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VMWARE ESXi VERSION 5 VIRTUAL MACHINE SECURITY TECHNICAL IMPLEMENTATION GUIDE (STIG) OVERVIEW

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1. INTRODUCTION

1.1 Executive Summary

This VMware ESXi Version 5 Virtual Machine (ESXi 5 VM) Technology Overview, along with the ESXi 5 VM STIG, provides the technical security policies, requirements, and implementation details for applying security concepts to virtual machines running under the ESXi Version 5 hypervisor.

The VMware vSphere 5 Security Hardening Guide contains product-specific, best-practices requirements for VMware ESXi 5 virtual machines. This hardening guide describes the ESXi 5 virtual machine built-in security features and the measures to safeguard ESXi 5 virtual machines from attack. This hardening guide may be used to secure the vSphere 5 environment for VMware vCenter Server 5 and VMware ESXi 5. This guide was used as input into this STIG.

The security requirements contained within this STIG are designed to assist Security Managers (SMs), Information System Security Managers (ISSMs), Information System Security Officers (ISSOs), and System Administrators (SAs) with configuring and maintaining security controls for virtual machines in a VMware vSphere environment.

This document is not a guide to ESXi 5 VM system administration.

1.2 Authority

DoD Instruction (DoDI) 8500.01 requires that “all IT that receives, processes, stores, displays, or transmits DoD information will be [...] configured [...] consistent with applicable DoD cybersecurity policies, standards, and architectures” and tasks that Defense Information Systems Agency (DISA) “develops and maintains control correlation identifiers (CCIs), security requirements guides (SRGs), security technical implementation guides (STIGs), and mobile code risk categories and usage guides that implement and are consistent with DoD cybersecurity policies, standards, architectures, security controls, and validation procedures, with the support of the NSA/CSS, using input from stakeholders, and using automation whenever possible.” This document is provided under the authority of DoDI 8500.01.

Although the use of the principles and guidelines in these SRGs/STIGs provides an environment that contributes to the security requirements of DoD systems, applicable NIST SP 800-53 cybersecurity controls need to be applied to all systems and architectures based on the Committee on National Security Systems (CNSS) Instruction (CNSSI) 1253.

1.3 Vulnerability Severity Category Code Definitions

Severity Category Codes (referred to as CAT) are a measure of vulnerabilities used to assess a facility or system security posture. Each security policy specified in this document is assigned a Severity Code of CAT I, II, or III.

Table 1-1: Vulnerability Severity Category Code Definitions

	DISA Category Code Guidelines
CAT I	Any vulnerability, the exploitation of which will directly and immediately result in loss of Confidentiality, Availability, or Integrity.
CAT II	Any vulnerability, the exploitation of which has a potential to result in loss of Confidentiality, Availability, or Integrity.
CAT III	Any vulnerability, the existence of which degrades measures to protect against loss of Confidentiality, Availability, or Integrity.

1.4 STIG Distribution

Parties within the DoD and Federal Government's computing environments can obtain the applicable STIG from the Information Assurance Support Environment (IASE) website. This site contains the latest copies of any STIGs, SRGs, and other related security information. The address for the IASE site is <http://iase.disa.mil/>.

1.5 Document Revisions

Comments or proposed revisions to this document should be sent via email to the following address: disa.stig_spt@mail.mil. DISA will coordinate all change requests with the relevant DoD organizations before inclusion in this document. Approved changes will be made in accordance with the DISA maintenance release schedule.

1.6 Other Considerations

DISA accepts no liability for the consequences of applying specific configuration settings made on the basis of the SRGs/STIGs. It must be noted that the configuration settings specified should be evaluated in a local, representative test environment before implementation in a production environment, especially within large user populations. The extensive variety of environments makes it impossible to test these configuration settings for all potential software configurations.

For some production environments, failure to test before implementation may lead to a loss of required functionality. Evaluating the risks and benefits to a system's particular circumstances and requirements is the system owner's responsibility. The evaluated risks resulting from not applying specified configuration settings must be approved by the responsible Authorizing Official. Furthermore, DISA implies no warranty that the application of all specified configurations will make a system 100 percent secure.

Security guidance is provided for the Department of Defense. While other agencies and organizations are free to use it, care must be given to ensure that all applicable security guidance is applied both at the device hardening level as well as the architectural level due to the fact that some of the settings may not be able to be configured in environments outside the DoD architecture.

1.7 Product Approval Disclaimer

The existence of a STIG does not equate to DoD approval for the procurement or use of a product.

STIGs provide configurable operational security guidance for products being used by the DoD. STIGs, along with vendor confidential documentation, also provide a basis for assessing compliance with Cybersecurity controls/control enhancements, which supports system Assessment and Authorization (A&A) under the DoD Risk Management Framework (RMF). DoD Authorizing Officials (AOs) may request available vendor confidential documentation for a product that has a STIG for product evaluation and RMF purposes from disa.stig_spt@mail.mil. This documentation is not published for general access to protect the vendor's proprietary information.

AOs have the purview to determine product use/approval IAW DoD policy and through RMF risk acceptance. Inputs into acquisition or pre-acquisition product selection include such processes as:

- National Information Assurance Partnership (NIAP) evaluation for National Security Systems (NSS) (<http://www.niap-ccevs.org/>) IAW CNSSP #11
- National Institute of Standards and Technology (NIST) Cryptographic Module Validation Program (CMVP) (<http://csrc.nist.gov/groups/STM/cmvp/>) IAW Federal/DoD mandated standards
- DoD Unified Capabilities (UC) Approved Products List (APL) (<http://www.disa.mil/network-services/ucco>) IAW DoDI 8100.04

2. ASSESSMENT CONSIDERATIONS

2.1 Security Assessment Information

2.1.1 VMware ESXi Server 5.0 Security Technical Implementation Guide

The VMware ESXi 5 Security Technical Implementation Guide may be used as a guide for enhancing the security configuration of the ESXi 5 Server system, including the server's virtual machines and virtual networking components.

2.1.2 VMware vCenter Server Security Technical Implementation Guide

The VMware vCenter Server Security Technical Implementation Guide may be used as a guide for enhancing the security configuration of the vCenter Server system, including the vSphere Update Manager.

2.1.3 VMware Virtual Machine Security Technical Implementation Guide

The VMware Virtual Machine Security Technical Implementation Guide may be used as a guide for enhancing the security configuration of the ESXi 5 Server's virtual machines. This Overview is for ESXi 5 virtual machines.

2.2 Command Examples

Some check and fix procedures contain example commands that can be used to obtain information regarding compliance with a requirement or to change a setting to attain compliance with a requirement. These example commands assume use of a standard UNIX shell operating as the root user. The commands used in the ESXi 5 VM STIG are intended to only use the busybox utility, non-busybox ESXi 5 hypervisor command line commands, vSphere Client GUI software, and required parameters. If the busybox, command line, or GUI software used by these commands is not present on the system or does not recognize the specified options, the SA or the reviewer is responsible for determining compliance with the requirement using the tools available on the system. Check procedures also contain instructions for evaluating compliance based on the output of these commands.

2.3 File Paths

The check and fix procedures for the ESXi 5 VM STIG use absolute file paths where possible.

2.4 Alternate Software

vSphere 5 systems offer extreme flexibility in components provided by the vendor to meet operational needs. Many of the check and fix procedures in the ESXi 5 VM STIG assume the use of a specific command line or GUI utility provided by the vendor. The check and fix information, as provided, operates on a single VM at a time so as to minimize potential damage

to other VMs on the system. Alternate methods, such as PowerCLI, may be used to implement the checking and fixing processes more efficiently, with a slightly higher risk. If an alternate software Method is used to provide a function ordinarily provided by the default specified command line or GUI utility, the specific check and fix information for that function is no longer valid. The SA or the reviewer is responsible for evaluating the requirements based on documentation available for the alternate method used. The system accreditation package must contain information pertaining to the use of the alternate check and fix methodology used.

2.5 Requirements for Disabled Functions

The ESXi 5 VM STIG defines requirements for the further hardening and configuration of system functions that are required to be disabled. These requirements exist to address vulnerabilities in the system resulting from accidental activation, malicious intentional activation, or intentional activation of the system function based on acceptance of risk by the Authorizing Official (AO). Requirements for a system function remain applicable even when the system function is disabled. Requirements pertaining to software that is not installed on the system, and which has no remaining configuration files on the system, may be evaluated as not applicable.

3. CONCEPTS AND TERMINOLOGY CONVENTIONS

The ESXi 5 VM STIG assumes familiarity with some common vSphere 5 concepts and terminology. Some of these concepts and terms are defined and explained in this document in order to facilitate uniform interpretation of the requirements.

3.1 The ESXi 5 Server and Virtual Machines

To best understand the basic architecture of a virtualized system, the following definitions are provided:

Supervisor: A computer program (usually the kernel part of an operating system) that controls the execution of high-level routines and regulates scheduling, I/O operations, and system errors and regulates the flow of work in a data processing system. Historically, this term was associated with IBM's Mainframe OS/360. In other non-mainframe operating systems (OS), the supervisor is referred to as the kernel.

Hypervisor: A virtual machine manager/host (VMM) that allows multiple operating systems (also referred to as guests) to run concurrently on a host computer. It is so named because it is conceptually an abstraction of a supervisory program. The hypervisor presents, to the guest operating systems, a virtual operating platform, or virtual machine (VM). While ESXi 5 is an OS in the strictest sense, it is of a highly specialized and singularly purposed nature, not unlike an "appliance" with some initial configuration required. ESXi 5 is therefore atypical of what users would expect of an OS, due to the nature of how little it will actually support.

Hypervisor Type 1: A Type 1 (or native, bare metal) hypervisor runs directly on the host's hardware to control the hardware and to manage guest operating systems. The guest OS runs one level above the hypervisor. ESXi 5 is a Type 1 hypervisor.

Hypervisor Type 2: A Type 2 (or hosted) hypervisor runs within a conventional OS environment. With the hypervisor layer as a distinct second software level, guest operating systems run at the third level above the hardware. This does not apply to the ESXi 5 hypervisor.

In the ESXi 5 architecture, all of the VMware agents run directly on the ESXi 5 Server's VMkernel. Infrastructure services are provided natively through modules included in the VMkernel. Other authorized third-party modules, such as hardware drivers and hardware monitoring components, can run in the VMkernel as well. Only modules that have been digitally signed by VMware are allowed on the system, creating a tightly locked-down architecture.

Preventing arbitrary code from running on the ESXi 5 Server greatly improves the security and stability of the system.

A virtual machine is a tightly isolated software container, managed by the ESXi 5 Server, and can run its own operating systems and applications as if it were a physical computer. A virtual machine behaves exactly like a physical computer and contains its own virtual (i.e., software-based) CPU, RAM hard disk and network interface card (NIC).

An operating system cannot tell the difference between a virtual machine and a physical machine, nor can applications or other computers on a network. Even the virtual machine thinks it is a “real” computer. Nevertheless, a virtual machine is composed entirely of software and contains no hardware components whatsoever. As a result, virtual machines offer a number of distinct advantages over physical hardware.

The <virtual_machine>.vmx file contains all of the configuration information and hardware settings of the virtual machine. Whenever the settings of a virtual machine are modified, all of that information is stored in text format in this file. This file can contain a wide variety of information about the VM, including its specific hardware configuration (i.e., RAM size, network interface card info, hard drive info, and serial/parallel port info), advanced power and resource settings, VMware tools options, and power management options. While possible to manually modify the file to make changes to a VM’s configuration, it is not recommended to be done while the server VM is running, under normal operating conditions.

Alternatives to the manual editing of the <virtual_machine>.vmx file include scripts to automatically modify one or more configuration files and the use of the vSphere Client VM Properties Editor, i.e., connect to the vCenter Server via the vSphere Client. In the vSphere Client inventory, right-click the virtual machine and select Edit Settings. Select the Options tab, and under Advanced, select General. Next, select Configuration Parameters and change or add one or more parameters. Select OK to exit the Configuration Parameters dialog box and select OK to save the changes and close the dialog box.

Precautions must be taken to ensure the vCenter Server is “aware” of all changes. The <virtual_machine>.vmx file and contents (keywords and settings) are addressed in the virtual machine section of the ESXi 5 Virtual Machine STIG as the primary focus for virtual machine hardening.

All virtual disks are made up of two files, a large data file equal to the size of the virtual disk and a small text disk descriptor file, which describes the size and geometry of the virtual disk file.

The descriptor file also contains a pointer to the large data file as well as information on the virtual disk’s drive sectors, heads, cylinders and disk adapter type. In most cases these files will have the same name as the data file that it is associated with (i.e., vm_1.vmdk and vm_1-flat.vmdk).

The three different types of virtual disk data files that can be used with virtual machines are covered below:

- The -flat.vmdk file
This is the default large virtual disk data file that is created when you add a virtual hard drive to your VM that is not an RDM. When using thick disks, this file will be approximately the same size as what you specify when you create your virtual hard drive. One of these files is created for each virtual hard drive that a VM has configured, as shown in the examples below.

- The `-delta.vmdk` file
These virtual disk data files are only used when snapshots are created of a virtual machine. When a snapshot is created, all writes to the original `-flat.vmdk` are halted and it becomes read-only; changes to the virtual disk are then written to these `-delta` files instead. The initial size of these files is 16 MB and they are grown as needed in 16 MB increments as changes are made to the VM's virtual hard disk. Because these files are a bitmap of the changes made to a virtual disk, a single `-delta.vmdk` file cannot exceed the size of the original `-flat.vmdk` file. A delta file will be created for each snapshot created for a VM and their file names will be incremented numerically (i.e., `vm-000001-delta.vmdk`, `vm-000002-delta.vmdk`). These files are automatically deleted when the snapshot is deleted after they are merged back into the original `-flat.vmdk` file.
- The `-rdm.vmdk` file
This is the mapping file for the RDM that manages mapping data for the RDM device. The mapping file is presented to the ESXi Server as an ordinary disk file, available for the usual file system operations. However, to the virtual machine, the storage virtualization layer presents the mapped device as a virtual SCSI device. The metadata in the mapping file includes the location of the mapped device (name resolution) and the locking state of the mapped device. In a directory listing, these files will appear to take up the same amount of disk space on the VMFS volume as the actual size of the LUN that it is mapped to, but, in reality, the files just appear that way while the actual size is very small. One of these files is created for each RDM that is created on a VM.

3.2 ESXi 5 Virtual Networking

vSphere virtual networking provides services to the vSphere ESXi Server and virtual machines. There are four types of network services enabled in vSphere networking:

- Connecting virtual machines to each other within a single vSphere host
- Connecting virtual machines to the physical network
- Connecting VMkernel services (such as NFS, iSCSI, or vSphere vMotion) to the physical network
- Networking for the management interface, which runs management services for vSphere hosts (set up by default during installation)

vSphere networking consists of two logical building blocks: Virtual Ethernet Adapters and Virtual Switches.

A virtual machine can be configured with one or more virtual Ethernet adapters. Virtual Ethernet adapters are presented to the guest OS by the virtual machine hardware. These virtual adapters are seen by the guest OS as common network interface cards and will use standard drivers available for the OS.

Virtual switches allow virtual machines on the same vSphere ESXi Server to communicate with each other using the same protocols used with physical switches. The virtual switch emulates a traditional physical Ethernet network switch to the extent that it forwards frames at the data link layer.

The design of a virtual network with vCenter Server and ESXi 5 is very similar to building a physical network. Some of the factors that affect the design of a virtual network:

- vSphere Standard Switch – A VMkernel software-based switch that provides virtual machine traffic management. Standard switches must be managed independently on a host-by-host basis.
- vSphere Distributed Switch – A VMkernel software-based switch that provides traffic management for virtual machines and the VMkernel across all ESXi 5.0 Server hosts connected in a vCenter Server Cluster. Distributed switches (dvSwitches) do not exist by default and must be provisioned. For systems where dvSwitches (and associated dvPortGroups) are non-existent, the STIG requirements shall not apply.
- Ports and Port Groups – A logical object on a vSwitch that provides general-to-specialized services for the VMkernel and/or virtual machines. A virtual switch will contain a VMkernel port or a virtual machine port group but must never contain both. An exception, in extreme circumstances where hardware must be shared due to limited resources, must ensure isolation of production virtual machine traffic from management traffic through the use of VLANs for production virtual machine traffic.
- VMkernel Port – This is a specialized virtual switch port type that is configured with an IP address defined to implement functions such as vMotion, network attached storage (NAS), Network File Systems (NFS), and ESXi Server management connectivity.
- Virtual Machine Port Group – This is a group of virtual switch ports that share a common configuration, allowing virtual machines to access other virtual machines and/or the physical network.
- Uplink ports – Uplink ports provide the logical connectivity between the virtual switch and the physical adapters installed in the host. Uplink ports are connected to specific physical adapters based on configuration.
- Uplinks – Uplinks are physical Ethernet adapters that serve as bridges between the virtual and physical network. Currently, a host may have up to 32 uplinks.

3.3 The ESXi 5 vSphere Client

The vSphere Client is an application included with the ESXi 5 Server that enables management of a vSphere ESXi 5 Server installation. The vSphere Client provides an administrator with access to the key functions of vSphere without the need to access a vSphere server directly. The vSphere Client is the interface that must be used for all day-to-day ESXi 5 Server management tasks. It is a requirement that the vSphere Client first connect to the vCenter Server that the ESXi 5 Server is registered with, prior to conducting any day-to-day ESXi 5 Server management.

vCenter Server provides a single point of control in the datacenter. It provides essential datacenter services such as access control, performance monitoring, and configuration. It unifies the resources from the individual computing servers to be shared among virtual machines in the entire datacenter. It does this by managing the assignment of virtual machines to the computing servers and the assignment of resources to the virtual machines within a given computing server based on the policies that the system administrator sets. Computing servers continue to function even in the unlikely event that vCenter Server becomes unreachable (for example, if the network

is severed). Servers can be managed separately and continue to run the virtual machines assigned to them based on the resource assignment that was last set. After connection to vCenter Server is restored, it can manage the datacenter as a whole again.

It is a requirement that the vCenter Server be installed as a dedicated, physical machine, running a supported Microsoft Windows Operating System. vCenter Server requires running a supported database, hosted on a separate physical machine, running a supported operating system. vCenter Server supports IBM DB2, Oracle, and Microsoft SQL Server databases.

Once an ESXi 5 Server is registered with and managed by a vCenter Server, it must never be logged on to and managed locally, as any changes to the server or its virtual machines will eventually be overwritten by the configuration registered with the vCenter Server.

3.4 The ESXi 5 Shell and SSH

The ESXi 5 Shell is a simple shell intended for advanced troubleshooting under the guidance of technical support. When remote command-line tools are not capable of addressing a particular issue, the ESXi 5 Shell provides an alternative. Similar to how the COS is used to execute diagnostic commands and fix certain low-level problems, the ESXi 5 Shell enables users to view log and configuration files, as well as to run certain configuration and utility commands to diagnose and fix problems. The ESXi 5 Shell is not based on Linux. Rather, it is a limited-capability shell compiled especially for ESXi 5.

In addition to being available on the local console of a host, the ESXi 5 Shell can be accessed remotely through SSH. The ESXi 5 SSH implementation is not a full-featured version. Access to the ESXi 5 Shell is controlled in the following ways:

- Both SSH and the ESXi 5 Shell can be enabled and disabled separately in both the DCUI and the vSphere Client or through vSphere PowerCLI. Any authorized user, not just root, can use the ESXi 5 Shell. Users become authorized when they are granted the administrator role on a host (through Active Directory membership in a privileged group and through other methods).
- All commands issued in the ESXi 5 Shell are logged through syslog, providing a full audit trail. If a syslog server is configured, this audit trail is automatically included in the remote logging.
- A timeout for the ESXi 5 Shell (including SSH), will automatically disable the interface(s) after the configured time. Changes to the SSH timeout will apply only to new sessions. Existing sessions will not be timed out, but any new session is disallowed after the timeout period.
- The ESXi 5 Shell is vendor-recommended for use primarily for vendor support, initial configuration of complex configuration files, troubleshooting, and break-fix situations. It also can be used as part of a scripted installation, as described in a previous section. All other uses of the ESXi 5 Shell, including running custom scripts (i.e., development), are not recommended in most cases. Instead, the vSphere vCLI or vSphere PowerCLI must be used.

Note: Both the ESXi 5 Shell and SSH are disabled by default.

3.5 The ESXi 5 Server Local Access and Lockdown Mode

ESXi 5 provides the ability to fully control all direct access to the host via vCenter Server 5. After a host has been joined to vCenter Server 5, every direct communication interface with the host is configurable as an independent service in the Configuration tab for the host in the vSphere Client. This includes the following interfaces:

- DCUI (Direct Console User Interface)
- ESXi 5 Shell
- SSH

Each of these can be turned on and off individually through either the vSphere Client/vCenter interface or the DCUI.

When Lockdown Mode is enabled on the host, all direct remote access to the host is blocked, including:

- Any vSphere API client
- ESXi 5 Shell
- SSH

Even when Tech Support Mode is enabled, Lockdown Mode effectively overrides this by preventing any connection from succeeding. The only way to manage the host remotely is through vCenter Server. The interaction between the host and vCenter Server occurs through a special-purpose account called “vpxuser”; all other accounts, including root, can no longer connect remotely.

With Lockdown Mode enabled, the only direct access to the host that remains open is through the DCUI. The DCUI allows you to interact with the host locally using text-based menus. You can use the Direct Console User Interface to enable local and remote access to the ESXi 5 Shell. This provides a way to perform limited administrative tasks outside of vCenter Server. The DCUI can also turn off Lockdown Mode, disabling it without going through vCenter Server. This might be useful if vCenter Server is down or otherwise unavailable and users want to revert to direct management of the host. To log on to the DCUI in Lockdown Mode, however, the root password is required. No other user can log on, even if they have been granted an administrator role.

The requirement is that Lockdown Mode, including the DCUI, be enforced in ordinary, day-to-day operations but that it is temporarily disabled, as required, for a host, if the need arises to interact with it directly. Note that Lockdown Mode does not apply to standalone ESXi 5.0 installations.

4. SOFTWARE PATCHING GUIDELINES

Maintaining the security of an ESXi 5 system requires frequent reviews of security bulletins. Many security bulletins and IAVM notifications mandate the installation of software patches to overcome noted security vulnerabilities. The SA will be responsible for ensuring the installation of all such patches. The ISSO will ensure the vulnerabilities have been remedied. DISA guidelines for remediation, including IAVMs, are as follows:

- Apply the applicable patch, upgrade to required software release, or remove the binary/application to remediate the finding.
- Or, the mode of the vulnerable binary may be changed to 0000 to downgrade the finding (for example, a CAT I finding may be downgraded to a CAT II).

SAs and ISSOs will regularly check the operating system's vendor and third-party application vendor websites for information on new vendor-recommended updates and security patches that are applicable to their site. All applicable vendor-recommended updates and security patches will be applied to the system. A patch is deemed applicable if the product is installed, even if it is not used or is disabled.

Operating system, virtual machine, and virtual network patching is accomplished through the use of three VMware products:

- vCenter Server
- VMware's Update Manager
- VMware's Update Manager Download Service/Server

The vCenter Server (vCS) is the central management system for ESXi 5. The VMware Update Manager (vUM) is responsible for updating the ESXi 5 server and VMs. The VMware vSphere Update Manager Download Service (vUMDS) is an optional module of the Update Manager.

The vUMDS downloads software upgrades for virtual appliances, patch metadata, patch binaries, and notifications that would not otherwise be generally available to the Update Manager server.

Virtual machine guest operating systems cannot be updated by the vCS, vUM, or vUMDS. A separate product, VMware Protect, centralizes patch management and asset inventory for Windows and third-party applications for both virtual and physical machines. The details of VMware Protect are not discussed within the scope of the ESXi 5 VM STIG.