Cisco ASR 1001, 1001-X, 1002, 1002-X, 1004, 1006 and 1013

Firmware version:

IOS XE 3.13

Hardware versions:

ASR1001, ASR1001-X, ASR1002, ASR1002-X, ASR1004, ASR1006 and ASR1013;

Embedded Services Processor (ESP) Hardware versions:

ASR1000-ESP5, ASR1000-ESP10, ASR1000-ESP20, ASR1000-ESP40, ASR1000-ESP100 and ASR1000-ESP200;

Route Processor (RP) Hardware versions:

ASR-1000-RP1 and ASR-1000-RP2;

Line Card Hardware versions:

ASR1000-6TGE and ASR1000-2T+20X1GE;

FIPS-140 Security Policy - Security Level 1

Cisco Systems, Inc.

Table of Contents

1 Introduction

This is a non-proprietary Cryptographic Module Security Policy for the Cisco ASR 1001 and 1001-X with integrated Route Processor (RP) and integrated Embedded Services Processor (ESP), ASR 1002 with integrated RP and single ESP5 or ESP10, ASR1002-X with integrated RP and integrated ESP, ASR 1004 with single RP1 and single ESP10, ESP20 or RP2 and single ESP10, ESP20, ESP40, ASR1000-6TGE, or ASR1000-2T+20X1GE, ASR 1006 with dual RP1 and dual ESP10, ESP20 or dual RP2 and dual ESP10, ESP20, ESP40, ESP100, single ASR1000-6TGE, ASR1000-2T+20X1GE, ASR 1013 with dual RP2 and ESP40, ESP100, ESP200, ASR1000-6TGE, or ASR1000-2T+20X1GE from Cisco Systems, Inc., referred to in this document as the modules, routers, or by their specific model name. This security policy describes how modules meet the security requirements of FIPS 140-2 and how to run the modules in a FIPS 140-2 mode of operation.

FIPS 140-2 (Federal Information Processing Standards Publication 140-2 — Security Requirements for Cryptographic Modules) details the U.S. Government requirements for cryptographic modules. More information about the FIPS 140-2 standard and validation program is available on the NIST website at http://csrc.nist.gov/groups/STM/cmvp/index.html.

1.1 References

This document deals only with operations and capabilities of the module in the technical terms of a FIPS 140-2 cryptographic module security policy. More information is available on the module from the following sources:

- The Cisco Systems website (http://www.cisco.com) contains information on the full line of products from Cisco Systems.
- The NIST Cryptographic Module Validation Program website (http://csrc.nist.gov/groups/STM/cmvp/index.html) contains contact information for answers to technical or sales-related questions for the module.

1.2 FIPS 140-2 Submission Package

The security policy document is one document in a FIPS 140-2 Submission Package. In addition to this document, the submission package includes:

- Vendor Evidence
- Finite State Machine
- Other supporting documentation as additional references

With the exception of this non-proprietary security policy, the FIPS 140-2 validation documentation is proprietary to Cisco Systems, Inc. and is releasable only under appropriate non-disclosure agreements. For access to these documents, please contact Cisco Systems, Inc. See “Obtaining Technical Assistance” section for more information.

2 Module Description

2.1 Cisco ASR (1001, 1001-X, 1002, 1002-X, 1004, 1006, and 1013)

The Cisco ASR 1000 Series Router (ASR 1001, ASR 1001-X, ASR 1002, ASR 1002-X, ASR 1004, ASR 1006, and ASR 1013) is a highly scalable WAN and Internet Edge router platform that delivers embedded hardware acceleration for multiple Cisco IOS XE Software services without the need for separate service blades. In addition, the Cisco ASR 1000 Series Router is designed for business-class resiliency, featuring redundant Route and Embedded Services Processors, as well as software-based redundancy.

With routing performance and IPsec Virtual Private Network (VPN) acceleration around ten-fold that of previous midrange aggregation routers with services enabled, the Cisco ASR 1000 Series Routers provides a cost-effective approach to meet the latest services aggregation requirement. This is accomplished while still leveraging existing network designs and operational best practices.

Figure 1: ASR 1001

Figure 2: ASR 1001-X

Figure 3: ASR 1002

Figure 4: ASR 1002-X

Figure 5: ASR 1004

Figure 6: ASR 1006

Figure 7: ASR 1013

2.2 Embedded Services Processor (5, 10, 20, 40, 100 and 200 Gbps)

The Cisco ASR 1000 Series Embedded Service Processors (ESPs) are based on the innovative, industry-leading Cisco QuantumFlow Processor for next-generation forwarding and queuing in silicon. These components use the first generation of the hardware and software architecture known as Cisco QuantumFlow Processor.

The 5-, 10-, 20-, 40-, 100-, and 200-Gbps Cisco ASR 1000 Series ESPs provide centralized forwarding-engine options for the Cisco ASR 1000 Series Aggregation Services Routers.

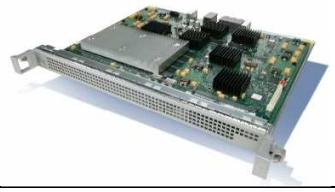
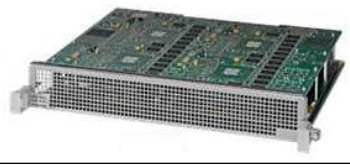
ESP5	
ESP10	
ESP20	
ESP40	
ESP100	
ESP200	

Figure 8: ESPs

The Cisco ASR 1000 Series ESPs are responsible for the data-plane processing tasks, and all network traffic flows through them. The modules perform all baseline packet routing operations, including MAC classification, Layer 2 and Layer 3 forwarding, quality-of-service (QoS) classification, policing and shaping, security access control lists (ACLs), VPN, load balancing, and NetFlow.

It should be noted that the ASR1001 and ASR1001-X uses an integrated ESP. They do not have a distinct part number but is referred to as the ESP2.5. Additionally, the ESP5 when used on both the ASR1002 and ASR1002-X is integrated into the module as well.

2.3 Router Processor (RP1, RP2)

The Cisco ASR 1000 Series Route Processors running IOS XE 3.13 address the route-processing requirements of carrier-grade IP and Multiprotocol Label Switching (MPLS) packet infrastructures. Not only do they provide advanced routing capabilities, but they also monitor and manage the other components in the Cisco ASR 1000 Series Aggregation Services Router.

It should be noted that both the ASR1001 and the ASR1002-X employ an integrated RP. The ASR1002 also has an integrated RP which in effect is an RP1.

Figure 9: (a) RP1 and (b) RP2

2.4 Fixed Ethernet Line Cards (ASR1000-2T+20X1GE and ASR1000-6TGE)

The Cisco ASR 1000 Series Fixed Ethernet Line Cards (ASR1000-2T+20X1GE and ASR1000-6TGE) are fixed‑port Ethernet line cards for the Cisco ASR 1000 Series Aggregation Services Routers. The line cards are capable of 40-Gbps full-duplex traffic forwarding using a fixed-port interface design. ASR1000-2T+20X1GE has twenty 1 Gigabit Ethernet ports and two 10 Gigabit Ethernet ports (Figure 1). ASR1000-6TGE has 6 10 Gigabit Ethernet ports (Figure 2).

Figure 10: (a) ASR1000-2T+20X1GE and (b) ASR1000-6TGE

The validated configurations are comprised of the following components:

Chassis:

1. ASR1001
2. ASR1001-X
3. ASR1002
4. ASR1002-X
5. ASR1004
6. ASR1006
7. ASR1013

Route Processors (RP):

1. ASR-1000-RP1
2. ASR-1000-RP2

Embedded Service Processors (ESP):

1. ASR1000-ESP5
2. ASR1000-ESP10
3. ASR1000-ESP20
4. ASR1000-ESP40
5. ASR1000-ESP100
6. ASR1000-ESP200

Line Cards (LC):

1. ASR1000-6TGE
2. ASR1000-2T+20X1GE

#	Chassis	Hardware Configuration		
		Route Processor	Embedded Service Provider	Line Card
1	ASR 1001	Fixed configuration		Not Applicable
2	ASR 1001-X	Fixed configuration		Not Applicable
3	ASR 1002	Integrated RP	N/A	ASR1000-6TGE, AST1000-2T+20X1GE
4			N/A	
5	ASR 1002-X	Fixed configuration		Not Applicable
6	ASR 1004	Single RP1	N/A	ASR1000-6TGE, AST1000-2T+20X1GE
7			N/A	
8		Single RP2	N/A	
9			N/A	
10			Single ESP40	
11	ASR 1006	Dual RP1	Dual ESP10	ASR1000-6TGE, AST1000-2T+20X1GE
12			Dual ESP20	
13		Dual RP2	Dual ESP10	
14			Dual ESP20	
15			Dual ESP40	
16			Dual ESP100	
17	ASR 1013	Dual RP2	Dual ESP40	ASR1000-6TGE, AST1000-2T+20X1GE
18			Dual ESP100	
19			Dual ESP200	

Table 1: Module Hardware Configurations running IOS XE 3.13

2.5 Module Validation Level

The following table lists the level of validation for each area in the FIPS PUB 140-2.

No.	Area Title	Level
1	Cryptographic Module Specification	1
2	Cryptographic Module Ports and Interfaces	1
3	Roles, Services, and Authentication	3
4	Finite State Model	1
5	Physical Security	1
6	Operational Environment	N/A
7	Cryptographic Key management	1
8	Electromagnetic Interface/Electromagnetic Compatibility	1
9	Self-Tests	1
10	Design Assurance	3
11	Mitigation of Other Attacks	N/A
Overall	**Overall module validation level**	**1**

Table 2: Module Validation Level

3 Cryptographic Boundary

The cryptographic boundary for the Cisco ASR 1001, ASR 1001-X, ASR 1002, ASR 1002-X, ASR 1004, ASR 1006, and ASR 1013 are defined as encompassing the "top," "front," "left," "right," and "bottom" surfaces of the case; all portions of the "backplane" of the case.

4 Cryptographic Module Ports and Interfaces

Each module provides a number of physical and logical interfaces to the device, and the physical interfaces provided by the module are mapped to four FIPS 140-2 defined logical interfaces: data input, data output, control input, and status output. The logical interfaces and their mapping are described in the following tables:

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port	Data Input Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port	Data Output Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port Power Switch	Control Input Interface
Port Adapter Interface (3) LEDs USB Ports (Up to 2) Console Port Auxiliary Port 10/100 Management Ethernet Port	Status Output Interface
Power Plug	Power interface

Table 3: ASR 1001

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port	Data Input Interface
Port Adapter Interface (3) Console Port Auxiliary Port	Data Output Interface

Physical Interfaces	FIPS 140-2 Logical Interfaces
10/100 Management Ethernet Port	
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port Power Switch	Control Input Interface
Port Adapter Interface (3) LEDs USB Ports (Up to 2) Console Port Auxiliary Port 10/100 Management Ethernet Port	Status Output Interface
Power Plug	Power interface

Table 4: ASR 1001-X

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (4)	Data Input Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (4)	Data Output Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port Power Switch	Control Input Interface
Port Adapter Interface (3) LEDs USB Ports (Up to 2) Console Port Auxiliary Port 10/100 Management Ethernet Port	Status Output Interface
Power Plug	Power interface

Table 5: ASR 1002 with ESP5 or ESP10

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (6)	Data Input Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (6)	Data Output Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port Power Switch	Control Input Interface
Port Adapter Interface (3) Console Port Auxiliary Port 10/100 Management Ethernet Port LEDs USB Ports (Up to 2)	Status Output Interface
Power Plug	Power interface

Table 6 - ASR 1002-X

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (8) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (10)	Data Input Interface
Port Adapter Interface (8) Console Port Auxiliary Port 10/100 Management Ethernet Port GigE port (10)	Data Output Interface
Port Adapter Interface (8)	Control Input Interface

Console Port Auxiliary Port 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port Power Switch	
Port Adapter Interface (8) LEDs USB Ports (Up to 2) Console Port Auxiliary Port 10/100 Management Ethernet Port	Status Output Interface
Power Plug	Power interface

Table 7: ASR 1004 with RP 1 or RP 2 and ESP10 or ESP20 or ESP40

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) GigE port (10)	Data Input Interface
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) GigE port (10)	Data Output Interface
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) Power Switch	Control Input Interface
Port Adapter Interface (12) LEDs USB Ports (Up to 2 per RP) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP)	Status Output Interface
Power Plug	Power interface

Table 8: ASR 1006 with dual RP 1 or RP 2 and dual ESP10 or ESP20 or ESP40

Physical Interfaces	FIPS 140-2 Logical Interfaces
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) GigE port (10)	Data Input Interface
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) GigE port (10)	Data Output Interface
Port Adapter Interface (12) Console Port Auxiliary Port (1 per RP) 10/100 BITS Ethernet Port (1 per RP) 10/100 Management Ethernet Port (1 per RP) Power Switch	Control Input Interface
Port Adapter Interface (12) LEDs USB Ports (Up to 2 per RP) Console Port Auxiliary Port (1 per RP) 10/100 Management Ethernet Port (1 per RP)	Status Output Interface
Power Plug	Power interface

Table 9: ASR 1013 with dual RP 2 and dual ESP40 or ESP 100or ESP 200

5 Roles, Services, and Authentication

Authentication is identity-based. Each user is authenticated upon initial access to the module. There are two main roles in the router that operators may assume: the Crypto Officer role and the User role. The administrator of the router assumes the Crypto Officer role in order to configure and maintain the router using Crypto Officer services, while the Users exercise only the basic User services. The module supports RADIUS and TACACS+ for authentication. A complete description of all the management and configuration capabilities of the modules can be found in the Cisco ASR 1000 Series Aggregation Services Routers Software Configuration Guide Manual and in the online help for the modules.

The User and Crypto Officer passwords and all shared secrets must each be at least eight (8) characters long, including at least one letter and at least one number character, in length (enforced procedurally). See the Secure Operation section for more information. If six (6) integers, one (1) special character and one (1) alphabet are used without repetition for an eight (8) digit PIN, the probability of randomly guessing the correct sequence is one (1) in 4,488,223,369,069,440 (this calculation is based on the assumption that the typical standard American QWERTY computer keyboard has 10 Integer digits, 52 alphabetic characters, and 32 special characters providing 94 characters to choose from in total. Since it is claimed to be for 8 digits with no repetition, then the calculation should be 94 x 93 x 92 x 91 x 90 x 89 x 88 x 87). In order to successfully guess the sequence in one minute would require the ability to make over 74,803,722,817,824 guesses per second, which far exceeds the operational capabilities of the module.

Additionally, when using RSA-based authentication, RSA key pair has a modulus size of at least 2048 bits, thus providing at least 112 bits of strength. Assuming the low end of that range, an attacker would have a 1 in 2^{80} chance of randomly obtaining the key, which is much stronger than the one in a million chance required by FIPS 140-2. To exceed a one in 100,000 probability of a successful random key guess in one minute, an attacker would have to be capable of approximately $1.2x10^{19}$ attempts per minute, which far exceeds the operational capabilities of the modules to support.

5.1 User Services

A User enters the system by accessing the console/auxiliary port with a terminal program or SSH v2 session to a LAN port or the 10/100 management Ethernet port. The module prompts the User for their username/password combination. If the username/password combination is correct, the User is allowed entry to the module management functionality. The services available to the User role consist of the following:

- Status Functions - View state of interfaces and protocols, firmware version
- Terminal Functions - Adjust the terminal session (e.g., lock the terminal, adjust flow control)
- Directory Services - Display directory of files kept in memory
- Perform Self-Tests – Perform the FIPS 140 start-up tests on demand

- Perform Cryptography – Use the cryptography provided by the module (e.g., IPsec and GDOI)

5.2 Cryptographic Officer Services

A Crypto Officer enters the system by accessing the console/auxiliary port with a terminal program or SSH v2 session to a LAN port or the 10/100 management Ethernet port. The Crypto Officer authenticates in the same manner as a User. The Crypto Officer is identified by accounts that have a privilege level 15 (versus the privilege level 1 for users). A Crypto Officer may assign permission to access the Crypto Officer role to additional accounts, thereby creating additional Crypto Officers.

The Crypto Officer role is responsible for the configuration and maintenance of the router. The Crypto Officer services consist of the following:

- Configure the module - Define network interfaces and settings, create command aliases, set the protocols the router will support, enable interfaces and network services, set system date and time, and load authentication information.

- Define Rules and Filters - Create packet Filters that are applied to User data streams on each interface. Each Filter consists of a set of Rules, which define a set of packets to permit or deny based characteristics such as protocol ID, addresses, ports, TCP connection establishment, or packet direction.

- Status Functions - View the module configuration, routing tables, active sessions, use get commands to view SNMP MIB statistics, health, temperature, memory status, voltage, packet statistics, review accounting logs, and view physical interface status.

- Manage the module - Log off users, shutdown or reload the router, manually back up router configurations, view complete configurations, manage user rights, initiate power-on self-tests on demand and restore router configurations.

- Set Encryption/Bypass - Set up the configuration tables for IP tunneling. Set keys and algorithms to be used for each IP range or allow plaintext packets to be set from specified IP address.

- Perform Self-Tests – Perform the FIPS 140 start-up tests on demand

5.3 Unauthenticated User Services

The services for someone without an authorized role are to view the status output from the module's LED pins, perform bypass services and cycle power.

6 Cryptographic Key/CSP Management

The module securely administers both cryptographic keys and other critical security parameters such as passwords. The tamper evidence seals provide physical protection for all keys. All keys are also protected by the password-protection on the Crypto Officer operator logins, and can be zeroized by the Crypto Officer. All zeroization consists of overwriting the memory that stored the key. Keys are exchanged and entered electronically or via Internet Key Exchange (IKE).

The module supports the following critical security parameters (CSPs):

CSP#	Name	Key Type	Description	Storage	Zeroization
1	DRBG entropy input	CTR (using AES-256) 256-bit	This is the entropy for SP 800-90 RNG.	DRAM (plaintext)	Power cycle the device
2	DRBG Seed (IOS XE)	CTR (using AES-256) 384-bits	This DRBG seed is collected from the onboard Cavium cryptographic processor.	DRAM (plaintext)	Automatically every 400 bytes, or turn off the router.
3	DRBG V	CTR (using AES-256) 256-bit	Internal V value used as part of SP 800-90 CTR_DRBG	DRAM (plaintext)	Power cycle the device
4	DRBG Key	CTR (using AES-256) 256-bit	Internal Key value used as part of SP 800-90 CTR_DRBG	DRAM (plaintext)	Power cycle the device
5	Diffie-Hellman Shared Secret	DH 2048 – 4096 bits	The shared exponent used in Diffie-Hellman (DH) exchange. Created per the Diffie-Hellman protocol.	DRAM (plaintext)	Zeroized upon deletion.
6	Diffie Hellman private exponent	DH 2048 – 4096 bits	The private exponent used in Diffie-Hellman (DH) exchange. This CSP is created using the ANSI X9.31 RNG (Nitrox/Octeon II).	DRAM (plaintext)	Zeroized upon deletion.
7	Diffie Hellman public key	DH 2048 – 4096 bits	The p used in Diffie-Hellman (DH) exchange. This CSP is created using the ANSI X9.31 RNG (Nitrox/Octeon II).	DRAM (plaintext)	Zeroized upon deletion.
8	skeyid	Keyed SHA-1 160-bits	Value derived per the IKE protocol based on the peer authenticationSSH method chosen.	DRAM (plaintext)	Automatically after IKE session terminated.

CSP#	Name	Key Type	Description	Storage	Zeroization
9	skeyid_a	Keyed SHA-1 160-bits	The IKE key derivation key for non ISAKMP security associations.	DRAM (plaintext)	Automatically after IKE session terminated.
10	skeyid_d	Keyed SHA-1 160-bits	The IKE key derivation key for non ISAKMP security associations.	DRAM (plaintext)	Automatically after IKE session terminated.
11	skeyid_e	Keyed SHA-1 160-bits	The IKE key derivation key for non ISAKMP security associations.	DRAM (plaintext)	Automatically after IKE session terminated.
12	IKE session encrypt key	Triple-DES -168 bits AES -128, 192, or 256 bits	The IKE session encrypt key. This key is created per the Internet Key Exchange Key Establishment protocol.	DRAM (plaintext)	Automatically after IKE session terminated.
13	IKE session authentication key	SHA-1 HMAC 160-bits	The IKE session authentication key. This key is created per the Internet Key Exchange Key Establishment protocol.	DRAM (plaintext)	Automatically after IKE session terminated.
14	ISAKMP preshared	Secret At least eight characters	The key used to generate IKE (non-compliant) skeyid during preshared-key authentication. **# no crypto isakmp key** command zeroizes it. This key can have two forms based on whether the key is related to the hostname or the IP address. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext)	# no crypto isakmp key
15	IKE RSA Private Key	RSA (Private Key) 2048 – 4096 bits	The key used in IKE authentication. **# crypto key zeroize rsa** command zeroizes it.	NVRAM (plaintext)	# crypto key zeroize rsa
16	IKE RSA Public Key	RSA (Public Key) 2048 – 4096 bits	The key used in IKE authentication. **# crypto key zeroize rsa** command zeroizes it.	NVRAM (plaintext)	# crypto key zeroize rsa
17		Triple-DES -168 bits			

CSP#	Name	Key Type	Description	Storage	Zeroization
	IPsec encryption key	AES -128, 192, or 256 bits	The IPsec encryption key. This key is created per the Internet Key Exchange Key Establishment protocol.	DRAM (plaintext)	Automatically when IPsec session terminated.
18	IPsec authentication key	SHA-1 HMAC 160-bits	The IPsec authentication key. This key is created per the Internet Key Exchange Key Establishment protocol.	DRAM (plaintext)	Automatically when IPsec session terminated.
19	Operator password	Shared Secret, at least eight characters	The password of the operator. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext)	Overwrite with new password
20	Enable password	Shared Secret, at least eight characters	The plaintext password of the CO role. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext)	Overwrite with new password
21	Enable secret	Shared Secret, at least eight characters	The obfuscated password of the CO role. However, the algorithm used to obfuscate this password is not FIPS approved. Therefore, this password is considered plaintext for FIPS purposes. This password is zeroized by overwriting it with a new password. The Cryptographic Operator optionally configures the module to obfuscate the Enable password. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext)	Overwrite with new password
22	RADIUS secret	Shared Secret, 16 characters	The RADIUS shared secret. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext), DRAM (plaintext)	# no radius-server key
23	TACACS+ secret	Shared Secret, 16 characters	The TACACS+ shared secret. This CSP is entered by the Cryptographic Officer.	NVRAM (plaintext), DRAM (plaintext)	# no tacacs-server key

CSP#	Name	Key Type	Description	Storage	Zeroization
24	SSH Private Key	RSA (Private Key) 2048 – 4096 bits	The SSH private key for the module. RSA key sizes 2048 - 4096 bits.	NVRAM (plaintext)	SSH private key is zeroized by either deletion (via **# crypto key zeroize rsa**) or by overwriting with a new value of the key
25	SSH Public Key	RSA (Public Key) 2048 – 4096 bits	The SSHpublic key for the module. RSA key sizes 2048 - 4096 bits.	NVRAM (plaintext)	Zeroized upon deletion.
26	SSH Session Key	Triple-DES 168- bits AES 128-, 192-, or 256- bits	The SSH session key. This key is created through SSH key establishment.	DRAM (plaintext)	Automatically when the SSH session is terminated.
27	GDOI Data Security Key (TEK)	Triple-DES 168-bits AES 128-, 192-, or 256- bits	This key is created using the "GROUPKEY-PULL" registration protocol with GDOI.	DRAM (plaintext)	Automatically when session terminated.
28	GDOI Group Key Encrypting Key (KEK)	Triple-DES 168- bits AES 128-, 192-, or 256- bits	This key is created using the "GROUPKEY-PUSH" registration protocol with GDOI.	DRAM (plaintext)	Automatically when session terminated.
29	TLS Server RSA private key	RSA (Private Key) 2048-, 4096-bit	Identity certificates for module itself and also used in TLS negotiations. Generated using the "crypto key generate rsa"	NVRAM plaintext	TLS Server RSA private key is zeroized by either deletion (via **# crypto key zeroize rsa**) or by overwriting with a new value of the key.
30	TLS Server RSA public key	RSA (Public Key) 2048-, 4096-bit	Identity certificates for module itself and also used in TLS negotiations. Generated using the "crypto key generate rsa"	NVRAM plaintext	Zeroized upon deletion.

CSP#	Name	Key Type	Description	Storage	Zeroization
31	TLS pre-master secret	Shared Secret, 384-bits	Shared secret created using asymmetric cryptography from which new TLS session keys can be created. Created as part of TLS session establishment	DRAM (plaintext)	Automatically when TLS session terminated.
32	TLS Traffic Keys	Triple-DES 168-bits	This is the TLSsession key. Generated using the TLS protocol.	DRAM (plaintext)	Automatically when TLS session terminated.
		AES 128-,192-,256-bits			
		HMAC SHA-1 160-bits			
33	SNMPv3 Password	Secret 256 bits	This secret is used to derive HMAC-SHA1 key for SNMPv3 Authentication	DRAM	Powercycle
34	snmpEngineID	Shared secret 32-bits	Unique string to identify the SNMP engine	NVRAM	# no snmp-server engineID local engineid-string, overwriitten with new engine ID
35	SNMP session key	AES 128-bit	Encrypts SNMP traffic	DRAM	Power cycle

Table 10: CSPs

The services accessing the CSPs, the type of access – read (r), write (w) and zeroized/delete (d) – and which role accesses the CSPs are listed below.

CSP#	User Role				CO Role				
	Network	Status	Terminal	Directory	Configure	Define Rules and Filter	Status	Management	Set Encryption/ Bypass
1	r							d	rwd
2	r							d	rwd
3	r							d	rwd
4	r							d	rwd
5	r								rwd
6	r								rwd
7	r								rwd
8	r								rwd
9	r								rwd
10	r								rwd
11	r								rwd
12	r								rwd
13	r								rwd
14	r								rwd
15	r							d	rw
16	r							d	rw
17	r								rwd
18	r								rwd
19	r							rwd	
20								rwd	
21								rwd	
22								rwd	
23								rwd	
24								rwd	

CSP#	User Role				CO Role				
	Network	Status	Terminal	Directory	Configure	Define Rules and Filter	Status	Management	Set Encryption/ Bypass
25								rwd	
26								rwd	
27	r							rwd	
28	r							rwd	
29								rwd	
30								rwd	
31								rwd	
32								rwd	
33								rwd	
34								rwd	
35								rwd	

Table 11: Role CSP Access

7 Cryptographic Algorithms

7.1 Approved Cryptographic Algorithms

The Cisco ASR 1000 supports many different cryptographic algorithms. However, only FIPS approved algorithms may be used while in the FIPS mode of operation. The following table identifies the approved algorithms included in the ASR 1000 for use in the FIPS mode of operation.

Algorithm	Supported Mode	Cert. #
IOS XE (Route Processor 1 and Route Processor 2)		
AES	ECB (128 , 192 , 256); CBC (128 , 192 , 256); CFB128 (128 , 192 , 256), CTR (128 , 192 , 256), GCM (128 , 192 , 256)	2817
	CBC (128 , 192 , 256)	2783
SHS	SHA-1, -256, -384, and -512 (Byte Oriented)	2361
	SHA-1, -256, -384, and -512 (Byte Oriented)	2338
HMAC SHS	SHA-1, -256, -384, and -512	1764
DRBG	CTR (using AES-256)	481
RSA	PKCS#1 v.1.5, 1024-4096 bit key 1024-bit keys allowed for signature verification only The following methods are non-approved: • Key Generation: MOD: 1024-bit keys and 1536-bit keys • Signature Generation: 1024-bit keys and 1536-bit keys	1471
Triple-DES	TCBC (KO 1,2)	1670
	TCBC (KO 1,2)	1671
	TCBC (KO 1,2)	1688
CVL	TLS KDF, IKEv1/IKEv2 KDF, SSH KDF, SNMP KDF Note: The TLS, IKEv1/IKEv2, SSH, and SNMP protocols have not been reviewed or tested by the CAVP and CMVP.	253
Cavium Nitrox CN2420 (Embedded Services Processors 2.5 and, 5)		

Algorithm	Supported Mode	Cert. #
AES	CBC (128, 192, 256)	333
SHS (SHA-1)	Byte Oriented	408
HMAC SHA-1	Byte Oriented	137
Triple-DES	KO 1 & 2, CBC	397
Cavium Nitrox CN2435 (Embedded Services Processor 10)		
AES	CBC (128, 192, 256)	333
SHS (SHA-1)	Byte Oriented	408
HMAC SHA-1	Byte Oriented	137
Triple-DES	KO 1 & 2, CBC	397
Cavium Nitrox CN2450 (Embedded Services Processor 20)		
AES	CBC (128, 192, 256)	333
SHS (SHA-1)	Byte Oriented	408
HMAC SHA-1	Byte Oriented	137
Triple-DES	KO 1 & 2, CBC	397
Cavium Nitrox CN2460 (Embedded Services Processor 40)		
AES	CBC (128, 192, 256)	333
SHS (SHA-1)	Byte Oriented	408
HMAC SHA-1	Byte Oriented	137
Triple-DES	KO 1 & 2, CBC	397
Cavium Octeon II CN6870 (Embedded Services Processor 100)		
AES	ECB, CBC (128, 192, 256)	2346
SHS (SHA-1)	Byte Oriented	2023
HMAC SHA-1	Byte Oriented	1455
Triple-DES	KO 1,2 - CBC	1469
Cavium Octeon II CN6880 (Embedded Services Processor 200)		
AES	ECB, CBC (128, 192, 256)	2346
SHS (SHA-1)	Byte Oriented	2023
HMAC SHA-1	Byte Oriented	1455
Triple-DES	KO 1,2 - CBC	1469

Table 12: FIPS-Approved Algorithms for use in FIPS Mode

7.2 Non-Approved Algorithms allowed for use in FIPS-mode

The ASR 1000 cryptographic module implements the following non-Approved algorithms that are allowed for use in FIPS-mode:

- Diffie-Hellman – provides between 112 and 150-bits of encryption strength. Diffie-Hellman with less than 112-bit of security strength is non-compliant and may not be used.

- RSA Key Wrapping – provides 112-bits of encryption strength. RSA with less than 112-bit of security strength is non-compliant and may not be used.
- Non-approved RNG for seeding the DRBG.

7.3 Non-Approved Algorithms

The ASR 1000 cryptographic module implements the following non-approved algorithms that are not permitted for use in FIPS 140-2 mode of operations:

Service	Non-Approved Algorithm
SSH*	Hashing: MD5, MACing: HMAC MD5 Symmetric: DES, Asymmetric: 1024-bit RSA, 1024-bit Diffie-Hellman
TLS*	Hashing: MD5, MACing: HMAC MD5 Symmetric: DES, RC4 Asymmetric: 1024-bit RSA, 1024-bit Diffie-Hellman
IPsec*	Hashing: MD5, MACing: HMAC MD5 Symmetric: DES, RC4 Asymmetric: 1024-bit RSA, 1024-bit Diffie-Hellman
SNMP*	Hashing: MD5, MACing: HMAC MD5 Symmetric: DES, RC4 Asymmetric: 1024-bit RSA, 1024-bit Diffie-Hellman
Initialization**	SHA-1 (non-compliant)

Table 12: Non-Approved Algorithms

Note: Services marked with a single asterisk (*) may use non-compliant cryptographic algorithms. Use of these algorithms are prohibited in a FIPS-approved mode of operation.

Note: Services marked with a double asterisk (**) make use of a non-compliant hash algorithm at various points during initialization. This algorithm is does not provide any cryptographic protection.

The modules support the following key establishment schemes[1]:

- GDOI (key wrapping; key establishment methodology provides 112 or 128 bits of encryption strength);

7.4 Self-Tests

The modules include an array of self-tests that are run during startup and periodically during operations to prevent any secure data from being released and to insure all components are functioning correctly. The modules implement the following power-on self-tests:

- Route Processor (Integrated, RP1 and RP2)
  - Known Answer Tests:
    - AES KAT (2),
    - AES-GCM KAT,
    - SHA-1 KAT (2),
    - SHA-256 KAT (2),
    - SHA-384 KAT (2),
    - SHA-512 KAT (2),
    - HMAC SHA-1 KAT,
    - HMAC SHA-256 KAT,
    - HMAC SHA-384 KAT,
    - HMAC SHA-512 KAT,
    - Triple-DES KAT (3),
    - DRBG KAT,
    - RSA KAT.
  - Firmware Integrity Test (SHA-256)
- Embedded Services Processor (Integrated, ESP5, ESP10, ESP20, ESP40, ESP100, and ESP200)
  - Known Answer Tests:
    - AES KAT,
    - SHS KAT,
    - HMAC KAT,
    - Triple-DES KAT,

The modules perform all power-on self-tests automatically at boot. All power-on self-tests must be passed before any operator can perform cryptographic services. The power-on self-tests are performed after the cryptographic systems are initialized but prior any

[1] In addition to Diffie-Hellman listed above.

other operations; this prevents the module from passing any data during a power-on self-test failure. In addition, the modules also provide the following conditional self-tests:

- Route Processor (Integrated, RP1, and RP2)
  - Continuous Random Number Generator test for the FIPS-approved DRBG
  - Continuous Random Number Generator test for the non-approved RNG
  - Pair-Wise Consistency Test for RSA signature keys
  - Pair-Wise Consistency Test for RSA keys used in key establishment (key transport)
  - Conditional Bypass Test
- Embedded Services Processor (Integrated, ESP5, ESP10, ESP20, ESP40, ESP100, and ESP200)
  - Conditional Bypass Test

8 Physical Security

The modules are production grade multi-chip standalone cryptographic modules that meet level 1 physical security requirements.

9 Secure Operation

9.1 System Initialization and Configuration

Step1 - The value of the boot field must be 0x0102. This setting disables break from the console to the ROM monitor and automatically boots. From the “configure terminal” command line, the Crypto Officer enters the following syntax:

config-register 0x0102

Step 2 - The Crypto Officer must create the “enable” password for the Crypto Officer role. Procedurally, the password must be at least 8 characters, including at least one letter and at least one number, and is entered when the Crypto Officer first engages the “enable” command. The Crypto Officer enters the following syntax at the “#” prompt:

enable secret [PASSWORD]

Step 3 - The Crypto Officer must set up the operators of the module. The Crypto Officer enters the following syntax at the “#” prompt:

Username [USERNAME]

Password [PASSWORD]

Step 4 – For the created operators, the Crypto Officer must always assign passwords (of at least 8 characters, including at least one letter and at least one number) to users. Identification and authentication on the console/auxiliary port is required for Users. From the “configure terminal” command line, the Crypto Officer enters the following syntax:

line con 0

password [PASSWORD]

login local

Step 5 - The Crypto Officer may configure the module to use RADIUS or TACACS+ for authentication. Configuring the module to use RADIUS or TACACS+ for authentication is optional. If the module is configured to use RADIUS or TACACS+, the Crypto-Officer must define RADIUS or TACACS+ shared secret keys that are at least 8 characters long, including at least one letter and at least one number.

Step 6 - Dual IOS mode is not allowed. ROMMON variable IOSXE_DUAL_IOS must be set to 0.

Step 7 - In service software upgrade (ISSU) is not allowed. The operator should not perform in service software upgrade of an ASR1000 FIPS validated firmware image

Step 8 - Use of the debug.conf file is not allowed. The operator should not create the bootflash:/debug.conf file and use it for setting environment variables values.

Step 9 – Execute the “platform ipsec fips-mode” command.

NOTE: The keys and CSPs generated in the cryptographic module during FIPS mode of operation cannot be used when the module transitions to non-FIPS mode and vice versa. While the module transitions from FIPS to non-FIPS mode or from non-FIPS to FIPS mode, all the keys and CSPs are to be zeroized by the Crypto Officer.

9.2 IPsec Requirements and Cryptographic Algorithms

Step 1 - The only type of key management that is allowed in FIPS mode is Internet Key Exchange (IKE) (non-compliant).

Step 2 - Although the IOS implementation of IKE allows a number of algorithms, only the following algorithms are allowed in a FIPS 140-2 configuration:

- ah-sha-hmac
- ah-sha256-hman
- ah-sha384-hman
- ah-sha512-hman
- esp-sha-hmac
- esp-sha256-hman
- esp-sha384-hman
- esp-sha512-hman
- esp-3des
- esp-aes
- esp-gcm
- esp-gmac

Step 3 - The following algorithms shall not be used:

- MD-5 for signing
- MD-5 HMAC
- DES

9.3 Protocols

Secure DNS is not allowed in FIPS mode of operation and shall not be configured.

9.4 Remote Access

SSH access to the module is allowed in FIPS approved mode of operation, using SSH v2 and a FIPS approved algorithm.

TLS communications with the module are allowed in FIPS approved mode.

SNMPv3 communications with the module are allowed in FIPS approved mode.

9.5 Key Strength

Key sizes with security strength of less than 112-bits may not be used in FIPS mode.

10 Related Documentation

This document deals only with operations and capabilities of the security appliances in the technical terms of a FIPS 140-2 cryptographic device security policy. More information is available on the security appliances from the sources listed in this section and from the following source:

- The NIST Cryptographic Module Validation Program website (http://csrc.nist.gov/groups/STM/cmvp/index.html) contains contact information for answers to technical or sales-related questions for the security appliances.

11 Obtaining Documentation

Cisco documentation and additional literature are available on Cisco.com. Cisco also provides several ways to obtain technical assistance and other technical resources. These sections explain how to obtain technical information from Cisco Systems.

11.1 Cisco.com

You can access the most current Cisco documentation at this URL:

http://www.cisco.com/techsupport

You can access the Cisco website at this URL:

http://www.cisco.com

You can access international Cisco websites at this URL:

http://www.cisco.com/public/countries_languages.shtml

11.2 Product Documentation DVD

Cisco documentation and additional literature are available in the Product Documentation DVD package, which may have shipped with your product. The Product Documentation DVD is updated regularly and may be more current than printed documentation.

The Product Documentation DVD is a comprehensive library of technical product documentation on portable media. The DVD enables you to access multiple versions of hardware and software installation, configuration, and command guides for Cisco

products and to view technical documentation in HTML. With the DVD, you have access to the same documentation that is found on the Cisco website without being connected to the Internet. Certain products also have .pdf versions of the documentation available.

The Product Documentation DVD is available as a single unit or as a subscription. Registered Cisco.com users (Cisco direct customers) can order a Product Documentation DVD (product number DOC-DOCDVD=) from Cisco Marketplace at this URL:

http://www.cisco.com/go/marketplace/

11.3 Ordering Documentation

Beginning June 30, 2005, registered Cisco.com users may order Cisco documentation at the Product Documentation Store in the Cisco Marketplace at this URL:

http://www.cisco.com/go/marketplace/

Nonregistered Cisco.com users can order technical documentation from 8:00 a.m. to 5:00 p.m. (0800 to 1700) PDT by calling 1 866 463-3487 in the United States and Canada, or elsewhere by calling 011 408 519-5055. You can also order documentation by e-mail at tech-doc-store-mkpl@external.cisco.com or by fax at 1 408 519-5001 in the United States and Canada, or elsewhere at 011 408 519-5001.

12 Documentation Feedback

You can rate and provide feedback about Cisco technical documents by completing the online feedback form that appears with the technical documents on Cisco.com.

You can send comments about Cisco documentation to bug-doc@cisco.com.

You can submit comments by using the response card (if present) behind the front cover of your document or by writing to the following address:

Cisco Systems
Attn: Customer Document Ordering
170 West Tasman Drive
San Jose, CA 95134-9883

We appreciate your comments.

13 Cisco Product Security Overview

Cisco provides a free online Security Vulnerability Policy portal at this URL:

http://www.cisco.com/en/US/products/products_security_vulnerability_policy.html

From this site, you can perform these tasks:

- Report security vulnerabilities in Cisco products.

- Obtain assistance with security incidents that involve Cisco products.
- Register to receive security information from Cisco.

A current list of security advisories and notices for Cisco products is available at this URL:

http://www.cisco.com/go/psirt

If you prefer to see advisories and notices as they are updated in real time, you can access a Product Security Incident Response Team Really Simple Syndication (PSIRT RSS) feed from this URL:

http://tools.cisco.com/security/center/rss.x?i=44

13.1 Reporting Security Problems in Cisco Products

Cisco is committed to delivering secure products. We test our products internally before we release them, and we strive to correct all vulnerabilities quickly. If you think that you might have identified vulnerability in a Cisco product, contact PSIRT:

- Emergencies — security-alert@cisco.com

An emergency is either a condition in which a system is under active attack or a condition for which a severe and urgent security vulnerability should be reported. All other conditions are considered nonemergencies.

- Nonemergencies — psirt@cisco.com

In an emergency, you can also reach PSIRT by telephone:

- 1 877 228-7302
- 1 408 525-6532

Tip

We encourage you to use Pretty Good Privacy (PGP) or a compatible product to encrypt any sensitive information that you send to Cisco. PSIRT can work from encrypted information that is compatible with PGP versions 2.*x* through 8.*x*. Never use a revoked or an expired encryption key. The correct public key to use in your correspondence with PSIRT is the one linked in the Contact Summary section of the Security Vulnerability Policy page at this URL:

http://www.cisco.com/en/US/products/products_security_vulnerability_policy.html

The link on this page has the current PGP key ID in use.

14 Obtaining Technical Assistance

Cisco Technical Support provides 24-hour-a-day award-winning technical assistance. The Cisco Technical Support & Documentation website on Cisco.com features extensive online support resources. In addition, if you have a valid Cisco service contract, Cisco Technical Assistance Center (TAC) engineers provide telephone support. If you do not have a valid Cisco service contract, contact your reseller.

14.1 Cisco Technical Support & Documentation Website

The Cisco Technical Support & Documentation website provides online documents and tools for troubleshooting and resolving technical issues with Cisco products and technologies. The website is available 24 hours a day, at this URL:

http://www.cisco.com/techsupport

Access to all tools on the Cisco Technical Support & Documentation website requires a Cisco.com user ID and password. If you have a valid service contract but do not have a user ID or password, you can register at this URL:

http://tools.cisco.com/RPF/register/register.do

Note

Use the Cisco Product Identification (CPI) tool to locate your product serial number before submitting a web or phone request for service. You can access the CPI tool from the Cisco Technical Support & Documentation website by clicking the **Tools & Resources** link under Documentation & Tools. Choose **Cisco Product Identification Tool** from the Alphabetical Index drop-down list, or click the **Cisco Product Identification Tool** link under Alerts & RMAs. The CPI tool offers three search options: by product ID or model name; by tree view; or for certain products, by copying and pasting **show** command output. Search results show an illustration of your product with the serial number label location highlighted. Locate the serial number label on your product and record the information before placing a service call.

14.2 Submitting a Service Request

Using the online TAC Service Request Tool is the fastest way to open S3 and S4 service requests. (S3 and S4 service requests are those in which your network is minimally impaired or for which you require product information.) After you describe your situation, the TAC Service Request Tool provides recommended solutions. If your issue is not resolved using the recommended resources, your service request is assigned to a Cisco engineer. The TAC Service Request Tool is located at this URL:

http://www.cisco.com/techsupport/servicerequest

For S1 or S2 service requests or if you do not have Internet access, contact the Cisco TAC by telephone. (S1 or S2 service requests are those in which your production network is down or severely degraded.) Cisco engineers are assigned immediately to S1 and S2 service requests to help keep your business operations running smoothly.

To open a service request by telephone, use one of the following numbers:

Asia-Pacific: +61 2 8446 7411
Australia: 1 800 805 227
EMEA: +32 2 704 55 55
USA: 1 800 553-2447

For a complete list of Cisco TAC contacts, go to this URL:

http://www.cisco.com/techsupport/contacts

14.3 Definitions of Service Request Severity

To ensure that all service requests are reported in a standard format, Cisco has established severity definitions.

Severity 1 (S1) – Your network is "down," or there is a critical impact to your business operations. You and Cisco will commit all necessary resources around the clock to resolve the situation.

Severity 2 (S2) – Operation of an existing network is severely degraded, or significant aspects of your business operation are negatively affected by inadequate performance of Cisco products. You and Cisco will commit full-time resources during normal business hours to resolve the situation.

Severity 3 (S3) – Operational performance of your network is impaired, but most business operations remain functional. You and Cisco will commit resources during normal business hours to restore service to satisfactory levels.

Severity 4 (S4) – You require information or assistance with Cisco product capabilities, installation, or configuration. There is little or no effect on your business operations.

15 Obtaining Additional Publications and Information

Information about Cisco products, technologies, and network solutions is available from various online and printed sources.

- Cisco Marketplace provides a variety of Cisco books, reference guides, documentation, and logo merchandise. Visit Cisco Marketplace, the company store, at this URL:

http://www.cisco.com/go/marketplace/

- *Cisco Press* publishes a wide range of general networking, training and certification titles. Both new and experienced users will benefit from these publications. For current Cisco Press titles and other information, go to Cisco Press at this URL:

http://www.ciscopress.com

- *Packet* magazine is the Cisco Systems technical user magazine for maximizing Internet and networking investments. Each quarter, Packet delivers coverage of the latest industry trends, technology breakthroughs, and Cisco products and solutions, as well as network deployment and troubleshooting tips, configuration examples, customer case studies, certification and training information, and links to scores of in-depth online resources. You can access Packet magazine at this URL:

http://www.cisco.com/packet

- *Internet Protocol Journal* is a quarterly journal published by Cisco Systems for engineering professionals involved in designing, developing, and operating public and private internets and intranets. You can access the Internet Protocol Journal at this URL:

http://www.cisco.com/ipj

- Networking products offered by Cisco Systems, as well as customer support services, can be obtained at this URL:

http://www.cisco.com/en/US/products/index.html

- Networking Professionals Connection is an interactive website for networking professionals to share questions, suggestions, and information about networking products and technologies with Cisco experts and other networking professionals. Join a discussion at this URL:

http://www.cisco.com/discuss/networking

- World-class networking training is available from Cisco. You can view current offerings at this URL:

http://www.cisco.com/en/US/learning/index.html

16 Definitions List

ACL	Access Control List
AES	Advanced Encryption Standard
ASR	Aggregation Services Router
CMVP	Cryptographic Module Validation Program
CSE	Communications Security Establishment (Canada)
CSP	Critical Security Parameter
DRAM	Dynamic RAM
DRBG	Deterministic random bit generator
EDC	Error Detection Code
ESP	Embedded Services Processor
FIPS	Federal Information Processing Standard
Gbps	Gigabits per second
GDOI	Group Domain of Interpretation
GigE	Gigabit Ethernet
HMAC	Hash Message Authentication Code
HTTP	Hyper Text Transfer Protocol
IKE	Internet Key Exchange
IP	Internet Protocol
ISAKMP	Internet Security Association and Key Management Protocol
ISSU	In service software upgrade
KAT	Known Answer Test
KDF	Key Derivation Function
LAN	Local Area Network
LED	Light Emitting Diode
MAC	Message Authentication Code
MPLS	Multiprotocol Label Switching
NIST	National Institute of Standards and Technology
NVRAM	Non-Volatile Random Access Memory
PIN	Personal Identification Number
QoS	Quality of Service
RADIUS	Remote Authentication Dial-In User Service

RAM	Random Access Memory
RNG	Random Number Generator
RP	Route Processor
RSA	Rivest Shamir and Adleman method for asymmetric encryption
SHA	Secure Hash Algorithm
SNMP	Simple Network Management Protocol
SSH	Secure Shell
TACACS	Terminal Access Controller Access Control System
TCP	Transmission Control Protocol
TDES	Triple Data Encryption Standard
TLS	Transport Layer Security
USB	Universal Serial Bus
VPN	Virtual Private Network