application that links a software module library is considered a user of the module. As a result, any direct *run-time* action taken by the application on that module is considered to be an operator action.

A software module library **shall** be designed with a mechanism that forces the OS loader to transfer control over to the library immediately after loading it. The designed mechanism **shall** ensure that the transfer results into an automatic execution of a library function or a designated library code block without any intervention from an application and before the control is returned back to an application initiating the load. The power-on self-tests of the module **shall** be triggered from within that library function or code block. This execution paradigm satisfies **AS09.08** and **AS09.09** for a validated module.

Note1: While under control of the library function or code block, the determination of whether the module is a *validated* module may be performed. This may require the examination of data parameters indicating the module configuration. These parameters **shall** be set by the Crypto Officer during the module setup and initialization procedure. The Security Policy **shall** contain the detailed setup procedure with the specific instructions for establishing these parameter values. If the determination performed by the module while under the control of the library function or code block invoked by the OS loader is that the module is validated, then the power-on self-tests **shall** be initiated.

Note2: In modern operating systems, libraries may execute in user-space or in the OS kernel. A module implemented as a kernel library/extension **shall** utilize a mechanism that forces the kernel to transfer control over to the library/extension immediately after loading it. Most operating systems allow kernel extensions and provide specific mechanisms for implementing them, including the definition of a *default entry point* (DEP). If a DEP mechanism is provided, it is recommended that the kernel extension **shall** use it to initiate the power-on tests. This applies also to libraries used by other OS services (daemons) that are executing on behalf of the OS.

Note3: If a cryptographic software module is implemented as a static library with a DEP to satisfy the power-up self-test requirements, it **shall** also perform its runtime integrity check in memory by identifying and verifying the library's object code data and text segments in order to comply with **AS.09.13** without including the application into the module boundary. This also applies to shared or dynamic libraries that are loaded when it is impossible to verify the integrity of the library file image.

Note4: The module library **shall** be compiled appropriately so that the execution of constructor/destructor routines is *not* suppressed. If the operating system provides mechanisms to change the OS loader behavior and prevent the automatic invocation of the DEP to meet **AS09.09**, the tester **shall** verify that such mechanisms are specifically disallowed in the crypto officer and operator guidance subject to **AS10.23** and **AS10.25**.

Note5: This guidance also applies to software-hybrid modules when the software part is implemented as a library.

Additional Comments

Dynamically loaded (dynamic) libraries are loaded at times other than during the startup of an application using them. Shared libraries are loaded by the application when it starts. In contrast, static libraries are embedded into the executable of the application at link time. Most compilers allow the definition of a DEP for software libraries, even for static ones. The presence of a library DEP forces the OS loader to call the DEP when it loads the library on behalf of the application linking it. The DEP is executed automatically and independently of the application code before the OS loader hands control back to the application. The OS loader utilizes a standard mechanism for invoking the DEP, which is agnostic of the library programming interface and completely independent of the application code. These nuances are important because while a cryptographic module is allowed to intercept calls to a service when the power-up tests are running and suppress any output of results until the tests complete, a module is not allowed to initiate the tests from within that service. In other words, a software module implemented as a library **shall not** rely on calls inside any function exported as a supported service to initiate the power-up tests. Only a function or a block of code, e.g. static blocks in Java, that is automatically invoked by the operating environment, e.g. the OS Loader, may initiate them.

Here are some examples for how a default entry point in a software module implemented as a library may be defined:

On Unix, Linux, Mac OS X:

```
void __attribute__((constructor)) runModulePOST() {
  /*… perform module self-tests…*/
}
```

On Windows for Win32 API:

```
BOOL WINAPI DllMain(
    HINSTANCE hinstDLL,  // handle to DLL module
    DWORD fdwReason,     // reason for calling function
    LPVOID lpReserved )  // reserved
{
    // Perform actions based on the reason for calling.
    switch( fdwReason )
    {
        case DLL_PROCESS_ATTACH:
         // Initialize once for each new process.
         // Here is where the module POST should be invoked
         // Return FALSE to fail DLL load in case POST fails
            break;

        case DLL_THREAD_ATTACH:
         // Do thread-specific initialization.
            break;

        case DLL_THREAD_DETACH:
         // Do thread-specific cleanup.
            break;

        case DLL_PROCESS_DETACH:
         // Perform any necessary cleanup.
            break;
    }
    return TRUE;  // Successful DLL_PROCESS_ATTACH.
}
```

Note6: Static constructors, i.e. DEP-equivalent mechanisms, exist also for C++ and .NET libraries and libraries implemented in other object oriented languages. To substitute for `DllMain` or to define a DEP in a .NET library, one could employ a static constructor on the exported class to invoke the initialization code. The default constructors of static C++ objects are executed automatically upon loading the library containing them. Similarly, Java provides static code blocks that are executed automatically when the Java Virtual Machine class loader loads the class.

Note7: The OS loaders of some operating systems do not provide a DEP mechanism for software libraries. In such cases the module **shall** utilize the available programming language capabilities to implement a DEP-like initialization as described in **Note6** above. If the module is written in a procedural language, such as the C programming language, to avoid a complete rewrite in an object-oriented language, a judicious switch to a different compiler should be considered. For example, switching to a C++ compiler and placing the original C code inside `extern “C”{}` brackets, would enable static objects with the desired properties for the module.

Test Requirements

The vendor and tester evidence **shall** be provided under **VE.09.09.01, TE.09.09.01, TE.09.09.02** and **TE.09.22.01-TE.09.22.07**.

9.11 Reducing the Number of Known Answer Tests

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2017*
Effective Date:	*08/07/2017*
Last Modified Date:	*11/30/2018*
Relevant Assertions:	*AS09.07 and AS09.16*
Relevant Test Requirements:	*TE09.07.01 and TE09.16.01*
Relevant Vendor Requirements:	

Background

AS.09.16 requires that a cryptographic algorithm test using a Known-Answer-Test (KAT) **shall** be conducted for all cryptographic functions of each approved cryptographic algorithm implemented by the cryptographic module and used in FIPS mode of operation.

Question/Problem

How should the “all” in **AS.09.16** be interpreted? One possible interpretation is that each time the module is powered-up, a separate known answer test is performed for each approved algorithm supported by the module. However, given the serious burden this requirement imposes on the module in terms of the amount of time spent before any data can be output by the module, it will be desirable to reduce the number of these tests if some other indication of the health of the module could be presented at the time of the module’s power-up.

A certain reduction in the number of KATs has already been implemented. IG 1.7 allows the module to perform only those KATs that apply to algorithms in the Approved mode of operations chosen at power-up. Various IGs in Section 9 of the FIPS 140-2 Implementation Guidance show that if the module successfully passes some other tests then performing a KAT for a particular algorithm may be unnecessary.

Can the number of KATs be further reduced given the knowledge that the module passed its software/firmware integrity test which is anyway required when the module contains any software or firmware?

Resolution

The module **shall** pass a complete set of power-on self-tests (an integrity test and the algorithm self-tests for all approved algorithms in the chosen approved mode of operation per IG 1.7) upon the module’s installation/configuration in each operational environment. Once the module has passed this initial set of power-on self-tests, in any subsequent restart the module is required to perform the power-on self-tests only for the approved algorithms which have not yet been self-tested because they have not been defined in any of the approved modes of operation used previously in the operational environment of the current power-on. The software/firmware integrity test, as defined in Section 4.9.1 of FIPS 140-2 and further clarified in IG 9.12 is mandatory for every restart of the module.

This guidance can be applied to all algorithms that are either implemented fully within firmware/software (and therefore covered by an integrity test), or *partially* implemented in hardware (such as a PAA per IG 1.21). For algorithms that are fully implemented in hardware (such as a PAI per IG 1.21) and are not covered by an integrity test, this guidance **shall not** be applied and power on self-tests for these algorithms are required during each power on. The same guidance applies for embedded algorithms. For example, if a firmware RSA Signature implementation uses a hardware SHA-256, then the SHA-256 **shall** have a POST, unless the SHA-256 implementation is protected by the module's integrity test. However, provisions from this IG can be used by the RSA Signature to reduce the self-testing, since the RSA implementation is covered by an integrity test. Guidance, as explained in this paragraph, will have an **effective date of May 10, 2019** whereby after this date, every new submission that utilizes IG 9.11 provisions **shall** meet these requirements. Before this date, a module may be validated by using provisions of IG 9.11 without the guidance as explained in this paragraph.

The module **shall** still provide an operator with the capability to request the execution of the KATs for all approved algorithms supported by the module at any stage of the module's lifecycle. This includes software, firmware, hardware, and/or hybrid implementations.

Rationale

If the module and its algorithm implementations have been tested by an accredited testing lab, this already provides strong guarantees that all algorithms produce the correct results. If, further, the module's firmware/software integrity has been tested, and all KAT succeed at the module's first start-up in the same operational environment, then it is all but impossible that a particular algorithm implementation running in the same operational environment has been corrupted. Thus, performing the KATs at each subsequent start-up, at the same time when the module's integrity test is performed, does not add to the assurance of the module's ability to correctly perform the cryptographic operations. While the FIPS 140-2 standard does require that all algorithms are tested by a KAT at power-up, it can be argued that this requirement is met by the combination of lab testing, the testing upon the initial installation of the module on the platform of use which includes the power-up integrity test and the full set of KATs, and the software/firmware integrity test at each power-on of the module.

This IG does not apply to Hardware Modules with no firmware present, as these are assumed not to be covered by an integrity test. Any such module is required to perform the power-on self-tests for all approved algorithms defined for an approved mode selected for a given power-on.

Additional Comments

1. This Implementation Guidance does not change the requirements of the FIPS 140-2 standard. The FIPS 140-2 requirement **AS09.16** continues to apply. The current guidance gives the vendor a choice of how a known answer test may be conducted. The tests may be performed either by a direct computation of a cryptographic function and comparing the result of said computation to a pre-computed value, or by claiming one of the exceptions from this rule already specified in several other IGs, or – an option introduced in this Guidance – by observing and claiming that the successful passing of the known answer tests is already guaranteed by the module being tested initially and executing a software/firmware integrity test at each power-on.

2. If a pair-wise consistency test may be used in lieu of a known answer test, this guidance applies and the use of this test is not needed when the guidance says that an execution of the corresponding known answer test is not required.

3. The module is required to have the capability to perform the applicable power-up tests on demand for the approved algorithms implemented in the module.

4. To take advantage of the provisions of this IG, the module **shall** know whether a particular power-up is performed when the module is first installed or configured in a new operational environment. If the module needs to use a parameter that "remembers" that the module has already been installed in a given environment and the algorithms have been self-tested, then this parameter's value **shall** be treated the same as a public key, in which case the integrity of this parameter is assured by the module.

In the absence of a parameter that keeps track of the earlier execution of the power-up self-tests, the module's operator may make the determination (without violating AS09.09) if the power-up algorithm self-tests need to be performed, based on the operator's knowledge of the history of performing these tests in each environment. If neither the module itself nor the operator is able to determine if this is the first time the module is instantiated in a given environment, the module **shall** perform all of the applicable algorithmic power-up self-tests for the approved algorithms implemented in the module.

9.12 Integrity Test Using Sampling

Applicable Levels:	*All*
Original Publishing Date:	*12/04/2017*
Effective Date:	*12/04/2017*
Last Modified Date:	*12/04/2017*
Relevant Assertions:	*AS.06.08 and AS.09.22*
Relevant Test Requirements:	*TE06.08.01-02 and TE09.22.01-07*
Relevant Vendor Requirements:	*VE.06.08.01 and VE.09.22.01*

Background

AS.09.22 requires that a software/firmware integrity test using an error detection code (EDC) or approved authentication technique (e.g., and approved message authentication code or digital signature algorithm) **shall** be applied to all validated software and firmware components within the cryptographic module when the module is powered up.

Question/Problem

Some cryptographic modules running in a limited Operational Environment include an operating system and hardware drivers together with applications, which results in a large installation binary image (e.g. a few Gigabytes installation image for a network appliance). Some other modules may not have a large (in terms of its bit size) firmware image, but they run on a resource-constrained platform (e.g. smart cards with a low processor speed). In both cases, an integrity check, even if it is using an EDC, takes such a long time to complete that it significantly slows the power-up process and renders the devices with such FIPS validated modules useless. This raises a problem of how the integrity test required in FIPS 140-2 should be performed in a reasonably short time for modules containing firmware.

How should the "all" in **AS.09.22** be interpreted? One possible interpretation is that each time the module is powered-up a firmware integrity test is performed on the *entire* image of the firmware. This technique is unacceptably slow for some devices, as indicated above. It will be desirable to reduce the amount of firmware image subject to the integrity check while still maintaining the evidence of the integrity of the module's firmware. Sampling is the method commonly used in various industries to reduce the testing space while maintaining an acceptable level of assurance.

Will sampling methods be acceptable in a firmware integrity test?

Resolution

The module may choose to perform the firmware integrity test either on the whole firmware image or it may use a sampling method.

The following assumptions are made:

1. The firmware image can be viewed as a bitstring or a set of files.
2. The bitstring or files consisting of the firmware image can be divided into up to 20 portions, each of which has the total size no less than 100,000 bits.
3. The probability of any bit taking an erroneous value in the firmware image bitstring is very low.

The first time an integrity self-test is performed upon the installation or reconfiguration of the module or upon a factory reset, the integrity test **shall** be performed on the entire firmware image. Then for a firmware integrity test at each subsequent power-on, the integrity test is performed on a portion of the firmware that will be chosen by a sampling method. This speeds up the operations significantly. Furthermore, by using a sampling method to determine which portion of the firmware is tested on each application of an integrity test, all parts of firmware will get tested after the integrity tests are performed sufficiently many times. Therefore, it can be claimed that the test does apply to all cryptographic firmware components within the module, thus literally meeting the requirements of **AS.09.22**.

Suppose that the firmware has been divided into n portions labeled as $P_1, P_2, \ldots, P_n$, where $1 \leq n \leq 20$ and bitsize(P_i) $\geq 100{,}000$ for $1 \leq i \leq n$. Each time when an execution of an integrity test is required, the module samples, either **deterministically** or **randomly**, the integers between 1 and n to select the portion of the firmware which will be integrity-tested.

Deterministic Sampling Method

This method predefines the order in which a portion of the firmware for integrity test will be selected. Without the loss of generality, suppose that the predefined order is $P_1, P_2, \ldots, P_n$. When the deterministic integrity test is performed for the first time, it is performed on portion P_1. The module saves the current index counter: 1. Each subsequent time the integrity test is performed, the index counter is incremented by 1 and the portion P_j, where j is the newly incremented index, is tested. The new index j is now saved and **shall** be treated as the module's public key: the module **shall** prevent any unauthorized modification of this parameter. When the last index n needs to be incremented, the counter is reset to 1 and the process continues. If this deterministic method is used, after n invocations of the integrity test the entire firmware image will have been tested.

Random Sampling Method

To use the random method, the module **shall** implement a random number generator ϒ. This random number generator, which can generate integers between 1 and n, each of them at the same rate $1/n$, does not have to be approved for use in cryptographic applications; however, it **shall** generate its own entropy. The amount of the generated entropy **shall** be sufficient to make possible the choice of any integer number between 1 and n. The module **shall** be able to generate this small amount of entropy at the time of each invocation of the integrity check, including at power-up.

When a firmware integrity test is performed, the random number generator is called to select an index j between 1 and n and then the module performs an integrity test on the portion P_j.

Additional Comments

1. A firmware integrity test is a health test only. It is not designed nor is it intended to guard against the targeted attacks. The cryptographic module will have other means of defense – commensurate with the module's Security Level – to protect against the deliberate attacks.
2. In the event of an integrity test failure, recovery from the error state **shall** require that the module perform an integrity check of the entire firmware as was done in the initial installation of the module. If the

integrity check of the entire firmware is successful, the module may return to running an integrity check using sampling either via the deterministic or the random method described in this IG.

3. The module **shall** be designed to perform, at the request of an operator, an integrity test on its entire firmware image.
4. A natural partition of the module's firmware may contain more than 20 files or bitstrings. The vendor may group some of these portions together to meet the requirement of having no more than 20 P_i's for the purpose of performing the integrity test using sampling.
5. If the random sampling method is used, the testing lab **shall** provide to the CMVP the design of the random number generator ϒ along with the rationale for why this random number generator is suitable for its purpose and how its entropy is generated from the environment; especially, when ϒ is invoked at the power-up. The vendor's analysis of the collected entropy **shall** to be clear and logical; however, it does not need to meet the scrutiny of the analysis of the module's NDRNG that generates the entropy used for key generation.
6. This is an example of a random number generator that may be used to provide the entropy for the random sampling. It can be assumed that the module has a built-in clock and can measure time. At each power-up, the module will record the time and compute a number based on the last three decimal digits of the time's reading. That is, if the time is 13 hours, 51 minutes and 6.533146 seconds, the RNG will output the number m=146. If only the millisecond precision is available and the recorded time is 13 hours, 51 minutes and 6.533 seconds, the output is 533. The power-ups should not occur very frequently, so the outputs can be considered independent.
7. Take the output from the previous step (e.g., 533) and mod it by the number of the portions of the firmware (e.g., 20) and increase it by 1: (533 mod 20) + 1 = 14. Then perform the integrity test on the portion P_{14}.
8. The upper bound (20) on n and the lower bound (100,000) on the bit size of each portion P_i in the subdivision of the module's firmware image have been chosen to assure that a significant part of the module's firmware is integrity-tested at each power-up of the module.
9. The tester **shall** document how the module meets each shall statement in this IG in the Assessment for TE.09.22.01.
10. The sampling method presented in this IG applies only to the cryptographic modules with a limited operational environment. The software modules, typically operating on a GPC with a modifiable operational environment are expected to operate with a sufficiently fast processor that will assure the execution of the full integrity test within an acceptable time limit.

9.13 Non-Reconfigurable Memory Integrity Test

Applicable Levels:	*All*
Original Publishing Date:	*12/04/2017*
Effective Date:	*12/04/2017*
Last Modified Date:	*12/04/2017*
Relevant Assertions:	*AS09.22*
Relevant Test Requirements:	*TE09.22.01*
Relevant Vendor Requirements:	*VE09.22.01, VE09.22.02*

Background

Software/firmware integrity test. A software/firmware integrity test using an error detection code (EDC) or Approved authentication technique (e.g., an Approved message authentication code or digital signature algorithm) **shall** (per AS.09.22) be applied to all validated software and firmware components within a cryptographic module when the module is powered up. The software/firmware integrity test is not required for any software and firmware components excluded from the security requirements of this standard (refer to Section 4.1 of FIPS 140-2).

Question/Problem

What is the definition of "non-reconfigurable memory"? Is software or firmware located in non-reconfigurable memory subject to the AS09.22 software/firmware integrity test?

Resolution

Non-reconfigurable memory **shall** be defined as a memory technology that stores data using a mechanical means (e.g. masked ROM, CD-ROM) that will never change once manufactured.
The software or firmware integrity test is not required for executable code stored in non-reconfigurable memory. This code is considered hardware. Therefore, the provisions of IG 9.11 *Reducing the Number of Known Answer Tests* do not apply in that if an integrity test is not performed on the non-reconfigurable memory area of the module, and if any of the approved cryptographic algorithms are implemented in this area, then the power-on self-tests **shall** be performed on these algorithms.

Additional Comments

The reason for the above definition on what constitutes non-reconfigurable memory is that most common read-only memory technologies (e.g. OTP, PROM, WORM, CD-R) store data using a chemical change or electrical charge that is subject to degradation over time. This IG does not apply to such cases where degradation is a factor, and the memory would still be subject to the integrity test. However, IG 9.12 *Integrity Test Using Sampling* provides strategies for reducing the burden of the integrity test.

Section 10 – Design Assurance

Section 11 – Mitigation of Other Attacks

11.1 Mitigation of Other Attacks

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Effective Date:	
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*AS.11.01*
Relevant Test Requirements:	*TE11.01.01-02*
Relevant Vendor Requirements:	*VE.11.01.01-02*

Background

AS.11.01: (Levels 1, 2, 3, and 4) If the cryptographic module is designed to mitigate one or more specific attacks, then the module's security policy shall specify the security mechanisms employed by the module to mitigate the attack(s).

Question/Problem

When is this section applicable?

Resolution

If a cryptographic module has been *purposely* designed, built and publicly documented to mitigate one or more specific attacks, this section is applicable and **AS.11.01** **shall** be addressed regardless if the vendor of the module wishes to address the claim or not. Mitigation mechanisms may address both invasive (physical) or non-invasive mechanisms. The testing laboratory, upon inspection of the modules design and documentation (both proprietary and public), **shall** verify the implemented mitigation mechanisms and/or mitigations claimed by the vendor as specified in **AS.11.01**.

Example: FIPS 140-2 Section 4.5 Level 2 is claimed. However, the vendor states that module design includes a switch that will cause zeroization of CSPs if some part of the module is opened or penetrated. Since this is not required at Level 2, for the vendor to claim this feature, it **shall** be addressed in FIPS 140-2 Section 4.11 as an additional mitigation mechanism.

Section 12 – Appendix A: Summary of Documentation Requirements

Section 13 – Appendix B: Recommended Software Development Practices

Section 14 – Appendix C: Cryptographic Module Security Policy

14.1 Level of Detail When Reporting Cryptographic Services

Applicable Levels:	*All*
Original Publishing Date:	*11/15/2001*
Effective Date:	*11/15/2001*
Last Modified Date:	*08/07/2017*
Relevant Assertions:	*AS.01.02, AS.01.03, AS.01.12, AS.01.16, AS.03.14, AS.10.06, AS.14.02, AS.14.03, AS.14.04, AS.14.06, AS.14.07*
Relevant Test Requirements:	*TE01.03.01, TE01.03.02, TE01.16.01, TE03.14.01, TE10.06.01, TE14.07.01, TE14.07.02*
Relevant Vendor Requirements:	*VE.01.03.01, VE.01.03.02, VE.01.16.01, VE.03.14.01, VE.03.14.02, VE.10.06.01, VE.14.07.01, VE.14.07.02, VE.14.07.03*

Question/Problem

What is the level of detail that the non-proprietary security policy must contain in order to describe the cryptographic service(s) implemented by a cryptographic module?

Resolution

When presenting information in the non-proprietary security policy regarding the cryptographic services that are included in the module validation, the security policy **shall** include, at a minimum, the following information **for each service**:

- The service name
- A concise description of the service purpose and/or use (the service name alone may, in some instances, provide this information)
- A list of approved security functions (algorithm(s), key management technique(s) or authentication technique) used by, or implemented through, the invocation of the service.
- A list of the cryptographic keys and/or CSPs associated with the service or with the approved security function(s) it uses.
- For each operator role authorized to use the service:
    - Information describing the individual access rights to all keys and/or CSPs
    - Information describing the method used to authenticate each role.

The presentation style of the documentation is left to the vendor. FIPS 140-2, Appendix C, contains tabular templates that provide non-exhaustive samples and illustrations as to the kind of information to be included in meeting the documentation requirements of the Standard.

Additional Comments

FIPS 140-2 requires information to be included in the module security policy which:

- Allows a user (operator) to determine when an approved mode of operation is selected (**AS.01.16**).
- Lists all security services, operations or functions, both approved and non-approved, that are provided by the cryptographic module and available to operators (**AS.01.12, AS.03.07, AS.03.14, AS.14.03**). The only exception is services that belong to "group 4" defined in IG 3.5.

- Provides a correspondence between the module hardware, software, and firmware components (**AS.10.06**)
- Provides a specification of the security rules under which the module **shall** operate, including the security rules derived from the requirements of FIPS 140-2. (**AS.14.02**)
- For each service documented in the module Security Policy, specifies a detailed specification of the service inputs, corresponding service outputs, and the authorized roles in which the service can be performed. **(AS.03.14, AS.14.03)**

See also the definitions of ***Approved mode of operation*** and ***Approved security function*** in FIPS 140-2.

14.2 Level of Detail When Reporting Mitigation of Other Attacks

Applicable Levels:	*All*
Original Publishing Date:	*11/15/2001*
Effective Date:	*11/15/2001*
Last Modified Date:	*11/15/2001*
Relevant Assertions:	*AS.14.09*
Relevant Test Requirements:	*TE14.09.01*
Relevant Vendor Requirements:	*VE.14.09.01*

Question/Problem

What is the level of detail that the non-proprietary security policy must contain that describes the security mechanism(s) implemented by the cryptographic module to mitigate other attacks?

Resolution

The level of detail describing the security mechanism(s) implemented by the cryptographic module to mitigate other attacks required to be contained in the security policy must be similar to what is found on advertisement documentation (product glossies).

14.3 Logical Diagram for Software, Firmware and Hybrid Modules

Applicable Levels:	*All*
Original Publishing Date:	*07/03/2007*
Effective Date:	*07/03/2007*
Last Modified Date:	*07/03/2007*
Relevant Assertions:	*AS.14.01*
Relevant Test Requirements:	*TE14.01.01*
Relevant Vendor Requirements:	*VE.14.01.01*

Background

VE.14.01.01 specifies the requirement for the vendor to provide in the security policy a diagram or image of the physical cryptographic module.

While the requirement is vague when applied to a software, firmware or hybrid cryptographic module, it is intended as well to clearly illustrate the logical boundary of the module as well as the other logical objects and the operating environment with which the module executes with.

Question/Problem

For a software, firmware or hybrid cryptographic module, what are the requirements of the *logical diagram* contained in the security policy as specified in **VE.14.01.01**?

Resolution

The *logical diagram* must illustrate:

- the logical relationship of the software, firmware or hybrid module with respect to the operating environment. This **shall** include, as applicable, references to any operating system, hardware components (i.e. hybrid) other supporting applications, and illustrate the physical boundary of the platform. All the logical and physical layers between the logical object and the physical boundary **shall** be clearly defined.

Additional Comments

The *logical diagram* must convey basic information to the operator of the cryptographic module about its relationship respective to the operating environment.

The *logical diagram* could be a subset of the block diagram specified in **AS.01.13**.

14.4 Operator Applied Security Appliances

Applicable Levels:	*Level 2, 3 or 4*
Original Publishing Date:	*01/27/2010*
Effective Date:	
Last Modified Date:	*08/07/2017*
Relevant Assertions:	*AS.05.15, AS.05.26, AS.05.35, AS.05.49, AS.10.04, AS.10.22, AS.14.01 and AS.14.08*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 Section 4.5, *Physical Security*, addresses specific requirements at Level 2. This IG addresses the following two requirements:

1. a module **shall** be constructed in a manner to provide tamper evidence, and
2. a module **shall** have an opaque tamper evident coating or enclosure.

IG 5.1 provides guidance on opacity and IG 5.2 on testing of tamper evident seals. Many module implementations are constructed in a manner where the operator of the module is required to install or affix items such as tamper evident seals or security appliances (e.g. baffles, screens, etc.) to configure the module to operate in the approved mode of operation. In addition, the operator may over the life-cycle of the module, modify some of the non-security relevant aspects of the module that would require the removal and replacement of tamper evident seals or security appliances.

Question/Problem

What specific information **shall** be included in the test report, certificate and Security Policy when a module validated at Physical Security Level 2 has tamper evident seals or security appliances that the operator will apply or modify over the lifecycle of the module?

Resolution

The following specific information **shall** be included in the test report, certificate and Security Policy to meet the relevant assertions:

1. If the module is shipped unassembled, then **AS.14.03** **shall** be addressed with appropriate detail.
2. In addition to other applicable caveats, the certificate caveat **shall** include as applicable the following:

   (The <tamper evident seals> and <security devices> installed as indicated in the Security Policy)

3. The Security Policy **shall** include the following:
   a. The reference photo/illustration required in **AS.14.01** **shall** reflect the validated module configured or constructed as specified on the validation certificate. Additional photos/illustrations may be provided to reflect other configurations that may include parts that are not included in the validation.
   b. If filler panels are needed to cover unpopulated slots or openings to meet the opacity requirements, they **shall** be included in the photo/illustration with tamper seals affixed as needed. The filler panels **shall** be included in the list of parts in **AS.01.08**.
   c. There **shall** be unambiguous photos/illustrations on the precise placement of any tamper evident seal or security appliance needed to meet the physical security requirements.
   d. The total number of tamper evident seals or security appliances that are needed **shall** be indicated (e.g. 5 tamper evident seals and 2 opacity screens). The photos/illustrations which provide instruction on the precise placement **shall** have each item numbered in the photo/illustration and will equal the total number indicated (the actual tamper evident seals or security appliances are not required to be numbered).
   e. If the tamper evident seals or security appliances are parts that can be reordered from the module vendor, the Security Policy **shall** indicate the vendor name and part number of the seal, security appliance or applicable security kit.

      Note: After reconfiguring, the operator of the module may be required to remove and introduce new tamper evident seals or security appliances.
   f. There **shall** be a statement in the Security Policy stating:

      The <tamper evident seals> and <security devices> **shall** be installed for the module to operate in the approved mode of operation.
   g. The Security Policy **shall** identify the operator role responsible for:
      - securing and having control at all times of any unused seals, and
      - the direct control and observation of any changes to the module such as reconfigurations where the tamper evident seals or security appliances are removed or installed to ensure the security of the module is maintained during such changes and the module is returned to a FIPS approved state.
   h. If tamper evident seals or security appliances can be removed or installed, clear instructions **shall** be included regarding how the surface or device **shall** be prepared to apply a new tamper evident seal or security appliance.

Additional Comments

If a cryptographic module requires more than one tamper evident seal to be applied, the Physical Security Test report that is submitted to the CMVP for review **shall** address the testing of each tamper evident seal individually if the surface topography or surface material is different between different sets of seals.

14.5 Critical Security Parameters for the SP 800-90 DRBGs

Applicable Levels:	*All*
Original Publishing Date:	*12/23/2010*
Effective Date:	
Last Modified Date:	*11/05/2021*
Relevant Assertions:	*AS.01.15, AS.07.09, AS.07.13, AS.07.14, AS.07.23, AS.14.04, AS.14.06*
Relevant Test Requirements:	*TE01.15.01, TE07.13.01*
Relevant Vendor Requirements:	

Background

The FIPS 140-2 cryptographic module Security Policy **shall** specify all cryptographic keys and CSPs employed by the cryptographic module.

Question/Problem

Which are the critical security parameters that determine the security of the **SP 800-90A** DRBG mechanisms?

Resolution

The entropy input string and the seed **shall** be considered CSPs for all the DRBG mechanisms.

During the instantiation of a DRBG the initial state is derived from the seed. The internal state contains administrative information and the working state. Some values of the working state are considered secret values of the internal state. These values are listed below:

1. Hash_DRBG mechanism

   The values of V and C are the "secret" values of the internal state.
2. HMAC_DRBG mechanism

   The values of V and Key are the "secret values" of the internal state.
3. CTR_DRBG mechanism

   The values of V and Key are the "secret values" of the internal state.

Additional Comments

1. The **SP 800-90A** requires that the internal state is protected at least as well as the intended use of the pseudorandom output bits requested by the consuming application. **SP 800-90A** further requires that the DRBG internal state is contained within the DRBG mechanism boundary and **shall not** be accessed by non-DRBG functions or other instantiations of that or other DRBGs.

   TE.01.15.01 **shall** specify how the above requirements are met.
2. The following assessments: **AS07.09**, **AS07.14** and **AS07.23** are no longer applicable, as the only approved random number generators (not otherwise approved for classified applications) are the **SP 800-90A**-compliant DRBGs. The DRBGs do not use the *seed key* parameter.
3. In the case of the CTR_DRBG, the test report **shall** indicate if a derivation function is used during the instantiation and reseeding. If the derivation function is not used, the test report **shall** demonstrate that the DRBG is seeded by an entropy source producing the full-entropy outputs, as required in Section 10.2.1 of **SP 800-90A**. An entropy source seeding the CTR_DRBG without a derivation function **shall** be located inside the module's physical boundary and provide full entropy as evaluated by the CMVP.

   SP 800-90A Section 10.2.1 references "an approved RBG" as another option to seed the CTR_DRBG, but this IG only allows an entropy source producing full-entropy outputs. The reason for this is the “approved RBG” is referring to the future RBG construction – specifically, RBG3 - that is shown (as of the latest modification date of this IG) in the draft of **SP 800-90C**.

FIPS 140-2 Annex A – *Approved Security Functions*

A.1 Validation Testing of SHS Algorithms and Higher Cryptographic Algorithm Using SHS Algorithms

Applicable Levels:	*All*
Original Publishing Date:	*08/19/2004*
Effective Date:	*08/19/2004*
Last Modified Date:	*08/19/2004*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

The Cryptographic Algorithm Validation Program (CAVP) validates every SHS algorithm implementation: SHA-1, SHA-224, SHA-256, SHA-384 and SHA-512. Several higher cryptographic algorithms use those SHS hashing algorithms in their operation.

Question/Problem

What are validation testing requirements for the SHS algorithms and higher cryptographic algorithms implementing SHS algorithms for their use in FIPS approved mode of operation?

Resolution

To be used in a FIPS approved mode of operation:

- every SHS algorithm implementation must be tested and validated on the appropriate OS.
- for DSA, RSA, ECDSA and HMAC, every implemented combination must be tested and validated on the appropriate OS.

The algorithmic validation certificate annotates all the tested implementations that may be used in a FIPS approved mode of operation.

Any algorithm implementation incorporated within a FIPS 140-2 cryptographic module that is not tested may not be used in a FIPS approved mode of operation. If there is an untested subset of a FIPS approved algorithm, it would be listed as non-approved and non-compliant on the FIPS 140-2 validation certificate.

A.2 Use of non-NIST-Recommended Elliptic Curves

Applicable Levels:	*All*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*11/05/2021*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

The NIST **FIPS 186-4** standard allows (in Section 6.1.1) the use of the non-NIST-Recommended curves in the ECDSA algorithm in the approved mode. Similarly, the NIST **SP 800-56A Rev2** standard allows (in Section 5.5.1.2) the use of the non-NIST-Recommended curves in the elliptic-curve-based key agreement methods, EC Diffie-Hellman and ECMQV. IG D.8 allows the use in the approved mode of the non-approved methods (that is, not compliant with **SP 800-56A, SP 800-56A Rev2** or **SP 800-56A Rev3**) in the key agreement schemes; if scenario 4 or scenario X2 of IG D.8 is claimed, these non-approved but allowed methods may utilize the non-NIST-Recommended curves.

Question/Problem

What are the rules for using the non-NIST-Recommended elliptic curves in the ECDSA signature algorithm and the ECC-based key agreement schemes in the approved mode of operation?

Resolution

The CMVP allows the use of non-approved elliptic curves in the approved mode of operation providing:

- the algorithm implementation **shall** use approved underlying algorithms, such as the message digests,
- the security policy **shall** list all approved and non-approved curves that are implemented,
- the security policy **shall** indicate the associated security strength for all non-approved curves that are implemented. The vendor **shall** check that the curve is not singular; provide to the CMVP the information about the curve's underlying field (which **shall** be either of a prime order or of the order 2^m, where m is prime) and about the number of points on the curve; present the factorization of the number of points on the curve into a large prime n and a co-factor h as shown in **FIPS 186-4**; verify that h is within the limits established in Table 1 of Section 6.1.1 of **FIPS 186-4**; check that the curve is non-anomalous (the number of points on the curve is not equal to the size of the field), and that the MOV condition is met for all $B \leq 100$. See **ANS X9.62** or the ECC textbooks for details, and
- if ECDSA or an ECC-based KAS is listed on the certificate's approved line, the algorithm implementation **shall** have been CAVP-tested and validated for at least one NIST-Recommended curve. A KAS (**SP 800-56Arev2**, vendor affirmed) or a KAS-SSC (vendor affirmed) entry requires vendor affirmation of the module's compliance (with **SP 800-56A Rev2** or **SP 800-56A Rev3**, correspondingly) when using at least one NIST-recommended curve.

A.3 Vendor Affirmation of Cryptographic Security Methods

Applicable Levels:	*All*
Original Publishing Date:	*01/25/2007*
Effective Date:	*01/25/2007*
Last Modified Date:	*01/05/2021*
Transition End Dates	*As specified below*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01-4*
Relevant Vendor Requirements:	*VE.01.12.01-4*

Background

FIPS 140-2 describes approved security functions which can be used in the approved mode of operation, and non-approved security functions which cannot be used in the approved mode of operation. Approved security functions are expected to be CAVP tested, but CAVP testing has not always been available for these methods.

In such cases where CAVP testing is not available, guidance must be written to permit using these algorithms in the approved mode. These algorithms may be "vendor affirmed" to meet the applicable standard(s).

In addition, security methods that fall outside of the list of approved methods cannot be used in the approved mode, *unless* guidance is written to permit such special cases, where these methods are *allowed* to be used in the approved mode of operation.

This Implementation Guidance explains when vendor affirmed or *allowed* methods are permitted.

Questions/Problems

What is the CAVP release schedule for approved algorithms and what is the transition schedule in which CAVP testing will be required for these algorithms? If CAVP testing is not available for approved security functions, approved random number generators or approved key establishment techniques specified in FIPS 140-2 Annexes A, C, and D, can the approved methods be used in FIPS mode, and if so, how shall it be tested and annotated on the module validation certificate and security policy? If security methods are not considered approved, is there any way to use such methods in the approved mode of operation?

Resolution

When a security function is newly approved or allowed, and either the CAVP testing for this function is available or an IG has been written that shows the function's validation status (approved and tested, or vendor affirmed, or allowed), the self-test rules, the documentation requirements, etc., this function will be added to the relevant FIPS 140-2 Annexes. Algorithm and component testing will be added to the CAVP ACVTS production server as they become ready and will not be bundled into releases in the same way as was historically done with CAVS. The CAVP and CMVP also anticipate that algorithm/component testing will be available shortly after, if not before, a standard is finalized and added to the FIPS 140-2 Annexes.

When CAVP testing is released on the production server in any of the 3-month periods identified below, the transition occurs at the end of the following 3-month Transition date. More specifically:

CAVP testing release	CMVP Transition Dates (CMVP report must be submitted by)
January 1 – March 31	June 30
April 1 – June 30	September 30
July 1 – September 30	December 31
October 1 – December 31	March 31

So, for example, if the CAVP releases new testing for algorithm A, B and C, during the July 1 – September 30 period, then the transition date will be September 30 + three months, so December 31, where after that date vendor affirming to algorithms A, B, or C will be prohibited in submitted reports.

During the transition period, a new approved method would either be listed on the module's certificate as approved with a reference to a CAVP validation certificate, or as vendor affirmed if CAVP testing was not performed and an IG that supports vendor affirmation of this algorithm was met.

When the transition period ends, for newly received test reports:

- only approved methods that have been tested and received a CAVP validation certificate would be allowed. All other methods would be listed as non-approved and not allowed in an approved mode of operation.

- the vendor could optionally follow up with testing of un-tested vendor affirmed methods and if so, the reference to vendor affirmed would be removed and replaced by reference to the algorithm certificate. If there are no changes to the module or if the changes are non-security relevant this change can be submitted under scenario 1 of IG G.8. If the module is changed with security relevant changes, this can be submitted under scenarios 3 or 5 as applicable.

Note: To track the algorithms and their transition dates, the CMVP keeps a table available on their website (https://csrc.nist.gov/Projects/cryptographic-module-validation-program/programmatic-transitions);

If CAVP testing is not available or the module is submitted during a transition period, then the following guidance is applicable.

If new approved methods (e.g. NIST FIPS, Special Publication, etc.) are added to the Annexes, until such time that CAVP testing is available or the transition period has not yet expired for the new method, the CMVP will:

- if applicable, allow methods as provided by existing guidance (e.g. untested and listed as non-approved but *allowed* in FIPS mode as shown in IGs D.8 and D.9); and
- allow the vendor to implement the new approved method if an IG that supports vendor affirmation of this algorithm is published and met (untested, listed as approved and allowed in FIPS mode with the caveat "*vendor affirmed"*). See IG G.13 for examples of the "vendor affirmed" caveat.

Note:

1. The Cryptographic Technology Group at NIST may determine that prior methods may be retroactively disallowed and moved to non-approved and not allowed in a FIPS mode of operation (e.g. DES). A transition notice would appear in NIST publications.
2. For all approved methods, all applicable FIPS 140-2 requirements **shall** be met. An IG may further clarify the self-test requirement for a vendor affirmed algorithm.

Additional Comments

Vendor Affirmed**:** a security method reference that is listed with this caveat has not been tested by the CAVP, and the CMVP or CAVP provide no assurance regarding its correct implementation or operation. Only the vendor of the module affirms that the method or algorithm was implemented correctly.

The users of cryptographic modules implementing vendor affirmed security functions must consider the risks associated with the use of un-tested and un-validated security functions.

Test Requirements

Required Vendor Information

VE.01.12.03: The vendor **shall** provide a list of all vendor affirmed security methods.

VE.01.12.04: The vendor provided nonproprietary security policy **shall** include reference to all vendor affirmed security methods.

Required Test Procedures

TE01.12.03: The tester **shall** verify that the vendor has provided the list of vendor affirmed security methods as described above.

TE01.12.04: The tester **shall** verify that the vendor provided documentation specifies how the implemented vendor affirmed security methods conform to the relevant standards.

Required Use of "Vendor Affirmed" Caveat

All cryptographic methods that are approved and *vendor affirmed* **shall** be specified on the certificate and in the security policy, and be annotated with, in addition to the other required caveats as applicable, the caveat (vendor affirmed). See IG G.13 for vendor affirmation examples.

A.4 moved to W.7

A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D

Applicable Levels:	*All*
Original Publishing Date:	*03/10/2009*
Effective Date:	*03/10/2009*
Last Modified Date:	*01/05/2021*
Relevant Assertions:	*AS01.12, AS07.03, AS14.02, AS14.03*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

SP 800-38D was added to FIPS 140-2 Annex A on December 18, 2007. **SP 800-38D** requires that "the probability that the authenticated encryption function ever will be invoked with the same IV and the same key on two (or more) distinct sets of input data **shall** be no greater than 2^{-32}".

One difficulty of testing the module's compliance with this requirement comes from the fact that each module is tested independently while **SP 800-38D** demands that the probability of the (Key, IV) pair collision between all modules at all times should be sufficiently low to ensure cryptographic strength.

Question/Problem

How shall a cryptographic module satisfy these requirements?

Resolution

An AES GCM key may either be generated internally or entered into the cryptographic module.

Techniques for generating an IV that are acceptable for the purposes of FIPS 140-2 validation are listed below.

1. Construct the IV in compliance with the provisions of a peer-to-peer industry standard protocol whose mechanism for generating the IVs for AES GCM has been reviewed and deemed acceptable by the appropriate validation authorities and subject to the additional requirements established in this guidance. The current list of acceptable protocols is shown below:

    a. TLS 1.2 GCM Cipher Suites for TLS, as described in RFCs 5116, 5246, 5288, and 5289 provisions;

    b. IPsec-v3 protocol, as described in RFCs 4106, 5282, and 7296.

    c. MACsec with GCM-AES-128, GCM-AES-256, GCM-AES-XPN-128 and GCM-AES-XPN-256 Cipher Suites, as described in IEEE 802.1AE (MACsec) and its amendments.

    d. SSHv2 protocol defined in RFCs 4251, 4252, 4253, 4254 and 5647.

The following are additional specific requirements for each acceptable protocol for the purposes of FIPS 140-2 validation.

TLS 1.2 protocol IV generation

If an IV is constructed according to the TLS 1.2 protocol, then this IV may only be used in the context of the AES GCM mode encryption within the TLS 1.2 protocol.

If the vendor claims that the IV generation is in compliance with the TLS 1.2 specification and only for use within the TLS 1.2 protocol, then the module's Security Policy and the Validation Test Report **shall** explicitly state the module's compatibility with TLS 1.2 and the module's support for acceptable AES GCM ciphersuites from Section 3.3.1 of **SP 800-52 Rev 1** or **SP 800-52 Rev 2**.

For the purposes of this Guidance, the module may demonstrate its compliance with the rules for TLS 1.2 compliance in one of the following two ways.

i) The operations of one of the two parties involved in the TLS 1.2 key establishment scheme **shall** be performed *entirely within* the cryptographic boundary of the module being validated. The testing laboratory **shall** check the module implementation and verify that the keys for the client and server negotiated in the handshake process (client_write_key and server_write_key) are compared and the module aborts the session if the key values are identical; or

ii) The laboratory **shall** check the TLS 1.2 protocol implementation that relies on the module being validated against an independently developed instance of TLS 1.2, such as the many TLS 1.2 client test sites on the Internet, verify that a session is successfully established, which implies that the client_write_key and server_write_key values are derived correctly, and the following condition **shall** be met:

   The module's implementation of AES GCM is used together with an application that runs either inside or outside the module's cryptographic boundary. This application negotiates the protocol session's keys and the 32-bit nonce value of the IV. The nonce is positioned where there is the "name" field in Scenario 3 of this Guidance.

Whether an implementation is using the i) or the ii) path to meet the compliance requirements, the counter portion of the IV **shall** be set by the module *within* its cryptographic boundary and the requirements of scenario 3 of this Guidance for the counter field (including the IV restoration conditions) are satisfied.

The implementation of the nonce_explicit management logic inside the module **shall** ensure that when the nonce_explicit part of the IV exhausts the maximum number of possible values for a given session key (e.g., a 64-bit counter starting from 0 and increasing, when it reaches the maximum value of 2^{64} -1), either party (the client or the server) that encounters this condition triggers a handshake to establish a new encryption key – see Sections 7.4.1.1 and 7.4.1.2 in RFC 5246. A statement to that effect **shall** be included in the Security Policy and Validation Test Report.

IPsec-v3 protocol IV generation

If an IV is constructed in compliance with the IPsec-v3 protocol, then this IV may only be used in the context of the AES GCM mode encryption within the IPsec-v3 protocol.

If the vendor claims that the IV generation is in compliance with the IPsec-v3 specification and only for use within the IPsec-v3 protocol then the module's Security Policy and the Validation Test Report **shall** explicitly state the module's compliance with RFC 4106 and/or RFC 5282 (depending on the protocols supporting GCM). The Security Policy and Validation Test Report **shall** also state that the module uses RFC 7296 compliant IKEv2 to establish the shared secret SKEYSEED from which the AES GCM encryption keys are derived.

Similar to the allowances shown above for the TLS 1.2 implementations, the module may demonstrate its compliance with the rules for IPsec-v3 compliance in one of the following two ways.

i) The operations of one of the two parties involved in the IKEv2 key establishment scheme **shall** be performed entirely within the cryptographic boundary of the module being validated. The testing laboratory **shall** check the module implementation and verify that the two keys established by IKEv2 for one security association (one key for encryption in each direction between the parties) are not identical and abort the session if they are; or

ii) The laboratory **shall** check the IPsec-v3 protocol implementation that relies on the module being validated against an independently developed instance of IPsec-v3 with IKEv2, verify that a session is successfully established, which implies that the two keys established by IKEv2 are derived correctly, and the following condition **shall** be met:

   The module's implementation of AES GCM is used together with an application that runs either inside or outside the module's cryptographic boundary. This application negotiates the protocol session's keys and the value in the first 32 bits of the nonce (see below).

Note that in RFC 5282 the term for what is called an IV in **SP 800-38D** and in this IG is "nonce", while the term "IV" in RFC 5282 refers only to the last 64 bits of the "nonce" field. In other words, IPsec-v3 requires four octets of salt followed by eight octets of deterministic nonce. Whether an implementation is using the i) or the ii) path to meet the compliance requirements, the construction of the last 64 bits of the "nonce" (the IV in RFC 5282) for the purposes of FIPS 140-2 validation **shall** be deterministic (e.g., using a counter) and satisfy one of the IV restoration conditions defined in scenario 3 of this Implementation Guidance.

The implementation of the management logic for the last 64 bits of the "nonce" (the IV in RFC 5282) inside the module **shall** ensure that when the IV in RFC 5282 exhausts the maximum number of possible values for a given security association (e.g., a 64-bit counter starting from 0 and increasing, when it reaches the maximum value of 2^{64} -1), either party to the security association that encounters this condition triggers a rekeying with IKEv2 to establish a new encryption key for the security association – see RFC 7296. A statement to that effect **shall** be included in the Security Policy and Validation Test Report.

MACsec protocol IV generation

A typical implementation of the MACsec protocol includes the components shown in Figure 1 below. The generation and management of IV's for the GCM cipher suites in the MACsec protocol is distributed among the three components. For the purposes of a FIPS 140-2 validation, the cryptographic functionality relevant for MACsec in each component **shall** be validated as a separate module. The requirement in Section 9.1 in **SP 800-38D** to contain the IV "generation unit" within a module boundary is satisfied by the composition of the **Peer**, **Authenticator** and optional **Authentication Server** modules. All modules – **Peer**, **Authenticator**, and, if applicable, **Authentication Server**, should be validated (or re-validated) after this Implementation Guidance takes effect, so that they all comply with the applicable requirements of this IG. While all modules are validated separately by the CMVP, each module's Security Policy **shall** tell what this module's role is in the MACsec protocol, explain what the module does in support of the IV generation for the MACsec's use of AES GCM, and state that when supporting the MACsec protocol in the approved mode, the module should only be used together with the CMVP-validated modules providing the remaining <**Peer**, **Authenticator**, …> functionalities.

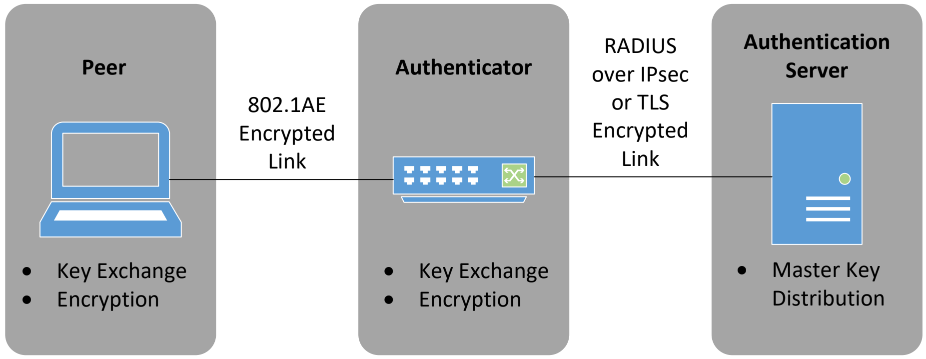


Figure 1. MACsec protocol components

The link between the **Authenticator** and the optional **Authentication Server** is typically implemented by the RADIUS protocol, which is a de-facto industry standard for communication to authentication servers. All references to RADIUS in this Guidance are applicable only to the use of this protocol in the MACsec context. To provide security the RADIUS traffic should be tunneled over an IPsec (cf. RFC 3162) or TLS channel (cf. RFC 6614). All configuration instructions for the link between the **Authenticator** and the **Authentication Server** **shall** be provided in the Security Policy of the module.

The **Peer** and the **Authenticator** Modules Security Policies **shall** state that the link between the **Peer** and the **Authenticator** should be secured to prevent the possibility for an attacker to introduce foreign equipment into the local area network – see Section 7.3 in IEEE Std 802.1X-2010.

SSHv2 protocol IV generation

A. Properties of the SSHv2 protocol

The current version of the SSH protocol is SSHv2. This protocol is defined in the IETF RFCs 4251, 4252, 4253 and 4254. The rules for using AES GCM are documented in RFC 5647. One of the advantages of the SSHv2 protocol, for the purpose of meeting the (key, IV) probability collision requirements of **SP 800-38D**, is that the encryption and the message authentication parameters are negotiated separately for each direction, with independent keys. This can be seen in Figure 1 in RFC 5647 showing the derivation methods for sessions' keys. A shared secret K is negotiated as shown in Section 8 of RFC 4253, employing a Diffie-Hellman or an EC Diffie-Hellman scheme, and this shared secret is used to negotiate the independent encryption keys. This construction guarantees that a key collision between the encryption keys from separate sessions may occur only if there is a shared secret collision or a hash collision. The probability of this happening is negligibly small in comparison with **SP 800-38D** bound of 2^{-32} for the tolerable probability of the (key, IV) pair collisions. Hence one should only be concerned with the probability of the IV collisions among the separate encryptions within the same SSHv2 session.

B. IV generation method

A new IV parameter is generated by the module for each AES GCM encryption. As shown in Section 7.1 of RFC 5647, the IV consist of a 4-byte fixed field and an 8-byte invocation counter. The initial IV value is generated as shown in Figure 1 of RFC 5647 and the fixed field of this IV remains the same for the duration of the session. Therefore, the method for minimizing the (key, IV) collision probability within the same session depends entirely on the management of the invocation field of the IV. The invocation counter is treated as a 64-bit integer and is incremented by one when performing an AES GCM encryption of a new binary packet. The formation of binary packets is explained in Section 7.2 of RFC 5647.

C. A Method of Compliance

If an IV is constructed in compliance with the SSHv2 protocol, then this IV **shall** only be used in the context of the AES GCM mode encryptions within the SSHv2 protocol.

If the vendor claims that the IV generation is in compliance with the SSHv2 specification and only for use within the SSHv2 protocol, then the module's Security Policy and the Validation Test Report **shall** explicitly state the module's compliance with RFCs 4252, 4253 and 5647. The tester **shall** verify that the module's management of the invocation counter of the AES GCM IV satisfies the following conditions:

- If the invocation counter reaches its maximum value $2^{64} – 1$, the next AES GCM encryption is performed with the invocation counter set to either 0 or 1.
- No more than $2^{64} – 1$ AES GCM encryptions may be performed in the same session. (This requirement may be met by either implementing an encryption counter or by reviewing the maximum number of encryptions that the module can produce.)
- When a session is terminated for any reason, a new key and a new initial IV **shall** be derived. (The session_id parameter in Figure 1 of RFC 5647 may remain unchanged.)

Meeting all of the requirements in this section will ensure that the **SP 800-38D** probability bound for the (key, IV) collisions will not be exceeded.

2. The IV may be generated internally at its entirety *randomly*. In this case,

   - The generation **shall** use an Approved DRBG that is internal to the module's boundary and
   - The IV length **shall** be at least 96 bits (per **SP 800-38D**). See Additional Comments for the discussion of why an IV of less than 96 bits may not be generated randomly and concatenated to the remaining part of an IV.

   A statement to that effect **shall** be included in the Security Policy and Validation Test Report.

3. If an AES GCM Key is generated either internally or externally and the IV is constructed at its entirety internally *deterministically* then the requirement of **SP 800-38D** quoted in the Background section above will be modified. Instead of requiring that the probability of any (key, IV) collision anywhere in the Universe at all times did not exceed 2^{-32} , it will only be required that for a given key distributed to one or more cryptographic modules, the (key, IV) collision probability would not exceed 2^{-32} . This is equivalent to the requirement that for any key distributed to one or more modules the probability of a collision between the deterministically-generated IVs is no greater than 2^{-32} .

   The module **shall** use at least 32 bits of the IV field as a name and use at least 32 bits as a deterministic non-repetitive counter for a combined IV length between 64 bits and 128 bits. The name field **shall** include an encoding of the module name and the name construction **shall** allow for at least 2^{32} different names. For example, if the module name is such that it consists of at least 8 hexadecimal characters then this condition is satisfied, since 16^8 is no smaller than (indeed, equal to) 2^{32} . Alternatively, if the name consists of at least 6 alphanumeric characters, each having at least 62 values, then this is also sufficient. Even though not all possible names are equally likely to be used, the fact that the modules can possibly have at least 2^{32} different names will be sufficient to meet this requirement.

   The implementation of the deterministic non-repetitive counter management logic inside the module **shall** ensure that when the counter part of the IV exhausts the maximum number of possible values for a given session key (e.g., a 32-bit counter starting from 0 and increasing, when it reaches the maximum value of 2^{32} -1) the encryptor **shall** abort the session.

   Further, at least one of the IV restoration conditions **shall** be satisfied for the deterministic non-repetitive counter.

   The IV restoration conditions are as follows (for additional details, see Section 9.1 of **SP 800-38D**):

(1) The module's memory **shall** be set in such a way that it will reset to the last IV value used in case the module's power is lost and then restored. (This condition is enforced by the module and **shall** be tested by a testing lab.)

(2) There will be a human operator who will reset the IV to the last one used in case the module's power is lost and then restored. (This condition is not enforced but **shall** be stated in the module's Security Policy, under the "User Guide" heading.)

(3) In case the module's power is lost and then restored, a new key for use with the AES GCM encryption/decryption **shall** be established. (This condition may or may not be enforced but **shall** be stated in the module's Security Policy, under the "User Guide" heading.)

A statement explaining how the deterministic IV generation is performed and how the IV restoration conditions are met **shall** be included in the Security Policy and Validation Test Report.

NOTE. The module does not need to comply with any particular Scenario (1 – 3) shown in this section of the IG. Meeting the rules of any one of these Scenarios, whether protocol-dependent or not, when generating the IVs for AES GCM is sufficient. The Security Policy **shall** explain the rules under which the module must operate in compliance with this Implementation Guidance.

4. If an implementation does not meet the requirements of any of the Scenarios 1 through 3 explained above in this Implementation Guidance, the vendor may present their own proof of the compliance with the **SP 800-38D** requirement stated in the **Background** section of this IG. The burden of proof is on the vendor. The testing laboratory **shall** review the proof and verify its correctness. Each proof will be examined by the CMVP reviewers who will make the final determination of the proof's validity.

5. If an implementation is generating an IV in compliance with the provisions of an industry [1] protocol supporting AES GCM encryption, that is not included among the acceptable protocols in Scenario 1 above, the vendor's may build their own case for the security of the IV generation method using the following guidelines.

   The generated IV **shall** only be used in the context of the AES GCM encryption executing the provisions of the protocol within which the IV was generated. The module's Security Policy **shall** state the protocol's name and version number and confirm that the IV is generated and used within this protocol's implementation. The Security Policy **shall** list the documents (such as the IETF RFCs) where the protocol and, specifically, the use of the AES GCM encryption within the protocol are defined.

   It is often the case that while a protocol's implementation may be compliant with **SP 800-38D** this implementation is distributed across several different modules and apps. Testing one cryptographic module at a time may not guarantee compliance with **SP 800-38D**; in particular, with the provision of this standard requiring that the (key, IV) pair collision probability does not exceed 2^{-32}. The vendor **shall** identify the features of the protocol and of the specific implementation, as well as the selected testing mechanisms and use this information to prove that the system that includes the module under test meets the **SP 800-38D** collision probability requirement, even if not all relevant operations are performed within one cryptographic module. The proof will be reviewed by the CMVP who will have the final word as for the correctness of the vendor's analysis.

   Some of the following considerations may be used, when applicable, while constructing a proof. This list is not exclusive; depending on the protocol, the vendor and the testing lab may identify some other properties of the protocol or of the specific implementation that could be used to make a claim of the implementation's security.

   - The protocol's implementation is contained within the boundary of the module under test.
   - The protocol implementation may be split between several other modules and applications, but the AES GCM IVs are generated within the boundary of the module under test.

[1] An "industry protocol" is either defined or documented and supported by one of the well-recognized standards bodies, such as the IEEE, IETF, ANSI or ISO SC27 (the list is not exclusive).

- The protocol implementation may be split between several modules and applications, each of them validated by the CMVP, thus providing the assurances of the overall compliance with the protocol's method for generating the AES GCM IVs.
- The vendor is running a protocol implementation that includes the module under test against an independently developed instance of the same protocol.
- The protocol properties might include the guarantees – with a very high probability - of the systemwide uniqueness of the key, which would reduce the (key, IV) collisions to the collisions of the IVs. The latter can be estimated, under the reasonable assumptions acceptable to the CMVP reviewers, by examining the IV construction process under the rules of the protocol.
- If portions of the IV value are generated within different modules/entities, the vendor's proof **shall** state which party generates which bits of the IV and explain why this method keeps the (key, IV) collision probability below the **SP 800-38D** bound.

Additional Comments

1. This Implementation Guidance does not introduce any new requirements. On the contrary, the purpose of this Implementation Guidance is to relax some of the **SP 800-38D** requirements. This relaxation is needed because **SP 800-38D** imposes some system-wide requirements, including those that concern the probabilities of the (key, IV) pair collisions. The compliance with such system-wide requirements cannot be tested within the scope of the CMVP program where each module is validated separately.

   In some Scenarios allowed by this IG, the (key, IV) collision probability is calculated as it applies to one module. To reconcile this interpretation of the **SP 800-38D** requirement with the security goals stated in **SP 800-38D**, the module needs to operate within the certain limits established by this Implementation Guidance. One possibility is for the module to comply with the specific confines of the known industry protocols. If this is the case, the reliance on the properties of the protocol allows the CMVP to modify the rules of **SP 800-38D** without introducing any security risks or exposures.

   Scenarios 2 and 3 in the **Resolution** section are protocol independent. Scenario 4 is the general case which permits the vendor to show the module's implementation's compliance with **SP 800-38D**. Scenario 5 allows the vendor to extend the protocol-specific cases of Scenario 1 developed by the CMVP to the protocols that are not examined in this Implementation Guidance.

2. When the module uses a (non-protocol-specific) deterministic IV construction, the name field provides an assurance that the IVs are not repeated even when they are generated independently by different modules, possibly manufactured by different vendors. If this name field is only 32 bits long, then it is barely sufficient to provide for the 2^{32} different values. Operators of the modules that use the 32-bit long names need to ensure that there is no possibility of name collisions in the systems they operate. When it is not possible to control the name assignment (as in the case when a session that uses an AES GCM encryption runs over a network managed without a central control over the names of the modules) then a 32-bit field may be insufficient. In such cases, it is highly recommended to switch to 64-bit or even 96-bit long names and limit the number of encrypted blocks under the same key to 2^{32}.

3. As stated in this Implementation Guidance, if the entire IV is generated randomly, the length of the random field **shall** be at least 96 bits. The reason for it is that with 2^{32} possible AES GCM encryptions under the same key, the probability of having at least one (key, IV) collision (i.e., an IV collision, as the key stays the same) can be estimated to be of the order of 2^{-32}. However, to maintain the same probability of collisions in the case of a 64-bit random field, one would have to reduce the maximum number of AES GCM encryptions with the same key to only 2^{16}.

4. In Scenario 2 it is recommended but not required that the entropy source producing the DRBG seed is located inside the module's physical boundary. The reason for not making this a firm requirement is that even if little or no entropy is supplied to the DRBG, this **SP 800-90A**-compliant random bit generator will be generating the non-repeating outputs. The probability of producing the matching DRBG outputs depends on the details of the design of the DRBG, as shown in **SP 800-90A**, but in all cases this probability is much lower than 2^{-32}. Therefore, the probability of generating the matching (key, IV) pairs, which is no greater than the probability of generating the matching IV parameters, is less than 2^{-32}, if the IVs are generated by the same module.

   Are there any potential vulnerabilities in a scheme that does not require an internal (to module's boundary) generation of the DRBG seed by a **SP 800-90B**-compliant entropy source? Yes. For example, if the module's DRBG is seeded with the same entropy each time the module gets restarted or instantiated, *and* the same sequence of generating keys and IVs is repeated during separate restarts/instantiations after the module receives the initial DRBG seed, *and* the DRBG does not retain its state between the restarts, the module may generate the identical (key, IV) pairs that will be used in separate AES GCM encryptions.

   In a different scenario, if two modules using the same AES GCM encryption key receive an identical DRBG seed from a third party *and* each module is using the DRBG outputs in the same order as the other module until each module generates an IV, then two separate AES GCM encryptions may be performed with the same (key, IV) pair.

   The CMVP considers these scenarios to be far-fetched and significantly less likely to occur than receiving a poorly generated key from outside the module's boundary. Hence, generating entropy inside the module's boundary, while recommended, is not required. The entropy caveats shown in IG 7.14 must be documented in the module's certificate, as applicable.

   Note that while the entropy may be generated externally, the requirement that an approved and tested DRBG located within the module's boundary is used to generate the AES GCM IVs must be met in Scenario 2.

5. Including the module's name in the IV field does not amount to a passphrase-based key derivation. The IV is not a key. Their cryptographic properties are different.

6. The methods presented in this IG apply to the module's generation of an IV parameter for the AES GCM encryption. When an IV is used for decryption, the responsibility for the IV generation lies with the party that performs the AES GCM encryption therefore none of the **SP 800-38D** requirements and none of the Scenarios presented in this Guidance are applicable to the module performing the decryption.

7. Some proprietary implementations of MACsec allow the static configuration of a pre-shared key for the Security Association Key (SAK) used by the protocol. The static configuration of a pre-shared SAK **shall not** be used in the approved mode of operation.

8. If any of the IETF or IEEE documents referenced in Scenario 1 of this IG become obsolete or get updated by another IETF RFC or an IEEE standard, then the new document number **shall** be considered the replacement of the number listed in this Guidance. However, a new *version* of a protocol (say, TLS 1.3) is not automatically covered by this Guidance. Until this new version of a protocol is included in Scenario 1 by the CMVP vendors may use Scenario 5 to demonstrate the required security properties of their modules' protocol implementations.

A.6 moved to W.8

A.7 moved to W.9

A.8 Use of a Truncated HMAC

Applicable Levels:	*All*
Original Publishing Date:	*03/02/2015*
Effective Date:	*03/02/2015*
Last Modified Date:	*11/15/2019*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01, TE.01.12.02*
Relevant Vendor Requirements:	

Background

The Keyed-Hash Message Authentication Code (HMAC) function is used by the message sender to produce a value, called the MAC, which is formed by condensing the secret key and the message input. The HMAC function may use any approved hash algorithm. HMAC is documented in FIPS 198-1.

Some internet protocols such as IPsec and SSH use HMAC-SHA-1 and truncate the MAC to 96 (leftmost) bits. Other implementations use HMAC-SHA-384 truncated to 192 bits. Some other truncations may also be considered by implementers.

Question/Problem

Can a truncated HMAC be used in the approved mode?

Resolution

According to SP 800-107rev1, published August 2012, the truncated forms of an approved HMAC are the approved algorithms if an HMAC output is truncated to its λ leftmost bits with $\lambda \geq 32$. In particular, HMAC-SHA-1-96 and HMAC-SHA-384-192 are approved algorithms and can be used in the approved mode of operation. This includes their use as an approved integrity technique required in Section 4.6.1 of FIPS 140-2 and as an approved authentication technique when performing the software/firmware load test described in Section 4.9.2 of FIPS 140-2.

Additional Comments

1. In compliance with the transition requirements specified in SP 800-131A, any key for a full-length-output HMAC or a truncated HMAC that possesses less than 112 bits of strength **shall not** be used in approved mode.
2. When a truncated HMAC is used in the approved mode, the corresponding full-output HMAC **shall** have a CAVP algorithm certificate. The module's validation certificate needs to show this CAVP certificate and does not need to reference the truncated HMAC. The use of the latter **shall** be shown in the module's security policy.
3. The security of the truncated HMAC values is addressed in SP 800-107rev1. The permission to use in the approved mode an HMAC output truncated to (the minimum of) 32 bits does not contradict the requirement of SP 800-131A of providing at least 112 bits of equivalent encryption strength. The cryptographic strength of HMAC depends primarily on the strength of the HMAC key. See SP 800-107rev1 for details.
4. While SP 800-107rev1 allows the truncation of HMAC to its λ leftmost bits with $\lambda \geq 32$, that Special Publication discourages the HMAC truncations to less than 64 bits. For the purposes of the FIPS 140-2 validations, it is the 32-bit requirement that will be enforced.

5. HMAC-SHA-3 is subject to the same truncation rules as the other HMACs that utilize the approved hash functions.

6. The **SP 800-131A** notation in this Implementation Guidance refers to the latest published revision of this standard.

A.9 XTS-AES Key Generation Requirements

Applicable Levels:	*All*
Original Publishing Date:	*12/28/2015*
Effective Date:	*07/01/2016*
Last Modified Date:	*12/04/2017*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01*
Relevant Vendor Requirements:	

Background

XTS-AES is approved in **SP 800-38E** by reference to **IEEE Std. 1619-2007**. The IEEE standard specifies a key, denoted by *Key*, that is 256 [or 512] bits long; *Key* is then parsed as the concatenation of two AES keys, denoted by *Key_1* and *Key_2*, that are 128 [or 256] bits long. Sec. D.4.3 (pp. 31-32) explains that XTS-AES differs from the generic XEX construction (due to Rogaway) in that *Key_1 = Key_2* for XEX but not for XTS-AES. Annex D of the IEEE standard is labeled as informative, not normative and there are no other requirements on the generation of Key otherwise in that standard.

Question/Problem

Misuse of XTS-AES with a class of improper keys results in a security vulnerability. An implementation of XTS-AES that improperly generates *Key* so that *Key_1 = Key_2* is vulnerable to a chosen ciphertext attack that would defeat the main security assurances that XTS-AES was designed to provide. In particular, by obtaining the decryption of only one chosen ciphertext block in a given data sector, an adversary who does not know the key may be able to manipulate the ciphertext in that sector so that one or more plaintext blocks change to any desired value. Rogaway illustrates the attack for disallowed parameterizations of XEX (without fully exploring its consequences) in Sec. 6 of his 2004 paper Efficient Instantiations of Tweakable Blockciphers and Refinements to Modes OCB and PMAC, available at http://web.cs.ucdavis.edu/~rogaway/papers/offsets.pdf.

Resolution

Key_1 and *Key_2* are intended to be distinct keys, and they must each be generated pseudo-randomly to comply with approved key generation guidelines. The module **shall** check explicitly that *Key_1 ≠ Key_2,* regardless of how *Key_1* and *Key_2* are obtained. See section **Additional Comments** below for further implementation considerations. In addition, the CST testing lab **shall** document in TE.01.12.01 of the Test Report how the module meets the above requirement.

Additional Comments

This interpretation of the IEEE standard is consistent with the requirements on the generation of secret keys for other NIST approved cryptographic algorithms, namely, from a cryptographically strong pseudorandom source or approved KDF and with support from a good entropy source.

The check for *Key_1 ≠ Key_2* **shall** be done at any place BEFORE using the keys in the XTS-AES algorithm to process data with them. This allows for choosing an appropriate place for implementing the check, anywhere from within the algorithm boundary to the module boundary.

A.10 Requirements for Vendor Affirmation of SP 800-38G

Applicable Levels:	*All*
Original Publishing Date:	*06/17/2016*
Effective Date:	*06/17/2016*
Last Modified Date:	*08/12/2020*
Transition End Date:	***09/01/2020***
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.03-04*
Relevant Vendor Requirements:	

Background

SP 800-38G was published March 2016 and was added to FIPS 140-2 Annex A on April 6, 2016. **SP 800-38G** contains the description of two methods, FF1 and FF3, for format-preserving encryption (FPE).

Since the release of this publication, researchers have identified vulnerabilities when the number of possible inputs, i.e., the domain size, is sufficiently small. In response to the analysis of Durak and Vaudenay on FF3, NIST announced in April of 2017 the intention to revise the FF3 specification by reducing the size of its tweak parameter from 64 bits to 56 bits (in collaboration with the researchers) or to withdraw FF3. It was decided to update FF3 (called FF3-1) to address the vulnerability in a new version of **SP 800-38Grev1** (which is still in draft at the time this IG was last revised). This announcement also noted that FF3 is no longer suitable as a general-purpose FPE method.

Question/Problem

Considering the information presented in the Background section of this IG, what are the requirements for claiming compliance to the original version of **SP 800-38G**? What are the vendor affirmation requirements and are any portions of **SP 800-38G** available for CAVP testing?

Resolution

Vendors **shall** not claim any compliance to FF3 in an approved mode of operation (see Background for reasoning).

However, vendors may, through **September 1, 2020**, continue to submit modules that claim vendor affirmation to the FF1 mode described in **SP 800-38G**. After this date, all module submissions to the CMVP (2SUB, 3SUB or 5SUB) **shall** include a CAVP tested AES (FF1) certificate if it is utilized in an approved mode of operation.

Vendor affirmation for **SP 800-38G**, *Recommendation for Block Cipher Modes of Operation: Methods for Format-Preserving Encryption* includes validation testing for the underlying encryption function (AES), and documenting in the module's Security Policy the values of the following parameters from **SP 800-38G**: *radix*, $radix^{minlen}$, *minlen*, *maxlen*, and *maxTlen*. The value of *maxTlen* may not exceed $2^{32} – 1$. While **SP 800-38G** requires that the value of $radix^{minlen}$ must be greater than or equal to 100, it is *strongly recommended* that this value be at least one million in order to mitigate guessing attacks and analytic attacks (this aligns with the requirements in the draft **SP 800-38Grev1**).

The vendor **shall** document the **SP 800-38G**-compliant format preserving encryption in the list of the vendor affirmed security methods in TE.01.12.03 of the Test Report. In TE.01.12.04, the vendor **shall** demonstrate how their implementation complies with the appropriate provisions of **SP 800-38G**; in particular, with the requirement that the *radix*, *minlen*, *maxlen* and, if applicable, *maxTlen* parameters satisfy the constraints defined in Section 5.1 of **SP 800-38G** for FF1. The validation Test Report **shall** also show the possible byte lengths *t* of the tweak used by this module.

The module's validation certificate **shall** include an entry for the AES algorithm that has been tested and is being used as an underlying encryption function in the format-preserving algorithms. The AES algorithm certificate **shall** show the validation of the mode of AES that has been used as an underlying block cipher (encryption function) in format preserving encryption.

Additional Comments

1. **SP 800-38G** requires that the underlying encryption function used in the format-preserving algorithms is an approved block cipher operating on the 128-bit blocks of data. As of August 2020, and for the foreseeable future, the only such function is the AES algorithm. The length of an AES key may be 128, 192, or 256 bits.
2. It is sufficient to test the underlying AES encryption function in any approved mode of AES that uses this underlying encryption engine.
3. No special acronym is required in the validation certificate to annotate the module's compliance with **SP 800-38G**. Use "AES" as with any other approved mode of AES.
4. AES FF1 testing is not available in CAVS but is available via ACVTS. Before the September 1, 2020 transition date, vendors can choose to test the FF1 mode by either vendor affirming per this IG, or by testing it via ACVTS.
5. This IG applies to the original version of **SP 800-38G** (March 2016). Once **SP 800-38Grev1** is published, ACVTS will have testing available for both the FF1 and FF3-1 modes. Therefore, following the transition date of September 1, 2020 and the publication of **SP 800-38Grev1** (whichever comes later), this IG will be withdrawn.

A.11 The Use and the Testing Requirements for the Family of Functions defined in FIPS 202

Applicable Levels:	*All*
Original Publishing Date:	*08/01/2016*
Effective Date:	*08/01/2016*
Last Modified Date:	*08/07/2017*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

FIPS 202 was published in August 2015 and added to FIPS 140-2 Annex A on September 17, 2015. This standard includes the specifications for the SHA-3 family of hash functions: SHA3-224, SHA3-256, SHA3-384 and SHA3-512, as well as for the two extendable-output functions, SHAKE128 and SHAKE256. CAVP testing for all of these functions became available on January 29, 2016.

Question/Problem

1. Are there any limitations on the use of hash functions defined in **FIPS 202** in the CMVP-validated cryptographic modules?
2. What are the validation testing requirements for the **FIPS 202**-compliant algorithms and the higher-level cryptographic algorithms that are using the functions defined in **FIPS 202**? In particular, how to address the case when CAVP testing is available for a higher-level cryptographic algorithm when this

algorithm uses the hash functions defined in **FIPS 180-4** but there is still no testing when the same higher-level algorithm uses the **FIPS 202** functions?

3. Which self-tests are required for the **FIPS 202**-defined functions?

Resolution

1. To be used in the FIPS approved mode of operation, the SHA-3 hash functions may be implemented either as part of an approved higher-level algorithm, for example, a digital signature algorithm, or as the standalone functions. The SHAKE128 and SHAKE256 extendable-output functions may only be used as the standalone algorithms.

2. The validation, testing and the certificate documentation requirements are as follows.

   a. Every implementation of each SHA-3 and SHAKE function **shall** be tested and validated on the appropriate OS.

   b. If any of the SHA-3 hash functions are used as part of a higher-level algorithm and the CAVP testing that supports SHA-3 is available for this higher-level algorithm, then, upon the expiration of a transitional period defined when such CAVP testing becomes available, to use the higher-level algorithm in the approved mode the vendor **shall** obtain a CAVP certificate for this algorithm. If the vendor does not obtain such a certificate, then the higher-level algorithm that uses the SHA-3 functions may not be used in the approved mode and **shall** not be listed on the module's validation certificate.

   c. If any of the SHA-3 hash functions are used as part of a higher-level approved algorithm and the CAVP testing that supports SHA-3 is NOT yet available for this higher-level algorithm or the transitional period has not yet expired, then to use this higher-level algorithm in the approved mode the vendor **shall** claim the vendor affirmation for this algorithm. This **shall** be accompanied by obtaining the CAVP certificates for the SHA-3 functions used in the higher-level algorithm. If the module implemented the same higher-level algorithm with a **FIPS 180-4** hash function and there is a corresponding entry on the approved line of the module's validation certificate, then the vendor affirmation of the same algorithm using SHA-3 does not need to be shown separately on the certificate's approved line but **shall** be documented in the module's Security Policy.

   d. Until CAVP testing for a higher-level algorithm with the SHA-3 hash functions is available, IG A.3 is applicable.

3. The self-test requirements.

   a. At the minimum, the cryptographic module **shall** perform a known answer test for one of the functions defined in **FIPS 202**: SHA3-224, SHA3-256, SHA3-384, SHA3-512, SHAKE128 and SHAKE256, no matter how many of these functions the module may be designed to use. A known answer test for a hash function may be performed as part of the known answer test of a higher-level approved algorithm.

   b. If a SHA-3 hash function is used as part of a higher-level approved algorithm that is tested by the CAVP, then the module **shall** perform a known answer test for this higher-level algorithm. No additional power-on self-tests for any of the **FIPS 202**-compliant functions implemented by this module are required.

   c. If a SHA-3 hash function is used as part of a higher-level approved algorithm that is vendor affirmed but not tested by the CAVP or the transitional period has not yet expired, then the module **shall** perform a known answer test either for the higher-level algorithm or for one of the SHA-3 hash functions this higher-level algorithm uses.

   d. No conditional self-tests are required in support of the **FIPS 202**-compliant algorithms.

Additional Comments

1. The reason for requiring a known answer test for only one of the **FIPS 202**-compliant hash functions is that all of these functions, including SHAKE128 and SHAKE256, rely on the same underlying

Keccak-p permutation. Note that this is different from the SHA-1 and SHA-2 self-test requirements where separate self-tests are needed for SHA-1, SHA-256 and SHA-512, if the module is designed to use these hash functions.

2. If the module implements several Keccak-p permutation engines, a self-test **shall** be performed for more than one implementation of the **FIPS 202**-defined functions so that each permutation engine's implementation is self-tested.

3. Examples for how to annotate the use of the **FIPS 202** algorithms in the module's validation certificate.

   a. **SHA-3 (Cert. #55)**. This demonstrates that one or more of the following functions: SHA3-224, SHA3-256, SHA3-384, SHA3-512, SHAKE128, SHAKE256 is implemented in the module and tested by the CAVP. There is no separate acronym for the SHAKE functions.

   b. **RSA (SHA-3 Cert. #55, vendor affirmed)**. This is the case when the implementation of the RSA signature algorithm supported by the module uses only the SHA-3 hash functions, and no CAVP testing is available for the configuration of the RSA algorithm that uses the SHA-3 hash functions (or if such testing is available but the transitional period announced upon the introduction of this testing has not yet expired.)

   c. **DSA (Cert. #200)**. [No change from the existing notation.] The module's DSA algorithm implementation(s) may use both the **FIPS 180-4** and the **FIPS 202** hash functions. One entry in the module's validation certificate is sufficient. The Security Policy **shall** indicate that the use of the DSA with the SHA-3 hash functions is vendor affirmed if the CAVP testing for the DSA that uses the SHA-3 hash functions is not yet available.

4. The future updates of this Implementation Guidance will keep track of the testing availability status for the approved higher-level algorithms that might use the SHA-3 hash functions.

A.12 Requirements for Vendor Affirmation to the Addendum to SP 800-38A

Applicable Levels:	*All*
Original Publishing Date:	*11/15/2016*
Effective Date:	*11/15/2016*
Transition End Date:	***09/01/2020***
Last Modified Date:	*08/28/2020*
Relevant Assertions:	*AS.01.12, AS.09.16*
Relevant Test Requirements:	*TE01.12.03-04, TE.09.16.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-38A was published in December 2001. This standard defines several approved modes of AES: ECB, CBC, CFB, OFB, and CTR. In a further development, in October 2010, NIST published an **Addendum to SP 800-38A** to expand the definition of the Cipher Block Chaining mode (CBC). The reason for writing this Addendum was that the version of the AES CBC mode in the original publication of **SP 800-38A** assumed that plaintext consisted of a whole number of the 128-bit-long blocks of data. When this requirement was not met, Appendix A of **SP 800-38A** showed how to "pad" a partial block of plaintext to its full 128-bit size (the length of an AES encryption block). Unfortunately, this also resulted in an expansion of the ciphertext.

The 2010 **Addendum to SP 800-38A** introduces three different modes of making the complete 128-bit plaintext blocks when performing the AES CBC encryption. These modes are: CBC-CS1, CBC-CS2 and CBC-CS3. As explained in the **Addendum to SP 800-38A**, the "CS" notation stands for "ciphertext stealing", meaning that the bits needed to make all plaintext blocks complete are taken from one of the ciphertext blocks. These three modes do not require the ciphertext expansion.

The **Addendum to SP 800-38A** was added to FIPS 140-2 Annex A on November 24, 2010. Until CAVP testing for the three modes introduced in the **Addendum to SP 800-38A** is available, IG A.3 is applicable. The current Guidance explains the rules for vendor affirmation when any of the three AES modes, CBC-CS1, CBC-CS2 and CBC-CS3 are used in the approved mode.

Question/Problem

When is CAVP testing required for compliance to the **Addendum to SP 800-38A**? To claim *vendor affirmation* to the **Addendum to SP 800-38A**, which sections of the standard need to be addressed and what are the documentation requirements?

Resolution

Vendors may, through **September 1, 2020**, continue to submit modules that claim vendor affirmation to the **Addendum to SP 800-38A**. After this date, all module submissions to the CMVP (2SUB, 3SUB or 5SUB) **shall** include a CAVP tested AES (CBC-CS1, CBC-CS2, and/or CBC-CS3) certificate if it is utilized in an approved mode of operation.

The entire text of the **Addendum to SP 800-38A** is applicable. To simplify the notation on the module's validation certificate, if the module supports any of the three modes of AES: CBC-CS1, CBC-CS2 and CBC-CS3 and the module's validation certificate already includes an AES entry on the approved line with an AES algorithm certificate showing that testing has been performed for the CBC mode of AES, then no additional entries on the module's certificate are needed. If the module's certificate does not show an AES algorithm entry that includes the CBC mode, then a separate vendor affirmation entry AES-CBC-CS **shall** be included in the module's certificate, even if the module's certificate already shows an AES algorithm certificate on the approved line.

The Security Policy **shall** show vendor affirmation to the applicable modes: CBC-CS1, CBC-CS2 or CBC-CS3. The Test Report **shall** list these instances of vendor affirmation in the applicable assessments.

Annotation

An entry **AES-CBC-CS (vendor affirmed)** may be required on the approved line. It is not necessary to specify in the module's certificate which of the AES CBC ciphertext stealing modes (CS1, CS2, or CS3) are implemented. The details will be provided in the module's Security Policy and the Test Report.

Additional Comments

1. There are several ways that the documentation requirements for vendor affirmation to the CBC-CS1, CBC-CS2 and CBC-CS3 modes of AES could be addressed. One solution would not require any new entries in the module's certificate. However, this would misinform the user when the module implemented the AES CBC ciphertext stealing modes and the vendor affirmed the implementation's compliance with the **Addendum to SP 800-38A**. Another alternative would be to always require a vendor affirmation entry if any of the three modes in questions were supported in the approved mode.

   This Guidance shows a compromise solution that relies on the explanations in the module's Security Policy and the Test Report with an exception of an unlikely case when the module supports one of the AES CBC ciphertext stealing modes, but not the AES CBC mode defined in **SP 800-38A**. In this case, a separate vendor affirmation entry in the module's certificate is highly informative and is, therefore, required.

2. If the module supports one of the approved modes of AES in the approved mode then it is necessary to perform the AES known answer tests for both the encryption and the decryption functions, if both functions are supported. The known answer tests may be performed using any approved mode of AES shown in the module's validation certificate. This requirement applies even if the module's implementation does not include any tested AES modes and the module's only approved modes of AES are the vendor-affirmed AES CBC ciphertext stealing modes addressed in this Guidance.

3. The use of the CBC mode with or without the ciphertext stealing requires the presence of an IV parameter. The requirements on the IV for its use in the CBC-CS1, CBC-CS2 and CBC-CS3 modes of AES are the same as those when the IV is used in the AES CBC mode. Specifically, the IV does not need to be secret but must be unpredictable. See Appendix C of **SP 800-38A** for the precise meaning of the unpredictability in this context.

A.13 SP 800-67rev1 Transition

Applicable Levels:	*All*
Original Publishing Date:	*05/10/2017*
Effective Date:	*05/10/2017*
Last Modified Date:	*03/27/2018*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-67rev1 was published in January 2012 and added to FIPS 140-2 Annex A in February 2017. **SP 800-67rev1** added a requirement prohibiting users from performing more than 2^{32} 64-bit data block encryptions under the same three-key Triple-DES key. In an earlier version of **SP 800-67**, this requirement was a "should not" rather than a "**shall not**" statement. In compliance with **SP 800-67rev1**, NIST on July 11, 2017, placed on the Computer Security Division's Website a document that explained the rationale for this restriction on the number of the Triple-DES encryptions using the same key.

Then, in November 2017, NIST published SP 800-67rev2, which further tightened the restriction on the number of the Triple-DES encryptions with the same key. Per **SP 800-67rev2**, one key **shall not** be used to encrypt more than 2^{20} 64-bit data blocks. This version of the **SP 800-67** standard was added to FIPS 140-2 Annex A in January 2018.

Question/Problem

How **shall** the aforementioned evolving requirement on the limit of the number of the Triple-DES encryptions with the same key be enforced? In particular, how can a user of a validated cryptographic module be confident that other modules are not performing the Triple-DES encryptions with the same key thus, possibly, exceeding the overall limit on the number of such encryptions?

Resolution

Each validated module **shall** have a limit of either 2^{20} or 2^{16} 64-bit data block encryptions with the same Triple-DES key.

The limit of 2^{20} encryptions with the same Triple-DES key applies when keys are generated as part of one of the recognized IETF protocols. To use this provision, the Security Policy **shall** say which of the IETF protocols governs the generation of the Triple-DES keys and list the IETF RFC(s) where the details of this protocol, relevant to the generation of the Triple-DES encryption keys, are documented. A proof of the implementation's compliance with the referenced protocol is not required.

If a key is not generated as part of a recognized IETF protocol (or, at least, no such claim is made by the vendor) then a further restriction on the number of encryptions with the same Triple-DES key is necessary, to avoid a "system-wide" violation of the overall limit on the number of encryptions with the same key. This limit is 2^{16} encryptions by each validated module.

For modules validated at Security Levels 1 or 2 in Section 4.1 of FIPS 140-2, the requirement limiting the number of encryptions with the same key may be enforced by policy. If this approach is taken, the module's

Security Policy **shall** state that the user is responsible for ensuring the module's compliance with this requirement.

For modules validated at security levels 3 or 4 in Section 4.1 of FIPS 140-2, the module **shall** enforce this requirement. See an Additional Comment below for an example of how this *may* be done. The Security Policy **shall** explain how the module performs the enforcement.

Additional Comments

1. If an encryption key is generated as part of an IETF protocol implementation, there is a strong reason to believe (even though the module's compliance to the protocol is not tested by the CMVP) that the same key will not be used by any entity except for the two parties that are involved in the encryption session that required the generation of this key. Therefore, if each module performs no more than 2^{20} encryptions with the same key, then system-wide the number of the Triple-DES encryptions with that key will usually be limited to 2^{20} or, *in the worst possible case*, if the module's partner in this session can also perform the encryptions with the same key, to 2^{21}. While 2^{21} exceeds that stated limit, for the purposes of compliance with this IG, this solution is acceptable.
2. If an encryption key is not generated as part of a known protocol, then it is impossible to tell, in the general case, how many modules may use this encryption key. The limit on the number of same-key Triple-DES encryptions is set at 2^{16}. If the number of modules using this key for encryption is no greater than 16 then the overall limit of 2^{20} will not be exceeded. In the highly unusual scenario when more than 16 modules share the same key, it is likely that at least some of these modules will not perform the number of encryptions that is close to the allocated maximum (2^{16}). Even if they did and the total number of same-key encryptions exceeded 2^{20}, it would be difficult for the attacker to increase the chances of success when the encryptions are performed by the unrelated modules.
3. Here is an example of how the module may enforce this requirement when having Section 4.1 validated at Security Levels 3 or 4. The module will have a counter associated with each Triple-DES encryption key. When the counter reaches a certain value, the key can only be used for the decryption operations.

   An easier solution would be for the module to have only one counter that will be increased by one every time the module performs a Triple-DES encryption. When the counter reading reaches the prescribed threshold, the module blocks all Triple-DES keys stored in the module at that time from being used to perform encryption. Of course, in this case the new Triple-DES encryption keys would need to be generated more often.

   If the encryption counters are used in an implementation, then, in the case when the module's power is lost, the module may have a mechanism to restore the counters, or it may establish *all* new Triple-DES keys upon the restoration of power.
4. An earlier version of this Implementation Guidance contained a relaxed form of this requirement: the module was required to comply with the limit of 2^{32} Triple-DES encryptions established in **SP 800-67rev1**. This earlier version of the IG has established a transition period for modules being validated at Security Levels 3 and 4 in Section 4.1 of FIPS 140-2 to have this requirement enforced by the module. The new, tighter requirement of **SP 800-67rev2** takes effect during this period, so here is an updated transition schedule. The effective date refers to the date of a CST laboratory's original submission of the module's test report.

   - Effective immediately, the Security Policy of the module **shall** state the limit (2^{20} or 2^{16}, as explained in this Implementation Guidance) on the number of the Triple-DES encryptions with the same key.
   - If a vendor is claiming a Security Level 3 or 4 for Section 4.1 of FIPS 140-2, the module **shall** enforce the following limits on the number of the Triple-DES encryptions with the same key:
     - Effective May 10, 2018, the 2^{32} limit, if the key is used within an IETF protocol; the 2^{28} limit, otherwise.
     - Effective May 10, 2019, the 2^{20} limit, if the key is used within an IETF protocol; the 2^{16} limit, otherwise.

The Security Policy **shall** explain the method of the module's enforcement of the appropriate limits on the number of the Triple-DES encryptions.

5. The provisions of this IG apply to the Triple-DES key wrapping the same way as to the data encryption.

6. The provisions of this IG apply only to the three-key Triple-DES encryption. The use of the two-key Triple-DES encryption for the protection of sensitive data is no longer allowed.

A.14 Approved Modulus Sizes for RSA Digital Signature and Other Approved Public Key Algorithms

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2017*
Effective Date:	*08/07/2017*
Last Modified Date:	*10/07/2022*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01-04*
Relevant Vendor Requirements:	

Background

The **FIPS 186-4** digital signature standard was published in July 2013. This standard specifies three possible RSA modulus sizes for signature generation and verification: 1024, 2048 and 3072 bits. Because of the transition to the stronger algorithms and key sizes, as documented in **SP 800-131A Rev2**, the 1024-bit RSA modulus may now be used in the approved mode for signature verification, but not for signature generation.

Question/Problem

Several NIST standards and the CMVP Guidance imply various restrictions on the sizes of the RSA moduli approved for use in the RSA signature generation and the RSA signature verification algorithms. **FIPS 186-4** approves the use of three modulus sizes: 1024, 2048, and 3072 bits. **FIPS 186-2** defers to an ANSI standard **X9.31**, which permits the use of the RSA moduli sizes that can be represented as $1024 + 256*s$ bits, where s is a non-negative integer. IG G.18 limits the approved use of RSA in **FIPS 186-2** to signature verifications. **SP 800-131A Rev2** approves for signature generation all RSA modulus sizes no smaller than 2048.

In view of these restrictions placed in different documents, which modulus sizes can be used (a) when generating the RSA signatures and (b) when verifying the RSA signatures? For example, is the use of the 4096-bit modulus approved? What are the testing requirements for the RSA key generation if the key pair used in the RSA signature algorithm is generated by the module?

If modulus sizes other than 1024, 2048 and 3072 bits are approved for use then what are the restrictions on the bit lengths of the auxiliary primes and on the numbers of the Miller-Rabin tests used when performing the primality testing? (**FIPS 186-4** in its Appendixes B and C does not specify these restrictions for any other modulus size.) Will the expected publication of **FIPS 186-5** affect these restrictions?

Resolution

Signature generation. When performing an RSA signature generation, a module may use any modulus size greater than or equal to 2048 bits. It is the responsibility of the vendor to extend the prime generation and signature generation techniques shown in **FIPS 186-4** to the RSA modulus sizes not listed in that standard. At least one of the RSA modulus lengths supported by the module for RSA signature generation **shall** be 2048, 3072, or 4096 bits.

The RSA signature algorithm implementations **shall** be tested by an accredited testing lab for all implemented RSA modulus lengths where CAVP testing is available. If there is no CAVP testing for the generation of RSA keys of a particular size, then the requirement of IG 7.12 to obtain a CAVP certificate for the RSA key-generation algorithm does not apply to this key size. If no CAVP testing is available for the RSA signature generation with a particular approved RSA modulus size (e.g., 2304, 2560, 8192, or 16384 bits), then the untested status of these modulus sizes **shall** be documented in the Security Policy. Note that the requirement to support at least one of the 2048-, 3072-, or 4096-bit sizes for an RSA modulus in the **FIPS 186-4** RSA signature generation algorithm guarantees that at least one modulus size can be tested by the CAVP.

Some of the RSA key generation methods described in Appendix B.3 of **FIPS 186-4** rely on the use of the auxiliary primes p_1, p_2, q_1 and q_2 that must be generated before the module generates the RSA primes p and q. Table B.1 in **FIPS 186-4** specifies, for the RSA modulus lengths of 2048 and 3072 bits only, the minimum bit lengths and the maximum total lengths of the auxiliary primes. This guidance shows an updated table that includes the limitations on the sizes of the auxiliary primes which are used when generating the 2048-bit RSA primes p and q for a 4096-bit RSA modulus. Please see an Additional Comment for an explanation of the Table 1 entries.

Table 1. Minimum and maximum lengths of p_1, p_2, q_1 and q_2

nlen	**Minimum length of auxiliary primes p_1, p_2, q_1 and q_2**	**Maximum values of len(p_1) + len(p_2) and len(q_1) + len(q_2)**	
		p, q Probable Primes	**p, q Provable Primes**
$2048 \leq nlen \leq 3071$	> 140 bits	< 1007 bits	< 494 bits
$3072 \leq nlen \leq 4095$	> 170 bits	< 1518 bits	< 750 bits
$4096 \leq nlen$	> 170 bits	< 2030 bits	< 1005 bits

The minimum number of the Miller-Rabin tests used in primality testing **shall** be consistent (based on the entries in Tables C.2 and C.3 in **FIPS 186-4**) with the bit sizes of p, q, p_1, p_2, q_1 and q_2 taken from Table B.1 of **FIPS 186-4** (and not from Table 1 in this IG). When implementing the RSA signature generation algorithm with the approved RSA modulus sizes not found in Tables C.2 and C.3 of **FIPS 186-4**, the vendor **shall** perform the number of the Miller-Rabin tests that applies to the longest RSA modulus shown in Table C.2 or C.3 of **FIPS 186-4** whose length does not exceed that of the implementation's RSA modulus. Hence, for an RSA modulus of bit length 4096 or larger, if the target primality-testing error probability is 2^{-100} then the minimum number of the Miller-Rabin tests when generating and testing each of the auxiliary primes is 27 and the minimum number of the Miller-Rabin tests for p and q is 3.

The use of the approved hash functions in digital signatures is documented in **SP 800-131A Rev2**, Table 8. The choice of a hash function may affect the security strength of the RSA signature algorithm.

Per IG 9.4, Note7, an RSA known-answer test for signature generation may be implemented for any approved RSA modulus size supported by the cryptographic module; that is, any implemented RSA modulus size of at least 2048 bits.

Signature verification. When performing a **FIPS 186-4** signature verification, a module may support all RSA modulus sizes no smaller than 2048, as well as a 1024-bit modulus. When performing a **FIPS 186-2** signature verification, the module may support all modulus sizes shown in **FIPS 186-2**; that is, all numbers in the form of 1024+256*s, where s is a nonnegative integer. The use of RSA modulus sizes listed in this paragraph is approved for signature verification within their respective standard (**FIPS 186-4** or **FIPS 186-2**).

If the module performs the **FIPS 186-4** RSA signature verification, then this algorithm **shall** be tested by the CAVP with at least one modulus size. Similarly, if the module performs the **FIPS 186-2** RSA signature verification, this algorithm **shall** be tested for at least one modulus size. All modulus sizes in which testing is available **shall** be tested by the CAVP. If no CAVP testing is available for the RSA signature verification with a particular approved RSA modulus size, then the untested status of these modulus sizes **shall** be documented in the Security Policy.

Additional Comments

1. This Implementation Guidance is concerned with a description of the approved modulus sizes (and, therefore, the approved key sizes) for the RSA digital signature algorithm only. For completeness, here is the status of the approved and allowed key sizes in other asymmetric-key-based algorithms and schemes. This information is largely based on **SP 800-131A Rev2**.

   a. RSA-based key transport (encapsulation) schemes. The modulus sizes of 2048 bits and larger are approved per **SP 800-56B Rev2** and the RSA key generation, including the primality testing, **shall** be performed under the same rules that apply to the RSA signature keys. This includes the limits on the sizes of the auxiliary primes and on the minimum number of the Miller-Rabin tests stated in this Implementation Guidance.

      Certain implementations that are not compliant with **SP 800-56B Rev2** are allowed per **SP 800-131A Rev2** and IG D.9. All modulus sizes of 2048 bits and higher are allowed. It is strongly recommended that if an allowed scheme uses the auxiliary primes p_1, p_2, q_1 and q_2 then the bounds on the minimum sizes of these primes, on their maximum total size and on the number of the Miller-Rabin tests for all primes used in an allowed RSA-based key transport scheme are also the same as those specified in this IG for the RSA digital signature implementations.

   b. DSA signatures. The approved bit sizes of the primes p and q used in the DSA algorithm are given in Section 4.2 of **FIPS 186-4**. Of these sizes, only the following pairs (2048, 224), (2048, 256) and (3072, 256) can be used in the approved mode for signature generation. For signature verification, these primes' sizes and the (1024, 160) pair are approved.

   c. FFC-based key agreement schemes. The original publication of **SP 800-56A** showed the following three sets of the sizes of the p and q primes used in the FFC-based key agreement and shared secret computation schemes: FA: (1024, 160), FB: (2048, 224) and FC: (2048, 256). Of the three, only FB and FC are currently approved (see **SP 800-56A** for details), each resulting in the 112-bit strength in the established symmetric keys.

   d. ECDSA signatures. Digital signature generation and verification algorithms shown in **FIPS 186-4** are approved, as long as the chosen elliptic curves are acceptable for their specific use. That is, all NIST-recommended curves are approved for signature verification. All but the following three NIST-recommended curves that provide less than 112 bits of encryption strength: P-192, B-163 and K-163, are also approved for signature generation. In addition, the use of any elliptic curve satisfying the requirements of IG A.2 is approved for signature verification. The use of these curves is also approved for signature generation, if the bit length of n, as shown in Table 1 in **FIPS 186-4**, is least 224. It is vendor's responsibility to demonstrate that a non-NIST-recommended curve meets these requirements.

   e. There are no 'non-approved but allowed' ECDSA versions.

   f. ECC-based key agreement and shared secret computation schemes are approved, if they are compliant with one of the schemes specified in **SP 800-56A Rev3**. The elliptic curve used in a key-agreement scheme and the associated domain parameters **shall** provide at least 112 bits of security. If an elliptic curve is not a NIST-recommended curve, an ECC-based key agreement or a shared secret computation scheme using this curve may be allowed if the security requirements are met. See IG D.8 and IG A.2 for details.

   g. RSA-based key agreement and DLC-based key transport schemes. These schemes are rarely used. There exist only the approved versions, no 'non-approved but allowed' ones. The RSA-based key agreement schemes are described in Sections 8.2 and 8.3 of **SP 800-56B Rev2**. The DLC-based key-transport schemes are addressed in Section 4.3 of **SP 800-56Arev3** and amount to establishing a symmetric key using a **SP 800-56Arev3**-compliant key agreement scheme and then using the established symmetric key to wrap (transport) another key in compliance with the requirements of **SP 800-38F**.

2. When implementing a key agreement scheme (or a shared secret computation as part of a key agreement scheme), the vendor **shall** indicate in the module's Security Policy whether the scheme is of the Diffie-Hellman or the MQV variety.

3. The line in Table 1 above that corresponds to the 4096+ bit RSA modulus *nlen* is different from the corresponding line in Table A.1 of the current (as of August 31, 2021) draft of **FIPS 186-5**. The minimum size of the auxiliary primes is shown in Table A.1 of **FIPS 186-5** as " > 200 bits". However, an Implementation Guidance cannot enforce a requirement from a yet-to-be-published standard. Leaving the entry at " > 170 bits" does not tighten the existing requirements.

   The entries for the maximum values of len(p_1) + len(p_2) and len(q_1) + len(q_2) on the line for 4096 ≤ *nlen* are taken from the formulas in footnote 3 in Appendix B.3.1 of **FIPS 186-4**. These entries represent the weakening of the constraints for the 3072-bit modulus in Table B.1 of **FIPS 186-4** and are consistent with the corresponding entries for the 4096+ bit modulus in the draft of **FIPS 186-5**. Since no new requirements are introduced, the constraints in Table 1 are effective immediately.

   Note that the upper bounds for the values of len(p_1) + len(p_2) and len(q_1) + len(q_2) provided in Table 1 of this IG for both the probable and the provable primes p and q are the sanity-check constraints. If p_1 and p_2 were large enough to exceed the stated upper bound for len(p_1) + len(p_2) then there would be very few possibilities left (in some cases, none) for choosing the prime number p. The CMVP is not aware of any security rationale for generating the auxiliary primes p_1, p_2, q_1 and q_2 greater that their minimum length stated, as a function of *nlen*, in Table 1 of this IG and does not encourage vendors to use the auxiliary primes whose lengths exceed the minimum stated values.

4. The number of the Miller-Rabin tests applied when checking the probabilistic primality for the prime candidates p, q, p_1, p_2, q_1 and q_2 corresponding to the RSA modules *nlen* whose length is at least 4096 bits is taken from the entries in Tables C.2 and C.3 in **FIPS 186-4** and not from Tables B.1 and B.2 in the draft of **FIPS 186-5**.

   While applying the algorithm from Appendix F of **FIPS 186-4** for determining the minimum number of the Miller-Rabin primality tests, which is used to populate the entries in Tables C.2 and C.3 of **FIPS 186-4** and Tables B.1 and B.2 of the draft of **FIPS 186-5**, one should remember, as stated in **FIPS 186-4**, that to the developer of a cryptographic module it is not the probability that a composite number taken among all integers of a given size passes t rounds of the Miller-Rabin tests with the randomly-selected bases that is of most interest, but the probability that a given number passing t rounds of the Miller-Rabin tests with the random bases is composite.

   When computing the latter probability, one does not average over all numbers of the same bit size. Since the probabilities of the different composites of the same size to pass the Miller-Rabin tests may be very different, averaging the probability over all numbers of the same size can be misleading. However, the result of this averaging is what is used when computing the minimum required number of the Miller-Rabin tests in Appendix F of **FIPS 186-4**. Hence, this IG does not allow, at least not until **FIPS 186-5** is published, to lower the number of the required Miller-Rabin tests for the 4096+ bit RSA moduli primes from the current recommendations for the 3072-bit RSA modulus. Moreover, the CMVP strongly recommends that for any candidate prime (an RSA prime or an auxiliary prime) the number t of the Miller-Rabin tests with the random bases is selected as at least $\lceil -log_2(p_{target})/2 \rceil$, where p_{target}, defined in Appendix F.1 of **FIPS 186-4**, is the maximum allowed probability of accidentally generating a composite number. See a Warning in Appendix F.2 of **FIPS 186-4** for the justification of this recommendation for the number of the Miller-Rabin tests.

A.15 Vendor Affirmation for the SP 800-185 Algorithms

Applicable Levels:	*All*

Original Publishing Date:	*12/04/2017*
Effective Date:	*12/04/2017*
Last Modified Date:	*08/28/2020*
Transition End Date:	***09/01/2020***
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.03, TE01.12.04*
Relevant Vendor Requirements:	*VE.01.12.03, VE01.12.04*

Background

SP 800-185 was published in December 2016. This standard includes specifications for several algorithms that are based on the SHAKE and KECCAK[c] constructions defined in **FIPS 202**. The functions are:

- cSHAKE128
- cSHAKE256
- KMAC128
- KMAC256
- KMACXOF128
- KMACXOF256
- TupleHash128
- TupleHash256
- TupleHashXOF128
- TupleHashXOF256
- ParallelHash128
- ParallelHash256
- ParallelHashXOF128 and
- ParallelHashXOF256.

Of these, cSHAKE128 and cSHAKE256 are the modifications of SHAKE128 and SHAKE256 defined in **FIPS 202.** These modifications allow the use of the customization strings, one of which is a function-name bit string with all of the function names defined by NIST. Another is the user-defined customization string (the "S" parameter in the **SP 800-185** notation.)

TupleHash and ParallelHash are the new hash function families based on the cSHAKE construction. The KMACs are the versions of the keyed message authentication mechanism also defined in terms of the cSHAKE use. The security strength of each algorithm (assuming that a KMAC key is sufficiently strong) is 128 or 256 bits, as indicated in the algorithm's name. The KMACs and all of the hash functions defined here have a variable output length. The output length parameter may either be built into the computational procedures itself (in the KMAC, TupleHash or ParallelHash functions without XOF in the name) or the computations may be independent of the desired output length but the output string would end once the desired length is reached (if XOF is present in the name of the function).

Question/Problem

When is CAVP testing required for compliance to **SP 800-185**? To claim the vendor affirmation of the correct implementation of all or some of the functions defined in **SP 800-185**, which sections of the standard need to be addressed and what are the self-test and the documentation requirements?

Resolution

Vendors may, through **September 1, 2020**, continue to submit modules that claim vendor affirmation to the **SP 800-185**. After this date, all module submissions to the CMVP (2SUB, 3SUB or 5SUB) **shall** include a

CAVP tested certificate (cSHAKE, KMAC, ParallelHash, and/or TupleHash) if it is utilized in an approved mode of operation.

IG A.11 specifies the KECCAK family of sponge functions and defines the SHA-3 and SHAKE hash functions that are based on KECCAK. CAVP testing is available for the SHA-3 algorithms with the 224, 256, 384 and 512-bit output lengths and for the SHAKE128 and SHAKE256 hash functions. IG A.11 further addresses the anticipated use of the SHA-3 by the existing high-level algorithms such as HMAC, RSA, etc. **SP 800-185**, on the other hand, introduces the new families of algorithms, which are based on the cSHAKE functions also defined in **SP 800-185**. Some of these algorithms – the KMACs - can be viewed as "high-level", while the others are the new hash functions. The roles and the uses of these algorithms will likely be different and hence the algorithms will require the separate certificate annotation.

To claim the vendor affirmation to the **SP 800-185** standard for any subset of the cSHAKE, TupleHash and ParallelHash functions listed above, the vendor **shall**

1. Obtain a CAVP certificate for the applicable underlying SHAKE128 and/or SHAKE256 functions,
2. Verify that the cSHAKE functions are implemented in compliance with **SP 800-185**,
3. If the vendor affirmation is claimed for any of the TupleHash and ParallelHash functions, verify their implementations' compliance with **SP 800-185**,
4. If applicable, explain in the Security Policy the rules for setting the user-customized strings "S" in the hash functions for which the vendor affirmation is claimed,
5. Place the following entry into the module's validation certificate: **SHA-3-Customized (SHA-3 Cert. #nnn, vendor affirmed)**, and
6. Individually list in the Security Policy all algorithms named in the Background section of this Implementation Guidance for which the vendor affirmation is claimed. The vendor is responsible for making security claims commensurate with the choice of the **SP 800-185**-compliant hash functions (128 or 256 bits of security.)

To claim the vendor affirmation to the **SP 800-185** standard for any subset of the KMAC functions listed above, the vendor **shall**

1. Obtain a CAVP certificate for the underlying SHAKE128 and/or SHAKE256 functions,
2. Verify that the cSHAKE functions are implemented in compliance with **SP 800-185**,
3. Verify the KMAC implementations' compliance with **SP 800-185** for all versions of KMAC where the vendor affirmation is claimed,
4. If applicable, explain in the Security Policy the rules for setting the user-customized strings "S" in the hash functions for which the vendor affirmation is claimed,
5. Place the following entry into the module's validation certificate: **KMAC (SHA-3 Cert. #nnn, vendor affirmed)**, and
6. Individually list in the Security Policy all functions named in the Background section of this Implementation Guidance for which the vendor affirmation is claimed. The vendor is responsible for making security claims commensurate with the choice of KMACs. If the KMAC's key strength is smaller than the security strength indicated in the KMAC function's name (128 or 256), document in the Security Policy the reduction in the strength of this message authentication algorithm.

No self-tests are required to claim the vendor affirmation for the algorithms defined in **SP 800-185**. A self-test is required to the underlying SHAKE128 and/or SHAKE256 algorithms defined in **FIPS 202**, as their implementation and testing is a pre-requisite for the vendor affirmation of the **SP 800-185**-compliant algorithms and, therefore, the self-test requirements of IG A.11 apply.

FIPS 140-2 Annex B – *Approved Protection Profiles*

FIPS 140-2 Annex C – *Approved Random Number Generators*

C.1 moved to W.3

C.2 moved to W.4

FIPS 140-2 Annex D – *Approved Key Establishment Techniques*

D.1 moved to W.10

D.1-rev2 CAVP Requirements for Vendor Affirmation of SP 800-56A-rev2

Applicable Levels:	*All*
Original Publishing Date:	*07/08/2015*
Effective Date:	*07/08/2015*
Transition End Date:	***12/31/2020*** *– See Below* ***06/30/2022*** *– See Below*
Last Modified Date:	*08/28/2020*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-56A was originally added to FIPS 140-2 Annex D on January 24, 2007. Its publication was followed by a release, on December 24, 2008, of a CAVS version containing tests for (most of the features of) the algorithms in that version of **SP 800-56A**. As of March 24, 2009, all newly submitted modules claiming to contain the **SP 800-56A**-compliant key agreement schemes were required to be tested.

The second revision of **SP 800-56A**, denoted **SP 800-56A-rev2**, was published in May 2013. There are several important differences between the two versions of **SP 800-56A**, the main one being that **SP 800-56A-rev2** incorporates the use of many additional key derivation functions (KDF's) into the key agreement schemes. These are the KDF's documented in **SP 800-135rev1** and **SP 800-56C**.

Question/Problem

Some vendors would like to claim vendor affirmation to **SP 800-56A-rev2** while others may continue testing their modules to the original version of **SP 800-56A** and receiving the KAS certificates not yet available for the modules' compliant with **SP 800-56A-rev2**. How does this co-existence of two different versions of **SP 800-56A** along with two different methods of claiming the module's compliance get administered by the CMVP?

When is the transition date for vendor affirming to **SP 800-56A-rev2** or testing to the original **SP 800-56A**?

Further, to claim *vendor affirmation* to **SP 800-56A-rev2**, what sections of the publication need to be addressed?

Resolution

Vendors may continue testing their modules' implementations of key agreement schemes to the original version of **SP 800-56A**, for which a CAVP test is currently available. While it is possible that an implementation compliant with the first release of **SP 800-56A** will also be compliant with **SP 800-56A-rev2**, no testing to **SP 800-56A-rev2** is available and therefore no claims can be made of the tested compliance to **SP 800-56A-rev2**.

Vendors may, through **December 31, 2020**, submit modules that claim compliance to the original version of **SP 800-56A** via CAVP testing, or vendor affirmation to **SP 800-56A-rev2**. After **June 30, 2022**, modules that claim compliance to **SP 800-56A** or **SP 800-56A-rev2** in the approved mode will be moved to the historical list.

To claim *vendor affirmation* to **SP 800-56A-rev2**, information contained in the following sections in that standard that are supported by the implementation under test (IUT) **shall** be implemented:

Section 5.6.2.3.1	Finite Field Cryptography (FFC) Full Public Key Validation Routine (if FFC is implemented)
Section 5.6.2.3.2	Elliptic Curve Cryptography (ECC) Full Public Key Validation Routine (if ECC is implemented)
Section 5.7	DLC Primitives (the Diffie-Hellman or the various ECC MQV primitives)
Section 5.8	Key Derivation Functions for Key Agreement Schemes (any function from the newly expanded list of key derivation functions)
Section 5.9	Key Confirmation, if the implementation supports it (see also the scheme-specific key confirmation information in various parts of **Section 6**)
Section 6	Key Agreement (any of the schemes presented in this section)

Note the change in section numbering from the original publication of **SP 800-56A**.

Additional Comments

1. The requirements specified in **SP 800-56A-rev2** depend on several NIST approved security functions. To claim vendor affirmation to **SP 800-56A-rev2**, the underlying security functions used by an IUT **shall** be tested and validated prior to claiming vendor affirmation. These include:

    - Approved hash algorithms (SHA1, SHA224, SHA256, SHA384, and/or SHA512)
    - Approved Message Authentication Code (MAC) algorithms (CMAC, CCM, GMAC and/or HMAC)
    - Approved Random Number Generators (RNG and DRBG)
    - If FFC is supported,
        - If the IUT generates domain parameters, the DSA PQG generation and/or verification tests from **FIPS 186-4**.
        - If the IUT generates key pairs, the DSA key pair generation tests from **FIPS 186-4**.
    - If ECC is supported,
        - If the IUT generates key pairs, the ECDSA key pair generation test and/or the Public Key Validation (PKV) test from **FIPS 186-4**.

2. **SP 800-56A-rev2** self-tests required in cryptographic module implementations must consist of the known answer tests that validate the correctness of the implemented DLC primitives and the known answer tests for all key derivation functions implemented in the key agreement schemes. See Implementation Guidance 9.6 for details.

3. There is no guidance provided to claim vendor affirmation to the DLC-based Key Transport schemes from **SP 800-56A-rev2**.

4. To claim vendor affirmation with **SP 800-56A-rev2**, the implementation **shall** comply with the requirements of **SP 800-131A**. That is, the key lengths and the Mac Tag and Mac Key lengths (if key confirmation is supported) must be appropriate to guarantee at least the 112-bit security strength. Thus the FA and EA domain parameters **shall** not be used in an approved mode. See Tables 8 and 9 in **SP 800-56A-rev2** for the minimum lengths of the key confirmation parameters.

5. Vendors may, through **December 31, 2020**, continue to submit modules that claim vendor affirmation to **SP 800-56A-rev2** in an approved mode. See IG D.8 for more information.

Annotation

Refer to IG G.13 for annotation examples.

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their module implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

D.1-rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard

Applicable Levels:	*All*
Original Publishing Date:	*08/16/2019*
Effective Date:	*08/16/2019*
Last Modified Date:	*11/05/2021*
Transition End Date:	***12/31/2020** – See Below* ***06/30/2022** – See Below*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-56A was originally added to FIPS 140-2 Annex D on January 24, 2007. Its publication was followed by a release, on December 24, 2008, of a CAVS version containing tests for (most of the features of) the algorithms in that version of **SP 800-56A**. As of March 24, 2009, all newly submitted modules claiming to contain the **SP 800-56A**-compliant key agreement schemes were required to be tested.

The second revision of **SP 800-56A**, denoted **SP 800-56A Rev2**, was published in May 2013. There were several important differences between **SP 800-56A Rev2** and **SP 800-56A**, the main one being that **SP 800-56A Rev2** permits the use of many additional key derivation functions in the key agreement schemes. These are the key derivation functions documented in **SP 800-135rev1** and **SP 800-56C**.

In April 2018 NIST published **SP 800-56A Rev3** that replaced the previous versions. **SP 800-56A Rev3** was added to Annex D of FIPS 140-2 on June 10, 2019. There are several significant differences between **SP 800-56A Rev3** and its predecessor. First, the new standard defines different sets of the FFC domain parameters that are now approved for use. These sets use the so-called "safe" primes with $p = 2q+1$ and with g, the generator of the cyclic group of size q, being equal to 2. These safe primes are not generated from a random seed. Instead, they are defined in Appendix D of **SP 800-56A Rev3** and are consistent with the FFC domain parameters defined in the IETF publications **RFC 3526** and **RFC 7919**.

The domain parameter sets generated in compliance with **SP 800-56A Rev2** are still included in **SP 800-56A Rev3** but are only recommended for use in legacy applications.

The second significant change from **SP 800-56A Rev2** is that **SP 800-56A Rev3** no longer contains the descriptions of the key derivation functions. These have been moved to **SP 800-56C Rev1**, also published in April 2018. In addition to the key derivation functions in **SP 800-56C Rev1** (and **Rev2**), the key derivation functions included in **SP 800-135 Rev1** continue being approved for use in the key agreement schemes based on the **SP 800-56A Rev3** methods. Section 5.8 of **SP 800-56A Rev3** does explain how to use SP **800-56C Rev1** to complete the key agreement computation. However, the details of the key derivation are not included in **SP 800-56A Rev3**.

See Appendix E of **SP 800-56A Rev3** for the full list of revisions that separate this version of the standard from **SP 800-56A Rev2**.

Question/Problem

1. At the time **SP 800-56A Rev3** was published, vendors could choose to either claim vendor affirmation to **SP 800-56A Rev2** or obtain a **KAS** algorithm certificate by successfully running the existing CAVP tests to demonstrate the module's compliance with **SP 800-56A**. Can they continue making these claims?
2. How to make a vendor affirmation claim to SP **800-56A Rev3**?
3. What is required to satisfy the transition rules specified in **SP 800-131A Rev2**?
4. To claim *vendor affirmation* to one of the revisions of **SP 800-56A**, which sections of the standard need to be addressed?

Resolution

CAVP testing to **SP 800-56A Rev2** is not available at the time of the publication of this IG. Vendors may, through **December 31, 2020**, continue testing their modules' implementations of the key agreement schemes to the original version of **SP 800-56A**, or claiming vendor affirmation to **SP 800-56A Rev2**. The **KAS** certificates showing compliance with the original version of **SP 800-56A** will continue to be issued until that date. The requirements for vendor affirmation to **SP 800-56A Rev2** are documented in IG D.1-rev2.

This IG permits vendors to claim vendor affirmation to **SP 800-56A Rev3** through **December 31, 2020**. After this date, CAVP testing to **SP 800-56A Rev3** is required.

After **June 30, 2022** all module validation certificates containing the **KAS** algorithm certificates or claims of vendor affirmation to **SP 800-56A Rev2** will be placed on the Historical list. A module may be moved back into the Active list if the vendor tests the module's compliance to **SP 800-56A Rev3**, or else removes all claims of compliance with any version of **SP 800-56A**. The validation certificate and the module's Security Policy **shall** be updated to reflect the new claims.

Validated modules containing the vendor-affirmation claims made under the rules of this IG will stay on the Active list (as long as there is no other reason to move them to the Historical list).

To claim vendor affirmation to **SP 800-56A Rev3**, the vendor and the CST testing lab **shall** determine that each requirement ('**shall**' statement) of this standard is either satisfied or is not applicable.

Additional Comments

1. If vendor affirmation to **SP 800-56A Rev3** is claimed, no CVL primitive **shall** accompany this affirmation statement.

2. In compliance with Section 5.6.2 of **SP 800-56A Rev3**, the conditional self-tests are performed on the pairs of asymmetric keys employed in the key agreement schemes. Therefore, no additional self-tests are necessary to meet the requirements of Section 4.9.2 of **FIPS 140-2**.

   If vendor affirmation is claimed for **SP 800-56A Rev3** then no power-up self-tests is required. For CAVP tested **SP 800-56A Rev3** implementations, self-test requirements, per IG D.8, are required.

3. The Finite Field Cryptography (FFC) domain parameters may be either selected from the safe prime groups, described in Appendix D of **SP 800-56A Rev3** and referenced earlier in this IG, or they can be generated as shown in Appendix A of **FIPS 186-4**. These **FIPS 186-4**-compliant sets of the domain parameters, called "FIPS 186-type" in **SP 800-56A Rev3**, may also be entered into the module if generated outside its boundary. The use of the FIPS 186-type domain parameters is recommended only for legacy applications.

4. If the Elliptic Curve Cryptography (ECC) is implemented and the vendor is claiming an affirmation to **SP 800-56A Rev3** then the elliptic curves **shall** be from the list of the NIST-recommended curves specified in **FIPS 186-4**. The choice of the elliptic curves **shall** guarantee the minimum of 112 bits of encryption strength.

   IG D.8 addresses the non-approved but allowed implementations of key agreement schemes that may use the curves that are not necessarily NIST-recommended.

D.2 Acceptable Key Establishment Protocols

Applicable Levels:	*All*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS.07.21*
Relevant Test Requirements:	*TE07.21.01*
Relevant Vendor Requirements:	*VE.07.21.01-02*

Background

Cryptographic modules may use various methods for establishing keys within a cryptographic module. These methods include the use of symmetric and asymmetric key establishment schemes within protocols to establish and maintain secure communication links between modules. FIPS 140-2 Annex D provides a list of approved key establishment techniques for establishing keying material that are applicable to FIPS 140-2.

Question/Problem

What are all the types of key establishment within a cryptographic module, and what are the approved and allowed methods for each type that may be used in the approved mode of operation?

Resolution

Key establishment is the process by which secret keying material is securely established either within the module or between two or more entities. This IG lists all types of methods for key establishment that may be performed in an approved mode of operation. The specifics of each type of key establishment are addressed in the corresponding IGs that this IG references. Therefore, this IG serves as an umbrella IG for the approved and allowed key establishment methods.

The following are the six types of methods that may be used in the approved mode for the establishment of keys within a cryptographic module.

Key agreement is a method of electronic key establishment where the resulting keying material is a function of information contributed by two or more participants, so that no party can predetermine the value of the secret keying material independently from the contribution of any other party. Key agreement is performed using key agreement schemes. The approved schemes for key agreement that may be implemented within a cryptographic module are referenced in Annex D of FIPS 140-2 and further discussed in IG D.8, which also lists the allowed key agreement schemes.

Key transport is a method of electronic key establishment whereby one party (the sender) selects a value for the secret keying material and then securely distributes that value to another party (the receiver). Key transport is performed using key transport schemes. The approved schemes for key transport that may be implemented within a cryptographic module are referenced in Annex D of FIPS 140-2 and further discussed in IG D.9, which also lists the allowed key transport schemes.

Key generation is the process for generating cryptographic keys within a particular cryptographic module. The approved methods for key generation are listed in **SP 800-133**.

Key entry is a method for key establishment where the key is manually or electronically entered into the module. It does not include the key transport schemes described earlier in this IG.IG 7.7 provides further information about mapping key entry and output states to the FIPS 140-2 requirements.

Key derivation is a method for deriving keys from the certain parameters using the approved key derivation functions. One possibility is to derive a key from an already existing related key as described in **SP 800-108**. Another is to derive a key for storage applications only, in compliance with **SP 800-132**.

Pre-loading of a key is a method by which a manufacturer of the module can establish a key within the module. A key pre-loaded by the manufacturer is available when the module is first powered-on.

Additional Comments

This IG does not address key establishment for use in authentication techniques.

The key establishment method(s) that involve key agreement or key transport used by the cryptographic module **shall** be listed under **AS.07.21**.

While some IGs referenced from this IG list various Key Agreement and Key Transport methods as either approved or allowed, it is important to keep in mind that the strength of these methods may be weaker than the strength of the transported or agreed-upon key. In this case, the resulting strength of the key should be properly documented. See IG 7.5 for ways to calculate the strength of the established key, and IG G.13 for the proper way to caveat the possible loss of the established key's cryptographic strength in the module's certificate.

D.3 Moved to W.15.

D.4 Requirements for Vendor Affirmation of SP 800-56B

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Effective Date:	*07/15/2011*
Last Modified Date:	*10/30/2023*
Transition End Date:	***12/31/2020*** *– see below*
Relevant Assertions:	*AS.07.17*
Relevant Test Requirements:	*TE07.17.01 and TE07.17.02*
Relevant Vendor Requirements:	*VE.07.17.01*

Background

SP 800-56B was published August 2009 and added to FIPS 140-2 Annex D on October 08, 2009. Until CAVP testing for SP **800-56B** is available, IG A.3 is applicable. **SP 800-56B** includes information beyond the specifications of the key establishment algorithm itself; i.e. instructions to the implementer to aid in the implementation of the algorithm.

Question/Problem

When is the transition date for vendor affirming to **SP 800-56B**? To claim *vendor affirmation* to **SP 800-56B**, what sections of the publication need to be addressed?

Resolution

Vendors may, through **December 31, 2020**, continue to submit modules that claim vendor affirmation to **SP 800-56B**.

To claim *vendor affirmation* to **SP 800-56B**, the vendor first needs to specify what parts of **SP 800-56B** are supported by the subject implementation. These parts include some (at least one) or all of the following: RSA key pair generation, public key validation, a key agreement scheme, and a key transport scheme.

Information contained in the following sections that are supported by the implementation under test (IUT) **shall** be implemented:

Section 6.3	Either **Section 6.3.1** or **Section 6.3.2** or both (if RSA key pair generation is claimed). This further requires the implementation of information contained in **Section 5.4** (Prime Number Generators).
Section 6.4	Either **Section 6.4.1** or **Section 6.4.2** or both (if public key validation is claimed)
Section 8	If a key agreement scheme is claimed
Section 9	If a key transport key is claimed
Section 5.9	Approved key derivation functions. This section applies if a vendor affirmation of either a key agreement or a key transport scheme is claimed

Annotation

Refer to IG G.13 for annotation examples (**KAS** or **KTS**).

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

Additional Comments

1. The components in **SP 800-56B shall** only be used within the **SP 800-56B** protocol.

2. The requirements specified in **SP 800-56B** depend on several NIST approved security functions, such as, SHA, DRBG, and the **FIPS 186-4** key pair generation for RSA. While validation testing for **SP 800-56B** concentrates largely on testing the algorithm unique to **SP 800-56B**, other supporting security functions may not be thoroughly tested by the testing in **SP 800-56B**, when such testing becomes available. The

validation tests for these supporting security functions are found in the validation test suite for this specific function. Therefore, these supporting security functions **shall** be validated as a prerequisite to **SP 800-56B** vendor affirmation.

To claim vendor affirmation to **SP 800-56B**, the underlying security functions used by this IUT **shall** be tested and validated prior to claiming vendor affirmation. These include:

- Hash algorithms as applicable
- If vendor affirmation is claimed for RSA key pair generation (Section 6.3), or a key agreement scheme (Section 8) or a key transport scheme (Section 9)
  - Supported Random Bit Generators (DRBG)
- If vendor affirmation is claimed for RSA key pair generation (Section 6.3)
  - An RSA key pair generation algorithm in **FIPS 186-4**

3. The **SP 800-56B** Self-Tests:

The RSA algorithms used in the key wrapping and key agreement schemes described in **SP 800-56B** require the known-answer tests. The module **shall** have an RSA encryption pre-computed and then, while performing a power-up self-test, the module **shall** perform the RSA encryption again and compare the newly-generated result to the pre-computed value.

The module **shall** also have a separate known answer for the RSA decryption by starting with a given value representing an RSA encryption (which could be either pre-computed or generated during a power-up test described earlier in this paragraph) and decrypting this value using the RSA algorithm. The result of said decryption operation is compared to a pre-computed result. If the module performs only one of the RSA encryption operations, say, either the wrapping or the unwrapping of a cryptographic key, then only the self-test that is attributable to this operation is required. If a key-agreement scheme from **SP 800-56B** is implemented then again only the RSA operations required by that scheme need to be tested using a known answer test.

While it may appear that the requirements for the RSA encryption and the RSA decryption (corresponding to the key wrapping and key unwrapping schemes) known answer tests are identical, they are not. The RSA encryption known answer test consists of checking the value of $M^e(mod\ \ N)$, while the RSA decryption known answer test consists of checking the value of $M^d(mod\ \ N)$, where (*e, N*) is the RSA public key with *e* taking one of the values allowed in **SP 800-56B**, and *d* is the RSA private key consistent with the public key (*e, N*). The *e* and *d* values **shall** be valid public and private key exponents, correspondingly.

D.5 moved to W.11

D.6 Requirements for Vendor Affirmation of SP 800-132

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Effective Date:	*07/15/2011*
Last Modified Date:	*08/28/2020*
Transition End Date:	***12/31/2020***
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	*TE07.11.01-02 and TE07.16.01-02*

Relevant Vendor Requirements:	*VE.07.11.01 and VE.07.16.01*

Background

SP 800-132 was published December 2010 and added to FIPS 140-2 Annex D on January 04, 2011. Until CAVP testing for **SP 800-132** is available, IG A.3 is applicable. This Special Publication defines the methods and the applicability for password-based key derivation.

Question/Problem

When is CAVP testing required for compliance to **SP 800-132**? To claim *vendor affirmation* to **SP 800-132**, what sections of the publication need to be addressed and what are the applicable documentation requirements?

Resolution

Vendors may, through **December 31, 2020**, continue to submit modules that claim vendor affirmation to the **SP 800-132**. After this date, all module submissions to the CMVP (2SUB, 3SUB or 5SUB) **shall** include a CAVP tested PBKDF certificate if it is utilized in an approved mode of operation.

The entire text of **SP 800-132** is applicable. In Section 5.4 of that Special Publication, two options are given for deriving a Data Protection Key from the Master Key. The vendor **shall** specify in the cryptographic module's Security Policy which option is used by the module. If the module is designed to support both options, then this **shall** be stated in the Security Policy.

The strength of the Data Protection Key is based on the strength of the Password and/or Passphrase used in key derivation. **SP 800-132** does not impose any strictly defined requirements on the strength of a password. It says that "passwords **should** be strong enough so that it is infeasible for attackers to get access by guessing a password." Therefore, the vendor **shall** document in the module's Security Policy the length of a password/passphrase used in key derivation and establish an upper bound for the probability of having this parameter guessed at random. This probability **shall** take into account not only the length of the password/passphrase, but also the difficulty of guessing it. The decision on the minimum length of a password used for key derivation is the vendor's, but the vendor **shall** at a minimum informally justify the decision.

The vendor **shall** also document the acceptable values of other parameters used in key derivation, see Section 5.3 of **SP 800-132**.

Further, the vendor **shall** indicate in the module's Security Policy that keys derived from passwords, as shown in **SP 800-132**, may only be used in storage applications.

The vendor **shall** comply with all "**shall**" statements in **SP 800-132**. These refer to but are not limited to the length of the salt parameter and the use of the approved hash functions, encryption algorithms and random number generators.

Annotation

Refer to IG G.13 for annotation examples (**PBKDF**).

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation complies with the requirements of **SP 800-132** and of the documentation requirements of this Implementation Guidance. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review.

Additional Comments

1. While the wording in IG D.9 specifically prohibits using password-based key establishment methods in FIPS mode, this does not contradict the statements in **SP 800-132** and in this IG, since **SP 800-132** allows the derived keys to be used only for storage applications. The key establishment addressed in IG D.9 shows how to establish a key used for protecting sensitive data that may leave the cryptographic module.

2. If vendor affirmation is claimed for **SP 800-132** then no power-up self-tests is required. For CAVP tested **SP 800-132** implementations, self-test requirements, per IG 9.4 (revision to this IG is underway), are required.

D.7 moved to W.12

D.8 Key Agreement Methods

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*04/23/2012*
Last Modified Date:	*11/05/2021*
Transition End Dates	***12/31/2020*** *– See Below* ***06/30/2022*** *– See Below* ***12/31/2023*** *– See Below*
Relevant Assertions:	*AS07.21*
Relevant Test Requirements:	*TE07.21.01*
Relevant Vendor Requirements:	*VE07.21.01-02*

Background

Cryptographic modules may implement various key establishment schemes to establish and maintain secure communication links between modules. Key establishment includes the processes by which secret keying material is securely established between two or more entities. Keying material is data that is necessary to establish and maintain a cryptographic keying relationship. These schemes are classified into key agreement schemes and key transport schemes. Key transport is addressed in IG D.9; this IG addresses key agreement.

Key agreement is a method of key establishment where the resulting keying material is a function of information contributed by two or more participants, so that no party can predetermine the value of the secret keying material independently from the contribution of any other party. Key agreement is performed using key agreement schemes.

Question/Problem

What are the approved and allowed key agreement techniques that can be used in an approved mode of operation?

Resolution

There are various *scenarios* for the full or partial **key agreement schemes** that have been approved and/or allowed for use in the FIPS approved mode of operation. Of the following six scenarios that have been in existence prior to the April 2018 publication of **SP 800-56A Rev3**, the first four scenarios apply when a key is established (i.e. key agreement) and the last two scenarios when only the primitive is implemented (e.g. in a software toolkit):

1. CAVP **KAS** Certificate
2. approved **SP 800-56B**-compliant RSA-based key agreement scheme
3. non-approved but *allowed* per this IG (a primitive as defined in **SP 800-56A** or **SP 800-56A Rev2** with a KDF specified in this IG or a SP)
4. non-approved but *allowed* legacy implementation of a key agreement scheme that, at the minimum, includes the computation of a shared secret and an application of a key derivation function. The key derivation function may be an identity function; in which case the computed shared secret becomes the key.
5. approved (compliant with **SP 800-56A**); primitive only
6. non-approved (not compliant with **SP 800-56A**); primitive only

The details of the stated scenarios are addressed below. These scenarios do not apply when vendor affirmation or testing to **SP 800-56A Rev3** is claimed. Scenarios 1, 3, 4, 5, and 6 will be accepted for validation in the newly submitted reports (3SUB and 5SUB submissions) through **December 31, 2020**. These scenarios cannot be used in the approved mode and will move the module to the historical list after **June 30, 2022**. Scenario 2 continues to be applicable and has been expanded after the publication of **SP 800-56Br2**.

Scenario 1 requires compliance with **SP 800-56A**, as demonstrated by a KAS certificate. Each scheme in SP **800-56A** consists of several elements:

- A primitive (i.e., an algorithm) that is used to generate a shared secret from the public and/or private keys of the initiator and responder in a key agreement transaction. The shared secret is an intermediate value that is used as input to a key derivation function.
- A key derivation function (KDF) that uses the shared secret and other information to derive the keying material.
- An optional message authentication code (MAC) that is used for key confirmation or implementation validation. Key confirmation is a procedure that provides assurance to one party (the key confirmation recipient) that another party (the key confirmation provider) actually possesses the correct secret keying material and/or shared secret.
- The rules for using the scheme securely. The rules specified in **SP 800-56A** include criteria for generating the domain parameters and asymmetric key pairs used during key agreement, methods for obtaining the required assurances, and specifications for performing key confirmation.

Scenario 2 is addressed in **SP 800-56B** and **SP 800-56Br2**. The module's implementation of a key agreement scheme **shall** either be vendor-affirmed to **SP 800-56B** or shown compliance with **SP 800-56Br2**.

Implementations claiming vendor affirmation to **SP 800-56B** must be submitted for validation no later than on **December 31, 2020**. Vendor affirmation to **SP 800-56B** will remain approved through **December 31, 2023**. After this date, only the **SP 800-56Br2**-compliant and CAVP-tested solutions may be used in the approved mode to perform an asymmetric-key-based key agreement.

The implementations claiming compliance to **SP 800-56Br2** may choose one of the following two paths, or both:

(1) A CAVP-tested compliance with the derivation of a shared secret *Z* in one of the schemes in Sections 8.2 and 8.3 of **SP 800-56Br2**. This compliance will be annotated as **KAS-RSA-SSC**. If compliance for party U with the KAS1-basic scheme from Section 8.2.2 is claimed, then the generation of C will be tested. In all other cases, the CAVP test will verify the correctness of the value of Z.

(2) A tested compliance with one or both RSA-based schemes KAS1 and KAS2, defined, respectively, in Sections 8.2 and 8.3 of **SP 800-56Br2**. The implemented schemes may be either "basic", shown in Sections 8.2.2 and 8.3.2, or include the key confirmation per sections 8.2.3 and 8.3.3 of **SP 800-56Br2**.

When path (2) is chosen, the CAVP testing may be performed either end-to-end, in which case the vendor is issued a **KAS-RSA** algorithm certificate [1], or split into (i) testing the computation of the shared secret, (ii) testing the key derivation function used in deriving the keying material, and, if applicable, (iii) testing the key confirmation step in Figure 7, 9, 10, or 11 in **SP 800-56Br2**. The key derivation function **shall** comply to either **SP 800-56C Rev1 or 2**, in which case this compliance will be documented as an algorithm, annotated as **KDA** in the module's certificate, or to one of the key derivation functions included in IG G.20, in which case the compliance with be shown as a **CVL**. Testing of the key confirmation functionality will be shown as a **CVL**. The module's Security Policy **shall** state which key agreement algorithms and algorithm components have been implemented and CAVP-tested.

The shared secret computation portion of a key agreement scheme includes, as applicable, the generation of the domain parameters, key pair generation, computing the RSA primitive(s) (based either on the RSA exponentiation or the use of the Chinese Remainder Theorem (CRT)) used by the module, and performing the public key validation either by the owner of the key pair or by the recipient of the public key.

The applicable self-tests

The known answer self-test (KAT) for a solution complying with path (1) above **shall** consist of either (when the module takes the role of party U in the KAS1-basic scheme) verifying the computation of an RSA primitive referenced in Action 1 in Section 8.2.2 of **SP 800-56Br2**, or (except for party U in the KAS1-basic scheme) performing and verifying the correctness of the computation of the shared secret Z. It is sufficient to perform one KAT for each implementation of an **SP 800-56Br2**-compliant solution, even if the implementation includes multiple shared secret computation and key agreement schemes.

The RSA parameters in the KAT, such as the modulus length and the private and public exponents, **shall** have the sizes consistent with those supported by the module. If the KAT includes an exponentiation using a random value z submitted to the test, the values m, z and n in the computation of $m^z (\bmod n)$, in the **SP 800-56Br2** notation, **shall** be such that $m^z > n$.

The KAT for a solution complying with path (2) **shall** consist of either performing the KAT(s) acceptable for path (1) for the implemented **SP 800-56Br2** shared secret computation scheme(s) followed by the KAT of a key derivation function used in the derivation of the keying material, or of verifying the value of the derived keying material for at least one implemented **SP 800-56Br2**-compliant key agreement scheme. All key derivation functions not included in the **SP 800-56Br2** KATs **shall** have their own known answer tests.

Scenario 3 addresses any implementations of the Discrete Logarithm Cryptography (DLC) key agreement schemes which do not completely conform to **SP 800-56A** or **SP 800-56A Rev2** but demonstrate the tested conformance to the **SP 800-56A** primitives. The module's DLC key agreement scheme **shall** include:

> One or more of the primitives specified in **SP 800-56A**. Domain parameters and key sizes **shall** conform to **SP 800-56A** and guarantees the key agreement scheme's security strength of at least 112 bits. A **CVL** algorithm validation certificate for a DLC primitive is required, and the KDFs **shall** conform to any of the following:
>
> - One of the key derivation methods shown in **SP 800-56C Rev1**, or
> - The KDFs specified in **SP 800-135rev1**. Each KDF **shall** have a **CVL** certificate and may be used only in a protocol where it is specifically allowed.

If key confirmation is claimed for a key agreement scheme, one or more of the key confirmation methods in **SP 800-56A** **shall** be used.

[1] A KAS-RSA certificate will only be issued if a key-agreement scheme implements a key derivation function from SP 800-56C Rev1 or Rev2.

An implementation **shall** conform to the key agreement rules specified in **SP 800-56A**, with the possible exception of the format of the KDF (see above).

Scenario 4 applies when the module implements a key agreement scheme which is not compliant with either the **SP 800-56A** or **SP 800-56A Rev2** primitives or the KDF standards listed in Scenario 3 or both. Such implementations are allowed in the approved mode subject to the requirements of IG D.11.

Scenario 5 requires compliance with one or more of the key agreement primitives specified in **SP 800-56A**. Domain parameters and key sizes **shall** conform to **SP 800-56A**. A **CVL** algorithm validation certificate for a DLC primitive is required.

Scenario 6 is self-explanatory.

The module may claim compliance with either of the additional scenarios described below, named **X1** and **X2**. After **June 30, 2022**, in addition to the RSA-based Scenario 2 above, only these scenarios may be used in the approved mode.

Scenario X1. The implementations claiming compliance to this scenario may choose one, or any combination of the following three paths:

(1) A CAVP-tested compliance with the derivation of a shared secret Z in one or more of the key agreement schemes in Section 6 of **SP 800-56A Rev3**. This compliance is annotated as **KAS-SSC** in the module's validation certificate.

(2) A tested compliance with one or more of the key agreement schemes in Section 6 followed by the derivation of the keying material as shown in Section 5.8 of SP **800-56A Rev3**. This may optionally be followed by the unilateral or bilateral key confirmation shown in Section 5.9 of SP **800-56A Rev3**.

(3) A vendor-affirmed compliance with the derivation of a shared secret Z in one or more of the key agreement schemes in Section 6 of **SP 800-56A Rev3**. The rules for this vendor affirmation are listed in IG D.1-rev3. This compliance is annotated as **KAS-SSC (vendor affirmed)** in the module's validation certificate.

When path (2) is chosen, the CAVP testing may be performed either end-to-end, in which case the vendor is issued a **KAS** certificate [1], or it may be split into (i) testing the computation of the shared secret, (ii) testing the key derivation function used in deriving the keying material, and, if applicable, (iii) testing the key confirmation step in Sections 5.9.1 or 5.9.2 of **SP 800-56A Rev3**. The key derivation function **shall** comply to either SP **800-56C Rev1 or Rev2** or to one of the key derivation functions included in IG G.20. In the former case, this compliance will be documented as an algorithm, annotated as **KDA** in the module's certificate. In the latter case, the compliance will be shown as a **CVL**. The testing of the key confirmation functionality will be shown as a **CVL**. The module's Security Policy **shall** state which key agreement algorithms and algorithm components have been implemented and CAVP-tested.

The shared secret computation portion of a key agreement scheme includes, as applicable, the domain parameter generation (if using the FIPS 186 primes) or selection, public key validation, key pair generation, the computation of the Diffie-Hellman or MQV primitives using the Finite Field or Elliptic Curve arithmetic, the key confirmation and an implementation of some of the schemes listed in Section 6 of **SP 800-56A Rev3**.

The applicable self-tests

The KAT for a solution complying with path (1) above **shall** consist of verifying the correctness of the computation of the shared secret Z in at least two of the schemes listed in Section 6 of **SP 800-56A Rev3**: one KAT for the Finite Field Cryptography (FFC) methods and one KAT for the Elliptic Curve Cryptography methods, if both the FFC and ECC methods are implemented; otherwise, just one. No separate KATs are required to test Diffie-Hellman and MQV schemes.

[1] A KAS certificate demonstrating compliance with the X1 scenario will only be issued if a key-agreement scheme implements a key derivation function from SP 800-56C Rev1 or Rev2.

If a KAT is performed for one of the FFC Diffie-Hellman schemes, the parameters p, g and x, in the notation of **SP 800-56A Rev3**, **shall** be chosen such that $g^x > p$, in order to check the modular arithmetic operation. The size of p **shall** be among those supported by the module.

For the ECC Diffie-Hellman KAT, it is sufficient to choose any NIST-recommended curve supported by one of the module's ECC-based key shared secret computation schemes, select any point Q in the subgroup of size n of points on that curve and verify the correct computation of the x-coordinate of point $P = hdQ$, with $2 \leq d \leq n\text{-}2$, and the parameters n and h are defined as in Section 3.2 of **SP 800-56A Rev3**.

If performing a KAT for an MQV scheme, the parameter p (for FFC) and the curve (for ECC) **shall** also be among those supported by the module. The points on the curve selected for this self-test need to be in the correct subgroup. The values d, representing the private keys, used in the Section 5.7.2.3 of the **SP 800-56A Rev3** ECC MQV primitive need to be between 2 and n-2.

The KAT for a solution complying with path (2) **shall** consist of either a KAT described above for path (1) for the implemented **SP 800-56A Rev3** shared secret computation schemes followed by the KAT of a key derivation function used in the derivation of the keying material, or of verifying the value of the derived keying material for one or more implemented key agreement schemes (Section 6 together with Section 5.8 of **SP 800-56A Rev3**). At least one FFC-based and one ECC-based shared secret computation scheme **shall** be self-tested, if both the FFC and ECC methods are implemented; otherwise, just one. All key derivation functions not included in the **SP 800-56A Rev3** KATs **shall** have their own known answer tests.

Per IG D.1-rev3, no additional self-tests are required if path (3) is selected.

Scenario X2. An ECC scheme using the elliptic curves compliant with IG A.2. This scheme **shall** be shown as *allowed* in the module's Security Policy and documented on the certificate's non-approved line. It is vendor's responsibility to demonstrate that

(a) the curve(s) are compliant with IG A.2,
(b) the rules of **SP 800-56A Rev3** have been followed whenever possible, given that the curves may not be defined in a NIST publication, and
(c) the module supports Scenario **X1** above using at least one NIST-recommended curve.

No additional KATs are required for Scenario **X2**, since the use of the key agreement schemes under this scenario is not approved but allowed. Moreover, the use of this scenario implies testing Scenario **X1** for at least one NIST-recommended elliptic curve, including the execution of the corresponding self-tests.

Additional Comments

1. This IG does not address key establishment techniques other than those used for key agreement.
2. The key establishment method(s) used by the cryptographic module **shall** be listed under **AS.07.21**.
3. For Scenario 2, KAS1 may be implemented as either a basic scheme (no key confirmation) or a Party_V-Confirmation scheme. KAS2 may be implemented as either a basic, or a Party_V-Confirmation, or a Party_U-Confirmation or a bilateral-confirmation scheme. The module's Security Policy **shall** state which of the following schemes have been implemented and tested.
4. Scenario 3 requires testing to the **SP 800-56A** primitives. This is why claiming vendor affirmation to **SP 800-56A Rev2** does not apply if the vendor wishes to claim this scenario.
5. The FIPS 140-2 certificate annotation examples for the key agreement schemes can be found in IG G.13.
6. The module **shall** obtain the appropriate assurances, as required in Sections 5.6.2 of **SP 800-56A Rev3** and 6.4 of **SP 800-56Br2**.
7. If a full key agreement scheme is implemented (path (2) in Scenarios 2 and **X1**) and its components are tested separately by the CAVP as shown by the (i) – (ii) – (optionally) (iii) sequence in these scenarios, then the module's certificate will show the **KAS-RSA** or **KAS** entries and reference the applicable tested

components within these entries. The certificate will also list these tested components as individual entries.

8. There is no self-test for the key confirmation functionality.

9. There is no requirement to perform the KATs for both the RSA exponentiation and the CRT methods. Separate KATs are required to test the FFC and ECC methods, if the module supports both: the difference between them is far more substantial than that among the various RSA techniques. No separate KATs are required to test the Diffie-Hellman and the MQV schemes.

10. The IG 9.6 self-test requirements and rules apply only to modules claiming compliance with the original version of **SP 800-56A**.

11. After **June 30, 2022**, every module that implements a full key agreement scheme **shall** use only the approved key derivation functions documented in **SP 800-56C Rev1** or **2** or in IG G.20. Note that all **SP 800-135 Rev1** kdfs and the TLS 1.3 kdf are included in IG G.20.

12. CAVP testing to **SP 800-56A Rev3** and the applicable self-tests per this IG are required for module submissions after **December 31, 2020**. Until this date, vendors who implement **SP 800-56A Rev3** may submit modules claiming vendor affirmation to **SP 800-56A Rev3** per IG D.1-rev3 or Scenario 4 above.

13. The acronym **SSC** stands for "shared secret computation".

D.9 Key Transport Methods

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*07/08/2015*
Last Modified Date:	*10/30/2023*
Transition End Dates	***12/31/2020*** *– See Below* ***12/31/2023*** *– See Below*
Relevant Assertions:	*AS07.21*
Relevant Test Requirements:	*TE07.21.01*
Relevant Vendor Requirements:	*VE07.21.01-02*

Background

Cryptographic modules may implement various key establishment schemes to establish and maintain secure communication links between modules. Key establishment includes the processes by which secret keying material is securely established between two or more entities. Keying material is data that is necessary to establish and maintain a cryptographic keying relationship [1]. These schemes are classified into key agreement schemes and key transport schemes. Key agreement is addressed in IG D.8; this IG addresses key transport.

Key transport is a method of key establishment whereby one party (the sender) selects a value for the secret keying material and then securely distributes that value to another party (the receiver). Key transport can be provided using either symmetric or asymmetric techniques.

Question/Problem

What are the approved and allowed key transport techniques that can be used in an approved mode of operation?

[1] The state existing between two entities when they share at least one cryptographic key.

Resolution

Symmetric and asymmetric algorithms are used to provide confidentiality and integrity protection of the keying material to be transported. Key transport includes some means of key encapsulation or key wrapping for the keying material to be transported. Key transport **shall** be performed using the appropriate key lengths classified as acceptable, deprecated or legacy-use as specified in SP 800-131Arev2.

> **Key Encapsulation** is a class of techniques whereby keying material is encrypted using asymmetric (public key) algorithms; integrity protection is also commonly provided. The amount of keying material is usually limited by the practicality of performing the encryption operation. The key used for key encapsulation is called a key encapsulation key, which is a public key for which the associated private key is known by the receiver.
>
> **Key Wrapping** is a class of techniques whereby keying material is encrypted using symmetric algorithms; integrity protection is also commonly provided. The key used by the key wrapping algorithm to wrap the key to be transported is called a key wrapping key, which is a key that must be known by both the sender and the receiver.

Approved methods for key transport.

- Employing an approved RSA-based key transport scheme, as specified in SP 800-56Br2. The implemented scheme **shall** be tested to **SP 800-56Br2**. A KTS-RSA entry **shall** be added to the module's validation certificate as shown in IG G.13. The Security Policy **shall** document the tested RSA modulus sizes, the method (from **FIPS 186-4**) of RSA key generation, the tested key confirmation (if applicable) and assurances, as defined in Sections 5 and 6 of **SP 800-56Br2**, and whether the encapsulation, un- encapsulation or both methods are supported. If an RSA private key is generated by the module, then the module's validation certificate **shall** include an RSA signature algorithm certificate which would confirm that the RSA prime generation method has been tested. In addition, the Security Policy **shall** indicate the module's support for the KTS-OAEP scheme and, if applicable, document the module's readiness to use the transported key in a hybrid scheme defined in Section 9.3 of **SP 800-56Br2**.

- Employing an RSA-based key-transport scheme that has been vendor-affirmed to the original version of **SP 800-56B** published in 2009.

  After **December 31, 2020**, the newly submitted reports (3SUB and 5SUB submissions) may not use this provision.

  After **December 31, 2023** the use of any mode of the vendor affirmed RSA-based key-transport is *strongly* discouraged (see SP 800-131Ar2). However, modules implementing this provision in the approved mode will *not* result in the module being moved to the Historical list.

- Employing a key wrapping key, shared by the sender and receiver, together with an approved symmetric key-wrapping algorithm to wrap the keying material to be transported. Approved key wrapping algorithms are specified in SP 800-38F. One method is to use the AES in either the KW or KWP mode, or the Triple-DES in the TKW mode. Another is to use a previously approved authenticated symmetric encryption mode, such as, AES GCM, for key wrapping. Yet another approved key-wrapping technique is a "combination" method: use any approved symmetric encryption mode, such as AES ECB, AES CBC, Triple-DES ECB, etc. together with an approved authentication method (for example, HMAC or AES CMAC, or KMAC). The entire wrapped message **shall** be authenticated.

  After **December 31, 2023** the use of any mode of the Triple-DES algorithm for key wrapping is *strongly* discouraged (see SP 800-131Ar2). However, modules implementing Triple-DES encryption in the approved mode will *not* result in the module being moved to the Historical list.

  The symmetric key encryption algorithm, and, if applicable, the authentication algorithm, used for key wrapping **shall** be tested and validated by the CAVP, and the algorithms' certificate numbers **shall** be shown on the module's certificate. If the security strength of the key wrapping algorithm and the wrapping algorithm's key can be lower than that of the (potential) security strength of the wrapped key, then the resulting security strength of the wrapped key is the security strength of the key wrapping key and algorithm, and **shall** be shown on the module's certificate in accordance with IG G.13.

Allowed methods for key transport.

The **SP 800-131Ar2** transition document, published in March 2019, has stipulated that most forms of the non-approved key encapsulation and key wrapping will be disallowed after December 31, 2020. However, based on the actual publication dates of **SP 800-56Br2** and of this Implementation Guidance the transition schedule has been modified.

Each of the following key transport methods is allowed for use in the approved mode.

- Any RSA-based key encapsulation/un- encapsulation algorithm that only uses a PKCS#1-v1.5 padding scheme and an RSA modulus that is at least 2048 bits long. The PKCS#1-v1.5 padding **shall** be performed as shown in Section 8.1 of RFC 2313. The module's Security Policy **shall** state that this padding method is used. The testing laboratory **shall** verify this claim by performing a code review and an analysis of an implementation's logic.
- Any RSA-based key wrapping/unwrapping algorithm that uses an RSA modulus that is at least 2048 bits long. The use of this provision **shall** be explained in the module's Security Policy. An implemented scheme does not have to be compliant with any revision of **SP 800-56B**. The deadline for submitting the 3SUB and 5SUB test reports claiming this allowance is **December 31, 2020**.

  After **December 31, 2023** the use of the provisions in either of the two bullets directly above is *strongly* discouraged (see SP 800-131Ar2). However, modules implementing these provisions in the approved mode will *not* result in the module being moved to the Historical list.
- A key *unwrapping* using any approved mode of AES or two-key or three-key Triple-DES. Key wrapping is not allowed if the algorithm does not meet the requirements of **SP 800-38F**.

The **SP 800-56Br2** Self-Tests:

When claiming compliance with the RSA algorithms used in the key encapsulation and un-encapsulation schemes described in **SP 800-56Br2**, the module is required to perform the known-answer tests (KATs). If an RSA encryption of keys is supported, the module **shall** have an RSA encryption of a vendor-selected message M pre-computed and then, while performing a power-up self-test, the module **shall** perform the RSA encryption again and compare the newly generated result to the pre-computed value. The bit length of the message **shall** be compatible with the bit length of a string encrypted by the RSA.

If an RSA decryption of keys is supported, the module **shall** have a KAT for the RSA decryption by starting with a selected value representing a ciphertext and decrypting this value using the RSA algorithm. The result of said decryption operation is compared to a pre-computed result. If an implementation of the RSA decryption supports both a decryption with the private key in the basic format and a decryption with the private key in the CRT (Chinese Remainder Theorem) format, then only one KAT – verifying the correct implementation of either method - is required. These two decryption methods are documented, correspondingly, in Sections 7.1.2.1 and 7.1.2.3 of **SP 800-56Br2**.

If the module performs only one of the RSA encryption/decryption operations, say, either the wrapping or the unwrapping of a cryptographic key, then only the self-test that is attributable to this operation is required.

While it may appear that the requirements for the RSA exponentiation encryption and decryption (corresponding to the key wrapping and key unwrapping schemes) KATs are identical, they are not. The encryption KAT uses the public key exponent e, while the decryption KAT uses the private key d. The RSA parameters used in a KAT, including the public modulus N, and, as applicable, the message M or the ciphertext c, **shall** have the sizes consistent with those supported by the module. When an exponentiation function is self-tested, the encryption KAT consists of checking the value of $M^e (\mathrm{mod}\ N)$, while the decryption KAT consists of checking the value of $M^d \pmod N$. Therefore, separate KATs are required to self-test the encryption and the decryption operations, if both are implemented.

If an RSA signature generation algorithm and an approved RSA-based key un-encapsulation scheme are both supported by the module using the same implementation (same hardware, same code for the RSA primitive computations) and the module is performing the signature generation power-up self-test then it is not necessary to also perform a power-up self-test for the key un-encapsulation scheme.

Similarly, if the same implementation performs the common functionality for both the RSA signature verification and an approved RSA-based key encapsulation scheme then it is sufficient to perform a power-up self-test just for the signature verification algorithm.

When an RSA key pair is generated, the conditional self-tests of Section 4.9.2 of FIPS 140-2, as further addressed in IG 9.9, **shall** be performed.

Additional Comments

1. This IG does not address key establishment mechanisms other than those used for key transport.
2. The key transport method(s) used by the cryptographic module **shall** be listed under **AS.07.21**.
3. While it may be sufficient, as explained in this Implementation Guidance, to perform only a digital signature self-test and not the key encapsulation/un-encapsulation self-tests, the reverse is not true, and the digital signature algorithm self-tests are always required. The reason is that the self-tests for the RSA-based key transport schemes described in this IG are more limited in scope (they only test the RSA primitives) than the digital signature self-tests.
4. The module's compliance with either the symmetric or the asymmetric key based approved key transport techniques **shall** be annotated on the validation certificate's FIPS approved Cryptographic Algorithms line as KTS or KTS-RSA, respectively, and in the approved cryptographic algorithms list in the Security Policy, with the caveats, as necessary and as shown in IG G.13. Note that the vendor affirmation to the original version of **SP 800-56B** is still annotated as KTS.
5. The use of the allowed methods for key transport **shall** be annotated on the certificate's Allowed Algorithm line as shown in IG G.13, and in the allowed algorithms list in the Security Policy.
6. As the **SP-800-38F**-compliant schemes are comprised of approved algorithms that must be tested and issued validation certificates from the CAVP, no vendor affirmation of this key transport scheme in the module's validation certificate is permitted.
7. For the **SP 800-38F** schemes, it is the tester's responsibility to verify that when using the "combination" method described above, the entire message gets authenticated.
8. The key wrapping used in many industry protocols, such as TLS and SSH, is likely to be compliant with one of the provisions of **SP 800-38F**. If a module implements such a protocol, then the key transport **shall** be documented as a KTS.
9. After **December 31, 2020**, CAVP testing to **SP 800-56Br2** and the applicable self-test requirements per this IG are required for module submissions that claim **SP 800-56Br2** compliance.

D.10 Requirements for Vendor Affirmation of SP 800-56C

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*11/30/2011*
Last Modified Date:	*08/28/2020*

Transition End Date:	***12/31/2020***
Relevant Assertions:	*AS07.11 and AS07.16*
Relevant Test Requirements:	*TE07.11.01-02 and TE07.16.01-02*
Relevant Vendor Requirements:	*VE07.11.01 and VE07.16.01*

Background

SP 800-56C was published November 2011 and added to FIPS 140-2 Annex D on December 20, 2011. This Special Publication provided recommendations for the two-step key derivation through extraction-then-expansion. Its later version, **SP 800-56C Rev1**, was published in April 2019 and added to FIPS 140-2 Annex D on June 10, 2019. In addition to the key derivation functions from **SP 800-56C**, the new version of the standard also includes the one-step key derivation functions previously documented in **SP 800-56A Rev2.**

Until CAVP/ACVP testing for **SP 800-56C Rev1** is available, IG A.3 is applicable.

Question/Problem

1. When is CAVP testing required for compliance to **SP 800-56C Rev1**?
2. To claim *vendor affirmation* to **SP 800-56C Rev1**, what sections of the publication need to be addressed and what are the applicable documentation requirements?
3. Will vendor affirmation to **SP 800-56C** be honored in view of the replacement of that standard with **SP 800-56C Rev1**?
4. Will vendors be able to claim a "standalone" vendor affirmation to **SP 800-56C Rev1**, or can this claim be made only in conjunction with a shared secret computation within a recognized key establishment scheme?

Resolution

Vendors may, through **December 31, 2020**, continue to claim vendor affirmation to **SP 800-56C Rev1**. After this date, all module submissions to the CMVP (2SUB, 3SUB or 5SUB) **shall** include a CAVP tested **SP 800-56C Rev1** certificate if it is utilized in an approved mode of operation.

The entire text of **SP 800-56C Rev1** is applicable, and to claim the affirmation the vendor **shall** comply with all "shall" statements in **SP 800-56C Rev1** that apply to the key derivation functions/methods implemented in the module.

The one-step key derivation process is shown in Section 4.1 of **SP 800-56C Rev1**, while Section 4.2 discusses the use of various auxiliary functions in this process. Note that **SP 800-56C Rev1** allows for the use of the KMAC algorithm defined in **SP 800-185**.

The two-step randomness extraction and key expansion procedure **shall** be performed as shown in Section 5.1 of **SP 800-56C Rev1**. The MAC functions suitable for the desired security strength of the algorithm are shown in Section 5.2.

Vendors will be able to claim the standalone vendor affirmation to **SP 800-56C Rev1**, regardless of the possible use of the affirmed key derivation functions in a key establishment scheme. It is conceivable that the module supports an **SP 800-56C Rev1** key derivation function by applying this function to a shared secret computed by another cryptographic module and passed to the module being validated. The vendor of the latter module may claim an affirmation to **SP 800-56C Rev1** if all applicable requirements have been met.

Vendors may also claim vendor affirmation to **SP 800-56C Rev1** as part of the allowed key agreement scheme, as long as this allowed scheme meets the requirements of IG D.8, Scenario 3 or 4.

Annotation

Refer to IG G.13 for annotation examples.

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation complies with the requirements of **SP 800-56C Rev1** and of the documentation requirements of IG G.13 and this Implementation Guidance. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review.

The tester **shall** verify that the vendor chose an auxiliary function H(x) or a MAC algorithm appropriately for the targeted security strength, as shown in Tables 1, 2, and 3 of **SP 800-56C Rev1** for the auxiliary functions and in Tables 4 and 5 for the MACs.

Additional Comments

1. As stated in the **Background** section of this Implementation Guidance, the key derivation functions documented in **SP 800-56C** are included in **SP 800-56C Rev1**. Hence vendor affirmation to **SP 800-56C** implies vendor affirmation to **SP 800-56C Rev1**. The certificate entries showing vendor affirmation to **SP 800-56C** will not be updated. However, any module *validated* after the date of publication of this Implementation Guidance may only show vendor affirmation to **SP 800-56C Rev1** in its validation certificate.

2. If vendor affirmation is claimed for **SP 800-56C Rev1** then no power-up self-tests is required. For CAVP tested **SP 800-56C Rev1** implementations, self-test requirements, per IG 9.4 (revision to this IG is underway), are required.

D.11 References to the Support of Industry Protocols

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*05/10/2017*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The cryptographic modules may implement various protocols known in the security industry. The examples of such protocols are IKE, TLS, SSH, SRTP, SNMP and TPM, listed in **SP 800-135rev1**. These protocols usually include a complete or partial key establishment scheme and, sometimes, an encrypted session that uses the newly-established key to protect sensitive data.

In the past, the Security Policy may have made references to modules' support of such protocols. The CMVP did not provide guidance to how and under what conditions the protocol references should be documented. Therefore, the supporting claims may be inconsistent from module to module and may not reflect the relevance of these protocols to the algorithms approved for or allowed for use in the FIPS 140-2 approved mode of operations. Nor did these claims reflect the level of the CAVP algorithm testing performed. In some cases, a test was available for a portion of the protocol, such as a key derivation function (KDF). However, the testing was not performed and the module's support for the corresponding protocol in the approved mode would still be claimed. In other cases, the generic description of a protocol contained several distinct key establishment schemes, such as in the TLS v1.1 protocol that could utilize either the RSA key transport (key encapsulation) scheme or the Diffie-Hellman key agreement scheme to establish a secret value known to the two parties in the protocol. By simply claiming the module's protocol support it may not be clear which components are compliant to FIPS 140-2.

Question/Problem

What are the module documentation requirements to show support for the protocols which have their key derivation functions listed in **SP 800-135rev1**?

Resolution

FIPS 140-2 and its Annexes do not address protocols. Only the cryptographic *algorithms* (such as, for example, AES or DSA) and *schemes* (such as the key agreement schemes from **SP 800-56A** or the RSA-based key encapsulation schemes) that are approved and allowed may be used in the approved mode of operations. These algorithms and schemes are referenced in the FIPS 140-2 Annexes.

The protocols' KDFs described in **SP 800-135rev1** are well-defined and are viewed as algorithms, not protocols within the scope of a FIPS 140-2 validation. The CAVP testing for such KDFs is available. The testing laboratories **shall** determine if any of the KDFs implemented in the module are the same those described in **SP 800-135rev1**.

There are four possible implementation and documentation cases as follows:

1. If the module implements a KDF from **SP 800-135rev1** and this KDF has not been validated by the CAVP, then the module's certificate **shall not** list this function. The module's Security Policy **shall** make it clear that the corresponding protocol **shall not** be used in an approved mode of operation. In particular, none of the keys derived using this key derivation function can be used in the approved mode.

2. If the module implements a KDF from **SP 800-135rev1** and this KDF has been validated by the CAVP, then the module's certificate **shall** list the KDF on the FIPS-approved algorithm line as a **CVL** entry. If the module's Security Policy claims that the module supports or uses the corresponding protocol, then the Security Policy **shall** state that no parts of this protocol, other than the KDF, have been tested by the CAVP and CMVP.

3. If the module does not implement any KDFs from **SP 800-135rev1** but the module's Security Policy claims that the module supports or uses parts of the corresponding protocol(s) then no entry on the certificate's approved or allowed algorithms lines is required. As in the case considered above (2), the Security Policy **shall** state that this protocol has not been reviewed or tested by the CAVP and CMVP.

   This situation may occur when a module implements a portion of a protocol, e.g. not including the KDF, and it is the calling application's responsibility to perform the entire protocol.

4. If the module does not implement a KDF from **SP 800-135rev1** and the module's Security Policy makes no claims that the module supports or uses any of the protocols named in **SP 800-135rev1** then the rules explained in this IG do not apply. The module may implement a (non-SP **800-135rev1**) key establishment scheme if it meets the applicable requirements of IG D.8 and IG D.9.

Additional Comments

The use of KDFs described in **NIST SP 800-108** and **NIST SP 800-56C** are out scope for the purposes of this **IG**.

D.12 Requirements for Vendor Affirmation to SP 800-133

Applicable Levels:	*All*
Original Publishing Date:	*08/07/2015*
Effective Date:	*08/07/2015*
Last Modified Date:	*08/12/2020*
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The FIPS 140-2 Implementation Guidance D.2 defines various methods for key establishment within the cryptographic module. These methods include key agreement, key transport, key generation, key entry and key derivation from other keys.

Key generation is a process of securely deriving a cryptographic key from various input sources. These sources **shall** include an output from an approved random number generator located within the physical boundary of the cryptographic module that is deriving the key. In December 2012, NIST published **SP 800-133** that showed how to derive symmetric cryptographic keys and the seeds used when generating private keys for the asymmetric-key algorithms. **SP 800-133** was added to FIPS 140-2 Annex D on February 26, 2014. In July 2019 NIST published **SP 800-133 Revision 1**, followed by **SP 800-133 Revision 2** in June 2020. See Appendix A in **SP 800-133 Revision 2** for the list of differences between the versions of the standard. **SP 800-133 Revision 2** was added to FIPS 140-2 Annex D in August 2020. In this Implementation Guidance below, "**SP 800-133**", with no revision version given, will refer to this revision of this standard.

Question/Problem

To claim the *vendor affirmation* to **SP 800-133**, what sections of the publication need to be addressed?

Resolution

To claim the vendor affirmation to **SP 800-133** the vendor **shall** generate the module's symmetric keys and seeds used for generating the asymmetric keys using methods described in Section 4 of **SP 800-133**. If a key-generating method involves an XOR, as when generating the bit string $B = U \oplus V$ shown in Section 4 of **SP 800-133**, this step and the nature of the parameters U and V **shall** be explained in detail by the vendor.

Note that the four examples in Section 4 of **SP 800-133** are informative, not normative. The vendor may either affirm that the module follows one of these examples, or demonstrate that the module uses a different method to meet the independence requirement for U and V. The requirement that U is an output of an approved Random Number/Bit Generator (updated, possibly, using a qualified post-processing method, as explained below) is normative.

The module may further generate a symmetric key, or a seed used in generating the asymmetric keys as shown in Section 6.3 of **SP 800-133**, provided that

(a) At least one of the component keys $K_1, \ldots, K_n$ is generated as shown in Section 4 of **SP 800-133** with an independence requirement of Section 6.3 met, and

(b) None of the component keys $K_1, \ldots, K_n$ is generated from a password.

The module's test report **shall** explain how the keys $K_1, \ldots, K_n$ are generated, how the values $D_1, \ldots, D_m$ (if used) are obtained, and present the assurances that the applicable Section 6.3 of **SP 800-133** requirements on these parameters are satisfied.

The module may perform a qualified post-processing, explained in IG 7.8, to the output U of an approved DRBG before passing this updated value of U to the key generation process.

Vendor affirmation to **SP 800-133** is required for all methods covered by Sections 4 and 6.3 of this standard; that is, when a symmetric key or a seed for asymmetric key generation is generated starting with a random bit string. The module's validation certificate **shall** have a CKG entry only if the module is generating keys for the symmetric-key algorithms. Only one CKG entry is required for the module's certificate, even if the module employs multiple key-generation methods that must be documented in the certificate. The Security Policy **shall** provide the details of each method.

Module's compliance with the key generation methods shown in sections of **SP 800-133** other than 4 and 6.3 is covered by other standards. If the vendor wishes to claim compliance with sections other than 4 and 6.3 and the CKG entry in the module's certificate is not needed, according to this Implementation Guidance, then the Security Policy (only; not the validation certificate) **shall** claim the vendor affirmation to **SP 800-133** and provide the details for the reader to understand this claim.

Additional Comments

1. If the module directly uses an output U from an approved DRBG or an output from a post-processing algorithm shown in IG 7.8 as a symmetric key or as a seed to be used in the asymmetric key generation, then it is not necessary to explain that this technique is equivalent to XORing of U and V where V is a string of binary zeros. The Security Policy **shall** state how the resulting symmetric key or a seed is generated.
2. Section 6.3 in **SP 800-133 Revision 2** corresponds to Section 6.6 of **SP 800-133 Revision 1**.
3. The method of generating a key by a key-extraction process defined in item 3 of Section 6.3 of **SP 800-133 Revision 2** is new to the **SP 800-133** series. This method is approved for use in the approved mode upon the publication of this Implementation Guidance.

Test Requirements

Code review, vendor documentation review, and mapping of the module's key generation procedures into the methods described in **SP 800-133**.

D.13 Elliptic Curves and the MODP Groups in Support of Industry Protocols

Applicable Levels:	*All*
Original Publishing Date:	*05/10/2017*
Effective Date:	
Last Modified Date:	*12/03/2019*
Relevant Assertions:	*AS07.17*
Relevant Test Requirements:	*TE.07.17.01-02*
Relevant Vendor Requirements:	

Background

Various industry protocols employ key establishment techniques. These techniques commonly use the Diffie-Hellman schemes, utilizing either the Finite Field or the Elliptic Curve cryptography. Over the years, the protocols developed a notation of their own to define the sets of the Diffie-Hellman domain parameters and the specific elliptic curves. This notation is often different from the corresponding terminology used in FIPS 186-4, SP 800-56A and in the FIPS 140-2 Implementation Guidance. This results in difficulties when establishing a module's compliance with the CMVP validation requirements and in understanding the key establishment scheme's encryption strength as expressed in the terminology adopted for the FIPS 140-2 Implementation Guidance.

It is therefore necessary to establish an unambiguous correspondence between the Finite Field Diffie-Hellman domain parameters as defined in SP 800-56A and those documented as the specific Modular Exponential (MODP) Diffie-Hellman groups used in various publications such as the IETF RFCs. Similarly, a mapping has to exist between the NIST Recommended Curves defined in FIPS 186-4 (and referenced in SP 800-56A) and those commonly used in various industry protocols.

Question/Problem

1. What is the relationship of the Diffie-Hellman domain parameters used in SP 800-56A and those defined by the MODP groups?
2. To which NIST recommended curves do the curves used in various industry protocols correspond?

Resolution

The MODP Diffie-Hellman groups used in industry protocols such as the Internet Key Exchange protocol (IKE) employ the so-called "safe" primes; that is, $p = 2q + 1$. Per Appendix D of SP 800-56A, only the safe primes defined in Sections 3-7 of RFC 3526 and in Appendix A of RFC 7919 may be used. The corresponding prime groups are named in RFC 3526 and are shown in Table 1 below. Each group's generator is g=2.

IKE v2 (RFC 3526)
2048-bit MODP group (ID=14)
3072-bit MODP group (ID=15)
4096-bit MODP group (ID=16)
6144-bit MODP group (ID=17)
8192-bit MODP group (ID=18)

Table 1. The MODP groups for industry protocols.

The SSHv2 protocol, as defined in RFC 4253, employs the "diffie-hellman-group14-sha1" key exchange method, which is based on the use of the 2048-bit MODP group.

The elliptic curves used in certain industry standards and the corresponding NIST Recommended Curves are listed in Table 2. Entries in the same row refer to the same elliptic curves under the different names. Absence of the equivalent entries is indicated by '-'.

FIPS 186-4 and **SP 800-56A**	**TLS (RFC 4492, SP 800-52)**	**IKE v2 (RFC 5903)**
P-224	secp224r1	-
P-256	secp256r1	secp256r1
P-384	secp384r1	secp384r1
P-521	secp521r1	secp521r1
K-233	sect233k1	-
K-283	sect283k1	-
K-409	sect409k1	-
K-571	sect571k1	-
B-233	sect233r1	-
B-283	sect283r1	-

B-409	sect409r1	-
B-571	sect571r1	-

Table 2. The correspondence between the elliptic curves defined in different standards

All curves listed in Table 2 may be used either in the approved key agreement schemes (if all other applicable requirements are met) or in the allowed schemes. See IG D.8 for more information.

Additional Comments

1. For the purposes of this Implementation Guidance, an industry protocol is any widely-recognized protocol that might be supported by the cryptographic modules being validated for compliance to FIPS 140-2. The MODP groups and the various elliptic curves shown in this Implementation Guidance as protocol-specific have been defined in the IETF RFC publications.
2. This Implementation Guidance does not discuss the Oakley Groups. The reader may refer to the IETF RFC 2409 for more information.
3. While FIPS 186-4 is a digital signature standard, some of its provisions also apply to the key establishment standards, such as SP 800-56A.
4. The **SP 800-56A** notation in this Implementation Guidance refers to the latest publication of the standard: NIST Special Publication 800-56A Rev3.

Code review, vendor documentation review, and mapping of the module's key generation procedures into the methods described in **SP 800-133**.

D.14 SP 800-56C Rev2 One-Step Key Derivation Function Without a Counter

Applicable Levels:	*All*
Original Publishing Date:	*11/05/2021*
Effective Date:	
Last Modified Date:	
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

NIST Special Publication **800-56C Rev2** Section 4 outlines a one-step key derivation function for use in an approved key establishment scheme. The key derivation function uses a counter to ensure uniqueness while iterating through a loop applying the auxiliary function H to the concatenation of the shared secret Z and the FixedInfo field. This allows the KDF to derive keys longer than the output of the auxiliary function used.

Question/Problem

Is it allowed to drop the counter inclusion in the **SP 800-56CRev2** one-step key derivation function when the implementation restricts the derived key to be no longer than the output of the auxiliary function used?

Resolution

A new approved algorithm definition is provided for this case. This is the no-iteration/no-counter variation of one-step key derivation. Implementations using this algorithm description **shall** proceed as follows:

Function call: KDM(*Z*, *OtherInput*).

Options for the Auxiliary Function H:

The options remain the same from those outlined in Section 4.1 in **SP 800-56C Rev2**.

Implementation-Dependent Parameters:

The implementation-dependent parameters remain the same from those outlined in Section 4.1 in **SP 800-56C Rev2**.

Input:

All the input requirements remain the same from those outlined in Section 4.1 in **SP 800-56C Rev2** outside of one change. The only change to the input parameter requirements is in item 2b in Section 4.1 in **SP 800-56C Rev2**. To meet the requirements of this IG, use the following definition of *L*.

L – A positive integer that indicates the length (in bits) of the secret keying material to be derived; *L* **shall not** exceed *H_outputBits*.

Process:

1. If $L > H\_outputBits$ or $L \leq 0$, output an error indicator and exit this process without performing the remaining actions (i.e., omit steps 2 through 4).
2. If $Z \parallel FixedInfo$ is more than *max_H_inputBits* bits long, then output an error indicator and exit this process without performing any of the remaining actions (i.e., omit steps 3 and 4).

3. Set *DerivedKeyingMaterial* equal to the leftmost L bits of H(Z || *FixedInfo*).
4. Output *DerivedKeyingMaterial*.

Output:

The bit string *DerivedKeyingMaterial* of length L bits (or an error indicator).

Notes:

The notes remain the same from those outlined in Section 4.1 in **SP 800-56C Rev2**.

Additional Comments

1. This solution was provided by the Cryptographic Technologies Group at NIST. It may appear in a future revision of **SP 800-56C**.
2. CAVP testing of the updated algorithm description is available under the algorithm name: "KDA", mode: "OneStepNoCounter", revision: "Sp800-56Cr2".
3. The self-test requirement for the algorithm specified in this IG is the same as those under the KDA bullet in IG 9.4 for the one-step KDF. If the module supports multiple one-step KDAs – one compliant to this IG and the other(s) to **SP 800-56C** – then only one self-test is required if the underlying implementation is the same. The Security Policy **shall** explain how each KDA is used by the module.

Withdrawn Guidance

W.1 Cryptographic Key Strength Modified by an Entropy Estimate

Applicable Levels:	*All*
Original Publishing Date:	*05/02/2012*
Date Withdrawn:	*08/07/2015*
Last Modified Date:	*01/17/2014*
Relevant Assertions:	*AS.07.13*
Relevant Test Requirements:	*TE.07.13.01, TE.07.13.02*
Relevant Vendor Requirements:	

Background

FIPS 140-2 Section 4.7 states that **"***compromising the security of the key generation method (e.g., guessing the seed value to initialize the deterministic RNG)* ***shall*** *require as least as many operations as determining the value of the generated key*.**"** To comply with this requirement **TE.07.13.02** states that "*The tester* ***shall*** *determine the accuracy of any rationale provided by the vendor. The burden of proof is on the vendor; if there is any uncertainty or ambiguity, the tester* ***shall*** *require the vendor to produce additional information as needed.*"

Question/Problem

A module implements AES-256; the module generates an encryption key to be used with the AES-256 algorithm; the only entropy available to the module is a 160 bit RNG seed that is loaded into the module before the module becomes operational. The RNG does not get re-seeded during the key generation. How can this module comply with the key generation requirements of **AS.07.13** when the generated key has insufficient entropy commensurate with the key length?

Resolution

This problem is similar to the key establishment requirements of **AS.07.19**. Legacy key establishment methods would often reduce the encryption strength of the established key. This scenario was addressed by the introduction of a caveat on the module's validation and annotated in the Security Policy that would clearly state the minimum and maximum security strengths of the established keys. With this additional caveat, the module can be validated by the CMVP.

Similar, the requirement of **AS.07.13** can be met by defining the true cryptographic strength of each key established by the module (using one of the key establishment procedures addressed in IG D.2). The strength of each key generated by the module **shall** be documented in the Security Policy and reflected in the testing laboratories test report submission in addition to all other required key characteristics. If **AS.07.13** is not met by all keys generated in the module, the modules validation **shall** include the following text added to any other applicable certificate caveats as a separate sentence:

> The module generates cryptographic keys whose strengths are modified by available entropy

If a key is generated within the module's cryptographic boundary using an approved RNG, the entropy limitation would be the only constraint on the key's encryption strength. If the key is established using a key agreement or a key wrapping algorithm has a strength limitation based on the entropy estimates, then this **shall** be taken into account when documenting the encryption strength of the established key.

For example, if an AES key is established using an EC Diffie-Hellman algorithm and the strength of the EC Diffie-Hellman key establishment is known to be between 112 and 192 bits but the entropy used in the generation of an Elliptic Curve private key does not exceed 160 bits, then the Security Policy and the test report **shall** state that the encryption strength for the AES key is between 112 and 160 bits.

The precise format of how the entropy-limitation-induced strength limitations will be annotated in the Security Policy and the test report is not addressed at this time. However, both the Security Policy and test report **shall** clearly annotate the entropy-limitation-induced strength for each key.

If the amount of entropy estimated is insufficient to support at least 112 bits of security strength, then the associated algorithm and key **shall** not be used in the approved mode of operation.

Test Requirements

The vendor and tester evidence **shall** be provided under **TE.07.13.01** and **TE.07.13.02**.

W.2 Validating the Transition from FIPS 186-2 to FIPS 186-4

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Date Withdrawn:	*01/06/2016*
Last Modified Date:	*01/17/2014*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01-02*
Relevant Vendor Requirements:	*VE.01.12.01-02*

Background

FIPS 186-3, *Digital Signature Standard*, was approved in June, 2009 to replace **FIPS 186-2**. **FIPS 186-3** was updated with some minor modifications and was replaced, in July, 2013 with **FIPS 186-4**. This IG outlines the details of a transition from **FIPS 186-2** to **FIPS 186-4**.

FIPS 186-2 specified the Digital Signature Algorithm (DSA) for the generation and verification of digital signatures, and adopted ANSI X9.31 for the generation and verification of digital signatures using the RSA algorithm, and ANSI X9.62 for the generation and verification of digital signatures using the Elliptic Curve Digital Signature Algorithm (ECDSA). Two additional techniques for the generation and verification of digital signatures using RSA were approved in FIPS 140-2, Annex A: RSASSA-PKCS1-v1_5 and RSASSA-PSS; both are specified in Public Key Cryptography Standard (PKCS) #1, version 2.1, RSA Cryptography Standard.

FIPS 186-4 includes the DSA specification from **FIPS 186-2**, and adopts the RSA techniques specified in ANSI X9.31 and PKCS #1 (i.e., RSASSA-PKCS1-v1.5 and RSASSA-PSS) and ECDSA as specified in ANSI X9.62. **FIPS 186-4** also increases the key lengths allowed for DSA, provides additional requirements for the use of RSA and ECDSA, and includes requirements for obtaining the assurances necessary for valid digital signatures and new methods for generating key pairs and domain parameters (see SP 800-89). While **FIPS 186-2** contained specifications for random number generators (RNGs), **FIPS 186-4** does not include such specifications, but requires the use of an approved random bit generator, such as one specified in SP 800-90A, for obtaining random bits.

Question/Problem

Transitioning from the validation of implementations of **FIPS 186-2** to the validation of implementations on **FIPS 186-4** is complicated by a planned transition to the use of key lengths for digital signature generation that provide higher security strengths. The transition schedule is provided in SP 800-131A. IG G.14 addresses the validation and revalidation issues associated with this transition, as well as the status of the validation of already-validated implementations.

This IG contains the transition rules specific to the validation to the **FIPS 186-2** and **FIPS 186-4** standards. These transition rules apply to both the cryptographic algorithm validations and the cryptographic module validations that are conducted by the CAVP and CMVP, respectively.

Resolution

1. **CAVP Validation Testing**

Cryptographic algorithm and key lengths that are categorized as acceptable, deprecated, restricted or legacy-use in **SP 800-131A shall** be validated for Federal government use.

The CAVP is currently testing the following digital signature-specific functions for FIPS186-4; the validation of auxiliary functions (e.g., hash functions and RNGs) is discussed in IG G.14, with reference to **SP 800-131A**.

- DSA: domain parameter generation and validation, key pair generation, public key validation, and digital signature generation and validation.
- ECDSA: key pair generation, public key validation, and digital signature generation and verification; only the NIST-recommended curves are used as domain parameters for testing ECDSA.
- RSA: key pair generation, public key validation, and digital signature generation and verification; RSA has no domain parameters.

For **FIPS 186-2**, the set of current CAVP tests is different:

- DSA: domain parameter validation, public key validation and digital signature verification.
- ECDSA: public key validation and digital signature verification; only the NIST-recommended curves are used as domain parameters for testing ECDSA.
- RSA: public key validation and digital signature verification; RSA has no domain parameters.

The parameter sets that can be tested for DSA, ECDSA and RSA are presented in Table 1 below, along with an indication of the applicable standard (**FIPS 186-2** or **FIPS 186-4**). For DSA, the key length is commonly considered to be the value of L. For ECDSA, the key length is considered to be the bit length of n. For RSA, the key length is considered to be nlen, which is the bit length of the modulus n. Note that the following testable parameter sets are subject to the transitions provided in **SP 800-131A**:

- DSA: L = 1024, N = 160,
- ECDSA: the B-163, K-163 and P-192 elliptic curves
- RSA: nlen = 1024 and 1536.

Also note that in **FIPS 186-4**, e = 3 and 17, and nlen ≠ 1024, 2048 or 3072 are not specified, so these values will not be tested during **FIPS 186-4** validation. The value of nlen = 1024 will be tested for public key validation and signature verification purposes only.

See **FIPS 186-4** for the precise meanings of L, N, nlen and e for the specific digital signature algorithm.

Table 1. CAVP-testable parameter sets for DSA, ECDSA and RSA

DSA (L, N)	**ECDSA**	**RSA**	
		Modulus length ($nlen$)	**Public exponent value** (e)
L = 1024, N = 160		$nlen$ = 1024	FIPS 186-2:

Both FIPS 186-2 and FIPS 186-4	All NIST-recommended curves	Both FIPS 186-2 and FIPS 186-4	$e = 3, 17, 2^{16} + 1$
$L = 2048, N = 224$ FIPS 186-4 only		$nlen = 1536$ FIPS 186-2 only	FIPS 186-4: $2^{16}+1 \leq e < 2^{256}$, where e is odd
$L = 2048, N = 256$ FIPS 186-4 only		$nlen = 2048$ Both FIPS 186-2 and FIPS 186-4	
$L = 3072, N = 256$ FIPS 186-4 only	Both FIPS 186-2 and FIPS 186-4	$nlen = 3072$ Both FIPS 186-2 and FIPS 186-4	
		$nlen = 4096$ FIPS 186-2 only	

2. **FIPS 186-2 to FIPS 186-4 Validation Transition Rules**

The validation transition rules are as follows:

1. Conformance to **FIPS 186-4**:

   a. Cryptographic algorithm and module implementations may be tested by the CST labs for conformance to **FIPS 186-4** (or parts of **FIPS 186-4**) and submitted for validation. An example of an algorithm or module implementation that conforms to only part of **FIPS 186-4** might be an implementation that performs key pair generation, but does not perform domain parameter generation or validation, or an implementation that performs signature verification, but not signature generation.

   CAVP: The CAVP will accept from the CST labs test results of cryptographic algorithm implementations of **FIPS 186-4** (or parts of **FIPS 186-4**) that contain testable parameter sets, with key lengths that are categorized as either acceptable, deprecated or legacy-use as specified in **SP 800-131A**. The testable parameter sets are listed in Table 1 above. Only implementations of those testable parameter sets whose key lengths are classified as either acceptable or deprecated in **SP 800-131A** may be validated for domain parameter generation, key pair generation and digital signature generation. Implementations of domain parameter validation, public key validation and digital signature verification may be validated at any testable key length. Further information about the validation of implementations containing key lengths categorized as deprecated or legacy-use is provided in IG G.14.

   CMVP: The CMVP will accept from the CST labs test reports of cryptographic modules containing implementations of **FIPS 186-4** (or parts of **FIPS 186-4**) for which the cryptographic algorithms and testable parameter sets have been validated by the CAVP. Further information about the validation and revalidation of modules containing key lengths categorized as deprecated or legacy-use is provided in IG G.14.

2. Conformance to **FIPS 186-2**:

   a. After **December 31, 2013,** implementations of domain parameter generation, key pair generation and digital signature generation as specified in **FIPS 186-2** are *no longer validated* by the CAVP or CMVP. Already-validated implementations remain valid, subject to the key length usage restrictions specified as disallowed in **SP 800-131A**.

As time and resources permit, the following actions will be taken by the CAVP or CMVP for already-validated implementations of these functions:

CAVP: Algorithm validation listings for already-validated implementations that contain one or more testable key lengths permitted by **FIPS 186-2** that are disallowed will be annotated to indicate the key lengths that are disallowed. If an already-validated implementation only supports testable key lengths permitted by **FIPS 186-2** that are disallowed, the algorithm validation will be revoked. Complete validations and parts of validations using testable key lengths that are categorized as acceptable will remain valid.

CMVP: For already-validated modules:

- If an algorithm validation listing has been annotated to disallow some, but not all, of the testable key lengths (i.e., only part of a validation is disallowed), the module's CMVP validation certificate will not be changed.

- If an algorithm validation is revoked by the CAVP, the module's CMVP validation certificate will be updated to remove the algorithm's listing from the "FIPS-approved algorithms" line of the certificate and placed on the "Other algorithms" line.

- For further information about the CMVP validation of a module containing transitioning algorithms and key lengths, see IG G.14.

b. Cryptographic algorithm and module implementations that perform domain parameter validation, public key validation and digital signature verification may be tested by the CST labs for conformance to **FIPS 186-2** (or parts of **FIPS 186-2**) and submitted for validation, subject to the following conditions.

CAVP: The CAVP will accept test results from the CST labs of cryptographic algorithm implementations of **FIPS 186-2** (or parts of **FIPS 186-2**) that contain testable key lengths permitted by **FIPS 186-2** that are categorized as either acceptable or legacy-use as specified in **SP 800-131A**.

CMVP: New modules (3SUB and 5SUB submissions) and already-validated modules containing digital signature processes conforming to **FIPS 186-2** that have algorithm validations issued by the CAVP may be validated or revalidated, as appropriate.

W.3 CAVP Requirements for Vendor Affirmation of SP 800-90

Applicable Levels:	*All*
Original Publishing Date:	*06/21/2007*
Effective Date:	*06/21/2007*
Transition End Date:	***02/15/2008***
Last Modified Date:	*06/21/2007*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-90 was added to FIPS 140-2 Annex C on January 24, 2007. FIPS 140-2 Implementation Guidance, IG A.3, was added January 25, 2007. Until CAVP testing for **SP 800-90** is available, IG A.3 is applicable. **SP 800-90** includes information beyond the specifications of the deterministic random bit generation (DRBG) algorithms themselves, e.g., stricter entropy requirements, and assurance.

Question/Problem

To claim *vendor affirmation* to **SP 800-90**, what sections of the publication need to be addressed?

Resolution

To claim *vendor affirmation*, the vendor **shall** affirm compliance with the following three sections of **SP 800-90**, *Recommendation for Random Number Generation Using Deterministic Random Bit Generators*:

Section 9	DRBG Mechanism Functions
Section 10	DRBG Algorithm Specifications
Section 11	Assurance

The vendor is not required to meet the requirements in Section 8, including the entropy requirements in Section 8.6. Entropy requirements are addressed in **AS.07.13**.

Additional Comments

The requirements of **SP 800-90** depend on several NIST approved security functions, for example, SHA, AES, and three-key Triple-DES. The validation testing for these supporting security functions is found in their corresponding validation test suites and, therefore, they **shall** be validated as a prerequisite to **SP 800-90** vendor affirmation.

To claim vendor affirmation to **SP 800-90**, the following supporting security functions, if used, **shall** be tested and validated:

- Supported hash algorithms (SHA224, SHA256, SHA384, and/or SHA512)
- Supported Message Authentication Code (MAC) algorithm (HMAC)
- Advanced Encryption Standard (AES)
- Three key Triple-DES

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

W.4 Use of other Core Symmetric Algorithms in ANSI X9.31 RNG

Applicable Levels:	*All*
Original Publishing Date:	*01/21/2005*
Effective Date:	*01/21/2005*
Last Modified Date:	*01/21/2005*
Relevant Assertions:	*AS.07.10*
Relevant Test Requirements:	*TE07.10.01*
Relevant Vendor Requirements:	*VE.07.10.01*

Background

ANSI X9.31 Appendix A.2.4 specifies 2-key Triple-DES as the core symmetric algorithm in its deterministic random number generator.

Question/Problem

Is it acceptable to use other FIPS approved symmetric algorithms as the ANSI X9.31 Appendix A.2.4 RNG core algorithm?

Resolution

In addition to 2-key Triple-DES, it is acceptable to use the following FIPS approved symmetric algorithms as the ANSI X9.31 RNG core algorithm:

- AES
- 3-key Triple-DES
- SKIPJACK

CAVS testing is available for the 2-key Triple-DES, 3-key Triple-DES and AES. Until CAVS testing is available for RNG testing using SKIPJACK, for module testing purposes, the core cryptographic algorithm SKIPJACK **shall** be validated and the RNG implementation will be marked as "vendor affirmed".

Additional Comments

FIPS 140-2 Annex C has been updated to include reference to the NIST RNG specification for implementing 3-key Triple-DES and AES with ANSI X9.31 Appendix A.2.4.

W.5 RNGs: Seeds, Seed Keys and Date/Time Vectors

Applicable Levels:	*All*
Original Publishing Date:	*11/16/2007*
Date Withdrawn:	*05/10/2016*
Last Modified Date:	*11/16/2007*
Relevant Assertions:	*AS.07.09*
Relevant Test Requirements:	*TE07.09.01*
Relevant Vendor Requirements:	*VE.07.09.01*

Background

An RNG may employ a seed and seed key and a Date/Time vector for its operation. FIPS 140-1 IG 8.7 provides a basis for the requirements related to the ANSI X9.31 RNG **seed**, **seed key** and Date/Time vector. The document titled *NIST Recommended Random Number Generator based on ANSI X9.31 Appendix A.2.4 using the 3-Key Triple DES and AES Algorithms* allows for the use of Triple-DES and AES.

Question/Problem

1. In the case where an RNG employs a **seed** and **seed key**, how does **AS.07.09** apply?
2. In the case where an RNG employs a Date/Time vector, what, if any, additional attributes apply?

Resolution

1. **AS.07.09** specifies that the seed and seed key **shall** not have the same value.

   During initialization of the **seed** or **seed key**, the initialization data provided for one, **shall** not be provided as initialization data to the other. The **seed** or **seed key** or both may be re-initialized prior to each call for a random data value.

2. The Date/Time vector **shall** be updated on each iteration or call to the RNG. In lieu of a Date/Time vector, an incrementer may be used. The Date/Time vector or incrementer **shall** be a non-repeating value during each instance of the module's power-on state.

Additional Comments

ANSI X9.31 specifies that the **seed** **shall** also be kept secret. As such, the **seed** is considered a CSP and **shall** meet all the requirements pertaining to CSPs.

AS.07.14 and **AS.07.23** are applicable to the **seed key**.

The seed key is sometimes referred as the RNG key; the key used by the underlining encryption algorithm(s) implemented by the RNG.

W.6 Definition of an NDRNG

Applicable Levels:	*All*
Original Publishing Date:	*05/02/2012*
Date Withdrawn:	*05/10/2016*
Last Modified Date:	*05/02/2012*
Relevant Assertions:	*AS.07.0, AS.07.07 and AS.07.10*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

FIPS 140-2 defines a random number generator as follows: *Random Number Generators (RNGs) used for cryptographic applications typically produce a sequence of zero and one bits that may be combined into sub-sequences or blocks of random numbers. There are two basic classes: deterministic and nondeterministic. A deterministic RNG consists of an algorithm that produces a sequence of bits from an initial value called a seed. A nondeterministic RNG produces output that is dependent on some unpredictable physical source that is outside human control.*

AS.07.07: (Levels 1, 2, 3, and 4) Nondeterministic RNGs shall comply with all applicable RNG requirements of this standard.

AS.07.10: (Levels 1, 2, 3, and 4) Documentation shall specify each RNG (Approved and non-Approved) employed by a cryptographic module.

SP 800-90A addresses deterministic RBGs and nondeterministic RBG definitions. ***Draft* SP 800-90B** addresses entropy testing.

Approved RNGs are referenced in FIPS 140-2 Annex C. At the time of this IGs publishing, the only approved RNGs referenced are deterministic. Non-approved nondeterministic RNGs (NDRNG) implemented in a cryptographic module may take various forms or implementations. The followings are examples:

- ring oscillator;
- noisy diode;
- transistor thermal noise;
- gathering or sampling of different nondeterministic machine states;
- gathering or sampling of different nondeterministic user actions (e.g. mouse movements, etc.);
- function calls to operating system provided services (e.g., /dev/rand); etc.

A NDRNG may collect entropy from one or many sources (e.g. sampling from a single physical noise source or from many sources such as the time between various operator actions and the time of day, etc.) and the number of random bits collected may be different each time.

Question/Problem

What defines a nondeterministic RNG (NDRNG) and what are the requirements that apply to it?

Resolution

Any hardware, firmware or software construct that collects or samples bits from single or multiple sources within the modules defined boundary and converts this collection into a single random stream of bits to be used as a seed input for an approved RNG or as random input bits for other processes **shall** be defined as a NDRNG within the scope of FIPS 140-2.

All the requirements of FIPS 140-2 Section 4.7.1; the self-test requirements specified in FIPS 140-2 Section 4.9; and the conditional Continuous Random Number Generator Test (CRNGT) addressed in IG 9.8 **shall** apply to an NDRNG implemented in a module. The NDRNG **shall** be identified in the security policy and fully described in the test report. The description **shall** include all entropy sources and applicable smoothing function.

W.7 CAVP Requirements for Vendor Affirmation of SP 800-38D

Applicable Levels:	*All*
Original Publishing Date:	*12/18/2007*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***03/24/2009***
Last Modified Date:	*12/18/2007*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-38D was added to FIPS 140-2 Annex A on December 18, 2007. IG A.3 was added January 25, 2007. Until CAVP testing for **SP 800-38D** is available, IG A.3 is applicable. **SP 800-38D** includes information beyond the specifications of the Galois/Counter Mode itself; i.e., uniqueness requirements on IVs and keys.

Question/Problem

To claim *vendor affirmation* to **SP 800-38D**, what sections of the standard need to be addressed?

Resolution

Validation testing for **SP 800-38D**, *Recommendation for Block Cipher Modes of Operation: Galois/Counter Mode (GCM) and GMAC* includes validation testing for the authenticated encryption function and the authenticated decryption function. To claim *vendor affirmation* to **SP 800-38D**, information contained in the following sections that are supported by the implementation under test (IUT) **shall** be implemented:

Section 5	Elements of GCM
Section 6	Mathematical Components of GCM
Section 7	GCM Specifications

Additional Comments

1. The GCM functions in **SP 800-38D** require the forward direction of an approved symmetric key block cipher with a block size of 128 bits. Currently, the only NIST-approved 128-bit block cipher is the Advanced Encryption Standard (AES) algorithm specified in Federal Information Processing Standard (FIPS) Pub. 197. The validation testing for the forward direction of this supporting algorithm, the AES Cipher (Encrypt) function, is found in its corresponding validation test suite and, therefore, **shall** be validated as a prerequisite to **SP 800-38D** vendor affirmation.
2. The **SP800-38D** Self Tests required in cryptographic module implementations **shall** consist of a known answer that validates the correctness of the GCM elements, GCM mathematical components and GCM specifications of the two GCM functions, namely, the authenticated encryption function and the authenticated decryption function.
3. Section 8, *Uniqueness Requirement on IVs and Keys*, and Section 9, *Practical Considerations for Validating Implementations*, contain requirements for module validation, which is conducted by the CMVP. Therefore, Section 8 and Section 9 are outside of the scope of algorithm validation.

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

W.8 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard

Applicable Levels:	*All*
Original Publishing Date:	*07/07/2009*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***10/02/2009*** *– See Below*
Transition End Date:	***06/30/2010*** *– See Below*
Transition End Date:	***08/27/2010*** *– See Below*
Transition End Date:	***06/03/2011*** *– See Below*
Last Modified Date:	*04/09/2010*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Transition

The Transition End Date for those elements of **FIPS 186-3** DSA which CAVP testing is currently available [if not supporting the generation and validation of provably prime domain parameters p and q and canonical generation and validation of domain parameter g] is: **October 02, 2009**.

With the March 31, 2010 CAVP release of CAVS 9.0, testing for all elements of **FIPS 186-3** DSA are available. For the new and final set of elements, the transition end date is: **June 30, 2010**

With the May 27, 2010 CAVP release of CAVS 10.0, testing for all elements of **FIPS 186-3** ECDSA are available. The transition end date is: **August 27, 2010**

With the March 03, 2011 CAVP release of CAVS 11.0, testing for all elements of **FIPS 186-3** RSA are available. The transition end date is: **June 03, 2011**

The transition plan for migration to **FIPS 186-3** is found in IG G.15.

Background

Federal Information Processing Standard (FIPS) 186-3, *Digital Signature Standard (DSS)* was added to FIPS 140-2 Annex A on June 18, 2009. **FIPS 186-3** specifies a suite of algorithms that can be used to generate a digital signature. These include the DSA, ECDSA, and RSA algorithms. CAVP testing is currently available for DSA as specified in **FIPS 186-3**, with the exception of generation and validation of provably prime domain parameters p and q and canonical generation and validation of domain parameter g. CAVP testing is not available for ECDSA and RSA. Until CAVP testing for **FIPS 186-3** is available for the above elements of DSA and for ECDSA and RSA algorithms, this IG is applicable.

Question/Problem

To claim *vendor affirmation* to the above listed domain parameter generation and validation methods of DSA, ECDSA, and RSA as specified in **FIPS 186-3**, what sections of the publication needs to be addressed?

Resolution

Validation testing for **FIPS 186-3**, *Digital Signature Standard (DSS)* is separated into the three digital signature algorithms. Validation testing is available for **FIPS 186-3** DSA, with the exception of the domain parameter generation and validation method listed above. These methods, along with **FIPS 186-3** ECDSA and RSA, will require *vendor affirmation* until validation testing is available in the CAVS tool.

Vendor Affirmation for FIPS 186-3 DSA Domain Parameter Generation and Validation for provable primes p and q and verifiable canonical generation of the generator g

To claim vendor affirmation for **FIPS 186-3** DSA generation of provably primes *p* and *q*:

1. The vendor must affirm that the method of **FIPS 186-3** A.1.2.1.2 is used to generate provable primes *p* and *q*.

2. 2. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this DSA implementation and report the validation number.

To claim vendor affirmation for **FIPS 186-3** DSA verifiable canonical generation of the generator *g*:

1. The vendor must affirm that the method of **FIPS 186-3** A.2.3 is used for verifiable canonical generation of the generator *g*.

2. 2. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this DSA implementation and report the validation number.

To claim vendor affirmation for **FIPS 186-3** DSA validation of provable primes *p* and *q*:

1. The vendor must affirm that the method of **FIPS 186-3** A.1.2.2 is used for validation of provable primes *p* and *q*.

2. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this DSA implementation and report the validation number.

To claim vendor affirmation for **FIPS 186-2** DSA validation when the canonical generation of the generator *g* was used:

1. The vendor must affirm that the method of **FIPS 186-3** A.2.4 is used for validation of *g* where the verifiable canonical generation of *g* was used.

2. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this DSA implementation and report the validation number.

Vendor Affirmation for FIPS 186-3 ECDSA

To claim vendor affirmation for **FIPS 186-3** ECDSA, the following **shall** be affirmed:

1. For all ECDSA implementations, the assurances listed in **FIPS 186-3**, Section 3 and 3.1 **shall** be defined. If Signature Validation is implemented, Section 3.3 Assurances are also required.

2. If Key Pair Generation is implemented:

    a. The vendor **shall** affirm that at least one of the methods in **FIPS 186-3** Appendix B.4 is used to generate d and Q, the private and public keys.

    b. The implementation must support at least one of the NIST curves in **FIPS 186-3** Appendix D.1.

    c. The vendor **shall** use the CAVP to validate the underlying RNG or DRBG implementation used by this ECDSA implementation and report the validation number.

3. If Public Key Validation (PKV) is implemented:

    a. The vendor must run the **FIPS 186-2** ECDSA PKV tests and report the validation number.

4. If Signature Generation is implemented:

    a. The vendor **shall** affirm compliance with **FIPS 186-3** Section 6.4.

    b. The vendor **shall** affirm compliance with **FIPS 186-3** Appendix B.5 for generation of the Per-message secret number.

    c. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this ECDSA implementation and report the validation number.

5. If Signature Validation is implemented:

    a. The vendor **shall** affirm compliance with **FIPS 186-3** Section 6.4.

    b. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this ECDSA implementation and report the validation number.

Vendor Affirmation for FIPS 186-3 RSA

To claim vendor affirmation for **FIPS 186-3** RSA, the following **shall** be affirmed:

1. For all RSA implementations, the assurances listed in Section 3 **shall** be defined.

2. If Key Pair Generation is implemented:

    a. The vendor **shall** affirm that at least one of the methods in **FIPS 186-3** Appendix B.3 is used to generate the key pairs.

    b. The vendor **shall** affirm that at least one of the modulus lengths 1024, 2048 or 3072 bits is supported by the implementation. Note, the length of the modulus is dependent on the generation method selected. See **FIPS 186-3** Appendix B.3.1.

    c. The vendor **shall** affirm that the public exponent e **shall** be selected with the following constraints:

        i. The public verification exponent e **shall** be selected prior to generating the primes p and q, and the private signature exponent d.

        ii. The exponent e **shall** be an odd positive integer such that $2^{16} < e < 2^{256}$.

    d. The vendor **shall** use the CAVP to validate the underlying SHA implementation used by this RSA Key Pair Generation implementation and report the validation number.

    e. The vendor **shall** affirm that the length in bits of the hash function output block **shall** meet or exceed the security strength associated with the bit length of the modulus *n* (see **SP 800-57**).

    f. If the RSA parameters are randomly generated (i.e., the primes *p* and *q*, and optionally, the public key exponent *e*), the vendor **shall** use the CAVP to validate the underlying RNG or DRBG implementation used by this RSA implementation and report the validation number.

3. If ANSI X9.31 RSA Signature Generation or Signature Verification is implemented:

    a. The vendor must run the ANSI X9.31 RSA validation tests and report the validation number. (Note that the specification in **FIPS 186-3** Section 5.4 concerning the extraction of the hash value *H(M)'* from the data structure *IR'* is tested in the ANS X9.31 RSA validation testing supplied by the CAVP.)

b. The vendor **shall** affirm that at least one of the modulus lengths 1024, 2048 or 3072 bits is supported by the implementation.

c. The vendor **shall** use the CAVP to validate the underlying RNG or DRBG implementation used by this RSA implementation and report the validation number.

4. If PKCS #1 Version 1.5 and/or PKCS #1 Version PSS is implemented:

a. The vendor **shall** confirm that implementations that generate RSA key pairs use the criteria and methods in **FIPS 186-3** Appendix B.3 to generate those key pairs.

b. The vendor **shall** use the CAVP to validate the underlying approved SHA implementation used by this implementation and report the validation number.

c. The vendor **shall** confirm that only two prime factors p and q **shall** be used to form the modulus n.

d. The vendor **shall** use the CAVP to validate the underlying RNG or DRBG implementation used by this RSA implementation and report the validation number.

e. If PKCS #1 Version 1.5 is implemented, the vendor must run the PKCS1.5 validation tests for Signature Generation and/or Signature Verification and report the validation number.

f. If PKCS#1 Version PSS is implemented, the vendor must run the PKCSPSS validation tests for Signature Generation and/or Signature Verification and report the validation number.

g. If PKCS#1 Version PSS is implemented, the vendor **shall** confirm that the implementation's salt length (*sLen*) satisfies $0 <= sLen <= hlen$, where *hlen* is the length of the hash function output block.

Annotation

Refer to IG G.13 for annotation examples.

FIPS 140-2 Section 4.9 Self-Tests

In addition to the above requirements, all algorithmic implementations **shall** meet all the applicable self-test requirements in FIPS 140-2 Section 4.9.

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

W.9 CAVP Requirements for Vendor Affirmation of NIST SP 800-38E

Applicable Levels:	*All*
Original Publishing Date:	*01/27/2010*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***06/30/2010***
Last Modified Date:	*04/09/2010*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

SP 800-38E, *Recommendation for Block Cipher Modes of Operation: The XTS-AES Mode for Confidentiality on Block-Oriented Storage Devices*, was added to FIPS 140-2 Annex A on January 27, 2010. Until CAVP testing for **SP 800-38E** is available, this IG is applicable. **SP 800-38E** approves the XTS-AES mode as specified in the Institute of Electrical and Electronics Engineers, Inc (IEEE) Std. 1619-2007, subject to one additional requirement on the lengths of the data units. That is, the data unit for any instance of an implementation of XTS-AES **shall not** exceed 2^{20} blocks.

Question/Problem

To claim vendor affirmation to **SP 800-38E**; what sections of the IEEE standard and the NIST Special Publication need to be addressed?

Resolution

To claim vendor affirmation to **SP 800-38E**, the information contained in the following sections that are supported by the Implementation Under Test (IUT) **shall** be implemented:

SP 800-38E	Section 4	Conformance
IEEE Std. 1619-2007	Section 5	XTS-AES transform

The following information **shall** be specified:

1. The underlying AES implementation **shall** be validated by the CAVP:

   a. For XTS-AES Encrypt: the validation referenced **shall** include an AES mode of operation that uses the forward cipher function.

   b. For XTS-AES Decrypt: the validation referenced **shall** include an AES mode of operation that uses the forward and inverse cipher function (i.e., AES ECB or AES CBC).

2. The XTS-AES key sizes supported: XTS-AES-128 (256 bits) AND/OR XTS-AES-256 (512 bits).

3. The block sizes supported: complete blocks only OR complete and partial blocks

4. Procedures supported: XTS-AES encryption AND/OR XTS-AES decryption

5. Provide assurance that the length of the data unit for any instance of an implementation of XTS-AES **shall** not exceed 2^{20} blocks.

6. Provide assurance that the XTS-AES key **shall** not be associated with more than one key scope.

Additional Comments

Bullets 5 and 6 above satisfy the **shall** statements included in **SP 800-38E** and IEEE Std 1619-2007 that are not testable by the CAVP.

Upon the following successful review, the CST Lab **shall** affirm by annotating the FIPS approved algorithm entry as follows:

AES (XTS-AES: AES Cert. #nnn, vendor affirmed)

When CAVP CAVS testing is available, the annotation will simply change to:

AES (Cert. #nnn)

Derived Test Requirements

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

W.10 CAVP Requirements for Vendor Affirmation of SP 800-56A

Applicable Levels:	*All*
Original Publishing Date:	*06/21/2007*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***03/24/2009*** *– See Below*
Transition End Date:	***07/12/2011*** *– See Below*
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Transition

With the December 24, 2008 CAVP release of CAVS 7.0, the Transition End Date for the *vendor affirmation* to one of the complete key agreement schemes from **SP 800-56A** was: **March 24, 2009**.

With the April 12, 2011 CAVP release of CAVS 11.1, testing for the **SP 800-56A** primitives have become available. As of **July 12, 2011**, all new module submissions to the CMVP that claim to implement the **SP 800-56A** primitives **shall** be tested by the CAVP (Per IG G.13 will be represented as a **CVL** validation).

Background

SP 800-56A was added to FIPS 140-2 Annex D on January 24, 2007. FIPS 140-2 Implementation Guidance, IG A.3, was added January 25, 2007. Until CAVP testing for **SP 800-56A** is available, IG A.3 is applicable. **SP 800-56A** includes information beyond the specifications of the key agreement algorithm itself; i.e. Instructions to the implementer to aid in the implementation of the algorithm.

Question/Problem

To claim *vendor affirmation* to **SP 800-56A**, what sections of the publication need to be addressed?

Resolution

Validation testing for **SP 800-56A**, *Recommendation for Pair-Wise Key Establishment Schemes Using Discrete Logarithm Cryptography* includes validation testing for the key agreement schemes and key confirmation. To claim *vendor affirmation* to **SP 800-56A**, information contained in the following sections that are supported by the implementation under test (IUT) **shall** be implemented:

Section 5.6.2.4	FFC Full Public Key Validation Routine (if implement FFC)
Section 5.6.2.5	ECC Full Public Key Validation Routine (if implement ECC)
Section 5.7	DLC Primitives
Section 5.8	Key Derivation Functions for Key Agreement Schemes
Section 6	Key Agreement

If key confirmation is supported by the implementation, the applicable information contained in the following section must be implemented:

Section 8	Key Confirmation

Additional Comments

1. The components in **SP 800-56A shall** only be used within the **SP 800-56A** protocol. This includes the full public key validation routines, the DLC primitives, the key derivation functions, the key agreement functions, and the key confirmation functions.

2. The requirements specified in **SP 800-56A** depend on several NIST approved security functions, for example, SHA, DSA, ECDSA, etc. While validation testing for **SP 800-56A** concentrates on the key agreement and key confirmation components, other supporting security functions are not thoroughly tested by the testing in **SP 800-56A**. The validation testing for these supporting security functions are found in the validation test suite for this specific function. Therefore, these supporting security functions **shall** be validated as a prerequisite to **SP 800-56A** vendor affirmation.

   To claim vendor affirmation to **SP 800-56A**, the underlying security functions used by this IUT **shall** be tested and validated prior to claiming vendor affirmation. These include:

   - Supported hash algorithms (SHA1, SHA224, SHA256, SHA384, and/or SHA512)
   - Supported Message Authentication Code (MAC) algorithms (CMAC, CCM, and/or HMAC)
   - Supported Random Number Generators (RNG)
   - If Finite Field Cryptography (FFC) is supported,
     - If the IUT generates domain parameters the DSA PQG generation and/or verification tests.
     - If the IUT generates key pairs, the DSA key pair generation tests.
   - If Elliptic Curve Cryptography (ECC) is supported,
     - If the IUT generates key pairs, the ECDSA key pair generation test and/or the Public Key Validation (PKV) test.

3. **SP 800-56A** self-tests required in cryptographic module implementations must consist of a known answer test that validates the correctness of the implemented DLC primitives and key derivation functions for each key agreement scheme implemented.

Annotation

Refer to IG G.13 for annotation examples.

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation implements the sections outlined above completely and accurately. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review. The tester **shall** verify the rationale provided by the vendor.

W.11 Requirements for Vendor Affirmation of SP 800-108

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***06/23/2012***
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	*TE07.11.01-02 and TE07.16.01-02*
Relevant Vendor Requirements:	*VE.07.11.01 and VE.07.16.01*

Background

SP 800-108 was published October 2009 and added to FIPS 140-2 Annex D on January 04, 2011. Until CAVP testing for **SP 800-108** is available, IG A.3 is applicable. This Special Publication defines the methods for deriving additional keying material from the already-established symmetric keys.

Question/Problem

To claim *vendor affirmation* to **SP 800-108**, what sections of the publication need to be addressed and what are the applicable documentation requirements?

Resolution

The entire text of **SP 800-108** is applicable. The cryptographic module may support key derivation using the key derivation functions from Section 5.1, Section 5.2 or Section 5.3 of **SP 800-108**. The module may implement any combination of these KDFs. This choice and the corresponding capabilities of the cryptographic module **shall** be clearly stated in the module's Security Policy.

The module's Security Policy **shall** state the possible range of the cryptographic strengths of the keys derived using the **SP 800-108** methodology. The instructions for how to determine this strength are in Section 7 of **SP 800-108**.

The vendor **shall** comply with all "**shall**" statements in **SP 800-108**. These refer to but are not limited to the sizes of the parameters used in the KDF computations and the possible uses of the derived keys.

Annotation

Refer to IG G.13 for annotation examples (**KBKDF**).

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation complies with the requirements of **SP 800-108** and of the documentation requirements of this Implementation Guidance. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review.

Additional Comments

No self-tests are required to claim *vendor affirmation* to **SP 800-108**.

W.12 Requirements for Vendor Affirmation of SP 800-135rev1

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Date Withdrawn:	*05/10/2016*
Transition End Date:	***06/23/2012***
Last Modified Date:	*07/15/2011*
Relevant Assertions:	*AS.07.11 and AS.07.16*
Relevant Test Requirements:	*TE07.11.01-02 and TE07.16.01-02*
Relevant Vendor Requirements:	*VE.07.11.01 and VE.07.16.01*

Background

SP 800-135rev1 was published December 2011 and added to FIPS 140-2 Annex D on April 23, 2012. Until CAVP testing for **SP 800-135rev1** is available, IG A.3 is applicable. This Special Publication defines the recommendation for existing application-specific key derivation functions.

Question/Problem

To claim *vendor affirmation* to **SP 800-135rev1**, what sections of the publication need to be addressed and what are the applicable documentation requirements?

Resolution

The entire text of **SP 800-135rev1** is applicable.

The vendor **shall** comply with all "**shall**" statements in **SP 800-135rev1**.

Annotation

Refer to IG G.13 for annotation examples (**CVL**).

Derived Test Requirements

Upon the following successful review, the CST Lab **shall** affirm by annotating the algorithm entry per the IG G.13 annotation requirements.

Required Vendor Information

The vendor **shall** provide evidence that their implementation complies with the requirements of **SP 800-135rev1** and of the documentation requirements of this Implementation Guidance. This **shall** be accomplished by documentation and code review.

Required Test Procedures

The tester **shall** review the vendor's evidence demonstrating that their implementation conforms to the specifications specified above. This **shall** be accomplished by documentation and code review.

Additional Comments

No self-tests are required to claim *vendor affirmation* to **SP 800-135rev1**.

W.13 Listing of DES Implementations

Applicable Levels:	*All*
Original Publishing Date:	*11/23/2005*
Date Withdrawn:	*12/21/2016*
Last Modified Date:	*01/16/2008*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

DEPARTMENT OF COMMERCE
National Institute of Standards and Technology
[Docket No. 040602169-5002-02]

Announcing Approval of the Withdrawal of Federal Information Processing Standard **FIPS 46-3**, Data Encryption Standard (DES); **FIPS 74**, Guidelines for Implementing and Using the NBS Data Encryption Standard; and **FIPS 81**, DES Modes of Operation.

Question/Problem

With the withdrawal of the DES cryptographic algorithm, how does the DES and DES MAC algorithms get listed on the FIPS 140-2 validation certificate?

Resolution

The DES transition period ended on May 19, 2007. DES and DES MAC are no longer approved security functions and **shall** be listed on the FIPS 140-2 certificate as non-approved algorithms.

W.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Date Withdrawn:	*12/03/2019*
Last Modified Date:	*05/10/2017*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01-02*
Relevant Vendor Requirements:	*VE.01.12.01-02*

Background

At the start of the 21st century, the National Institute of Standards and Technology (NIST) began the task of providing cryptographic key management guidance, which includes defining and implementing appropriate key management procedures, using algorithms that adequately protect sensitive information, and planning ahead for possible changes in the use of cryptography because of algorithm breaks or the availability of more powerful computing techniques. SP 800-57, Part 1 was the first document produced in this effort, and includes a general approach for transitioning from one algorithm or key length to another. SP 800-131Arev1 provides more specific guidance for transitions to the use of stronger cryptographic keys and more robust algorithms.

Question/Problem

How will the validation of the cryptographic algorithms and cryptographic modules be affected during the transition as specified in SP 800-131Arev1?

Resolution

1. Useful Terms

   1.1 **New Validations, Already Validated Implementations and Revalidations**

   The CAVP and CMVP, along with the accredited CST laboratories, have been in existence since 1995. Consequently, a large number of implementations have been tested and validated under these programs, and the number of new implementations that are validated continues to increase every year. The CMVP conducts revalidations of already-validated module implementations whenever changes are made to the module implementations or when new operational environments are added to an existing validation. These changes may require the validation of new implementations and/or the retesting of already-validated algorithm implementations.

   - *New Implementations* refers to the cryptographic algorithms or modules that have not been validated by the CAVP or CMVP, respectively.

     For algorithm implementations, new implementations are the algorithm implementations that are to be tested or are currently under test by an accredited CST laboratory for which the algorithm test results will be submitted to the CAVP.

     For cryptographic modules, new implementations refer to cryptographic modules that are either new modules or the revalidation of modules under IG G.8 Scenarios 3 and 5. These modules are either not yet tested, or are currently under test by an accredited CST laboratory for which the test report will be submitted to CMVP.

   - *Already-Validated Implementations* are algorithm or module implementations that have already been tested by a CST laboratory and validated by the CAVP or CMVP.

     Cryptographic module validations reference at least one approved algorithm implementation. These references are to algorithms that have been validated by the CAVP, algorithms for which standards may not have existed at the time of the CMVP validation, or algorithms for which CAVP validation testing was not available at the time of the module validation. Some algorithms in NIST-Recommendations may appear on a CMVP validation certificate as "non-approved, but allowed for use in an approved mode of operation." In addition, the level of specificity found on a module validation-entry has changed over the life of the CMVP program, as standards and testing methods emerged.

1.2 Terms Used in SP 800-131A

The use-categorization terms "**acceptable**", "**deprecated**" and "**legacy use**" are used in **SP 800-131A** to address the use of cryptographic algorithms and key lengths. The term **"restricted"** was also used in **SP 800-131A** since this category existed at the time **SP 800-131A** was published. It is no longer used for any purpose.

- **Acceptable** is used to mean that the algorithm and key length is safe to use; no security risk is currently known.
- **Deprecated** means that the use of the algorithm and key length is allowed, but the user must accept some risk.
- **Legacy-use** means that the algorithm or key length may be used to process already-protected information (e.g., to decrypt ciphertext data or to verify a digital signature) that was protected using an algorithm or key length that has since been deprecated, restricted or disallowed for applying cryptographic protection.

An algorithm or key length is considered to be disallowed (i.e., no longer approved) for its purpose if it is not classified as acceptable, deprecated or allowed for legacy-use.

2. General Validation Strategy

The general validation strategy to be used by the CAVP and CMVP for new and already-validated implementations is the following:

- New implementations: When applied to cryptographic algorithms, the dates in the tables of **SP 800-131A** refer to the algorithm's validation date that is assigned by the CAVP.

  When applied to cryptographic modules, the dates in the tables refer to the dates of the CST laboratory's initial submission of a module test report to the CMVP for validation.

  Security policies for new module implementations are discussed in Section 5.

- Already-validated implementations: As resources permit, the CAVP and CMVP will review these implementations and their validations for compliance with the new security requirements as stated in **SP 800-131A** when a transition date occurs.

  The CAVP will review the algorithm validations to determine if a validated algorithm or a key length is disallowed in **SP 800-131A**. If a complete algorithm validation is disallowed, the CAVP will revoke the algorithm validation; references to these revoked validations will continue to be available for historical purposes. If only parts of a validation are disallowed (e.g., one of the validated key lengths is disallowed), the validation listing will be annotated to indicate the disallowed parts of the validation.

  The CMVP will review the list of module validations and take the appropriate actions, based on the module's provided algorithm validation references.

  - If an algorithm validation is revoked by the CAVP, the module's validation reference will be removed from the "FIPS Approved algorithms" line. If the algorithm could still be used in the non-approved mode, it **shall** be listed in the security policy.
  - References to revised algorithm validations will remain unchanged; i.e., if only part of the validation is disallowed by the CAVP, the certificate reference will not be revised.
  - References to other algorithms will be changed only if sufficient information was provided that would allow modification. The information provided at the time of module validation and presented on the validation-list entry may be insufficient to determine whether a module continues to satisfy all of the new security requirements or whether the module's validation continues to be valid. Therefore, the CMVP will flag validations that have been partially revoked

by the CAVP; this flag may be removed by the voluntary submission of an appropriately-updated security policy by the vendor that addresses the transition issue.

- If all algorithm validations for a module are revoked, the module validation will be revoked, and the validation listing will be annotated to indicate the revocation. For historical purposes, the annotated entry in the validation listing will be retained.
- It is the user's responsibility to determine that the algorithms and keys lengths utilized by their system are in compliance with the requirements of **SP 800-131A**. All questions regarding the implementation and/or use of any module located on the CMVP module validation lists should first be directed to the appropriate vendor point-of-contact (listed for each entry).
- As appropriate, the CMVP will only modify the module validation entry information; however, the security policy provided with each module validation will not be modified except by vendor request. The CMVP encourages vendors to submit updated security policies with appropriate revisions. Updated security policies may be submitted directly to the CMVP; the updated policies will be placed on the CMVP web site, and the updated security policy and the validation listing for the associated module will be annotated to indicate the update.
- Cryptographic modules revalidated under Scenarios 1 and 4 of IG G.8 will be treated as already-validated implementations.

3. **Validation of Cryptographic Algorithms and Cryptographic Modules by Use Categorization**

SP 800-131A addresses the use of cryptographic algorithms and key lengths during given time periods, categorizing them as acceptable, deprecated, legacy-use and disallowed. These categorizations affect the validation of new implementations and the status of already-validated implementations.

Cryptographic algorithms and key lengths that are categorized as acceptable, deprecated or legacy-use **shall** be validated for Federal government use.

3.1 **Acceptable**

New algorithm validation submissions and new module validation submissions will be accepted by the CAVP or CMVP, respectively, through December 31st of the end-year indicated, if an end-year is provided, or with no date restriction if an end-year is not provided.

Already-validated algorithm or module implementations will remain valid during this period.

No additional requirements are placed on the cryptographic modules revalidated under Scenarios 1, 2 and 4 of IG G.8.

3.2 **Deprecated**

In general, new algorithm or module validation submissions will be accepted for validation by the CAVP or CMVP, respectively, through December 31st of the end-year for the deprecation period.

Already-validated algorithm and module implementations will remain valid through December 31st of the end-year of the deprecation period.

3.3 **Legacy-Use**

The legacy-use categorization is intended to allow the processing of already-protected information – information for which the protection was originally applied using an algorithm or key length that was acceptable, or deprecated at the time of applying the protection, but is now disallowed for that purpose.

New algorithm and module validation submissions will be accepted for validation by the CAVP or CMVP, respectively, until disallowed.

Algorithm and module validations for already-validated implementations will remain valid for processing already-protected information only.

Example 1: After December 31, 2015, two-key Triple DES decryption can be validated, while two-key Triple DES encryption will not (see Section 4.5).

Example 2: After December 31, 2013, implementations that verify digital signatures that were generated using 1024 bit RSA keys can continue to be validated, even though the generation of signatures using this key length will no longer be validated.

3.4 **Disallowed Algorithms and Key Lengths**

New module validation submissions and submissions for the revalidation of modules containing only algorithms and key lengths that are disallowed for their purpose will not be accepted for validation by the CMVP; submissions containing one or more algorithms and/or key lengths categorized as acceptable, deprecated, or legacy-use will continue to be accepted for validation.

4. **The Remaining Use of FIPS 186-2**

Implementations of domain parameter generation, key pair generation and digital signature generation as specified in **FIPS 186-2** are *no longer validated* by the CAVP or CMVP.

Cryptographic algorithm and module implementations that perform domain parameter validation, public key validation and digital signature verification may be tested by the CST labs for conformance to **FIPS 186-2** (or parts of **FIPS 186-2**) and submitted for validation, subject to the following conditions.

- **CAVP**: The CAVP will accept test results from the CST labs of cryptographic algorithm implementations of **FIPS 186-2** (or parts of **FIPS 186-2**) that contain testable key lengths permitted by **FIPS 186-2** that are categorized as either acceptable or legacy-use as specified in SP 800-131Arev1.

- **CMVP**: New modules (3SUB and 5SUB submissions) and already-validated modules containing digital signature processes conforming to **FIPS 186-2** that have algorithm validations issued by the CAVP may be validated or revalidated, as appropriate.

5. **Documentation Requirements for CMVP Validations**

Module security policies submitted for new validations and (optional) updated security policies provided for already-validated implementations **shall** either include or make a reference to the transition tables that will be available at the CMVP Web site (http://csrc.nist.gov/groups/STM/cmvp/). The data in the tables will inform users of the risks associated with using a particular algorithm and a given key length.

This documentation requirement applies to all new validation submissions made three months after the publication of this IG. This requirement also applies to revalidation submissions, Scenarios 3 and 5 of IG G.8.

W.15 Assurance of the Validity of a Public Key for Key Establishment

Applicable Levels:	*All*
Original Publishing Date:	*10/21/2009*
Effective Date:	*10/21/2009*
Last Modified Date:	*12/03/2019*
Date Withdrawn	*03/17/2023*
Relevant Assertions:	*AS.07.17*
Relevant Test Requirements:	*TE07.17.01-02*
Relevant Vendor Requirements:	*VE.07.17.01*

Background

The correct functioning of public key algorithms depends, in part, on the arithmetic validity of the public key.

Both the owner and the recipient of a public key need to obtain assurance of public key validity before using the key for operational purposes after key establishment. Public key algorithms for key establishment are specified in **SP 800-56A** and **SP 800-56B**. Methods for obtaining assurance of public key validity are provided in Section 5.6.2 of **SP 800-56A**, and in Section 6.4 of **SP 800-56B**.

The key establishment schemes in **SP 800-56A** are specified using either static (long term, multi-use) keys or ephemeral (short term, single use) keys or both. The keys used in the **SP 800-56B** schemes are generally long term (i.e., static) keys.

Since a static key is normally used for a relatively long period of time, and a number of methods are provided for obtaining assurance of public key validity either by the owner or recipient directly, or by using a trusted third party, the process of obtaining the assurance is not too onerous. However, methods for obtaining this assurance for ephemeral keys are more limited, since a trusted third party is normally not available for obtaining the required assurance. The owner of an ephemeral public key generates that key, and obtains assurance of ephemeral public key validity by virtue of generating the key as specified in **SP 800-56A** (see Section 5.6.2.1; Note that this section applies to the owner assurances of both Static and Ephemeral public key validity). However, the recipient of an ephemeral public key must obtain the assurance by performing an explicit public key validation process.

Question/Problem

Public key validation requires a certain amount of time to perform, which can significantly affect communication performance. Can this process be omitted if at least some of the security goals (i.e., authentication of the public key owner and the integrity of the ephemeral key) are fulfilled by other means?

Resolution

The owner or a recipient of a static public key **shall** obtain assurance of the validity of that public key using one or more of the methods specified in **SP 800-56A** or **SP 800-56B**, as appropriate. The owner of an ephemeral public key **shall** obtain assurance of the validity of that key as specified in **SP 800-56A**. Explicit public key validation of an ephemeral public key is required as specified in **SP 800-56A** by a recipient, except in the following situation; in this case, explicit public key validation of the ephemeral public key by the recipient is optional:

1. The ephemeral public key was generated for use in an FFC dhEphem key agreement scheme or an ECC Ephemeral Unified Model key agreement scheme, and
2. The key agreement scheme is being conducted using a protocol that authenticates the source and the integrity of each received ephemeral public key by means of an approved security technique (e.g., a digital signature or an HMAC).

Protocols that satisfy #2 above and, therefore, may omit the explicit ephemeral public key validation process include:

- Internet Key Exchange protocol, versions IKEv1 and IKEv2,
- Transport Layer Security (TLS) protocol and Datagram Transport Layer Security (DTLS) protocol, versions 1.0 and higher.

In this case, when explicit public key validation is not performed on the ephemeral public key by an implementation in the manner specified in **SP 800-56A** (and not tested by the CAVP, even when such test is available), the cryptographic algorithm's validation will indicate that the capability to provide assurance of ephemeral public key validity is not required for algorithm validation, based on this IG. However, the cryptographic algorithm validation and the cryptographic module validation may still claim that the algorithm and module are otherwise compliant with **SP 800-56A**.

Additional Comments

1. In this Guidance, both **SP 800-56A** and **SP 800-56B** refer to all published versions of the corresponding standards, unless explicitly stated otherwise.
2. If a cryptographic module implements a key agreement / shared secret computation scheme whereby the recipient of an ephemeral public key omits the explicit ephemeral public key validation, the modules Security Policy **shall** indicate the appropriate protocol listed above that allows the omission of the validation in order to claim conformance to this Implementation Guidance.
3. **SP 800-56A Rev3** provides a choice of how key validation may be performed when it is required by the standards. The module may perform either the full validation or, if applicable, a less partial validation of an ephemeral public key. The vendor may consider performing the partial ephemeral public key validation even if in those cases when this Implementation Guidance provides an exemption from the public key validation requirement.

   For the FFC schemes, a partial public key validation applies only when using "safe" primes. This includes all schemes claiming compliance with the most common IETF protocols. The partial key validation amounts to simply checking if a candidate public key y lies in the interval $2 \le y \le p–2$.
4. For the ECC schemes, the partial validation largely amounts to checking that the candidate key is a non-identity point on the elliptic curve used in the scheme. Unlike the full public key validation procedure, the partial validation does not verify that the key lies in the subgroup of the correct order.

Change Summary

New Guidance

- 11/05/21: D.14 SP 800-56C Rev2 One-Step Key Derivation Function Without a Counter
- 05/04/21: 7.20 Combining Entropy from Multiple Sources
- 08/28/20: 7.19 Interpretation of SP 800-90B Requirements
- 08/12/20: G.20 Tracking the Component Validation List
- 10/23/19: G.19 Operational Equivalency Testing for HW Modules
- 08/16/19: G.18 Limiting the Use of FIPS 186-2
- 08/16/19: D.1-rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard
- 05/07/19: 7.18 Entropy Estimation and Compliance with SP 800-90B
- 12/04/17: 9.13 Non-Reconfigurable Memory Integrity Test
- 12/04/17: 9.12 Integrity Test Using Sampling
- 12/04/17: A.15 Vendor Affirmation for the SP 800-185 Algorithms
- 08/07/17: G.17 Remote Testing for Software Modules
- 08/07/17: 1.23 Definition and Use of a non-Approved Security Function
- 08/07/17: 9.11 Reducing the Number of Known Answer Tests
- 08/07/17: A.14 Approved Modulus Sizes for RSA Digital Signature and Other Approved Public Key Algorithms
- 05/10/17: A.13 SP 800-67rev1 Transition
- 05/10/17: D.13 Elliptic Curves and the MODP Groups in Support of Industry Protocols
- 11/15/16: 1.22 Module Count Definition
- 11/15/16: 7.17 Zeroization of One Time Programmable (OTP) Memory
- 11/15/16: A.12 Requirements for Vendor Affirmation to the Addendum to SP 800-38A
- 08/01/16: A.11 The Use and the Testing Requirements for the Family of Functions defined in FIPS 202
- 06/17/16: A.10 Requirements for Vendor Affirmation to SP 800-38G
- 05/10/16: G.16 Requesting an Invoice Before Report Submission
- 12/28/15: A.9 XTS-AES Key Generation Requirements
- 08/07/15: 7.14 Entropy Caveats
- 08/07/15: 7.15 Entropy Assessment
- 08/07/15: 7.16 Acceptable Algorithms for Protecting Stored keys and CSPs
- 08/07/15: D.1-rev2 CAVP Requirements for Vendor Affirmation of SP 800-56A-rev2
- 08/07/15: D.12 Requirements for Vendor Affirmation to SP 800-133

- 03/02/15: 1.21 Process Algorithm Accelerators (PAA)
- 03/02/15: 1.20 Sub-Chip Cryptographic Subsystems
- 03/02/15: A.8 Use of HMAC-SHA-1-96 and Truncated HMAC
- 07/25/13: 3.5 Documentation Requirements for Cryptographic Module Services
- 07/25/13: 9.9 Pair-Wise Consistency Self-Test When Generating a Key Pair
- 07/25/13: 9.10 Power-Up Tests for Software Module Libraries
- 07/25/13: D.11 References to the Support of Industry Protocols
- 05/02/12: 9.8 Continuous Random Number Generator Tests
- 05/02/12: 7.13 Cryptographic Key Strength Modified by an Entropy Estimate
- 05/02/12: 7.12 Key Generation for RSA Signature Algorithm
- 05/02/12: 7.11 Definition of an NDRNG
- 05/02/12: 3.4 Multi-Operator Authentication
- 05/02/12: 3.3 Authentication Mechanisms for Software Modules
- 04/23/12: D.10 Requirements for Vendor Affirmation of SP 800-56C
- 04/23/12: D.9 Key Transport Methods
- 04/23/12: D.8 Key Agreement Methods
- 04/23/12: 1.19 non-approved Mode of Operation
- 04/23/12: 1.18 PIV Reference
- 04/23/12: G.15 Validating the Transition from FIPS 186-2 to FIPS 186-3
- 04/23/12: G.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths
- 07/15/11: 11.1 Mitigation of Other Attacks
- 07/15/11: D.4 Requirements for Vendor Affirmation of SP 800-56B
- 07/15/11: D.5 Requirements for Vendor Affirmation of SP 800-108
- 07/15/11: D.6 Requirements for Vendor Affirmation of SP 800-132
- 07/15/11: D.7 Requirements for Vendor Affirmation of SP 800-135
- 12/23/10: 1.16 Software Module
- 12/23/10: 1.17 Firmware Module
- 12/23/10: 2.1 Trusted Path
- 12/23/10: 5.5 Physical Security Level 3 Augmented with EFP/EFT
- 12/23/10: 9.7 Software/Firmware Load Test
- 12/23/10: 14.5 Critical Security Parameters for the SP 800-90 DRBGs
- 01/27/10: 5.4 Level 3: Hard Coating Test Methods
- 01/27/10: 14.4 Operator Applied Security Appliances
- 01/27/10: A.7 CAVP Requirements for Vendor Affirmation of NIST SP800-38E
- 10/22/09: 7.10 Using the SP 800-108 KDFs in FIPS Mode
- 10/21/09: 9.6 Self-Tests When Implementing the SP 800-56A Schemes
- 10/21/09: D.3 Assurance of the Validity of a Public Key for Key Establishment
- 07/07/09: 1.15 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard

- 04/01/09: 3.2 Bypass Capability in Routers
- 04/01/09: 9.5 Module Initialization during Power-Up
- 03/24/09: 7.9 Procedural CSP Zeroization
- 03/10/09: 1.14 Key/IV Pair Uniqueness Requirements from SP 800-38D
- 03/10/09: 5.3 Physical Security Assumptions
- 03/10/09: 7.8 Key Generation Methods Allowed in FIPS Mode
- 01/24/08: 7.7 Key Establishment and Key Entry and Output
- 12/18/07: 1.13 CAVP Requirements for Vendor Affirmation of SP 800-38D
- 11/16/07: 7.6 RNGs: Seeds, Seed Keys and Date/Time Vectors
- 07/03/07: 14.3 Logical Diagram for Software, Firmware and Hybrid Modules
- 06/28/07: G.13 Instructions for completing a FIPS 140-2 Validation Certificate
- 06/21/07: 1.11 CAVP Requirements for Vendor Affirmation of SP 800-56A
- 06/21/07: 1.12 CAVP Requirements for Vendor Affirmation of SP 800-90
- 01/26/07: G.12 Post-Validation Inquiries
- 01/25/07: 1.10 Vendor Affirmation of Cryptographic Security Methods

Modified Guidance

- 10/30/23: G.8 Revalidation Requirements – Added requirements in Scenario 3B for a table indicating which certificate fields have been updated.
- 10/30/23: G.17 Remote Testing for Modules – Updated to be consistent with the FIPS 140-3 remote testing guidance.
- 10/30/23: D.4 Requirements for Vendor Affirmation of SP 800-56B- Removed reference to the December 31, 2023 transition.
- 10/30/23: D.9 Key Transport Methods – Updated the language on the December 31, 2023 transitions.
- 03/17/23: G.8 Revalidation Requirements – Updated Additional Comment #1 to clarify Scenario 1 Option 3 can be used for historical validations if addressing an algorithm transition.
- 03/17/23: 3.1 Authorized Roles - Added SP 800-90B under Resolution b. Added Additional Comments #6 and #7.
- 03/17/23: 7.19 Interpretation of SP 800-90B Requirements - Added headers to group the Resolutions and added Resolution 19 on full entropy. Added requirements when a DRBG is considered a conditioning component (updates to Resolution 5 and Resolution 7 Note 1).
- 10/17/22: G.8 Revalidation Requirements - Added statement in the Resolution to generalize when a module will be included on the MIP list, and removed the individual references within each scenario.
- 10/17/22: 1.21 Processor Algorithm Accelerators (PAA) and Processor Algorithm Implementation (PAI) – Admin change to PAA and PAI certificate examples in that these are separate OE entries, and must include the processor.
- 10/07/22: G.8 Revalidation Requirements – Generalized Scenario 3B for algorithm transitions. Removed ECR references and pointed to website in Additional Comment 8.
- 10/07/22: 1.21 Processor Algorithm Accelerators (PAA) and Processor Algorithm Implementation (PAI) – Clarified the testing requirements when a module incorporates PAA or PAI functionality. Updated known PAA/PAIs.

- 10/07/22: 7.14 Entropy Caveats – Added Additional Comment #7 on claiming multiple scenarios from this IG and added Additional Comment #8 on which scenarios require an entropy assessment report.
- 10/07/22: A.14 - Approved Modulus Sizes for RSA Digital Signature and Other Approved Public Key Algorithms – Clarified algorithm status and requirements for RSA Signature Verification for both FIPS 186-2 and FIPS 186-4.
- 08/15/22: G.16 Requesting an Invoice Before Submitting a Report – Added reference to CMVP website for Cost Recovery fees.
- 08/15/22: G.8 Revalidation Requirements - .
- 03/14/22: G.13 Instructions for Validation Information Formatting – Added the following entry: “CVL (vendor affirmed)”, per IG G.20.
- 03/14/22: G.20 Tracking the Component Validation List – Added vendor affirmation of a SRTP KDF implementation.
- 02/14/22: 1.23 Definition and Use of a non-Approved Security Function - Added “with no security claimed” to the examples subtitle for clarity.
- 02/14/22: G.8 Revalidation Requirements - Abbreviated Additional Comment #9, as applicable text was moved to IG 1.23. Clarified lab requirements when open-source modules are rebranded per scenario 1A. Added the entropy submission as a separate file in Scenario 1 (when applicable).
- 02/14/22: G.17 Remote Testing for Software Modules - Clarified lab requirements when connecting to a vendor’s network in Resolution #2.
- 11/05/21: G.8 Revalidation Requirements - Added allowances to combine scenarios in Additional Comment #8. Generalized Scenario 1B to be combined with viable revalidation scenarios.
- 11/05/21: G.13 Instructions for Validation Information Formatting - Added the caveat: “No assurance of minimum strength or security of keys”. Removed MD5 from the approved algorithms line as it does not claim security per IG 1.23. Added a space to ENT entries to ENT (P) and ENT (NP) and did this throughout the entire IG.
- 11/05/21: G.20 Tracking the Component Validation List - Added references to SP 800-56Arev3 for the ECC-CDH primitive CVL in Resolution #2. Minor clean up including updating transition dates.
- 11/05/21: 1.23 Definition and Use of a non-Approved Security Function - Synchronized minor text edits in the Resolution to be consistent with IG 2.4.A (FIPS 140-3). Clarified XOR example with a note. Added Additional Comment #2 to further clarify when a vendor can apply this IG.
- 11/05/21: 7.18 Entropy Estimation and Compliance with SP 800-90B - Added Additional Comment #12 to clarify when other parties can write a labs’ entropy source description and its heuristic entropy analysis.
- 11/05/21: 9.4 Known Answer Tests for Cryptographic Algorithms - Spelled out the ENT self-test requirements to avoid ambiguity.
- 11/05/21: 14.5 Critical Security Parameters for the SP 800-90A DRBGs - Added Additional Comment on the CTR_DRBG without a derivation function.
- 11/05/21: A.2 Use of non-NIST-Recommended Elliptic Curves - Update name and KAS examples to match what is in G.13.
- 11/05/21: A.14 Approved Modulus Sizes for RSA Digital Signature and Other Approved Public Key Algorithms - Added Table 1 with a more relaxed upper bound limit and introduced supporting text including adding two new Additional Comments. Clarified the minimum number of the Miller-Rabin tests. Cleaned up old text in the Additional Comments.

- 11/05/21: D.1-rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard - Clarified that validated modules that vendor affirm to IG D.1-rev3 will not move to the Historical List come the SP 800-56A Rev3 transition, unless for another reason.
- 11/05/21: D.8 Key Agreement Methods - Added path (3) into Scenario X1. Changed transition date in Additional Comment #11 to June 30, 2022.
- 05/04/21: G.8 Revalidation Requirements – Updated Scenario 3A and 3B to replace "since the original validation" with "since the *submission of the original module*".
- 05/04/21: G.13 Instructions for Validation Information Formatting - Updated to align ENT references with that of IG 7.20.
- 05/04/21: 3.1 Authorized Roles - Clarified the requirements of the text "or other services that do not affect the security of the module".
- 05/04/21: 7.18 Entropy Estimation and Compliance with SP 800-90B - Updated to align ENT references with that of IG 7.20.
- 05/04/21: 9.4 Known Answer Tests for Cryptographic Algorithms – Clarified self-test rules around the PBKDF Iteration Count parameter.
- 05/04/21: D.1-rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard & D.8 Key Agreement Methods – Updated SP 800-56Arev3 transition date from January 1, 2022 to July 1, 2022.
- 05/04/21: D.9 Key Transport Methods - Added "if applicable" for key confirmation under the first approved method.
- 01/05/21: G.8 Revalidation Requirements – Introduced a new Scenario 3B for algorithm transitions.
- 01/05/21: G.13 Instructions for Validation Information Formatting – Clarified in section 9 that bound/embedded security functions must be included in the binding/embedding module's security policy and distinct from the module's implemented security functions.
- 01/05/21: 7.18 Entropy Estimation and Compliance with SP 800-90B - Changed language surrounding bound and embedded modules that are compliant to IG 7.15. Added references to IG 7.19.
- 01/05/21: 9.4 Known Answer Tests for Cryptographic Algorithms – Reformatted Question/Problem. Consolidated and clarified several algorithm self-test requirements, including SHA-3 (permutation-based, extendable-output functions and derived functions), ENT, PBKDF, KDA, key agreement and key transport schemes. Added optimization option for the DRBG KAT. Clarified language surrounding if different implementations of a single algorithm are implemented, with a reference to multiple approved modes.
- 01/05/21: A.3 Vendor Affirmation of Cryptographic Security Methods - Changed Background and some of the Question/Problem to be more applicable. Included transition schedule for CAVP testing. Combined two sections on vendor affirmation into one.
- 01/05/21: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – Removed Scenario 2's second and fourth bullets and added the reasoning as Additional Comment #4.
- 08/28/20: Incorporated algorithm transition dates where testing is now supported by the CAVP (IGs G.13, G.20, A.12, A.15, D.1rev2, D.1rev3, D.6, D.8, D.9, D.10).
- 08/12/20: G.13 Instructions for Validation Information Formatting – Added approved Key Agreement examples for compliance to SP 800-56Brev2 or SP 800-56Arev3. Added additional non-approved but allowed MQV examples. Added an example and two notes for the tested KDA (SP 800-56C Rev1/Rev2). Moved a paragraph from the top of Section 10 to the middle as it fits more logically. Small changes to footnotes for additional clarity.

- 08/12/20: 7.8 The Use of Post-Processing in Key Generation Methods – Minor update to address the second revision of SP 800-133. Formatting changes.
- 08/12/20: A.10 Requirements for Vendor Affirmation of SP 800-38G – Removed the allowance to vendor affirm the FF3 mode. Added a paragraph in the Background to explain the FF3 vulnerability and the draft of SP 800-38Grev1. Added a transition end date for vendor affirming to FF1. Moved two additional comments into the Resolution section. Added two additional comments (4, 5) to address FF1 testing (4) and what happens when SP 800-38Grev1 is published (5).
- 08/12/20: D.1rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard – Revised with new SP 800-56Arev3 transition schedule.
- 08/12/20: D.8 Key Agreement Methods – Revised with new SP 800-56Arev3 transition schedule. Specified transition rules when complying to the original SP 800-56B. Updated with guidance on CAVP testing options, self-test requirements, and documentation requirements when implementing SP 800-56Arev3 (scenario X1) or SP 800-56Brev2 (scenario 2) key agreement schemes.
- 08/12/20: D.9 Key Transport Methods – Clarified the self-test description based on lab comments.
- 08/12/20: D.12 Requirements for Vendor Affirmation to SP 800-133 – Updates to address the second revision of SP 800-133. Updated Additional Comment #1 to account for the case where post processing is applied.
- 06/29/20: G.8 Revalidation Requirements – Made it clear in the Resolution that all Scenarios must be processed and submitted to the CMVP by a CST Laboratory. Modified Scenario 1 to prevent allowing security relevant functions or services that were not tested but testing was available during the original validation (this should be a 3sub). Added language to Scenario 1 indicating an ECR may be applicable. Added a requirement to include an up-to-date entropy report for Scenario 1 (4) - adding new OE's to the module certificate - after November 7, 2020. Added a new requirement to Scenario 2 to submit an IG summary table as part of the change letter. Added language to make it clear that an up-to-date entropy report is required for Scenario 2 submissions, if applicable per IG 7.14.
- 06/29/20: G.13 Instructions for Validation Information Formatting – Added missing KMAC and SHA-3-Customized (IG A.15) to the list of approved algorithms with footnotes to explain each of them. Added approved algorithm examples for compliance to SP 800-56Brev2.
- 06/29/20: 9.4 Known Answer Tests for Cryptographic Algorithms – Added bullet #3 under the RSA algorithm to address IG D.9 self-test requirements.
- 06/29/20: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – Introduced Scenario 5 which allows the vendor to extend the industry protocol-specific cases of Scenario 1. Added version numbers to the protocol references mentioned throughout this IG.
- 06/29/20: D.9 Transport Methods – Introduced support for compliance to SP 800-56Brev2 and provided transition rules for compliance to the original SP 800-56B or non-compliance to any version of SP 800-56B. Clarified self-test requirements for SP 800-56Br2 compliance.
- 12/03/19: G.8 Revalidation Requirements – Removed "rev1" from a reference to SP 800-131A to apply to any revision of this standard.
- 12/03/19: G.13 Instructions for Validation Information Formatting – Added KAS-SSC (IG D.8) and KDA (IG D.10) to the list of approved algorithms with footnotes to explain each of them. Added a KTS example and footnote for AES that uses different certificate numbers for encryption and authentication. Added footnotes in the Allowed algorithms section to explain the reference to SP 800-56C and SP 800-56C Rev1. A footnote for the EC Diffie-Hellman entry has been clarified to reference IG D.8 applicable scenarios.

- 12/03/19: G.18 Limiting the Use of FIPS 186-2 – Extended the transition date to two months after ACVP Transition Date. Clarified which modules will be moved to the historical list, and the methods to remain on (or be moved back to) the active list.
- 12/03/19: 7.16 Acceptable Algorithms for Protecting Stored Keys and CSPs – Added an Additional Comment about the general SP 800-131A notation.
- 12/03/19: 7.18 Entropy Estimation and Compliance with SP 800-90B – Updated to explain the validation rules for the modules which receive their entropy from an embedded module.
- 12/03/19: 9.8 Continuous Random Number Generator Tests – Small formatting corrections and updated for consistency with SP 800-90B.
- 12/03/19: 9.9 Pair-Wise Consistency Self-Test When Generating a Key Pair – Cleaned up wording when referencing individual sections in each version of SP 800-56A.
- 12/03/19: A.2 Use of non-NIST-Recommended Asymmetric Key Sizes and Elliptic Curves – Introduced SP 800-56A Rev3 and scenario X2 of IG D.8.
- 12/03/19: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – Introduced compliance methods for SSH protocol AES GCM IV generation. Added a reference to SP 800-52 Rev 2 in the TLS protocol IV generation section.
- 12/03/19: A.8 Use of Truncated HMAC – Changed the IG title: removing a reference to HMAC-SHA-1, as this IG also applies to other forms of HMAC. Added an Additional Comment about the general SP 800-131A notation.
- 12/03/19: A.14 Approved Modulus Sizes for RSA Digital Signature and Other Approved Public Key Algorithms – Accounted for the existence of the different revisions of SP 800-56A (older revisions perform the key agreement while the newer revisions only a shared secret computation). Accommodated SP 800-131A Rev2. Addressed an approval of all RSA key transport modulus sizes ≥ 2048 bits. Changed the non-approved elliptic curve reference from FIPS 186-4 to IG A.2.
- 12/03/19: D.1-rev3 CAVP Requirements for Vendor Affirmation to SP 800-56A Rev3 and the Transition from the Validation to the Earlier Versions of This Standard – Removed “to be published soon” from SP 800-131 rev1 reference.
- 12/03/19: D.2 Acceptable Key Establishment Protocols – Changed a reference for the key generation methods from IG 7.8 to SP 800-133.
- 12/03/19: D.3 Assurance of the Validity of a Public Key for Key Establishment – Updated outdated text and provisions. Added Additional Comment #1 and #3 for clarity on newer standard revisions for SP 800-56A and SP 800-56B. Additional comments: removed unnecessary text and turned remaining text into Additional Comment #2.
- 12/03/19: D.12 Requirements for Vendor Affirmation to SP 800-133 – Updated to the new revision of SP 800-133. Updated language to clarify when CKG terminology is applicable.
- 12/03/19: D.13 Elliptic Curves and the MODP Groups in Support of Industry Protocols – Reworked the Resolution section to say that the use of safe primes is now approved. Explained that in each safe-prime triple (p, q, g) currently used in the IETF protocols, g is equal to 2. Changed additional comment reference from SP 800-56A Rev2 to Rev3. Eliminated altogether a reference to SP 800-131A.
- 08/16/19: G.8 Revalidation Requirements – Updated Scenario 3a to permit a 3a submission to incorporate 1sub (non-security relevant) changes to be submitted as a single package.
- 08/16/19: 9.4 Known Answer Tests for Cryptographic Algorithms - Added a requirement in the symmetric-key algorithms section to self-test the forward and inverse cipher functions (if implemented by the module). Corrected the authenticated encryption mode hierarchy since item 2 (AES KW) testing should not cover item 3 (Triple-DES KW). Clarified how to meet the requirements of the bullets #1-#4 and how they relate to each other. Updated the

Additional Comments paragraph to clarify when the PCT applies for an asymmetric key generation implementation.

- 08/16/19: D.8 Key Agreement Methods – Incorporated vendor affirmation to SP 800-56Arev3 and the new IG D.1rev3 into this IG.
- 08/16/19: D.10 Requirements for Vendor Affirmation of SP 800-56C - Updated to allow for vendor affirming to SP 800-56Crev1.
- 05/07/19: G.13 Instructions for Validation Information Formatting – Added the new "ENT" entry for 90B compliant modules per IG 7.18 *Entropy Estimation and Compliance with SP 800-90B*.
- 05/07/19: 7.14 Entropy Caveats – Added Additional Comment #5 to address the caveat required when a module generates random strings that are not keys, or generates both strings and keys. Added Additional Comment #6 to address the case where two entropy caveats can be applied, but only the stronger caveat is required.
- 05/07/19: IG 7.15 Entropy Assessment – Added a reference to the IG 7.18 *Entropy Estimation and Compliance with SP 800-90B*.
- 02/05/19: 2.1 Trusted Path – Updated to allow enforcement of the Trusted Path by applying cryptographic protection. Also, explains the applicability of FIPS 140-2 Sections 4.2 and 4.7 to the input/output requirements for keys and CSPs. Finally, updated documentation requirements when claiming the Trusted Path.
- 11/30/18: General: changed all references of Communications Security Establishment (CSE) to Canadian Centre for Cyber Security (CCCS).
- 11/30/18: G.2 Completion of a test report: Information that must be provided to NIST and CCCS – Added acceptance of draft certificate submissions from the CST lab to the CMVP in the RTF format (but still recommending DOC or DOCX formatting).
- 11/30/18: G.13 Instructions for Validation Information Formatting – Added a certificate caveat example to Section 4 starting with "When installed, initialized and configured…". Also updated footnotes in Section 10 for clarity on CVL references and removed the text "allowed in approved mode" since it is already understood that these algorithms are allowed in FIPS mode. Additionally, corrected the Triple-DES example in Section 10 to reference an approved certificate. Finally, updated Section 8 to require the tested processor(s) within the Configuration field on the Certificate with examples.
- 11/30/18: G.17 Remote Testing for Software Modules – Updated Resolution bullet 2 to specify that cloud environments are prohibited specifically for 3rd party vendors where the lab does not have control of the environment for testing.
- 11/30/18: 1.21 Processor Algorithm Accelerators (PAA) and Processor Algorithm Implementation (PAI) – Added two SHA extensions for Intel and AMD processors.
- 11/30/18: 9.4 Known Answer Tests for Cryptographic Algorithms – Added clarity on self-test requirements for algorithms that are symmetric that implement multiple modes, CVLs, KBKDF and vendor-affirmed. Added references to IG A.11 and IG A.15 for additional self-test requirements. Reiterated general self-test requirements for all approved algorithms and modes. Removed references to IG 9.1, 9.2 and 9.6. Removed the rationale in the Additional Comments.
- 11/30/18: 9.11 Reducing the Number of Known Answer Tests – Added a paragraph in the Resolution explaining: when an algorithm can or cannot take advantage of IG 9.11 provisions; how embedded algorithms fit into IG 9.11; and added an effective date of this guidance.
- 11/30/18: 14.5 Critical Security Parameters for the SP 800-90 DRBGs – Removed Additional Comment #2 as "full entropy", in this context, is an unreasonable expectation.
- 05/25/18: G.8 Revalidation Requirements – Removed the "2 year" limitation on 3sub revalidations, which stated that modules on the historical list could not be submitted as a 3sub if the

module's sunset date exceeded 2 years. Now, modules that are *Active* or *Historical* are eligible for Scenario 3 revalidation without this limitation.

- 05/25/18: 9.11 Reducing the Number of Known Answer Tests – Changed the "type" of the parameter that "remembers" that self-tests were run successfully on a specific environment, from a CSP, to something that is treated the same as a public key, in which case the integrity of this parameter is assured by the module.
- 03/27/18: G.8 Revalidation Requirements - Updated to add Alternative Scenario 3A (allowing vendors to submit module revalidations based on CVE patches).
- 03/27/18: G.13 Instructions for Validation Information Formatting - Updated to add clarification on how to document the binding module algorithm certificate. The same rules that apply to an embedding module also applies to a binding module.
- 03/27/18: 9.1 Known Answer Test for Keyed Hashing Algorithm – Updated to align with IG 9.4 and IG 9.11. Also, added clarification on HMAC self-testing with additional examples and comments.
- 03/27/18: 9.2 Known Answer Test for Embedded Cryptographic Algorithms – Updated to align with IG 9.11. Also, removed obsolete material (such as self-testing the embedded algorithms by means of the RNG KATs where the RNGs are no longer approved).
- 03/27/18: A.13 SP 800-67rev1 Transition – Updated to incorporate the latest requirements for the published SP 800-67rev2 standard; namely, a module has a limit of either 2^{20} or 2^{16} 64-bit data block encryptions with the same Triple-DES key (as opposed to 2^{32} or 2^{28} from SP 800-67rev1). The transition guidance is explained in this updated IG.
- 01/19/18: G.13 Instructions for Validation Information Formatting – Removed non-SP-800-38F compliant key wrapping methods from the allowed algorithm listing per SP 800-131A transition. Added allowed non-SP-800-38F compliant key *unwrapping* examples.
- 01/19/18: D.9 Key Transport Methods – Removed non-SP-800-38F compliant key wrapping methods from the allowed algorithm section per SP 800-131A transition. Added two additional comments for clarity on SP 800-131A transition and KTS implementations.
- 12/04/17: A.9 XTS-AES Key Generation Requirements – added text requiring the CST testing lab to document in TE.01.12.01 of the Test Report how the module meets IG A.9.
- 12/04/17: G.13 Instructions for Validation Information Formatting – added a caveat example when a module implements a DRBG but does not meet IG 7.14 and IG 7.15 requirements.
- 12/04/17: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – added bullet 4 in scenario 2 requiring the module to meet IG 7.15 for the strength of the IV.
- 12/04/17: G.8 Revalidation Requirements - added notes about which Scenarios should be included on the MIP list. Also updated Scenario 2 to allow for modules on the Historical list to be validated via this Scenario.
- 12/04/17: Revised IG for grammatical and formatting inconsistencies.
- 08/07/17: G.13 Instructions for Validation Information Formatting – added example for Truncated HMAC and moved virtual environment information to Section 10: Operational Environment.
- 08/07/17: 3.1 Authorized Roles – added Additional Comment to explain an exception to the rule that prohibited a CSP modification by a service called from an unauthenticated role at Levels 2+.
- 08/07/17: 14.1 Level of Detail When Reporting Cryptographic Services – clarified the requirement that all security services were listed in the Security Policy.
- 08/07/17: 14.4 Operator Applied Security Appliances – minor updates including addressing the confusing dates in the header.

- 08/07/17: 14.5 Critical Security Parameters for the SP 800-90 DRBGs – updated to remove the text that used to discuss the relationship between this IG and AS07.13 which is not relevant here. Also, made it clear that the FIPS 140-2 requirements on the “seed key” parameter was no longer applicable as none of the approved DRBGs used this parameter.
- 08/07/17: A.2. Use of non-NIST-Recommended Elliptic Curves – updated to allow new key sizes for RSA, DSA, and the corresponding key-establishment algorithms.
- 08/07/17: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – updated to include MacSec.
- 08/07/17: A.11 The Use and the testing Requirements for the Family of Functions defined in FIPS 202 – updated to reflect testing available in CAVS.
- 08/07/17: A.13 SP 800-67rev1 Transition – added transition dates that were originally only published in an email.
- 08/07/17: D.2 Acceptable Key Establishment Protocols – modified key entry description and added pre-loading of a key.
- 06/13/17: 9.9 Pair-Wise Consistency Self-Test When Generating a Key Pair – the scope is limited to the pair-wise consistency tests for keys used in RSA signature and RSA key transport schemes and removed “allowed” provision.
- 05/10/17: G.8 Revalidation Requirements – added definition for Scenario 2.
- 05/10/17: G.13 Validation Certificate Formatting – removed non-approved algorithms from the validation certificate, added examples for key establishment and included formatting instructions for virtual environments.
- 05/10/17: G.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths,
  7.5 Strength of Key Establishment Methods,
  A.11 The Use and the Testing Requirements for the Family of Functions defined in FIPS 202,
  D.8 Key Agreement Methods,
  D.11 References to the Support of Industry Protocols
  removed references to certificate formatting for non-approved algorithms.
- 05/10/17: 3.1 Authorized Roles – addressed relationship between authorized roles and operator authentication.
- 05/10/17: 3.4 Multi-Operator Authentication – resolve a conflict between IG 3.1 and IG 3.4.
- 05/10/17: A.8 Use of a Truncated HMAC – updated text, clarified examples and incorporated SP 800-107rev1 for all uses of a message authentication code.
- 05/10/17: D.9 Key Transport Methods – updated to explain that all approved key transport schemes shall use the KTS acronym and to allow an unwrapping of a key past the 2017 transition deadline.
- 04/25/17: D.12 Requirements for Vendor Affirmation to SP 800-133 – clarified some of the provisions.
- 04/17/17: 1.21 Processor Algorithm Accelerators (PAA) & Processor Algorithm Implementation (PAI) – add PAI where an accelerated function to support cryptographic algorithms is deemed to be the complete cryptographic algorithm and updated the list of known PAAs and PAIs.
- 02/06/17: 1.20 Sub-Chip Cryptographic Subsystems – updated 1.20 and 7.7 to resolve the asymmetric treatment of CM software and CM hardware.
- 02/06/17: 7.7 Key Establishment and Key Entry and Output – updated 1.20 and 7.7 to resolve the asymmetric treatment of CM software and CM hardware.
- 02/06/17: D.11 References to the Support of Industry Protocols – clarified items 2 and 3.
- 12/21/16: G.8 Revalidation Requirements – incorporated sunset validation policy and removed Scenario 2.

- 12/21/16: 1.8 - moved to W.13
- 11/15/16: G.13 Instructions for Validation Information Formatting – Added example for IG A.12, added HMAC-SHA-1-96 examples and corrected a KAS example.
- 11/15/16: 3.5 Documentation Requirements for Cryptographic Module Services – Updated to reduce the burden for documentation for some modules (e.g. IPSec VPN or PKCS#11 module).
- 08/01/16: G.9 FSM, Security Policy, User Guidance and Crypto Officer Guidance Documentation – added source code information is considered vendor-provided documentation and may be used in the FSM and/or Security Policy.
- 08/01/16: G.13 Instructions for Validation Information Formatting – FIPS algorithms shall be listed in alphabetical order; Other algorithms shall be listed with allowed algorithms in alphabetical order first, followed by non-approved algorithms in alphabetical order.
- 05/10/16: G.2 Completion of a Test Report: Information that must be provided to NIST and CSE - updated the file types, removed requirement for Report Overview.
- 05/10/16: G.13 Instructions for Validation Information Formatting – updated FIPS approved algorithm examples and non-approved random number generator description.
- 05/10/16: 14.5 Critical Security Parameters for the SP 800-90 DRBGs – removed Dual_EC_DRBG mechanism.
- 05/10/16: D.4 Requirements for Vendor Affirmation for SP 800-56B – updated RBG to DRBG, removed hash algorithm examples, fixed fonts for the equations and removed the exception phrase.
- 05/10/16: 7.6 – moved to W.5
- 05/10/16: 7.11 – moved to W.6
- 05/10/16: A.4 – moved to W.7
- 05/10/16: A.6 – moved to W.8
- 05/10/16: A.7 – moved to W.9
- 05/10/16: D.1 – moved to W.10
- 05/10/16: D.5 – moved to W.11
- 05/10/16: D.7 – moved to W.12
- 01/11/16: G.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths – update references to FIPS 186-4, define legacy use of 186-2 and other post RNG transition changes
- 01/11/16: 7.5 Strength of Key Establishment Methods - update references to FIPS 186-4 and other post RNG transition changes
- 01/11/16: 7.8 Key Generation Methods Allowed in FIPS Mode - update references to FIPS 186-4 and other post RNG transition changes
- 01/11/16: 7.12 Key Generation for RSA Signature Algorithm - update references to FIPS 186-4 and other post RNG transition changes
- 01/11/16: D.4 Requirements for Vendor Affirmation of SP 800-56B- update references to FIPS 186-4 and other post RNG transition changes
- 01/11/16: C.1 – moved to W.3
- 01/11/16: C.2 – moved to W.4
- 01/04/16: G.15 - moved to W.2
- 01/04/16: A.9 XTS-AES Key Generation Requirements – minor editorial change of the last sentence in Additional Comments.
- 12/22/15: 9.8 Continuous Random Number Generator Tests – introduced advanced options for continuous random number generation testing.

- 11/20/15: G.5 Maintaining validation compliance of software or firmware cryptographic modules – fixed a discrepancy in the wording of user porting rules. Now user affirmation is similar to that of vendors so that validation is only user-affirmed and does not imply a CMVP endorsement.
- 11/13/15: G.5 Maintaining validation compliance of software or firmware cryptographic modules – fixed a typo/poor text formatting - removed d) in 1) as it is just a continuation of c).
- 11/12/15: 7.16 Acceptable Algorithms for Protecting Stored Keys and CSPs – Fixed a typo – misspelled Tripe-DES.
- 11/12/15: G.5 Maintaining validation compliance of software or firmware cryptographic modules – fixed a logically inconsistent wording related to porting modules to a new untested operational environment.
- 11/12/15: 7.15 Entropy Assessment – introduced a transition period for third-party hardware entropy sources that cannot meet all documentation and test requirements.
- 09/15/15: 1.20 Sub-Chip Cryptographic Subsystems – Updated with multiple disjoint sub-chip subsystems and refinements of testing and documentation requirements.
- 08/07/15: 7.13 – moved to W.1.
- 08/07/15: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – Allow IPSec- and TLS 1.2-style of IV generation for AES-GCM cipher suites.
- 08/07/15: D.9 Key Transport Methods – Updated with more SP 800-38F examples.
- 08/07/15: G.1 Request for Guidance from the CMVP and CAVP – Updated contacts and set in writing requirement for requests.
- 08/07/15: G.2 Completion of a test report: Information that must be provided to NIST/CSE –Changed CSEC to CSE.
- 08/07/15: G.7 Relationships Among Vendors, Laboratories, and NIST/CSE –Changed CSEC to CSE.
- 08/07/15: G.9 FSM, Security Policy, User Guidance and Security Officer Documentation –Changed CSEC to CSE.
- 08/07/15: G.12 Post-Validation Inquiries –Changed CSEC to CSE.
- 08/07/15: G.13 Instructions for Validation Information Formatting – Updated with more examples.
- 01/15/15: A.5 Key/IV Pair Uniqueness Requirements from SP 800-38D – Allow TLS 1.2-style of IV generation for AES-GCM cipher suites.
- 04/25/14: 9.10 Power-Up Tests for Software Module Libraries – Editorial changes for additional clarity.
- 01/17/14: G.15 Validating the Transition from FIPS 186-2 to FIPS 186-4 – Editorial change.
- 01/17/14: 7.13 Cryptographic Key Strength Modified by an Entropy Estimate – Changed the minimum entropy requirement based on SP 800-131A transition effective 01-01-2014.
- 01/15/14: G.13 Instructions for Validation Information Formatting – Removed incorrect examples based on SP 800-131A transition effective 01-01-2014.
- 01/08/14: G.13 Instructions for Validation Information Formatting – Updated and corrected examples based on SP 800-131A transition effective 01-01-2014.
- 01/07/14: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Removed old report submission process information
- 01/07/14: G.3 Partial Validations and Not Applicable Areas of FIPS 140-2 – Minor editorial updates.
- 01/07/14: G.4 Design and testing of cryptographic modules – Updated "other associated documents" references.

- 01/07/14: G.13 Instructions for Validation Information Formatting – Updated examples based on SP 800-131A transition effective 01-01-2014.
- 01/07/14: G.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths – Updated based on SP 800-131A transition effective 01-01-2014.
- 01/07/14: G.15 Validating the Transition from FIPS 186-2 to FIPS 186-4 – Updated based on SP 800-131A transition effective 01-01-2014.
- 07/25/13: D.8 Key Agreement Methods – Resolution section has been updated.
- 07/25/13: D.9 Key Transport Methods – Resolution section has been updated.
- 06/07/13: G.8 Revalidation Requirements – Added Alternative Scenarios 1A and 1B.
- 12/21/12: G.5 Maintaining validation compliance of software or firmware cryptographic modules – Included reference to the impact to the generated key strength assurance when porting, and vendor Security Policy updates.
- 12/21/12: G.13 Instructions for Validation Information Formatting – For all embodiments, the OE shall be specified on the validation entry.
- 12/21/12: G.14 Validation of Transitioning Cryptographic Algorithms and Key Lengths – Addressed two-key Triple-DES requirements.
- 12/21/12: D.8 Key Agreement Methods – IG updated to address SP 800-135rev1
- 06/29/12: 7.7 Key Establishment and Key Entry and Output - References to key encryption changed to reference Key Establishment methods (e.g. Key Transport and Key Agreement).
- 06/20/12: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Added transition date for report submissions using CRYPTIK integrated review process.
- 06/20/12: 1.19 non-Approved Mode of Operation – Re-written to associate with existing clauses in FIPS 140-2 and this Implementation Guidance.
- 06/20/12: 7.12 Key Generation for RSA Signature Algorithm – Added Transition End Date.
- 06/20/12: 9.4 Known Answer Tests for Cryptographic Algorithms – Added Transition End Date in reference to NOTE4.
- 05/02/12: 1.19 non-approved Mode of Operation – Modified resolution when annotating non-approved services.
- 05/02/12: 1.7 Multiple Approved Modes of Operation – Modified resolution and additional comments text.
- 05/02/12: 1.2 FIPS Approved Mode of Operation – Modified resolution and additional comments text.
- 05/02/12: G.13 Instructions for Validation Information Formatting – Added annotation note regarding EFP/EFT when Section 4.5 is Level 3.
- 04/23/12: D.7 Requirements for Vendor Affirmation of SP 800-135rev1 – Transition end date of 06/23/2012 added and updated reference to SP 800-135 Revision 1.
- 04/23/12: D.6 Requirements for Vendor Affirmation of SP 800-132 – Algorithm validation acronym reference updated.
- 04/23/12: D.5 Requirements for Vendor Affirmation of SP 800-108 – Transition end date of 06/23/2012 added and algorithm validation acronym reference updated.
- 04/23/12: D.2 Acceptable Key Establishment Protocols – Completely revised as an umbrella IG for approved and allowed key establishment methods.
- 04/23/12: A.3 Vendor Affirmation of Cryptographic Security Methods – Removed caveat examples and replaced with referenced to IG G.13.

- 04/23/12: 9.6 Self-Tests When Implementing the SP 800-56A Schemes – IG expanded and clarifications added.
- 04/23/12: 9.4 Known Answer Tests for Cryptographic Algorithms – IG revised and expanded.
- 04/23/12: G.13 Instructions for Validation Information Formatting – Updated 2nd, 3rd, 4th, 8th, 9th and 10th bullets.
- 04/23/12: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Added clause to 3rd bullet regarding physical security test evidence traceability to DTR. Added 5th bullet regarding table templates.
- 04/23/12: G.1 Request for Guidance from the CMVP and CAVP – Updated CSEC contact.
- 07/15/11: G.3 Partial Validations and Not Applicable Areas of FIPS 140-2 – Modified in regard to new IG 11.1.
- 07/15/11: G.6 Modules with both a FIPS mode and a non-FIPS mode – Clarification that all implemented algorithms shall be referenced on the validation certificate.
- 07/15/11: G.8 Revalidation Requirements – Added security policy requirements for revalidation Scenarios 1 and 4.
- 07/15/11: G.13 Instructions for Validation Information Formatting – Added examples for CVL and KTS.
- 07/15/11: 1.4 Binding of Cryptographic Algorithm Validation Certificates – Added examples of an operational environment change.
- 07/15/11: D.1 CAVP Requirements for Vendor Affirmation of SP 800-56A – Modified the testing for primitives.
- 07/15/11: D.2 Acceptable Key Establishment Protocols – Modified the transition text and key agreement guidance.
- 05/11/11: G.13 Instructions for Validation Information Formatting – Corrected format of examples.
- 03/03/11: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Changes relative to the release of CRYPTIK v8.6b
- 03/03/11: G.13 Instructions for Validation Information Formatting – Changes relative to the release of CRYPTIK v8.6b
- 03/03/11: A.2 Use of Non-NIST-Recommended Asymmetric Key Sizes and Elliptic Curves – Updated for consistency with recent standards.
- 03/03/11: A.6 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard – Transition end date for FIPS 186-3 RSA is defined.
- 01/03/11: D.2 Acceptable Key Establishment Protocols – Change NIST CSD CT Group Contact to Mr. Tim Polk.
- 12/23/10: 9.6 Self-Tests When Implementing the SP 800-56A Schemes – Requirements changed.
- 08/02/10 G.8 Revalidation Requirements – For Scenarios 1 and 4 added clarification on required submission documents sent to the CMVP.
- 06/15/10: 5.4 Level 3: Hard Coating Test Methods – Removed reference to environmental conditions other than temperature and added Security Policy requirements.
- 06/10/10: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Updated submission and billing information requirements.
- 06/10/10: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Additional caveat examples.
- 06/10/10: 1.3 Firmware Designation – Updated platform versioning requirements if physical security is Level 2, 3 or 4.

- 06/10/10: 5.4 Level 3: Hard Coating Test Methods – Modified temperature testing limits and removed testing methods using solvents.
- 06/10/10: 7.5 Strength of Key Establishment Methods – Added reference to draft SP 800-131.
- 06/10/10: A.6 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard – Updated with transition end date for ECDSA.
- 04/09/10: A.6 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard – Updated with transition end date.
- 04/09/10 A.7 CAVP Requirements for Vendor Affirmation of NIST SP800-38E – Updated with transition end date.
- 03/19/10: 1.9 Definition and Requirements of a Hybrid Cryptographic Module - Updated the annotation for software-hybrid and, firmware-hybrid modules.
- 03/19/10: G.13 Instructions for completing a FIPS 140-2 Validation Certificate - Added examples for software-hybrid and firmware-hybrid modules.
- 01/27/10: 7.2 Use of IEEE 802.11i Key Derivation Protocols
  Guidance updated in regard to references to SP 800-56A and IG 7.10.
- 01/27/10: G.13 Instructions for completing a FIPS 140-2 Validation Certificate
  Removed PIV Middleware reference. Added XTS-AES annotation reference.
- 10/21/09: To align Implementation Guidance that is associated with underlying algorithmic standards referenced in FIPS 140-2 Annexes A, C and D, the following algorithm specific IGs have been moved to new IG Annex sections:

  Moved IG 1.5 to IG A.1, IG 1.6 to IG A.2, IG 1.10 to A.3, IG 1.11 to IG D.1, IG 1.12 t IG C.1, IG 1.13-15 to IG A..4-6, IG 7.1 to IG D.2 and IG 7.3 to IG C.2
- 10/20/09: G.1 Request for Guidance from the CMVP and CAVP – Updated contact information.
- 10/20/09: G.2 Completion of a test report: Information that must be provided to NIST and CSEC – Minor editorial changes.
- 10/20/09: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Added FIPS 186-3 and SP 800-56A annotation examples.
- 10/20/09: 1.11 CAVP Requirements for Vendor Affirmation of SP 800-56A – Added reference to the annotation requirements in IG G.13.
- 10/20/09: 1.15 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard – Added transition information and reference to the annotation requirements in IG G.13.
- 10/20/09: 7.1 Acceptable Key Establishment Protocols – Added transition information.
- 08/31/09: 7.1 Acceptable Key Establishment Protocols – Added references to DTLS.
- 08/04/09: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Added additional certificate annotation examples.
- 08/04/09: 1.10 Vendor Affirmation of Cryptographic Security Methods – Additional certificate annotation examples.
- 08/04/09: 1.15 CAVP Requirements for Vendor Affirmation of FIPS 186-3 Digital Signature Standard – Certificate annotation examples.
- 08/04/09: 7.1 Acceptable Key Establishment Protocols – For Key Agreement; removed the KDF specified in the SRTP protocol (IETF RFC 3711). For Key Transport; added reference to EAP-FAST and PEAP-TLS.
- 03/10/09: G.1 Request for Guidance from the CMVP – Updated NIST POC.

- 03/10/09: G.5 Maintaining validation compliance of software or firmware cryptographic modules – Updated references to firmware and hybrid modules.
- 03/10/09: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Updated examples.
- 03/10/09: 1.9 Definition and Requirements of a Hybrid Cryptographic Module – Updated to include hybrid firmware modules.
- 03/10/09: 7.1 Acceptable Key Establishment Protocols – For Key Agreement; added the KDF specified in the SRTP protocol (IETF RFC 3711) is allowed only for use as part of the SRTP key derivation protocol. For Key Transport; wrapping a key using the GDOI Group Key Management Protocol described in the IETF RFC 3547.
- 07/09/08: 1.10 Vendor Affirmation of Cryptographic Security Methods – Updated examples of certificate algorithm notation.
- 06/25/08: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Updated file naming convention syntax
- 05/22/08: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Updated reference for symmetric key wrapping annotation
- 02/07/08: 7.1 Acceptable Key Establishment Protocols – Updated AES Key Wrap URL.
- 01/24/08: G.2 Completion of a test report: Information that must be provided to NIST and CSE – Added reference to CMVP comments document.
- 01/24/08 G.8 Revalidation Requirements – Added reference to the CMVP FAQ in change Scenario 1.
- 01/16/08: G.13 Instructions for completing a FIPS 140-2 Validation Certificate – Added reference for listing multiple operating systems, and reference for symmetric key wrapping annotation.
- 01/16/08: 1.8 Listing of DES Implementations – Updated to reflect the ending of the DES transition period.
- 01/16/08: 7.1 Acceptable Key Establishment Protocols
- 01/16/08: 9.4 Cryptographic Algorithm Tests for SHS Algorithms and Higher Cryptographic Algorithms Using SHS Algorithms – Added RSA KAT requirements regarding the relationship of the exponents.
- 11/08/07: G.2 Completion of a test report: Information that must be provided to NIST and CSE – Added clarification on output type of draft certificate.
- 10/18/07: Updated links
- 07/26/07: Minor editorial updates.
- 06/26/07: 7.1 Acceptable Key Establishment Protocols – Updated to reflect the publishing of SP 800-56A.
- 06/26/07: G.8 Revalidation Requirements – Additional guidelines for determining <30% change for Scenario 3.
- 06/22/07: G.2 Completion of a test report: Information that must be provided to NIST and CSE - editorial changes for clarification.
- 06/22/07: G.8 Revalidation Requirements - editorial changes for clarification.
- 06/14/07: 3.1 Authorized Roles
- 03/19/07: Updated references to revision of SP 800-57
- 02/26/07: 1.6 Use of Non-NIST-Recommended Asymmetric Key Sizes and Elliptic Curves
- 02/23/07: 7.4 Zeroization of Power-Up Test Keys
- 01/25/07: G.8 Revalidation Requirements
- 01/25/07: 7.5 Strength of Key Establishment Methods

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