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

National Institute of Standards and Technology
Communications Security Establishment Canada

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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 Communications Security Establishment Canada (CSE), 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 CSE to questions posed by the CST Labs, vendors, and other interested parties. *Information in this document is subject to change by NIST and CSE.*

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 CSE by contacting the appropriate points of contact listed below. The complete list of NIST and CSE 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 CSE 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 CSE, 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 CSE Points of Contact:

- **National Institute of Standards and Technology – CMVP**
  CMVP@nist.gov
- **National Institute of Standards and Technology (NIST) – CAVP**
  CAVPask@nist.gov
- **Communications Security Establishment Canada (CSE) – CMVP**
  CMVP@cse-cst.gc.ca

Additional Comments

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

Applicable Levels:	*All*
Original Publishing Date:	*02/25/1997*
Effective Date:	*02/25/1997*
Last Modified Date:	*05/10/2016*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

What information should be submitted to NIST and CSE upon completion of the CST laboratory conformance testing in order for NIST and CSE 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 CSE 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>

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

   c. **Full Report with Assessments < PDF>**

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

      1. The RTF output from CRYPTIK **shall** be renamed to a DOC or DOCX file.
      2. **Shall** include PIV Card Application certificate number reference as applicable.

   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.

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

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 CSE points of contact:

- **NIST:** CMVP@nist.gov
- **CSE:** CMVP@cse-cst.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@cse-cst.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 CSE 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 publically 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. Note 1

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

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 a 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 the not originating vendor as specified on the validation certificate.

Note: 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.

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** list all Approved algorithms implemented in the module and **shall** list all non-FIPS Approved algorithms implemented in 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.

Additional Comments

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

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/CSE?

Resolution

The CST laboratories are accredited by NVLAP to perform cryptographic module validation testing to determine compliance with FIPS 140-2. NIST/CSE 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/CSE 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/CSE. 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/CSE to the vendor on the issue will be issued through the laboratory point of contact.

Additional Comments

G.8 Revalidation Requirements

Applicable Levels:	*All*
Original Publishing Date:	*08/17/2001*
Effective Date:	*08/17/2001*
Last Modified Date:	*06/07/2013*
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 crypto module or a new model based on an existing model.)

A cryptographic module that is changed under change Scenarios 1, 2 and 4 below, must meet ALL standards, implementation guidance and algorithm testing that were met at the time of original validation. A module does not need to continue to meet requirements that were removed or added since the time of original validation.

A cryptographic module that is changed under change Scenarios 3 and 5 below, must meet ALL standards, implementation guidance and algorithm testing in effect at the time of module report submission to the CMVP. 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 IGs. 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 AES prior to when AES testing was available. If the same cryptographic module is later submitted for revalidation under scenarios 3 and 5, this AES implementation to be used in an Approved mode of operation **shall** be tested and validated against FIPS 46-3, and the cryptographic module must meet the applicable FIPS 140-2 requirements, e.g., self-tests.

There are five possible **change** Scenarios:

1. Modifications are made to hardware, software or firmware components **that do not affect any FIPS 140-1 or 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.

   The CST laboratory **shall** review the vendor-supplied documentation and identify any additional documentation requirements. The CST laboratory **shall** also determine additional testing as necessary to confirm that FIPS 140-1 or FIPS 140-2 security relevant items have not been affected by the modification.

   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. 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 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 it unique versioning information and the differences between each module instance.

   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 submission at a minimum **shall** consist of an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf> and the _vendor.txt file. The ZIP file and files within the ZIP file **shall** follow all programmatic naming conventions and submitted to the CMVP using the specified encryption methods.

Please refer to CMVP FAQ Section 5.8 for other non-security relevant change requests.

Alternative Scenario 1A:

If there are no modifications to a module and the new module is a re-branding of an already validated OEM module. The CST laboratory **shall** determine that the re-branded module is identical to the OEM module. The test report 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.) and an updated Security Policy reflecting the new re-branded module. The Security Policy **shall** be technically identical to the OEM module.

The laboratory **shall** submit 1SUB submission. NIST CR is applicable. <u>A new validation certificate will be issued</u>.

Alternative Scenario 1B:

A CST laboratory has been contracted to perform a 1SUB submission for a validated module which the laboratory did not perform the testing which the module the 1SUB submission is based on.

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 with the non-security relevant changes.
b. The laboratory **shall** determine that the provided base documentation and implementation is identical to the base validated module.
c. The laboratory **shall** examine each modification and confirm that the change is non-security relevant.

   The laboratory **shall** determine that no other modifications, including unintentional, have been made that are not documented and verified to be non-security relevant.

   The laboratory **shall** submit 1SUB submission to the CMVP. NIST CR is applicable. <u>A new validation certificate will be issued with reference to the new laboratories NVLAP code</u>. The new entry will only reference the new version that reflects the non-security relevant change. The validation entry caveat will include the following text: *This validation entry is a non-security relevant modification to Cert. #nnnn*

2. No modifications are made to any hardware, software or firmware components of the cryptographic module. All version information is unchanged. Post validation, Approved security relevant functions or services for which testing was not available at the time of validation, or security relevant functions or services that were not tested during the original 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.

   The CST laboratory **shall** identify the assertions affected 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 are newly tested;
   c. Identify additional assertions that were previously tested but should now be re-tested; and
   d. Review assertions where specific Implementation Guidance (IG) was provided at the time of the original validation to confirm that the IG is still applicable.

The CST laboratory does not need to perform the regression test suite of operational tests since there is no change to the module.

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 newly tested and retested (selecting the re-tested option in CRYPTIK). A new security policy **shall** be provided for posting that updates the new services or functions that are now included in an Approved mode of operation. 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. If new algorithm certificates were obtained, they **shall** be listed. A new certificate will not be issued.

3. 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.

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.

When a cryptographic module is tested for revalidation from FIPS 140-1 to FIPS 140-2, the CST laboratory may re-use information contained in the FIPS 140-1 test report for the preparation of the FIPS 140-2 test report. The table found in Mapping FIPS 140-2 to FIPS 140-1 can be used to guide the tester.

Note: Included in the table are the ASs, TEs, VEs (AS2 for FIPS 140-2 and AS.1 for FIPS 140-1, etc.), security level(s), single chip (S), multi chip embedded (ME), multi chip standalone (MS), operational test (Op - x is used for the operational tests, r is used for regression test), applicable to FIPS 140-2 (M - match), and comment (describes the applicability of FIPS 140-1 results to FIPS 140-2, and may include info on the FIPS 140-2 requirement). The CST laboratory **shall** perform all the operational tests (TEs labeled with an x and an r in the Op field).

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

[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%).

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. A new certificate will be issued.

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. 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 security levels 2, 3 and 4, the submission of an updated Physical Security Test Report is mandatory.
   e. A new security policy **shall** be provided 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 it unique versioning information and the differences between each module instance.

   Each request will be handled on a case-by-case basis. The CMVP will accept such letters against cryptographic modules already validated to FIPS 140-1 and FIPS 140-2. A new certificate will not be issued[1].

   The submission at a minimum shall consist of an encrypted ZIP file containing the unsigned letter <pdf>, image of the signed letter <pdf> and the _vendor.txt file. The ZIP file and files within the ZIP file **shall** follow all programmatic naming conventions and submitted to the CMVP using the specified encryption methods.

   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.

5. If modifications are made to hardware, software, or firmware components **that do not meet 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.

If the overall Security Level of the crypto module changes 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.

[1] A certificate may be issued on a case by case basis.

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				

Additional Comments

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

Applicable Levels:	*All*
Original Publishing Date:	*05/29/2002*
Effective Date:	*05/29/2002*
Last Modified Date:	*08/07/2015*
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 FSM, Security Policy, User Guidance and Security 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 CSE **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 reforming 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 Security Officer Guidance:

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

Additional Comments

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.

Additional Comments

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 CSE 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 a 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.

Additional Comments

G.13 Instructions for Validation Information Formatting

Applicable Levels:	*All*
Original Publishing Date:	*06/28/2007*
Effective Date:	*06/28/2007*
Last Modified Date:	*05/10/2016*
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 character.[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.

[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.

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) **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 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.

   (Hardware Versions[2]: 5.2 [1] and 5.3 [2], Build 3; Firmware Versions[2]: 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.

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 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

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

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

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.

The module generates cryptographic keys 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.

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 modules 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 both the operating system(s) and the tested platform(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;**
Sun Solaris Version 2.6SE running on a Sun Ultra SPARC-1 workstation;
Microsoft Windows XP with SP2 running on an HP Pavilon 4.5;
HP-UX 11.23 running on an IBM RISC 6000RB2 (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**

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: **Crypto Unit (Hardware Version: 1.0) with Little OS® Version 3.7b**

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

Example: **Debian GNU/Linux 4.0 (Linux kernel 2.6.17.13) running on 4402-A ViPr Desktop Terminal (single-user mode)**

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

Example: **BlackBerry 8700c with BlackBerry OS Version 4.2**

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 modules 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.

If a module contains within it an already validated embedded cryptographic module, all Approved security functions that are used by the modules callable services and internal functions **shall** be annotated on the certificate (e.g. both those within the embedded module and in addition to the embedded module). Algorithms that are either in "dead code" or in the embedded module that are never called **shall** not be listed on the certificate.

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.

Examples: **AES (Cert. #1880);**
CKG[1] (vendor affirmed);
CVL[2] (Cert. #4);
DRBG[3] (Cert. #12);
DSA[4] (Cert. #200);
ECDSA[5] (Cert. #100);
HMAC (Cert. #23);
KAS[6] (Cert. #33, vendor affirmed);
KAS[7] (SP 800-56Arev2, vendor affirmed);
KAS[8] (SP 800-56Arev2 with CVL Certs. #24 and #32, vendor affirmed);
KAS[9] (SP 800-56B, vendor affirmed)
KBKDF[10] (Cert. #2);
KTS[11] (vendor affirmed);
PBKDF[12] (vendor affirmed);
RSA[13] (Cert. #133);
SHS (Cert. #23);
SHA-3[14] (Cert. #55);
Skipjack[15] (Cert. #45);
Triple-DES (Certs. #78 and #122);
Triple-DES MAC[16] (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] Cryptographic Key Generation; SP 800-133 and IG 7.8
[2] Component Validation List; CAVP CVL
[3] Deterministic Random Bit Generator; SP 800-90A
[4] FIPS 186-2 or FIPS 186-4
[5] FIPS 186-2 or FIPS 186-4
[6] Key Agreement Scheme; SP 800-56A (original publication)
[7] Key Agreement Scheme; vendor affirmed to SP 800-56A revision 2
[8] Key Agreement Scheme; vendor affirmed to SP 800-56A revision 2
[9] Key Agreement Scheme; vendor affirmed to SP 800-56B
[10] Key Based Key Derivation Function; SP 800-108
[11] Key Transport Scheme; SP 800-56B
[12] Password Based Key Derivation Function; SP 800-132
[13] FIPS 186-2 or FIPS 186-4
[14] FIPS 202
[15] Only decryption is Approved for Skipjack
[16] **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 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 is used for key wrapping. AES certs. #10 and #400 **shall** be listed separately on the Approved line.

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.

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.

10. **Other algorithms** - non-FIPS Approved or other cryptographic algorithms implemented in the cryptographic module. Other algorithms may be *allowed* in a FIPS Approved mode of operation and will be identified in the module Security Policy. A non-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-Approved implementations will include the caveat "*non-compliant*" so that it is clear the algorithm implementation **shall** not be used in an Approved mode of operation.

For DES and DES MAC, after May 19, 2007, these **shall** be listed as non-Approved without any additional caveat.

Examples: **AES**[1] **(non-compliant);**
Blowfish;
DES;
Diffie-Hellman[2]**;**
Diffie-Hellman[3] **(key agreement);**
Diffie-Hellman[4] **(CVL Certs. #5 and #6, key agreement);**
EC Diffie-Hellman[5] **(key agreement);**
EC Diffie-Hellman[6] **(CVL Cert. #4 with SP 800-56C, vendor affirmed, key agreement);**
MD5[7]**;**
RC4;
RSA[8] **(key wrapping);**
RSA[9] **(CVL Cert. #10, key wrapping);**
RSA Rabin-Williams (non-compliant)

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 (e.g. RSA) components, the two components **shall** be listed on the appropriate FIPS Approved and Other algorithms entry. The Security Policy **shall** indicate all uses of the algorithm.

Examples: **RSA (encrypt/decrypt)**
In this example, RSA is implemented and *only* used for encryption/decryption.

RSA (non-compliant)
Examples may include cases where RSA is implemented *only* less than 112 bits of strength, a KAT was not implemented or disallowed key sizes.

SHA-1 (non-compliant)
If *only* used for SigGen within the module.

AES (Cert. nnn; non-compliant)
In this example, AES is implemented, has an algorithm certificate, but the KAT was not implemented and fails the FIPS 140-2 requirements.

[1] Not validated by the CAVP or the requirements of FIPS 140-2 are not met (e.g. self-test).
[2] Only the untested shared secret computation primitive is implemented. This is allowed in an Approved mode of operation.
[3] No claim of compliance with SP 800-56A DLC or KDF computation. Allowed in an Approved mode of operation.
[4] Composite of two disjoint tested components (DLC and KDF) which forms key agreement. Allowed in an Approved mode of operation but the composite is not tested by the CAVP.
[5] No claim of compliance with SP 800-56A DLC or KDF computation. Allowed in an Approved mode of operation. **Shall** use the "EC Diffie-Hellman" annotation not the ECDH notation.
[6] Composite of two disjoint components (tested DLC and vendor-affirmed KDF) which forms key agreement. Allowed in an Approved mode of operation but the composite is not tested by the CAVP.
[7] 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.
[8] No claim of compliance with any testable component of SP 800-56B. Allowed in an Approved mode of operation.
[9] A component of SP 800-56B is tested but the composite is not tested by the CAVP. Allowed in an Approved mode of operation.

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)**" for that key establishment method as allowed in IG 7.5 – *Strength of Key Establishment Methods*. No caveat is required if the wrapping key used in key transport be equal or of greater strength than the wrapped key. 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: 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 and this IG for additional guidance and applicable caveats.

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)

EC Diffie-Hellman (shared secret computation provides 192 bits of encryption strength)[1]

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, RSA or EC Diffie-Hellman then only the range end points are indicated:

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

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 range end points are indicated and a caveat regarding the strength less than 112 bits:

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

[1] Do not claim "key agreement" when documenting a shared secret computation (not the full key-agreement scheme) using the FFC or ECC technology.

If a module implements a key establishment scheme of only a key size less than 112 bits of strength (for example 80 bits), then only the non-compliant caveat is required:

Diffie-Hellman (non-compliant)

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 800-56Arev2** and issued a CVL certificate, and the conditions are such that a reduction in the effective key strength may occur due to the sizes of the public and private keys used in the key agreement algorithm, then an example of the certificate annotation would be:

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

EC Diffie-Hellman (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 the key wrapping algorithms that are not compliant with **SP 800-38F** then this **shall** be annotated in the certificate. For example:

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

Triple-DES (Cert. #114, key wrapping; 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)

If AES MAC is implemented and not used for OTAR, it **shall** be specified as:

AES MAC (AES Cert. #2; 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 this field is not applicable, mark the field as N/A.

For non-Approved algorithms that have names similar to Approved security functions, the caveat "(non-compliant)" must be appended to alleviate misinterpretation.

Example: **AES (non-compliant)**
In this example, AES stands for Accelerated Encryption Scheme which is not AES specified in FIPS 197.

For non-approved random number generators, use the following names: NDRNG, if the generator is nondeterministic, and PRNG[1] if it is deterministic. The PRNG is non-compliant and cannot be used in the approved mode. The NDRNG may be used in the approved mode. If the NDRNG includes a deterministic component, this component is not annotated separately in the module's certificate.

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 Validation of Transitioning Cryptographic Algorithms and Key Lengths

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*01/01/2011*
Last Modified Date:	*01/11/2016*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE.01.12.01-02*
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 800-131A 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 800-131A?

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.

[1] Pseudo-Random Number Generator

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 and entered on the "Other algorithms" line of the CMVP validation certificate.

  - 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, 2 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 31st, 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 800-131A**.

- **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.

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.

Additional Comments

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:	
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

NIST Cost Recovery (CR) is currently levied on all 1A, 1B, 3 and 5 submissions. 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 Modules in Process 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 Modules in Process (MIP) list. The module can be automatically removed from On Hold and returned to the 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.

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 RNG may be used in a non-Approved mode. However the Approved RNGs 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 CAVS 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 Listing of DES Implementations

Applicable Levels:	*All*
Original Publishing Date:	*11/23/2005*
Effective Date:	*05/19/2007*
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.

Additional Comments

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
        - *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

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

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.

Additional Comments

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.

Additional Comments

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*[1]
Last Modified Date:	*09/15/2015*
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):

[1] The CMVP will continue to validate modules in the queue on 09/15/2015 in any of the four possible states (REVIEW PENDING, IN REVIEW, COORDINATION, and FINALIZATOIN) that are designed according to the version of IG 1.20 that became effective on 03/02/2015. No changes to the module design, documentation or test report will be required. Laboratories may submit requests for waivers to the CMVP for modules not in the queue on 09/15/2015 for validation according to the IG version of 03/02/2015 until December 31, 2016. The CMVP reserves the right to review such requests on a case by case basis and grant or deny them based on merit.

- 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
- The sub-chip cryptographic subsystem boundary **shall** be 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.

- The requirements for Cryptographic Key Management Key Entry and Output (FIPS 140-2 Section 4.7.4) **shall** be applicable at the defined sub-chip cryptographic subsystem boundary.
    - For sub-chip cryptographic subsystem boundary, the key establishment and key entry and output is considered **ED/EE** (see **IG** 7.7), therefore **AS07.29** and **AS07.30** **shall** apply with the following exception:
        - Transferring CSPs between two disjoint sub-chip cryptographic subsystems (see 4 of this IG) via a *Trusted Path* (**IG** 2.1).
    - In entering an entropy input to the sub-chip cryptographic subsystem boundary, **AS07.29** and **AS07.30** **shall** also apply with the same exception.
- 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, 2SUB 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. This porting guidance is not applicable when ported to other single-chip implementations where FIPS 140-2 Section 4.5 Physical Security is desired at Levels 2 or higher or if the overall Security Level changes (see **IG G.8**).

   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 (see **IG 7.11**) 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 of this IG) **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 CR 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. 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)

Applicable Levels:	*All*
Original Publishing Date:	*03/02/2015*
Effective Date:	*03/02/2015*
Last Modified Date:	*03/02/2015*
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.

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) functions to support complex cryptographic algorithms and how is it indicated on the validation certificate?

Resolution

If a cryptographic module is designed to utilize a processor chip that includes PAA, 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 capability, then the module **shall** be defined as a Software/Firmware-Hybrid Module Embodiment (CMVP **IG 1.9**).

- **Module versioning** information shall include the part number or version of the processor chip.
- **Operational Environment**: Tested as meeting Level 1 with <OS> running on <platform> with PAA.

Software/Firmware Module: If the software or firmware component of the module can support a cryptographic algorithm natively or by utilizing the PAA 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.

- **Algorithm certificates;** the accelerated algorithms shall be tested in both native execution and PAA execution.
- **Operational Environment**: Tested as meeting Level 1 with <OS> running on <platform> with PAA; <OS> running on <platform> without PAA

Known PAAs:

- Intel; Processors Xeon, Core i5 or i7: PAA = AES-NI
    - Accelerator sub-functions for AES implementations
- Oracle: Oracle SPARC processors based on SPARC Core S3 and later (e.g., SPARC T4, T5, M5, M6).
    - Accelerator sub-functions for AES, DES, SHA-1, SHA-256, SHA-512 and RSA

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 implementations and make a determination of whether it is a full cryptographic function or not.

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:	*12/23/2010*
Relevant Assertions:	*AS.02.17, AS.02.18 and AS.07.33*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

The implementation of a trusted path protects plaintext CSPs during the input or output from a cryptographic module when protections by cryptographic mechanisms are not employed (e.g. key establishment methods in FIPS 140-2 Section 4.7).

For example:

- **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).**

Question/Problem

How is a *trusted path* described when the connection (i.e. the source or destination of the path) is not under the direct control of the cryptographic module?

Resolution

If a cryptographic module utilizes the mechanisms of a trusted path at Level 3 or higher to input or output plaintext CSPs (i.e. cryptographic methods are not employed), in addition to the requirements specified in the FIPS 140-2 DTR, the Security Policy **shall** specify and document:

- characteristics of the trusted path,
- specify the controls that are used to maintain 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

The cryptographic module validation certificate **shall** provide a specific caveat regarding the use of the trusted path, e.g.

When operated in FIPS mode and utilizing a Trusted Path as specified in the Security Policy.

Additional Comments

Section 3 – Roles, Services, and Authentication

3.1 Authorized Roles

Applicable Levels:	*All*
Original Publishing Date:	*05/29/2002*
Effective Date:	*05/29/2002*
Last Modified Date:	*06/14/2007*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

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).

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.

Resolution

An operator **shall** assume an authorized role for all services utilizing Approved security functions with the following exceptions if cryptographic keys and CSPs are not created, modified, disclosed, or substituted:

– The Secure Hash Algorithms (SHA-1, SHA-224, SHA-256, SHA-384, and SHA-512) which are specified in *Secure Hash Standard*, FIPS 180-2 with Change Notice 1 dated February 25, 2004;

– The deterministic Random Number Generators which are specified in National Institute of Standards and Technology, *Recommendation for Random Number Generation Using Deterministic Random Bit Generators (Revised)*, **SP 800-90**A. If the RNG service is provided to an operator who is not required to assume an authorized role, the entropy source and seeding of the RNG **shall** be completely contained within the boundary of the cryptographic module and not subject to manipulation by any operator or service of the module;

– Processes used for authentication (e.g., symmetric algorithm secret sharing, asymmetric algorithms for authentication). The completion of the authentication mechanism **shall** be enforced (e.g., the module will cease to function, even after power up) until the authentication is completed before any generalized authenticated role for any services utilizing Approved security functions is allowed; and

– Show status, self-tests, zeroization or other services that do not affect the security of the module.

Additional Comments

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.

Additional Comments

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.

Additional Comments

3.4 Multi-Operator Authentication

Applicable Levels:	*Levels 2, 3 and 4*
Original Publishing Date:	*05/02/2012*
Effective Date:	
Last Modified Date:	*05/02/2012*
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 CO-role implements *identity-based authentication* while the User-role implements *role-based authentication* (Case1). In another example the CO-role implements *role-based authentication* while the User-role does not implement any *authentication* (Case2). Are these implementations FIPS 140-2 Section 4.3.3 compliant and if so, how are they addressed?

Note: For the above scenarios, it is assumed that Approved security services are included in each assumed role.

Resolution:

Following are the resolutions for the above two examples:

1. The first case (Case 1) is compliant to FIPS 140-2 Section 4.3.3 because *identity-based authentication* is a proper sub-set of *role-based authentication* and in all cases the operator must be authenticated to access an Approved security service(s). The section security level is the lower of the two methods described and is annotated as meeting Level 2.

   The CMVP provided test reporting tool (CRYPTIK) allows this scenario where FIPS 140-2 Section 4.3 is claimed at Level 2 and the "Identity Auth." option is selected in the Module Information form. This requires the testing laboratory to address both the Level 2 *role-based* assertions for the User and the Level 3 *identity-based* assertions for the CO while keeping the overall section annotated as Level 2.

   The Security Policy **shall** identify all roles, and for each role, the authentication method (i.e. either *role-based* or *identity-based*).

2. The second case (Case 2) is not compliant to FIPS 140-2 Section 4.3.3 Level 2 or above because while one role is authenticated, the other role is not. The section security level is annotated as meeting Level 1.

   In this case, FIPS 140-2 Section 4.3 is annotated at Level 1 and only Level 1 assertions are addressed.

   The Security Policy cannot claim operator authentication for any roles.

Additional Comments

IG 3.1 addresses authorized roles for Approved security services and non-authenticated services.

Some modules may appear to be Case 2, but the User role (unauthenticated) may in fact not be properly defined and may actually not exist. An example of this scenario is a router with the IP table established by the Crypto Officer: The CO authenticates to the module, sets up the IP table, and loads keys. Once done, packets stream in and are processed based on the IP table (encrypt, bypass or drop, and if encrypt – which keys to use). The packets may be misidentified as the unauthenticated User, but this is incorrect. The packets are simply processed data and as data (i.e. not a User), authentication does not apply.

3.5 Documentation Requirements for Cryptographic Module Services

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*07/25/2013*
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

Do the referenced requirements imply that 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

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,
2. services that use non-Approved security functions or mechanisms and therefore not available for use in an Approved mode,
3. 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), and
4. services that may perform actions that are not addressed in the above bullets. An example of such service would be "rotate an image 90 degrees clockwise."

The Security Policy **shall** list each service individually that belongs to groups 1 to 3, as per **AS14.07**.

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 *publically* 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 (i.e. callable service, function call, API, etc.) 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 as a primitive and **shall** not represent a group of services that invoke an operation and/or function that is performed by the module.

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 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 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 attached. 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 - References

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

Additional Comments

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

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.

Additional Comments

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.

Additional Comments

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.

Additional Comments

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.

Additional Comments

7.5 Strength of Key Establishment Methods

Applicable Levels:	*All*
Original Publishing Date:	*11/23/2005*
Effective Date:	*06/29/2005*
Last Modified Date:	*01/11/2016*
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 2, which provides comparable security strengths for the Approved algorithms.

Table 2: Comparable strengths

Bits of security	**Symmetric key algorithms**	**FFC (e.g., DSA, D-H)**	**IFC (e.g., RSA)**	**ECC (e.g., ECDSA)**
80	2TDEA[18]	L = 1024 N = 160	k = 1024	f = 160-223
112	3TDEA	L = 2048 N = 224	k = 2048	f = 224-255
128	AES-128	L = 3072 N = 256	k = 3072	f = 256-383
192	AES-192	L = 7680 N = 384	k = 7680	f = 384-511
256	AES-256	L = 15,360 N = 512	k = 15,360	f = 512+

[18] The 80 bit security of 2TDEA is based on the availability of 2^{40} matched plaintext and ciphertext blocks to an attacker (see ANSI X9.52, Annex B).

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 is 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 2TDEA and 3TDEA are specified in SP 800-67, and AES is specified in FIPS 197. 2TDEA is TDEA with two different keys; 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 ANSI X9.42 and 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 two-key Triple-DES key (80 bit strength) transported using a 2048 bit RSA key (112 bit strength).

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 (PKCS#1, 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 1024 and 2048 bit public key Diffie-Hellman with the private keys of 160 and 224 bits then the caveat would state “Diffie-Hellman (key agreement; key establishment methodology provides 112 bits of encryption strength; non-compliant less than 112 bits of encryption strength)". 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 4 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 4 provides recommendations that may be used to select an appropriate suite of algorithms and key sizes for Federal Government unclassified applications. A minimum of eighty bits of security **shall** be provided until 2010. 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: 2TDEA and 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 **FIPS186-4**.
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 4: 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 2010 (min. of 80 bits of strength)	2TDEA[21] 3TDEA AES-128 AES-192 AES-256	Min.: L = 1024; N =160	Min.: k=1024	Min.: f=160
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

[21] The 80 bit security of 2TDEA is based on the availability of 2^{40} matched plaintext and ciphertext blocks to an attacker (see **ANSI X9.52**, Annex B).

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:	*06/29/2012*
Relevant Assertions:	*General*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Question/Problem

Given different configurations of cryptographic modules, how can a modules 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*?

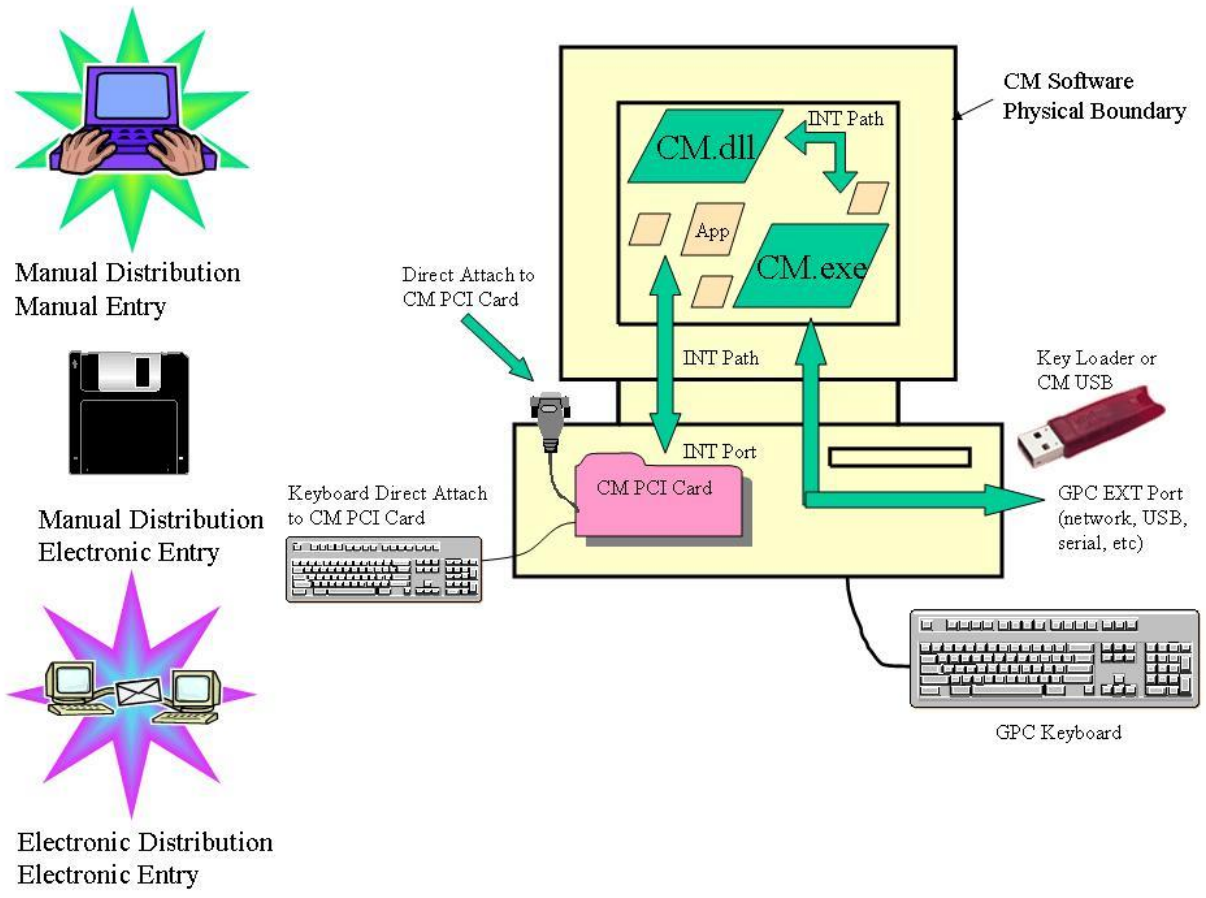
Resolution

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 140-1 or FIPS 140-2 *validated* Cryptographic Module
GPC:	General Purpose Computer
EXT:	a *validated* Cryptographic Module which lies *External* or outside of the boundary in regard to the reference diagrams CM software physical boundary. This also includes a standalone CM.
INT:	a *validated* Cryptographic Module which lies *Internal* or inside of the boundary in regard to the reference diagrams CM software physical boundary.
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		NA
CM Software[1] to/from App Software via GPC INT Path		**NA**
CM Software[1] to/from INT CM Hardware via GPC INT Path		**NA**
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 to/from GPC EXT Ports via GPC INT Path		**ED / EE**
INT CM Hardware from GPC Keyboard via GPC INT Path		**ED / 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

Legend:

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 plaintext at Levels 1 and 2.

Level 1 Software – General Purpose Operational Environment

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 Key Generation Methods Allowed in FIPS Mode

Applicable Levels:	*All*
Original Publishing Date:	*03/10/2009*
Effective Date:	*03/10/2009*
Last Modified Date:	*01/11/2016*
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

FIPS 140-2 Annex C, like all other Annexes to FIPS 140-2, exists in a draft form to allow updating as necessary. While the quote from FIPS 140-2 states that the Approved key generation methods are listed in Annex C, the annex itself lists the approved Random Number Generators (RNGs) and not the methods to derive a key from the generated random bits. How can this be reconciled and what additional processing may be applied within the cryptographic boundary of the module to the output of an RNG before this output becomes a cryptographic key?

Resolution

FIPS 140-2 Annex C is concerned with approved RNGs. Key generation is addressed in this IG.

The term "key generation" applies to the generation of secret and private keys to be used by the cryptographic algorithms. Many algorithms that are either approved or allowed in the FIPS-approved Mode of Operations, such as AES, Triple-DES, Skipjack, DSA, ECDSA, Diffie-Hellman (DH) and the Elliptic Curve Diffie-Hellman (ECDH) (including their MQV versions, MQV and ECMQV) require a secret or private key. The same is true for the RSA Signature and the RSA key wrapping algorithms, but the generation of keys is more complicated and will be defined in the **FIPS 186-4** standard; therefore, the generation of RSA keys will not be discussed in this Implementation Guidance. However, the prime generation seeds that will be required by **FIPS 186-4** standard to produce the secret primes *p* and *q* for RSA **shall** be generated according to this IG.

"Key generation" should not be confused with "key establishment", which is discussed in IG D.2. It is also different from using a key that has been entered into the module. Key generation refers to the generation of a cryptographic key or key pair "locally" within a module; the secret key of a symmetric algorithm or the public key of an asymmetric (public key) algorithm may subsequently be distributed to other parties, as appropriate. Key generation involves generating a random and/or unpredictable bit string and performing various operations that will turn it into the secret key or private key. While these operations could use certain values sent to the cryptographic module by another entity, the generating module is solely responsible for the key generation process, and, once generated, no other module knows the value of the key. (The module may later wrap this newly generated key and send it to another cryptographic module. This is outside the scope of this IG.)

To summarize, this Implementation Guidance is only concerned with the generation of a secret value K that will be used as 1) a secret key for a symmetric algorithm, such as AES or Triple DES, 2) a private key for an asymmetric (public key) algorithm, such as DSA, ECDSA, DH, ECDH, MQV or ECMQV, or 3) a prime generation seed for RSA. The secret value is sufficiently random for its use, although it may not be the direct output from a random number generator (see below).

To be used in FIPS mode, a secret value K can be any value of the form:

$$K = U \text{ XOR } V, \qquad (1)$$

where the components U and V are of the same length as K[1], are "independent" of each other, and U is derived, possibly using a *qualified post-processing* (see below), from the output of an approved RNG in the module that is generating K. In addition, each component may be a function of other values (e.g., U = F(U′), or V = F(V′)).

The security strength of the generated value K is equal to the larger of the security strengths of U and V. In general, the security strength of K is determined by the security strength of U, and the security strength of U is the minimum of the length of U (and K) and the security strength of the RNG used to generate U. Therefore, the length of U (and K), and the security strength of the RNG used to generate U **shall** meet or exceed the security strength required for K. However, a vendor can claim that the security strength of the generated value K is determined by the security strength of V if it can be demonstrated that V has a higher security strength than U.

The independence required for U and V is interpreted in the statistical sense; that is, knowing one of the values yields no information that can be used to derive the other one. The following are some examples of independent values. Note that the U component is determined by an approved RNG in all of these examples.

1. U is an output of an approved RNG within this module, and V is a constant. (Note, that if V is a string of binary zeroes, then K = U, i.e., the output of an approved RNG.)
2. U is an output of an approved RNG within this module, and V is produced by an approved or allowed key agreement scheme between this module and another module. Any seed used to instantiate an RNG in one module **shall** not intentionally be the same as the seed used in the other module. If the seeds are allowed to be the same, then a situation could occur, repeatedly, when the value of U is equal to that of V, and K would be equal to 0, each time.
3. U is an output of an approved RNG within this module, and V is a key wrapped or encapsulated by another module using an approved or allowed key transport method, and received and unwrapped by this module.
4. U is an output of an approved RNG within this module. V′ is either 1) a constant, 2) a value produced by an approved key agreement scheme between this module and another module, or 3) a key wrapped by another module using an approved or allowed key wrapping algorithm, and is received and unwrapped by this module. V is produced by hashing V′ using an approved hash function (i.e., V = H(V′)).
5. U′ is an output of an approved RNG within this module. V is either 1) a constant, 2) a value produced by an approved key agreement scheme between this module and another module, or 3) a key wrapped by another module using an approved or allowed key wrapping algorithm and received and unwrapped by this module. U is produced by hashing U′ using an approved hash function (i.e., U = H(U′)). Note that in this case, the length of U is the length of the output of the hash function, and the security strength of U is the minimum of the security strength of U′ and the length of the output of the hash function.
6. U′ is either 1) an output of an approved RNG within this module, or 2) the output of a hash function as specified in example 5 (i.e., U′ = H(U″)). V′ is either 1) a constant, 2) a value produced by an approved key agreement scheme between this module and another module, 3) a key wrapped by another module using an approved or allowed key wrapping algorithm and received and unwrapped by this module, or 4) the output of a hash function as specified in example 4 (i.e., V′ = H(V″)).

[1] If U and V are of different length, one can be padded with a string of 0's of the appropriate length to make them equal in length so that the XOR operation becomes meaningful.

However, both U′ and V′ **shall** not be the output of a hash function (i.e., the case where U = H(U″) and V = H(V″) is not allowed).

Either U′ or V′ or both of these values are truncated to produce the corresponding U or V value (i.e., U = U′ and V = T(V′); or U = T(U′) and V = V′; or U = T(U′) and V = T(V′)). The truncation may be performed either by dropping a certain number of the leftmost bits or a certain number of the rightmost bits from the bit strings that represents U′ or V′. Dropping bits on both sides or dropping any bits "in the middle" of the U′ or V′ strings is not permitted. The security strength of a truncated U′ value **shall** meet or exceed the security strength requirement for K. If the length of U′ is n bits, and it is truncated to k bits, the resulting security strength for U (the truncated U′ value) is the (original security strength of U′)*(k/n).

Note. The security strength of U may, in some rare cases, be higher, than what is calculated at the end of Example 6. However, if a vendor wants to claim a higher security strength for U, it is their responsibility to provide to the Security Technology Group at NIST the proof of their claim.

Finally, if K1 and K2 are two keys produced by formula (1) above, the module may derive a cryptographic key by concatenating K1 and K2:

$$K = K1 \,||\, K2. \qquad (2)$$

If K1 and K2 are calculated independently, then the security strength of K can be claimed to be the sum of the entropies of K1 and K2.

Qualified Post-Processing Algorithms

The U component described above uses the output of an approved RNG as an input parameter. As explained earlier, this RNG output may be further modified by applying a qualified post-processing algorithm *before* it is used to compute the secret value K. When post-processing is performed on RNG output, the output of the post-processing operation **shall** be used in place of any use of the RNG output.

Let M be the length of the output requested from the RNG 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 RNG, such that $N \leq M$. (The case $r_1 = r_2$ is permissible.) The post processor's output is the M-bit string $P_{F(r_1)}(r_2)$.

Note. Although some security strength is lost during post-processing, the loss is small enough to be ignored for the purposes of FIPS 140-2 validation.

The apparent complexity of this post-processing should not be of any concern to vendors and testing laboratories. The identical permutation (that is, no post-processing at all) is perfectly acceptable.

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 RNG. 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:

$$F(r_1) = \text{HMAC}(key, r_1) \bmod k \ ,$$

   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: $P_i(r_2) = (r_2$ 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, ‘02’ corresponds to 2, ‘03’ 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 effect a permutation. For example, $P_i(r_2)$ = Triple-DES(key_i, r_2) could be used on an RNG whose outputs were 64-bit strings. Similarly, $P_i(r_2)$ = AES(key_i, r_2) could be used to effect permutations on an RNG with 128-bit outputs.

   Suppose that there are ten 256-bit AES keys ($k = 10$). Let $F(r_1)$ = SHA256(r_1) mod 10. Then the post-processed output $P_{F(r_1)}(r_2)$ would be AES($key_{\text{SHA256}(r1) \bmod 10}$, 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 $F(r_1)$ = 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:

$$P_i(B_1||B_2|| \ldots ||B_{M/8}) = \text{SBOX}_i(B_1)||\text{SBOX}_i(B_2)||\ldots||\text{SBOX}_i(B_{M/8})$$

   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 $\text{SBOX}_{\text{parity}(r1)}(B_1)$ || $\text{SBOX}_{\text{parity}(r1)}(B_2)$ ||…|| $\text{SBOX}_{\text{parity}(r1)}(B_{16})$. 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. The concatenation step (formula (2)) must be performed last. An example of the danger of performing the concatenation earlier in the process, followed by other operations is the following: Let U be an n-bit-long output of the RNG with a security strength of n bits. Let V be an n-bit-long publically-known constant. Compute W as W = U || V. W is 2n bits long and has a security strength of n bits. Now, truncate the leftmost n bits of W to obtain key X (i.e., X now consists of the rightmost n bits, which is V, the constant). What we get is a constant. The module should not end up with a known constant and certainly the claim of the security strength of X = (security strength of W) * (n/2n) = n/2 bits would not apply to this constant.
2. The processes described in the "Qualified Post-Processing Algorithms" section must be performed prior to the operations performed individually on U and V in examples 1 through 6 in the Resolution section of this Implementation Guidance, since the latter processes may result in a change in the length of the processed value. The permutations must be applied first.
3. This Implementation Guidance only addresses key generation based, at least partially, on the output value from an approved RNG. It does not address the derivation (i.e., generation) of keys from other keys; this topic is addressed in SP 800-108. The CMVP will issue separate guidance for using SP 800-108.
4. The CMVP does not encourage the use of the Qualified Post-Processing Algorithms. In the vast majority of cases, the methodology shown in examples 1 through 6 should be sufficient to generate a secret value (e.g., a cryptographic key). However, post-processing, as described in this IG, is permitted.
5. It is the vendor's responsibility to demonstrate how their key generation method satisfies the requirements of this Implementation Guidance. The best way to do this is to map their method into one of the examples shown in this Implementation Guidance.
6. In order to make the language of this Implementation Guidance consistent with that of NIST Special Publication 800-90, the IG discusses the security strength (rather than the entropy) of the generated secret value K. The vendor is responsible for demonstrating that the Random Number Generator used in the generation of K received sufficient entropy for the purposes of its applications.

Test Requirements

Code review, vendor documentation review, and mapping of the module's key generation 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:	*08/07/2015*
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 filed, 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 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-generating NDRNG 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 RNG/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 RNG/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.

If the amount of entropy used to generate the module's cryptographic keys can be 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*.

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 RNG/DRBG inside the module's cryptographic boundary. The approved RNG/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.

    If the amount of entropy used to generate the module's cryptographic keys can be 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*.

(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.

    If the amount of entropy used to generate the module's cryptographic keys can be 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*.

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 NDRNG 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, **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 amount of entropy obtained actively to generate the module's cryptographic keys *is known to be* at least 112 bits and the module generates keys with an apparent strength greater than the amount of the available actively obtained entropy, then the following caveat **shall** be included in the module's certificate: *The module generates cryptographic keys whose strengths are modified by available entropy*.

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 IG 7.15.
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.

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:	*11/12/2015*
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.

[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.

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?

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 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 compete 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:	*11/12/2015*
Relevant Assertions:	*AS07.21 13*
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**.

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:	*09/22/2004*
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-SHA-2) 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

The following table summarizes the minimal KAT requirements:

KAT Requirements	Keyed Hashing algorithm	Underlying algorithm
Triple-DES MAC	No	Yes
HMAC-SHA-1	Yes	No
HMAC-SHA-224	Yes	No
HMAC-SHA-256	Yes	No
HMAC-SHA-384	Yes	No
HMAC-SHA-512	Yes	No

Rationale

Triple-DES MAC algorithms do not include much additional complexity over the underlying algorithmic engine (e.g. Triple-DES). However, keyed hashing algorithms such as HMAC-SHA-1 have additional complexity over the underlying algorithmic engine (e.g. SHA-1). A KAT performed on the Triple-DES algorithms adequately verifies their associated hashing algorithm. This is not the case for the keyed hashing algorithm using a SHS algorithm which implements several other functions in addition to the underlying SHS algorithm.

Additional Comments

As discussed in IG 9.3, if HMAC-SHA-1 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-SHA-1 or the underlying SHA-1 algorithm.

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:	*08/19/2004*
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, Triple-DES into RNGs). FIPS 140-2 requires that cryptographic modules that implement FIPS-approved algorithms used in FIPS mode perform a Known-Answer-Test (KAT) as part of their power-up self-tests. This requirement is also valid for the core cryptographic algorithm implementation. However, when the cryptographic module performs the 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 Triple-DES).

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.

Implementation of Triple-DES within an RNG such as ANSI X9.31 does not meet bullet #3 above since not all the Triple-DES cryptographic functions are tested (e.g. encrypt is performed in the RNG generation, not decrypt)

Implementation of SHA-1 within the FIPS 186-2 random number generation algorithms does not meet bullet #3 above since the hashing function is not completely performed

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.

Additional Comments

9.4 Known Answer Tests for Cryptographic Algorithms

Applicable Levels:	*All*
Original Publishing Date:	*08/19/2004*
Effective Date:	*08/19/2004*
Note4: Transition End Date	*12/31/2012*
Last Modified Date:	*06/20/2012*
Relevant Assertions:	*AS.09.08-09, 12-13, 16 and 18*
Relevant Test Requirements:	
Relevant Vendor Requirements:	

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 the symmetric-key algorithms that perform an invertible (encryption / decryption) operation? What are the minimum requirements placed on KATs for SHS algorithms and higher cryptographic algorithms implementing SHS algorithms so that they can be used in FIPS Approved mode of operation? What qualifies as a KAT for an asymmetric-key algorithm whose output does not vary for a given set of inputs? Which Approved algorithms allow the use of a pair-wise consistency test in lieu of a KAT? 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?

Resolution

Following is a subset of algorithm KAT specific implementation guidance:

- for symmetric-key algorithms, such as SKIPJACK, Triple-DES or AES,
  - 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;
  - 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.

Note1: The SKIPJACK algorithm can only be used for decryption in FIPS Approved mode so only a known-answer for decryption is required.

- if the module implements a SHS function, 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; and,
  - a KAT for SHA-384 is required if SHA-384 is implemented without SHA-512.

- if the module implements a HMAC function, a KAT for HMAC is required and **shall** be performed with the HMAC function using at least one of the implemented underlying SHS algorithms.

- if the module implements an Approved RNG or a DRBG algorithm then a KAT is required and **shall** be performed for each implemented algorithm. The values, such as seed and seed key that normally contribute to the "randomness" of an RNG or DRBG, **shall** be preset and used in the calculation of an output of the RNG or DRBG, which **shall** then be compared to the pre-computed result.

- 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-complaint scheme, it is not necessary to perform any additional known-answer tests for the implementations of the digital signature complaint with RSASSA-PSS or RSASSA-PKCS1-v1_5, even if these schemes are also supported by the module.

- for the RSA algorithm,

  - 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;

  - 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 with its target value.

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.

Note2: 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 pubic exponent values supported by the module.

Note3: an RSA KAT **shall** be performed at a minimum on any one Approved modulus size that is supported by the module.

Note4: 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) as represented in new test reports received after the **Transition End Date** of **December 31, 2012**.

- for algorithms whose output vary for a given set of inputs such as DSA and ECDSA, they **shall** be tested either,

  - as a KAT similar to RSA for signature generation or verification if the randomization parameter is fixed, or

  - as a *pair-wise consistency test*. This test does not require the comparison of the intermediate result (the generated signature) to a known value.

  Note5: 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.

  Note6: 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 where *GF(p)*, and binary field where $GF(2^m)$).

Additional Comments

This IG is consistent with IG 9.1 *Known Answer Test for Keyed Hashing Algorithm*.

IG 9.2 *Known Answer Test for Embedded Crypto Algorithms* applies.

Self-tests for **SP 800-56A** schemes are addressed in the IG 9.6.

If the module implements asymmetric key generation, the conditional (FIPS 140-2 Section 4.9.2) *pair-wise consistency test* is applicable. No power-up 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.

> Rationale: The purpose of a KAT is to perform a health-check of the cryptographic module to identify catastrophic failures or alterations of the module between power cycles and not that the implementation is correct. The implementation verification is performed during the cryptographic algorithmic testing and validation.

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 computating 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:	*12/22/2015*
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**-complaint 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 calculated 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 require a smaller false positive probability α than 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 establish formula (1) and show how it relates to the characteristics of a particular NDRNG one may consider a noise source with assessed min-entropy *H* and prove that the probability of generating *C* identical samples consecutively by such a source is at most $2^{-H(C-1)}$. Let $p_1, p_2, \ldots, p_k$ be the probabilities of the possible outcomes from sampling the NDRNG, with $p_1 \geq p_2 \geq \ldots \geq p_k$. 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

$$P = p_1^C + p_2^C + \ldots + p_k^C = p_1 p_1^{C-1} + p_2 p_2^{C-1} + \ldots + p_k p_k^{C-1}$$

$$\leq p_1 p_1^{C-1} + p_2 p_1^{C-1} + \ldots p_k p_1^{C-1} = (p_1 + p_2 + \ldots p_k) p_1^{C-1} = p_1^{C-1} =$$

$\left(2^{-H}\right)^{C-1} = 2^{-H(C-1)}$, by the definition of min-entropy.

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 sufficient strength for generating 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:	*07/25/2013*
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 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

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 asymmetric-key cryptography.

2. **Choice of the Pair-Wise Consistency Self-Test**

   If it is known at the time when the (private, public) key pair is generated how this key pair will be used, 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 had been generated for use in calculation and 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 had been generated to be used in an Approved or Allowed asymmetric-key key establishment scheme, such as the RSA key wrapping, Diffie-Hellman, EC Diffie-Hellman, or ECMQV, 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 digital signature or key establishment applications then either pair-wise consistency self-test described in **AS09.31** or **AS09.33** may be performed.

Additional Comments

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**.

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 publically 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.

Additional Comments

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:	*11/15/2001*
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.01.06, 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**).

- 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, 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).

Additional Comments

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:	*11/25/2009*
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 a FIPS 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 at 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 module vendor 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 a FIPS 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:	*05/10/2016*
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 800-90**A 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 Requirements

1. The **SP 800-90A** requires that the internal state **shall** be protected at least as well as the intended use of the pseudorandom output bits requested by the consuming application.

   The DRBG internal state **shall** be contained within the DRBG mechanism boundary and **shall** not be accessed by non-DRBG functions or by non-DRBG functions or other instantiations of that or other DRBG.

   TE.01.15.01 **shall** specify how the above requirements are met.

2. **AS.07.13: 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.07.13.01 shall provide information about the source of the entropy input and nonce . The test report shall provide information about the security strength(s) supported by the DRBG and how the requirements from SP 800-90A Table 2, Table 3 and Table 4 are met.

   In the case of the CTR_DRBG the test report **shall** indicate if a derivation function is used during the instantiation and reseeding.

Additional Comments

1. **AS.07.23: A seed key, if entered during key generation, shall be entered in the same manner as cryptographic keys.**

   Does not apply to an implementation of the **SP 800-90**A DRBG as no seed key is provided by the consuming application.

2. **AS.07.14: If a seed key is entered during the key generation process, entry of the key shall meet the key entry requirements specified in Section 4.7.4.**

   Does not apply to an implementation of the **SP 800-90**A DRBG as no seed key is provided by the consuming application.

3. **AS.07.09: The seed and seed key shall not have the same value.**

   Does not apply to an implementation of the **SP 800-90**A DRBG.

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.

Additional Comments

A.2 Use of non-NIST-Recommended Asymmetric Key Sizes and Elliptic Curves

Applicable Levels:	*All*
Original Publishing Date:	*09/12/2005*
Effective Date:	*09/12/2005*
Last Modified Date:	*03/03/2011*
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 implementations of DSA, RSA and ECDSA for Approved asymmetric key sizes and elliptic curves. The algorithm standards may allow the use of other non-Approved key sizes and curves.

FIPS 140-2 Glossary of Terms:

Approved: FIPS-Approved and/or NIST-recommended.

Question/Problem

Does the CMVP allow the use of non-Approved DSA and RSA key sizes and ECDSA curves in a FIPS Approved mode of operation? If so, what are the requirements for these to be used in FIPS Approved mode?

Resolution

The CMVP does not allow the use of non-Approved DSA and RSA key sizes. Only those key sizes specified in the respective standards in FIPS 140-2 Annex A can be used in a FIPS Approved mode of operation. Smaller *or* larger key sizes implemented and not specified in the respective standards in FIPS 140-2 Annex A can only be utilized in a non-FIPS Approved mode of operation.

The CMVP allows the use of non-Approved ECDSA curves in a FIPS Approved mode of operation providing:

– an algorithm implementation **shall** have been tested and validated for at least one Approved curve (ECDSA),

– the algorithm implementation **shall** use Approved message digest algorithms,

– the security policy **shall** list all Approved and non-Approved curves that are implemented, and,

– the security policy shall indicate the associated security strength for all non-Approved curves that are implemented.

Additional Comments

All Approved key and modulus sizes **shall** be tested and validated by the CAVP and all applicable FIPS 140-2 requirements **shall** be met in order for the algorithm implementation to be used in a FIPS Approved mode of operation.

For Approved ECDSA curves, the value of f is commonly considered to be the size of the private key (Table 2, **SP 800-57**). From this value the strength can be determined.

Refer to **IG 1.4** *Use of Cryptographic Algorithm Validation Certificates* for guidance on operational environment requirements.

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:	*04/23/2012*
Relevant Assertions:	*AS.01.12*
Relevant Test Requirements:	*TE01.12.01*
Relevant Vendor Requirements:	*VE.01.12.01*

Background

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 or allowed for use in an Approved mode of operation. 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. The vendor **shall** provide a validation certificate for all Approved cryptographic algorithms. The tester **shall** verify that the vendor has provided validated certificate(s) as described above.

Questions/Problems

For Approved security functions, Approved random number generators or Approved key establishment techniques specified in FIPS 140-2 Annexes A, C, and D, if CAVP testing is not available, 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?

Resolution

As new methods are published and Approved, they will be added to the relevant FIPS 140-2 Annexes. The annexes may reference FIPS 140-2 Implementation Guidance for methods *allowed* in lieu of Approved methods.

1. If a new Approved methods (e.g. NIST FIPS, Special Publication, etc) are added to the Annexes which provides a new method that did not exist before (e.g. key establishment), until such time that CAVP testing is available for the new method, the CMVP would continue to:

   – allow methods as provided by guidance (untested and listed as non-Approved but *allowed* in FIPS mode); and

   – allow the vendor to implement the new Approved method (untested, listed as Approved and allowed in FIPS mode with the caveat *vendor affirmed*).

   Once testing is deployed by the CAVP to the testing laboratories:

   a. a transition period (e.g. n months) would be provided for new test reports received by the CMVP:

      ▪ during the transition period, a new Approved method would either be listed as Approved with a reference to a CAVP validation certificate, or as *vendor affirmed* if testing was not performed; and

- allow continued implementation of methods as provided by guidance (untested and listed as non-Approved but *allowed* in FIPS mode).

b. 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 FIPS mode of operation.

c. 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, this change can be submitted under IG G.8 Scenario 1[1]. If the module is changed, this change can be submitted under IG G.8 Scenarios 1, 3 or 5 as applicable [26].

2. If a new Approved methods (e.g. NIST FIPS, Special Publication, etc) are added to Annexes which provides a new method commensurate with those that currently exist (e.g. an new symmetric key algorithm, RNG, DRBG, hash, digital signature, etc), until such time that CAVP testing is available for the new method, the CMVP would:

   – allow prior Approved methods (tested and listed as Approved); and

   – allow the vendor to implement the new Approved method (untested, listed as Approved and allowed in FIPS mode with the caveat *vendor affirmed*)

   Once testing is deployed by the CAVP to the testing laboratories:

   a. a transition period (e.g. n months) would be provided for new test reports received by the CMVP:

   - during the transition period, a new Approved method would either be listed as Approved with a reference to a CAVP validation certificate, or as *vendor affirmed* if testing was not performed.

   b. 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 FIPS mode of operation.

   c. the vendor could optionally follow up with testing of prior un-tested vendor affirmed methods and if so, the reference to *vendor affirmed* removed and replaced by reference to the algorithm certificate. If there are no changes to the module, this change can be submitted under IG G.8 Scenario 1[25]. If the module is changed, this change can be submitted under IG G.8 Scenarios 1, 3 or 5 as applicable [2].

3. 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 Federal Register notice would be published with a transition period to allow migration from the no longer Approved or allowed method.

[1] This is a special case where IG G.8 Scenario 2 would not apply.
[2] If the change is security relevant either to the module or the method, then IG G.8 Scenarios 3 or 5 would be applicable depending on the extent of the changes. If for example there was a non-security relevant change to the module not associated with the security method implementation, IG G.8 Scenario 1 could be applicable.

4. For all Approved methods, all applicable FIPS 140-2 requirements **shall** be met (e.g., key management, self-tests, etc.)

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

Until the FIPS 140-2 DTR and CRYPTIK tool are updated and released, please provide the following information under **VE.01.12.01** and **TE.01.12.01**.

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: *FIPS or NIST Special Publication #*). 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:	*08/07/2015*
Relevant Assertions:	
Relevant Test Requirements:	
Relevant Vendor Requirements:	

Background

SP 800-38D was added to FIPS 140-2 Annex A on December 18, 2007. IG A.4, which was added on December 18, 2007, specifies the requirements to claim the vendor affirmation to **SP 800-38D**. IG A.4 states that sections 8 and 9 of **SP 800-38D** are out of scope for CAVP. However, these sections of **SP 800-38D** are applicable to the CMVP cryptographic module testing and validation, and the probabilistic "uniqueness" of the (key, IV) pair is critical to the security of a cryptographic module that implements the AES Galois/Counter Mode (GCM). Specifically, **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 the requirements of Section 8 of **SP 800-38D**?

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 RFC 5116 and 5288 provisions;
   b. IPSec-v3 protocol, as described in RFC 6071, 7296 and 5282.

   The following are additional specific requirements for each acceptable protocol for the purposes of FIPS 140-2 validation.

   TLS protocol IV generation

   If an IV is constructed according to the TLS protocol, then this IV may only be used in the context of the AES GCM mode encryption within the TLS protocol.

   If the vendor claims that the IV generation is in compliance with the TLS specification and only for use within the TLS protocol then the module's Security Policy and the Validation Test Report must explicitly state the module's compliance with **SP 800-52** and its compatibility with the specified versions of TLS in Section 4 of RFC 5288. The operations of one of the two parties involved in the TLS key establishment scheme **shall** be performed *entirely within* the cryptographic boundary of the module being validated.

The TLS protocol implementation **shall** ensure that the keys for the client and server negotiated in the handshake process (client_write_key and server_write_key) are not identical. This **shall** be verified by the testing laboratory in one of the following two ways:

> the 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
>
> the laboratory **shall** check the TLS protocol implementation that relies on the module being validated against an *independently developed instance* of TLS, such as the many TLS client test sites on the Internet, and verify that a session is successfully established, which implies that the client_write_key and server_write_key are derived correctly.

Furthermore, the construction of the 64-bit nonce_explicit part of the IV **shall** be deterministic, e.g. a counter (see Additional Comments below for the explanation of why a random field may not be used) and satisfy one of the IV restoration conditions defined later in this Implementation Guidance.

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.

IPSec protocol IV generation

If an IV is constructed in compliance with the IPSec protocol, then this IV may only be used in the context of the AES GCM mode encryption within the IPSec protocol.

If the vendor claims that the IV generation is in compliance with the IPSec specification and only for use within the IPSec protocol then the module's Security Policy and the Validation Test Report must explicitly state the module's compliance with RFC 6071 with an additional provision that an IKEv2 protocol (RFC 7296) **shall** be used to establish the shared secret SKEYSEED from which the AES GCM encryption keys are derived. The operations of one of the two parties involved in the IKE key establishment scheme **shall** be performed *entirely within* the cryptographic boundary of the module being validated.

The IPSec protocol implementation **shall** ensure that the two keys established by IKEv2 for one security association (one key for encryption in each direction between the parties) are not identical. This **shall** be verified by the testing laboratory in one of the following two ways:

> the laboratory shall check the module implementation and verify that the module compares the two keys established by IKEv2 for one security association (one key for an encryption in each direction between the parties) and aborts the established security associations if the two keys are identical;
>
> OR
>
> the laboratory **shall** check the IPSec protocol implementation that relies on the module being validated against an *independently developed instance* of IPSec with IKEv2, and verify that a communication session between the two parties is successfully established, which implies that the two keys for each association are derived correctly.

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 requires four octets of salt followed by eight octets of deterministic nonce. 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. a counter (see Additional Comments below for the explanation of why a random field could not be used there) and satisfy one of the IV restoration conditions defined later in 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.

2. The IV may be generated internally *randomly*. In this case,

   - The generation **shall** use an Approved DRBG and
   - The DRBG seed **shall** be generated internally from data provided by a cryptographically strong random source.
   - 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.

3. If an AES GCM Key is generated either internally or externally and the IV is constructed 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 alphanumerical characters, each having at least 62 values, then this is also sufficient. Even though not all possible names are equally likely to be used, just 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 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.)

Additional Comments

1. The goal behind the limitations defined in this Implementation Guidance is to include the practical cases when the total number of blocks encrypted with the same key can be as large as 2^{32}. When the module uses a deterministic IV construction, the name field provides the 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 modules that use 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}.
2. As stated in this Implementation Guidance, if an 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^{-33}. 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}.
3. 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.
4. If any of the IV generation methods listed in this Implementation Guidance does not include a claim of full compliance with the acceptable peer-to-peer protocols shown above, the external generation of the IVs is not allowed when the IV is used for AES GCM encryption. However, when an IV is used for the decryption, the responsibility for the IV generation lies with the party that performs the AES GCM encryption therefore none of the requirements in this guidance are applicable.

A.6 moved to W.8

A.7 moved to W.9

A.8 Use of HMAC-SHA-1-96 and Truncated HMAC

Applicable Levels:	*All*
Original Publishing Date:	*03/02/2015*
Effective Date:	*03/02/2015*
Last Modified Date:	*03/02/2015*
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. HMAC-SHA-1 uses SHA-1 and has a MAC size of 160 bits.

Some internet protocols such as IPsec and SSH use HMAC-SHA-1 and truncate the MAC to 96 bits. This algorithm is called HMAC-SHA-1-96.

Question/Problem

Can HMAC-SHA-1-96 be used in Approved mode?

Resolution

HMAC-SHA-1-96 is an *allowed* algorithm in an Approved mode if the underlying HMAC is an Approved security function.

HMAC-SHA-1-96 **shall not** be used where the FIPS 140-2 standard, Annexes, and IGs explicitly require the use of an Approved security technique. An example of such a requirement would be the use of an Approved security technique when performing the software/firmware load test.

Additional Comments

1. The HMAC standard FIPS 198-1 specifies that the key for HMAC-SHA-1 is at least 80 bits of strength. Any key for HMAC-SHA-1 and HMAC-SHA-1-96 that is less than 112 bits of strength shall not be used in Approved mode.

2. The component of HMAC-SHA-1-96, HMAC-SHA-1, **shall** have CAVP algorithm validations.

HMAC-SHA-1-96 **shall** be listed on the certificate and HMAC-SHA-1-96 shall be documented in the Security Policy.

Examples:

HMAC-SHA-1-96 (HMAC Cert. nnn) {allowed in FIPS mode}

HMAC-SHA-1-96 {not allowed in FIPS mode}

A.9 XTS-AES Key Generation Requirements

Applicable Levels:	*All*
Original Publishing Date:	*12/28/2015*
Effective Date:	*07/01/2016*
Last Modified Date:	*01/04/2016*
Relevant Assertions:	
Relevant Test Requirements:	
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 **shal**l 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.

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.

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:	
Transition End Date:	
Last Modified Date:	*07/08/2015*
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?

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 CAVS 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. The KAS certificates showing compliance with the original version of **SP 800-56A** will continue to be issued until a further notice.

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 Conformation, 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. Once CAVS testing to **SP 800-56A-rev2** becomes available, and after passing of a suitable transition period, there will be no need to issue any more KAS certificates with testing performed to the original version of **SP 800-56A**.

Furthermore, there will be no more CVL certificates issued to show that the shared secret computation was performed as required in **SP 800-56A** (whether the original version of the standard or **SP 800-56A-rev2**.) The reason being is that with the addition of all of the key derivation functions from **SP 800-135rev1** and **SP 800-56C** to **SP 800-56A-rev2**, there is no good reason to implement the shared secret computation as in **SP 800-56A-rev2**, but to not implement at least one of the **SP 800-56A-rev2** key agreement schemes in its entirety. Therefore, in order to receive the credit for the **SP 800-56A-rev2**-compliant shared secret computation the vendor will have to obtain a KAS certificate.

Until testing to **SP 800-56A-rev2** is available, vendors may claim vendor affirmation to **SP 800-56A-rev2** along with the applicable key derivation function CVL certificates.

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.2 Acceptable Key Establishment Protocols

Applicable Levels:	*All*
Original Publishing Date:	*02/10/2004*
Effective Date:	*02/10/2004*
Last Modified Date:	*04/23/2012*
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 five 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 Annex D of FIPS 140-2 and IG 7.8.

Key entry is a method for key establishment where the key is manually or electronically entered into the module. The term "key entry" refers to both plaintext and encrypted entry of the key using a key transport method. The rules for key transport for key entry (and output), see IG D.9. IG 7.7 provides further information about mapping key entry and output states to the FIPS 140-2 requirements for *Cryptographic Module Ports and Interfaces* (Section 4.2), *Key Establishment* (Section 4.7.3) and *Key Entry and Output* (Section 4.7.4).

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**.

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 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:	*10/21/2009*
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 800-56**A (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 (IKE) protocol,

- Internet Key Exchange protocol, version 2 (IKEv2),
- Transport Layer Security (TLS) protocol, versions 1.0, and
- Datagram Transport Layer Security (DTLS) protocol, version 1.0.

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 therefore is not tested by the CAVS), 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

CAVP

Example of the Description/Notes field of a **SP800-56A** algorithm validation entry where the explicit public key validation of an ephemeral public key is not required for algorithm validation based on this IG (and therefore is not tested by the CAVS):

ECC: (ASSURANCES <5.5.2 #3>

ASSURANCE 5.6.2.3: requirement is not required for algorithm validation, based on IG 7.10)
SCHEMES [EphemeralUnified (KARole(s): Responder)
(EC: P-256 SHA256)]
SHS Val#650 DRBG Val#1

CMVP

If a cryptographic module includes a key agreement scheme whereby the recipient of an ephemeral public key omits the explicit 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 IG.

D.4 Requirements for Vendor Affirmation of SP 800-56B

Applicable Levels:	*All*
Original Publishing Date:	*07/15/2011*
Effective Date:	*07/15/2011*
Transition End Date:	
Last Modified Date:	*05/10/2016*
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

To claim *vendor affirmation* to **SP 800-56B**, what sections of the publication need to be addressed?

Resolution

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 $M^e \pmod N$, while the RSA decryption known answer test consists of checking the value of $M^d \pmod N$, 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*
Transition End Date:	
Last Modified Date:	*04/23/2012*
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

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

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. No self-tests are required to claim *vendor affirmation* to **SP 800-132**.

D.7 moved to W.12

D.8 Key Agreement Methods

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	
Last Modified Date:	*07/25/2013*
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 currently *six scenarios* for the full or partial **key agreement schemes** that are allowed in an Approved FIPS mode of operation. Of the following six scenarios, the first four scenarios apply when a key is established (i.e. key agreement) and 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** with a KDF specified in this IG or a SP)

4. non-Approved but *allowed* legacy implementation

5. Approved (compliant with **SP 800-56A)** primitive only

6. non-Approved (not compliant with **SP 800-56A**) primitive only

NIST has specified key agreement schemes in **SP 800-56A** using Discrete Logarithm Cryptography (DLC) and in **SP 800-56B** using Integer Factorization Cryptography (RSA). *The latter is a new technology and at this time it is only allowed in the Approved mode of operation if fully compliant with the key agreement provisions of* ***SP 800-56B****.* The remaining part of this IG deals with the details of the DLC-based key agreement schemes.

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 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**.

Scenario 3 addresses any implementations of DLC key agreement schemes which do not completely conform to **SP 800-56A** but claim conformance to **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**. 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**, 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.

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** 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.

Note that all implementations are subject to the transition rules of **SP 800-131A**.

Additional Comments

This IG does not address key establishment techniques other than those used for key agreement.

The key establishment method(s) used by the cryptographic module **shall** be listed under **AS.07.21**.

FIPS 140-2 certificate annotation examples for the key agreement schemes can be found in IG G.13.

D.9 Key Transport Methods

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*07/08/2015*
Transition End Date:	***12/31/2017**– See Below*
Last Modified Date:	*07/08/2015*
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?

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 800-57, Part 1** and **SP 800-131A**.

> **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.

[1] The state existing between two entities when they share at least one cryptographic key.

- Employing an appropriate DLC[1]-based key agreement scheme (to agree upon a key wrapping key), together with a key wrapping algorithm. Approved key transport methods of this type are specified in **SP 800-56A**.
- Employing an Approved IFC[2]-based key transport scheme (i.e., RSA), as specified in **SP 800-56B**.
- 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 will be provided in **SP 800-38F**.

  SP 800-38F presents several key wrapping mechanisms; all of which are currently Approved. One method is to use 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 to use any Approved symmetric encryption mode: AES ECB, AES CBC, Triple-DES TECB, etc. together with an Approved authentication method (for example, HMAC or AES CMAC). The entire wrapped message **shall** be authenticated.

  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. These methods will only be allowed for use in the approved mode through December 31, 2017. If any of the algorithms shown here are used by the module for key transport, the Security Policy **shall** state that the methods used are not compliant with the NIST key transport standards. The use of these algorithms by the module for key transport **shall** be annotated on the certificate's non-approved line as shown in IG G.13.

- Any key encapsulation scheme employing an RSA-based key methodology that uses key lengths specified in **SP 800-131A** as acceptable or deprecated. If key derivation functions (KDFs) are used to derive the key from the encapsulated shared secret, the use of these functions **shall** be in compliance with IG D.11.
- A key wrapping using any approved mode of AES or Triple-DES. The two-key Triple-DES may not be used past the end of 2015.

Additional Comments

This **IG** does not address key establishment mechanisms other than those used for key transport.

The key transport method(s) used by the cryptographic module **shall** be listed under **AS.07.21**.

[1] Discrete Logarithm Cryptography.
[2] Integer Factorization Cryptography.

D.10 Requirements for Vendor Affirmation of SP 800-56C

Applicable Levels:	*All*
Original Publishing Date:	*04/23/2012*
Effective Date:	*11/30/2011*
Transition End Date:	
Last Modified Date:	*04/17/2012*
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. Until CAVP testing for **SP 800-56C** is available, IG A.3 is applicable. This Special Publication defines the methods and the applicability for password-based key derivation.

Question/Problem

To claim *vendor affirmation* to **SP 800-56C**, what sections of the publication need to be addressed and what are the applicable documentation requirements?

Resolution

The entire text of **SP 800-56C** is applicable. The Randomness Extraction **shall** be performed as shown in Section 5 of **SP 800-56C** and this step **shall** be followed by Key Expansion using the key derivation functions defined in **SP 800-108**, as it is shown in Section 6 of **SP 800-56C**.

The vendor **shall** comply with all "**shall**" statements in **SP 800-56C**.

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** 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.

The tester **shall** verify that the vendor chose a MAC function appropriately for the targeted security strength, as shown in Tables 1, 2, and 3 of **SP 800-56C**.

Additional Comments

No self-tests are required to claim *vendor affirmation* to **SP 800-56C**.

D.11 References to the Support of Industry Protocols

Applicable Levels:	*All*
Original Publishing Date:	*07/25/2013*
Effective Date:	
Last Modified Date:	*07/25/2013*
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 NIST 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 **NIST 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 **NIST 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 **NIST 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 **NIST SP 800-135rev1**.

There are four possible implementation and documentation cases as follows:

1. If the module implements a KDF from **NIST SP 800-135rev1** and this KDF has not been validated by the CAVP, then the module's certificate **shall** list this function on the non-Approved line as *non-complaint* (for example: **TLS KDF (non-compliant)**). The module's Security Policy **shall** make it clear that the corresponding protocol (TLS, in the above example) **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. The module's certificate **shall** include the caveat "*The protocol(s) <TLS, SSH, …> shall not be used when operated in FIPS mode*".

2. If the module implements a KDF from **NIST SP 800-135rev1** and this KDF has been validated by the CAVP, then the module's certificate **shall** list the KDF on the Approved 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 this protocol has not been reviewed or tested by the CAVP and CMVP.

3. If the module does not implement any KDFs from **NIST 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 non-Approved 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 **NIST SP 800-135rev1** and the module's Security Policy makes no claims that the module supports or uses any of the protocols named in **NIST SP 800-135rev1** then the rules explained in this IG do not apply. The module may implement a (non NIST 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:	*08/07/2015*
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 a symmetric cryptographic key that can be used to protect sensitive data in an Approved mode of operations. **SP 800-133** was added to FIPS 140-2 Annex D on February 26, 2014.

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 using methods described in Section 5 of **SP 800-133**. If a key generating method involves an XOR as in formula (1) 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 this section 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 is normative.

The module may further generate a symmetric key as shown in Section 7.6 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 5 of SP 800-133 with an independence requirement of Section 7.6 met, and

(b) None of the component keys $K_1, \ldots, K_n$ is generated from a password.

The same rules apply to the generation of seed values that could be used as the starting points to generate the module's asymmetric keys.

Additional Comments

1. The key generation methods described in **SP 800-133** do not include the post-processing step shown in the FIPS 140-2 IG 7.8. This post-processing step is expected to be included in the upcoming version of **SP 800-90A**. Therefore, the vendor whose implementation of a key generation algorithm involves the post-processing will have this step tested as part of the CAVP-tested compliance with the future version of **SP 800-90A**. The vendor affirmation to **SP 800-133** may not include this post-processing step as **SP 800-133** does not have it.

2. The vendor is still allowed to claim compliance to IG 7.8 and use the symmetric keys generated as in the FIPS 140-2 IG 7.8 in the module's Approved mode of operation. In this case, the vendor may not claim the vendor affirmation to **SP 800-133**. Three months after the CAVP testing to the new **SP 800-90A** becomes available, the FIPS 140-2 IG 7.8 will become obsolete and the CMVP will stop accepting new test reports where the vendor claims that the module's symmetric keys (or seeds used for generating the module's asymmetric keys) are generated in compliance with IG 7.8. At that time it will be necessary for the vendor to generate the module's symmetric keys (and the asymmetric keys' seeds) in compliance with **SP 800-133** and either have their method tested to **SP 800-133** (if such CAVP test is available at that time) or to claim vendor affirmation to **SP 800-133** as explained in this Implementation Guidance.

3. If the module is vendor-affirmed to be compliant to **SP 800-133** then the appropriate notation on the Approved line is CKG (vendor affirmed), as shown in the FIPS 140-2 IG G.13.

Test Requirements

Code review, vendor documentation review, and mapping of the module's key generation procedures into the methods described in **SP 800-133**.

Withdrawn Guidance

W.1 Cryptographic Key Strength Modified by an Entropy Estimate

Applicable Levels:	*All*
Original Publishing Date:	*05/02/2012*
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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.

Additional Comments

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 Both FIPS 186-2 and FIPS 186-4	All NIST-recommended curves	*nlen* = 1024 Both FIPS 186-2 and FIPS 186-4	FIPS 186-2: $e = 3, 17, 2^{16} + 1$

L = 2048, N = 224 FIPS 186-4 only	Both FIPS 186-2 and FIPS 186-4	*nlen* = 1536 FIPS 186-2 only	FIPS 186-4: $2^{16}+1 \le e < 2^{256}$, 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		*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.

Additional Comments

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 such time as 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.

Questions/Problems

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.

Additional Comments

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 80056A** 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**.

Change Summary

New Guidance

- 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

- 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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