



*VMware® Software-Defined Data Center
(SDDC)
Product Applicability Guide for PCI DSS*

May 21, 2019

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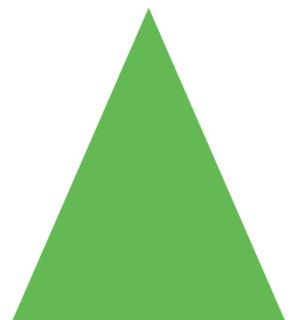


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Revision History

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Solution Area	Key Products
Software-Defined Compute	VMware ESXi™, VMware vCenter®, VMware Cloud Foundation™, VMware vSAN™, VMware vCloud Director®, VMware vCloud Director Extender, VMware vCloud® Usage Meter
Software-Defined Networking	VMware NSX®
Management and Automation	VMware vRealize® Network Insight™, VMware vRealize Automation™, VMware vRealize Orchestrator™, VMware vRealize Log Insight™, VMware vRealize Operations Manager™, VMware AppDefense™, VMware Identity Manager™
Disaster Recovery Automation	VMware Site Recovery Manager™, VMware vSphere® Replication™, VMware vCloud Availability for vCloud Director®

Disclaimer (Tevora)

The opinions stated in this guide concerning the applicability of VMware® products to the PCI DSS framework are the opinions of Tevora. All readers are advised to perform individual product evaluations based on organizational needs.

For more information about the general approach to compliance solutions, please visit [VMware Solution Exchange: Compliance and Cyber Risk Solutions](#). This whitepaper has been reviewed and authored by Tevora's staff of Information Security Professionals in conjunction with VMware, Inc.

Disclaimer (VMware)

This document is intended to provide general guidance for organizations that are considering VMware solutions to help them address compliance requirements. The information contained in this document is for educational and informational purposes only. This document is not intended to provide regulatory advice and is provided "AS IS." VMware makes no claims, promises or guarantees about the accuracy, completeness, or adequacy of the information contained herein. Organizations should engage appropriate legal, business, technical, and audit expertise within their specific organization for review of regulatory compliance requirements.

Executive Summary

Background

This Product Applicability Guide (PAG) will provide an evaluation of VMware products that make up and support the Software-Defined Data Center (SDDC), and how they may support the Payment Card Industry Data Security Standard, v3.2.1 (PCI DSS/PCI) controls. These products virtualize and abstract the physical technology layers such as compute, storage, and network, the essence of an SDDC. The changing technology landscape that is modernizing the data center is also modernizing the virtual desktop environment and mobile device management while making inroads to consolidate and automate Information Technology (IT) resources. VMware prioritizes data protection and system security features within the SDDC. The VMware Compliance Solutions team developed a framework that incorporates SDDC product capabilities aligned to PCI DSS controls. The product capabilities and framework of this PAG utilized NIST 800-53 as their foundational security framework to create a series of standards. These standards have then been used to illustrate how VMware products and their capabilities apply to other industry frameworks such as NIST 800-171 and PCI DSS.

VMware engaged Tevora, an independent third-party IT audit firm, to conduct a review of the SDDC and VMware Cloud™ solution's alignment to PCI DSS. This document is the culmination of Tevora's discussions with VMware product teams to perform a thorough evaluation of VMware product capabilities mapped to PCI DSS requirements.

Tevora is a leading security consulting firm specializing in enterprise risk, compliance, information security solutions, and threat research. Tevora offers a comprehensive portfolio of information security solutions and services to clients in virtually all industries. This PAG will navigate readers through the PCI DSS standard and highlight applicable VMware product capabilities.

VMware SDDC and PCI DSS

Today's infrastructures are heterogeneous in nature, built upon collaborations between internally constructed products and third-party sourced components, all guided by a customer's complex business and compliance requirements.

VMware approaches compliance with a view that understands the complexity in environments and addresses those areas where virtualization can be leveraged to develop a more secure environment. This focused view on compliance is reflected in the VMware Compliance Solutions framework, which allows for a wide-ranging adoption of regulatory controls.

The phrase "security by design" identifies architectural decisions and default settings inside VMware products that are integrated into the product lifecycle. This approach reflects the process VMware follows to weave in security through all stages of the product lifecycle, and not as an afterthought. This overlap between products and compliance requirements marries security and non-security product capabilities in an improved way to also achieve operational innovation. Due to the breadth of the NIST compliance framework, VMware selected NIST 800-53 as its foundation for all future PAGs including PCI DSS and as the acknowledgment across industry standards that have been derived from the larger NIST risk framework.

What is SDDC?

The Software-Defined Data Center architecture creates a completely automated, highly available environment for any application, and any hardware. SDDC can be used in any type of cloud model, and extends the existing concepts associated with the cloud such as abstraction, pooling, and virtualization across the cloud environment. Features of the SDDC can be deployed as a suite or can also work independently to allow for a controlled deployment over time.

What is PCI DSS?

The Payment Card Industry Data Security Standard (PCI DSS) is an information security standard for organizations that handle branded credit cards from the major credit card brands. The standard was created to increase security around cardholder data and protect consumers. This standard applies to any organization that stores, processes or handles cardholder data.

Cardholder data can consist of several items, including:

- Primary Account Number (PAN)
- Name of the cardholder
- The Card's expiration date
- The Card's service code

An individual business interaction with cardholder data will vary depending on their defined operations. This underscores that there is no one-size fits all recommendation to secure a cardholder data environment (CDE). The responsibility resides with the individual business to ensure they appropriately assess what requirements fit their environment to adequately protect cardholder data along PCI DSS standards.

Validation of compliance is performed annually, either by an external Qualified Security Assessor (QSA) that creates a Report on Compliance (ROC) for organizations handling large volumes of transactions, or by Self-Assessment Questionnaire (SAQ) for companies handling smaller volumes.

As with many security standards, PCI DSS takes a variety of its intentions from NIST 800-53 as guidance for defense in depth security within the cardholder environment.

Introduction

What is PCI DSS v3.2.1?

PCI DSS v3.2.1 is an updated version of the PCI Data Security Standard originally developed by PCI Standards Council in 2004. This version considers evolving technologies and threat vectors to consumers, merchants and other entities within the transaction chain.

How does PCI DSS work?

The PCI DSS standard requires organizations to comply with a robust set of requirements. The criteria are broken down into 6 objective areas and 12 requirements (listed below). Each requirement has a set of controls, the necessary testing procedures to ensure that they are implemented appropriately with expert guidance.

- Build and Maintain a Secure Network and Systems
 - Requirement 1 (Req.1): Install and maintain a firewall configuration to protect cardholder data
 - Requirement 2 (Req.2): Do not use vendor-supplied defaults for system passwords and other security parameters
- Protect Cardholder Data
 - Requirement 3 (Req.3): Protect stored cardholder data
 - Requirement 4 (Req.4): Encrypt transmission of cardholder data across open, public networks
- Maintain a Vulnerability Management Program
 - Requirement 5 (Req.5): Protect all systems against malware and regularly update anti-virus software or programs
 - Requirement 6 (Req.6): Develop and maintain secure systems and applications
- Implement Strong Access Control Measures
 - Requirement 7 (Req.7): Restrict access to cardholder data by business need to know
 - Requirement 8 (Req.8): Identify and authenticate access to system components
 - Requirement 9 (Req.9): Restrict physical access to cardholder data
- Regularly Monitor and Test Networks
 - Requirement 10 (Req.10): Track and monitor all access to network resources and cardholder data
 - Requirement 11 (Req.11): Regularly test security systems and processes.
- Maintain an Information Security Policy
 - Requirement 12 (Req.12): Maintain a policy that addresses information security for all personnel.

The scope of the PCI environment varies from organization to organization. VMware products help enforce controls configured by each client based on their individual environment. Organizations need to define the scope of their cardholder environment and controls.

Scope and Approach

The SDDC and VMware Cloud platform covers a wide number of products and architectures. The platforms and each of their component products contain features that could be mapped to some PCI DSS requirements. Of the 12 total requirements, 10 had mapping overlaps to VMware software capabilities. This guide expands to account for all products underneath the SDDC umbrella. The scope of this guide is limited to those requirements supported either technically or through direct API integration. People and process controls are defined as administrative controls, in support of PCI DSS requirement intents.

What Is a Cardholder Data Environment?

The CDE is the key area in question within PCI DSS. The CDE can be described as any computer system or network that either processes, stores, or transmits cardholder data or other sensitive payment information. The environment extends to include any device that maintains a direct connection to the device(s) meeting description of a CDE as outlined above.

The CDE can include but is not limited to any of the following devices:

- Firewalls
- Switches
- Routers
- Access Points
- Point of Sale (POS) Systems
- Point of Interaction (POI) Devices
- Servers (including Webservers, application servers, or database servers)
- Any application that accepts payments
- Any associated virtual components (including virtual machines (VMs) and virtual networking devices)
- Third-party support staff or systems

Our Approach

This Product Applicability Guide (PAG) is intended to provide information for all security and compliance practitioners on Tevora’s recommended usage of the VMware technical stack to address regulatory compliance obligations and enhance the security of their services through the security and compliance framework of PCI DSS. It is up to each organization to identify how their compliance will be stated and the expense of their CDE. The PAG focuses on capabilities of the SDDC product and VMware Cloud at the requirement level. A technical whitepaper, to be released later, will compile information gathered within this PAG and apply to each individual PCI DSS requirement and their underlying controls.

Appendix B outlines specific product capabilities for SDDC and VMware Cloud, and their alignment to PCI DSS requirements.

In addition to the PCI DSS standard requirements, eleven (11) security lenses were used to serve as a baseline to evaluate SDDC and VMware Cloud products. From the ground up, VMware strives to design, define, and deliver compliance solutions to customers. The compliance solution begins with a compliance context (e.g., requirements from the appropriate standards in question). Next, the technical requirements applicable to the VMware products are mapped to in-scope compliance requirements. Finally, an independent audit evaluation of the design is conducted. The output is a solution that has interwoven compliance requirements into the end solution available to customers. Below is an overview of this process.

Compliance Solutions

Regulatory Controls Mapping

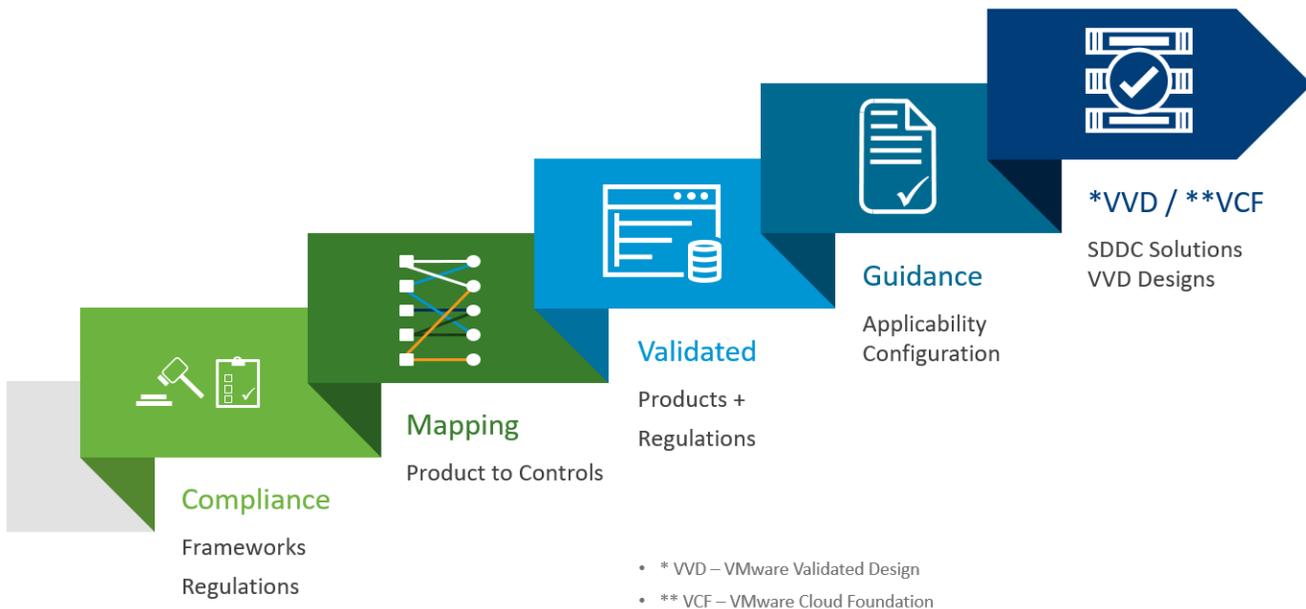


Exhibit 1: VMware Compliance Solutions Regulatory Controls Mapping

Outside of the process described above, these eleven (11) areas are broad categories of controls that are implemented within today's security programs. They can be used to further understand the broader technology concepts used to build security architectures and to implement controls to mitigate risks.

The eleven (11) security lenses include:

- Automated Security
- System Hardening
- Compliance Validation
- System Access
- Data Segmentation
- System Monitoring
- Data Encryption & Protection
- Network Protection
- Endpoint Protection
- Trusted Execution/Secure Boot
- Software Development Lifecycle (SDLC)

Evaluating the SDDC and VMware Cloud through the additional layer of security lenses helps security and compliance practitioners understand how products deliver the features required not only to support compliance with the PCI DSS standard but also to comport with general security best practices.

Tevora reviewed the high-level product design, followed by a detailed examination of data flows, features, architectures, and capabilities across all in-scope products to identify applicable controls. The testing considered all potential configurations that allow SDDC products to support each requirement.

This guide provides executives, technology experts, and security and compliance practitioners with insight to enhance security and compliance postures using VMware products. The SDDC's flexibility in feature deployment allows for connection with preexisting systems to further fortify security, privacy, and compliance. Understanding this flexibility is key to then understanding how VMware products can be deployed with continuous compliance in mind.

VMware Product Applicability to PCI DSS 3.2.1 Controls

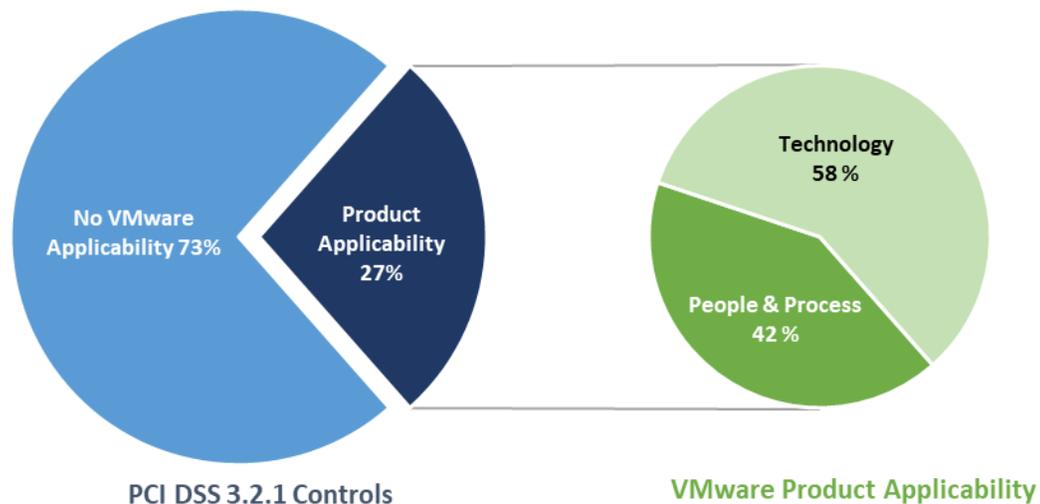


Exhibit 2: Percentage of SDDC Products that are capable of meeting the PCI DSS (v. 3.2.1) controls.

In-Scope VMware Product List

Software-Defined Data Center (SDDC)

VMware ESXi™ 6.0, 6.5, 6.7 – ESXi is a purpose-built bare-metal hypervisor that installs directly onto a physical server. With direct access to and control of underlying resources, ESXi is more efficient than hosted architectures and can effectively partition hardware to increase consolidation ratios and cut costs for customers.

VMware vCenter® 6.0, 6.5, 6.7 – vCenter provides centralized management of VMware vSphere® virtual infrastructure. IT administrators can prioritize security and availability, simplify day-to-day tasks, and reduce the complexity of managing virtual infrastructure.

VMware vSAN™ 6.2, 6.5, 6.6 – vSAN is a core building block for the Software-Defined Data Center, delivering enterprise-class, flash-optimized, and secure storage for all of a user's critical vSphere workloads.

VMware Cloud Foundation™

VMware Cloud Foundation and SDDC Manager 2.2 – Cloud Foundation is the integrated cloud infrastructure platform for the hybrid cloud. It provides dynamic software-defined infrastructure (compute, storage, networking, and security) to run enterprise applications in both private and public environments.

VMware Cloud Provider Platform

VMware vCloud Director® 9.5 – vCloud Director is the VMware flagship cloud management platform for cloud providers. vCloud Director enables cloud providers to deliver differentiated cloud services on their VMware cloud infrastructure and provides enterprises with self-service cloud capabilities.

VMware vCloud Director Extender 1.1 – vCloud Director Extender provides the ability to connect vCenter environments on-premises to a cloud based on vCloud Director to securely migrate virtual machines, and extend virtual networks to the cloud. vCloud Director Extender provides seamless hybridity between on-prem and cloud environments based on vSphere.

VMware vCloud Usage Meter 3.6.1 – vCloud Usage Meter helps cloud providers access VMware resources on a consumption-based monthly subscription, including vCloud Usage Insight, a SaaS tool that provides automated usage reporting, simple onboarding, secure data transfer and aggregation of usage across all contracts and sites.

VMware vCloud Availability for vCloud Availability Cloud to Cloud 1.5, 2.0.0 DR provides vSphere native replication of workloads for disaster recovery or migration purposes between vCloud Director organization virtual data centers. The solution is compatible to the vCloud Director self-service user interface (UI) or standalone and features symmetric source or destination execution of replication, migration, failover and failback of workload virtual machines and VMware vSphere vApps™ within vCloud Director. Using a consumption model, cloud providers are able to monetize their infrastructure by driving more breadth in their portfolios by offering additional managed or self-

service disaster recovery and contingency planning services between cloud instances on a tiered basis and drive professional service opportunities.

VMware Cloud Provider Pod 1.1 – Cloud Provider Pod automates and documents the deployment of a Cloud Provider Platform solution stack that adheres to VMware Validated Design for Cloud Provider principles and is thoroughly tested for interoperability and performance. The Cloud Provider Platform technologies deployed by Cloud Provider Pod enables providers to deliver self-service tenant capabilities such as data center extension, cloud management, cloud migration, metering and chargeback in an inherently multi-tenant infrastructure. Cloud Provider Pod helps cloud providers achieve a faster path to cloud services delivery based on vSphere.

Virtualized Networking

VMware NSX® 6.3.5 – NSX is the network virtualization and security platform for the Software-Defined Data Center (SDDC), delivering the operational model of a virtual machine for entire networks. With NSX, network functions including switching, routing, and firewalling are embedded in the hypervisor and distributed across the environment.

VMware vRealize® Suite

VMware vRealize Operations Manager™ 6.6 – vRealize Operations Manager is designed to automate and simplify the performance, troubleshooting, capacity, cost planning, and configuration management of applications and infrastructure across physical, virtual, and cloud environments.

VMware vRealize Log Insight™ 4.5 – vRealize Log Insight delivers heterogeneous and highly scalable log management with intuitive, actionable dashboards; sophisticated analytics; and broad, third-party extensibility, providing deep operational visibility and faster troubleshooting.

VMware vRealize Network Insight™ 3.4 – vRealize Network Insight delivers intelligent operations for software-defined networking and security. It helps customers build an optimized, highly available, and secure network infrastructure across multi-cloud environments. It accelerates micro-segmentation planning and deployment, enables visibility across virtual and physical networks, and provides operational views to manage and scale NSX deployments.

VMware vRealize Orchestrator™ 7.3 – vRealize Orchestrator is a powerful automation tool designed for system administrators and IT operations staff who must streamline tasks and remediation actions and integrate these functions with third-party IT operations software.

VMware vRealize Automation™ 7.3 – vRealize Automation empowers IT to accelerate the provisioning and delivery of IT services across infrastructure, containers, applications, and custom services. Leveraging the extensible framework provided by vRealize Automation allows for streamlining and automating the lifecycle management of IT resources from initial service model design through Day One provisioning and Day Two operations.

Business Continuity

VMware Site Recovery Manager™ 6.5 – Site Recovery Manager is the industry-leading solution to enable application availability and mobility across sites in private cloud environments. It is an automation software that integrates with an underlying replication technology to provide policy-based management, non-disruptive

testing, and automated orchestration of recovery plans. This provides simple and reliable recovery and mobility of virtual machines between sites, with minimal or no downtime.

VMware vSphere Replication™ 6.5 – vSphere Replication is an extension to VMware vCenter Server® that provides hypervisor-based virtual machine replication and recovery.

VMware AppDefense

VMware AppDefense™ 1.0 – AppDefense is a data center endpoint security product that protects applications running in virtualized and cloud environments.

Digital Workspace

VMware Identity Manager™ – 3.0 – VMware Identity Manager is an identify as a service (IDaaS) offering that provides single sign-on (SSO) capabilities and user-based controls for web, cloud and mobile applications

Appendix B in this guide showcases the capabilities of all products in alignment with PCI DSS intents.

Overview of VMware and PCI DSS Best Practices and Requirement Mapping

Best Practice Area (Lens)	PCI DSS Requirement(s)	Capability Description	VMware Product Applicability
Automated Security	Req.10, Req.11	Automated Deployment, Automated Remediation	Site Recovery Manager vSphere Replication vRealize Operations vCloud Director vCloud Availability for vCloud Director VMware Identity Manager
Data Segmentation	Req.1, Req.3, Req.11, Req.12	Network & Host Firewall, Information Flow	Network Virtualization and Security VMware Validated Design Cloud Foundation vRealize Network Insight vRealize Operations vRealize Log Insight AppDefense vCloud Usage Meter vCloud Director vCloud Director Extender vCloud Availability for vCloud Director
System Hardening	Req.1, Req.3, Req.4, Req.6, Req.12	Configuration Management, Patch Management, Vulnerability Management	vRealize Network Insight vRealize Operations vRealize Log Insight vSphere Update Manager Network Virtualization and Security ESXi AppDefense vCloud Usage Meter vCloud Director vCloud Director Extender vCloud Availability for vCloud Director
Compliance Validation	Req.6, Req.12	Configuration Management	vRealize Network Insight vRealize Operations vRealize Log Insight Network Virtualization and Security AppDefense vCloud Director
System Access	Req.7, Req.8	Two-Factor Authentication, Identity and Access Management	vCenter Network Virtualization and Security vRealize Network Insight vRealize Log Insight vRealize Operations ESXi AppDefense vCloud Usage Meter vCloud Director vCloud Director Extender

System Monitoring	Req.10, Req.11	Security Information Event Monitoring (SIEM), Database Monitoring	vCloud Availability for vCloud Director VMware Identity Manager vRealize Log Insight vRealize Network Insight vRealize Operations Site Recovery Manager vSphere Replication vSphere Update Manager vCenter AppDefense vCloud Usage Meter vCloud Director vCloud Director Extender vCloud Availability for vCloud Director VMware Identity Manager
Data Encryption & Protection	Req.1, Req.3, Req.4, Req.6	Data at Rest Encryption, Data in Motion Encryption, System Backup & Restore	EXSi VM Encryption feature vSAN Encryption feature VMware vSphere vMotion® encryption Network Virtualization and Security vRealize Operations vRealize Network Insight vRealize Log Insight VMware Validated Design Cloud Foundation vSphere Update Manager AppDefense vCloud Usage Meter vCloud Director vCloud Director Extender vCloud Availability for vCloud Director
Network Protection	Req.1, Req.3, Req.6, Req.11	Intrusion Prevention System, Web Application Firewall	Site Recovery Manager vSphere Replication Network Virtualization and Security vRealize Operations vRealize Network Insight vRealize Log Insight AppDefense vCloud Director vCloud Director Extender vCloud Availability for vCloud Director
Endpoint Protection	Req.2, Req.3, Req.5, Req.6, Req.7, Req.8, Req.11	Endpoint A/V and Malware Prevention, File Integrity Monitoring, Data Leakage Protection, Mobile Device Management	Network Virtualization and Security ESXi vRealize Operations vRealize Network Insight vRealize Log Insight AppDefense vCloud Director vCloud Director Extender vCloud Availability for vCloud Director VMware Identity Manager
Trusted Execution/Secure Boot	Req.3, Req.6	Execution Integrity	ESXi Network Virtualization and Security vRealize Operations AppDefense

			vCloud Director vCloud Director Extender VMware Validated Design Cloud Foundation
Software Development Lifecycle (SDLC)	Req.6	Configuration Integrity	

Exhibit 3 represents a high-level view of how VMware technology capabilities match up to best practices areas as well as PCI DSS requirement topics.

VMware Control Capabilities Detail

VMware Validated Design and Software Development Process

VMware developed the VMware Validated Design (VVD) to allow organizations to implement the full SDDC platform using a design that is validated and provides the detail required to confidently deploy SDDC. The VVD is available to anyone and is published on the VMware website.

The VMware Software Development Lifecycle (SDLC) designs security into all phases of SDDC and VMware Cloud products (Exhibit 4). This principled approach to designing security, overseen by VMware Product Security from the start, is important to PCI DSS compliance, as the products utilized are required to have security interwoven through their underlying substructures, to be supported by administrative policy.

With compliance and security woven into the SDLC, VMware improves the quality of its products and solution platforms that can support organizations needing to achieve PCI compliance.

As further reference to the primary purposes of a control family, each detail segment provides the applicable security lens defined within the VMware approach. These lenses are hallmarks of a mature security program addressing common areas of vulnerabilities.

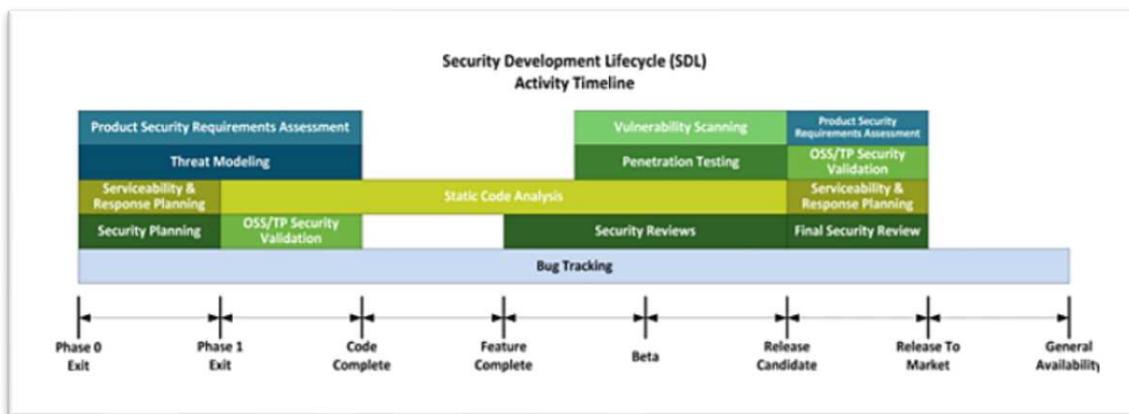


Exhibit 4: VMware SDL Activity Timeline

Core and Administrative Control Categories

Enforcing defense in depth throughout a CDE requires a combination of technical and process or policy-based controls. That results in PCI DSS requirements covering a wide spectrum of control types. To streamline the delivery of this PAG and the intent of each control family, those categories were tailored into core and administrative. Core control families are those that address the main structure of a PCI program through technical features and capabilities. Administrative control families support multiple control areas through policy development and general program, people, and process management tasks. Further details on these categories and the aligned control families can be found in the following sections.

VMware Administrative Support for PCI Requirements

PCI DSS establishes requirements for technical and operational controls, procedures, or other security standards, which can be met by leveraging VMware products or VMware technology capabilities. Other PCI controls may identify physical or operational requirements that are not able to be met by software alone. However, these controls may rely on or be supported by underlying VMware product capabilities. While VMware products do not map neatly to these controls, they support their fulfillment through alerts, scripting, and monitoring.

This is a common thread throughout the capabilities discussed below. An organization will be able to deploy VMware products, apply the PCI DSS requirements, and monitor them through the compliance-capable platform. In this way, implementing policy or operating procedures assists in maintaining a secure and compliant information architecture.

An example of an administrative requirement is Requirement 12. This requirement requires a documented information security policy or set of detailed security procedures. Using VMware products such as NSX or vRealize Log Insight, a company can enforce standards defined by existing policies and then monitor endpoints against those standards and be alerted as soon as a system deviated. In this way, VMware can support the definitions of Requirement 12, while not fulfilling the specific controls laid out in the requirement. Requirement 12 is more focused on the people and process behind the policy itself. Thus, this guide will treat the requirement as an administrative support requirement instead of a core requirement because VMware product capabilities support the administration of the requirement rather than actually fulfilling a control item.

The following requirements are classified as administrative:

- Requirement 9: Restrict physical access to cardholder data
- Requirement 12: Maintain a policy that addresses the information security for all personnel

VMware Core Support for PCI Requirements

For those PCI requirements where a product will partially or fully satisfy a control requirement, VMware capabilities are identified as core to the requirement in question. These are the areas within PCI DSS that best highlight how each product provides capabilities to strengthen the security and support a compliance-capable platform.

The details below showcase the SDDC and VMware Cloud components that support or apply to each PCI control requirement and their respective high-impact controls. Each area defines the intention of the PCI requirement, aligning security lenses as described in the “**Our Approach**” section (above), and the specifics of the product and their native features that meet control standards. Exhibit 2 (above) illustrates this information.

This guide provides organizations with the opportunity to harness the capability of modern virtualization technology to enhance their security program and processes. Organizations can be confident in their decision

to elevate the sophistication of techniques needed to meet complex requirements and secure modern technology infrastructure.

While all controls described within the PCI DSS must be adhered to for compliance, the following requirements are defined as “core” controls as native VMware features support or execute the intent of specific aspects of the requirement and underlying controls as shown in Appendix B:

- Requirement 1: Install and maintain a firewall configuration to protect cardholder data
- Requirement 2: Do not use vendor-supplied defaults for system passwords and other security parameters
- Requirement 3: Protect stored cardholder data
- Requirement 4: Encrypt transmission of cardholder data across open, public networks
- Requirement 5: Protect all systems against malware and regularly update anti-virus software or programs
- Requirement 6: Develop and maintain secure systems and applications
- Requirement 7: Restrict access to cardholder data by business need to know
- Requirement 8: Identify and authenticate access to system components
- Requirement 10: Track and monitor all access to network resources and cardholder data
- Requirement 11 Regularly test security systems and processes

VMware Core Controls

Requirement 1: Install and Maintain a Firewall Configuration to Protect Cardholder Data

PCI DSS Controls 1.1 – 1.5

Requirement 1 addresses the requirements for creating and maintaining firewalls and their configurations in the protection of cardholder data. This requirement details the protections required to prevent unauthorized access to sensitive data through the proper use and management of firewalls or similar components.

Applicable Security Lens:

- Data Segmentation
- System Hardening
- System Monitoring
- Network Protection
- Data Encryption & Protection

Applicable VMware Product(s):

- Cloud Foundation
- ESXi
- NSX
- SDDC Manager
- vCenter
- vCloud Availability for vCloud Director
- vCloud Director
- vCloud Director Extender
- vCloud Usage Meter
- vRealize Automation
- vRealize Operations
- vRealize Orchestrator

VMware Product Capabilities

NSX can be configured to deny all traffic by default, restricting outbound traffic and protecting corporate devices from malicious traffic entering the environment. Exceptions can be defined granularly to further ensure security in depth. vCloud Director can be leveraged to also provide additional monitoring functionality allowing audit logs to be produced that include environment analytics.

Micro-segmentation allows logical domain segmentation at a granular isolation level. For DDoS attacks, NSX builds in capabilities to perform malware analysis. These attributes supplement vulnerability scanning capabilities that exist within the SDLC. NSX and other SDDC products grant administrator functionality to restrict remote access to defined protocols, e.g., SSH and RDP. vCloud Usage Meter has transport layer security (TLS) enabled by default for all communications and conducts checksum verification for generated reports.

Beyond protocol restriction, vRealize Automation contains multiple default roles that segment information based on roles at scale. Coupled with vRealize Log Insight, this segmentation enables authentication to be authorized granularly across a designed environment without third-party integration. Similar to vRealize Automation, vRealize Operations permits the creation of groups utilizing RBAC to define segregation of certain areas or devices within an environment.

VMware NSX gateways give boundary protection and network isolation to user environments. Through its Dynamic Host Configuration Protocol (DHCP) service, VMware NSX Edge™ gateways set a static binding. By doing so, unique identifiers are set prior to any execution, fortifying an information system against malicious activity and defining a virtual boundary for organizations utilizing multi-tenant cloud environments.

For enhanced visibility, organizations can leverage vRealize Network Insight to provide context on information flow within the environment. vRealize Network Insight uses platform and proxy use certificates to restrict flow within an infrastructure. NSX and its micro-segmentation can then enforce defined information flow guidelines. VMware NSX Manager™ can sync with RBAC to restrict access based on specified group names. The information contained within these data flows is then secured at rest with the vSAN Encryption feature in vSAN and with the ESXi VM Encryption feature. ESXi further segments processes within resource pools. vCloud Director supports native integration into NSX Distributed Firewall to provide application isolation. vCloud Usage Meter provides further protection by allowing users to be segmented into three groups: root Unix user, non-root Unix user, and UI user, who has no system access.

VMware security programs and practices establish requirements “by design” to evolve methodologies of protection against new “in-the-wild threats.” This approach is followed throughout the development process. Products are tested by first-class vulnerability scans and penetration tests prior to any full release or version update.

For further information, please visit:

<https://www.vmware.com/content/dam/digitalmarketing/vmware/en/pdf/VMware-Product-Security.pdf>.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 2: Do Not Use Vendor-Supplied Defaults for System Password and Other Security Parameters

PCI DSS Controls 2.1 – 2.6

Requirement 2 provides guidance on removing any and all default settings or account information provided by vendors or third parties prior to production-level use within an organization's PCI environment.

Applicable Security Lens:

- System Hardening
- System Access
- System Monitoring
- Network Protection
- Data Encryption & Protection
- Trusted Execution/Secure Boot

Applicable VMware Product(s):

- Cloud Foundation
- ESXi
- vCenter
- vRealize Automation
- vRealize Log Insight

VMware Product Capabilities

VMware products provide numerous integration opportunities with existing access control software such as Active Directory to assist removing default account information. NSX can apply configuration requirements, while also removing unnecessary functions. vRealize Automation provides similar features, allowing for default services and settings to be disabled by default for any new infrastructure equipment or virtual machines that are created through its portal.

All products can reset default passwords for their associated accounts. vRealize Operations can be configured to force root users to reset their passwords during their initial login. All products in accordance with the VVD and SDLC are required to have minimum password standards that are stored in an encrypted fashion, never maintained in clear text format.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 3: Protect Stored Cardholder Data

PCI DSS Controls 3.1 – 3.7

Requirement 3 outlines requirements for storing and protecting sensitive cardholder data, including requirements for encryption and access.

Applicable Security Lens:

- System Hardening
- System Access
- System Monitoring
- Network Protection
- Data Encryption & Protection
- Data Segmentation

Applicable VMware Product(s)

- ESXi
- NSX
- vCenter
- vCloud Availability for vCloud Director
- vCloud Director
- vCloud Director Extender
- vCloud Usage Meter
- vSAN

VMware Product Capabilities

SDDC requires the use of AES256 cryptographic protocols. To assist with user authentication, Active Directory can be integrated for central management of credentials. The vSphere VM Encryption feature supports encryption so that all data stored within a customer's SDDC environment can be encrypted to meet industry standards and the requirements of PCI. vSphere VM Encryption uses XTS-AES-256 based data encryption and AES256 based key encryption.

Both vSphere VM Encryption and VMware vSAN encryption also allows for additional cryptographic management features such as key rotation, additional API integration, Key Management System (KMS) integration, and generally enabling or disabling encryption as appropriate. vSphere 6.7 encryption is FIPS 140-2 validated. NSX utilizes Root Certification Authority to support Public Key Infrastructure within the virtual network platform.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 4: Encrypt Transmission of Cardholder Data Across Open, Public Networks

PCI DSS Controls 4.1 – 4.3

Requirement 4 provides guidance for protecting cardholder data when it is transmitted over public networks that are accessible by malicious actors or when it is outside of the organization's administration.

Applicable Security Lens:

- System Monitoring
- Network Protection
- Data Segmentation
- Data Encryption & Protection

Applicable VMware Product(s):

- Cloud Foundation
- ESXi
- NSX
- Site Recovery Manager
- vCenter
- vCloud Director
- vCloud Usage Meter
- vRealize Automation
- vRealize Log Insight
- vRealize Network Insight
- vRealize Orchestrator
- vRealize Operations
- vSAN

VMware Product Capabilities

VMware considers encryption to be a core feature of a secure environment and integrates modern standards into products where appropriate.

vCenter and ESXi support the encryption of VMs and integrate with existing third-party key management systems to manage the keys associated with these VMs. The cryptographic management features offered by vSAN also apply to data in transit.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 5: Protect All Systems Against Malware and Regularly Update Anti-Virus Software or Programs

PCI DSS Controls 5.1 – 5.4

Requirement 5 details the guidance for deploying, updating, and monitoring anti-virus or malware programs, or software with similar features.

Applicable Security Lens:

- System Hardening
- Data Encryption & Protection
- System Monitoring
- Network Protection

Applicable VMware Product(s):

- ESXi
- vRealize Automation
- vRealize Log Insight

VMware Product Capabilities

Several VMware products and capabilities are relevant to this requirement. Harnessing the Unified Extensible Firmware Interface (UEFI) and Secure Boot, the hypervisor refrains from loading unless the signature database (containing the whitelisted and blacklisted signatures) validates. At each stage of the boot process, components of the hypervisor are validated using digital signatures. This includes each vSphere Installation Bundle (or VIB). ESXi creates an in-memory filesystem that maps to the contents of the digitally signed VIB. This whole process ensures that when Secure Boot is enabled that the hypervisor will only run code that is signed by VMware and VMware partners. If signatures are not validated, the hypervisor fails to activate. vCenter supports alerts to prevent unauthorized execution within the environment.

In the case of system failure or misconfiguration, no detailed error information is reported to the end-user or session, thereby reducing the opportunity for malicious actors to exploit known weaknesses or gather intelligence. NSX natively includes defined guest introspection framework that allows administrators to conduct analysis on the data plane level from North–South traffic flows.

In addition to the functionality provided by Secure Boot, vRealize Log Insight and vRealize Network Insight provide features that can be configured to notify the security team in the event a root account is being accessed, brute force attack, or attempt to attack an ESXi host. All alerts can be sent via email, allowing security personnel to intercept incidents at their earliest stages.

Natively, VMware products host multiple features and capabilities (as described above) that prevent the exploitation of malware-related attacks. It is important for organizations to ensure that alternative measures are in place to protect these incidents occurring in other scope-related quadrants of an environment.

Requirement 6: Develop and Maintain Secure Systems and Applications

PCI DSS Controls 6.1 – 6.7

Requirement 6 establishes controls related to the creation and maintenance of secure systems, applications, and policies. This family spans the underlying makeup of an organization's SDLC and the application of security. It focuses on understanding resource allocation; the security engineering principles employed; supply chain protection; and how developers, engineers, and other product development personnel are prepared to perform the duties defined by the organization.

Applicable Security Lens:

- Data Segmentation
- Data Encryption & Protection
- System Hardening
- Network Monitoring
- Software Development Lifecycle (SDLC)
- System Monitoring

Applicable VMware Product(s):

- AppDefense
- Cloud Foundation
- ESXi
- NSX
- Site Recovery Manager
- vCenter
- vRealize Orchestrator
- vSAN

VMware Product Capabilities

The VMware approach to security extends into its development process. While constant iteration is a priority, security is interwoven into every stage from ideation and design to development and into production. Static code analysis, security, and privacy considerations at the design phase run through multiple levels of approval, in addition to performance-level assessments. Developers participate in extensive secure code training and regularly attend working sessions in collaboration with security compliance and privacy teams to stay abreast of evolving trends and vulnerabilities.

The overlap in security emphasis between VMware internal SDLC processes and the Requirement 6 controls fulfills the requirements including process isolation at both personnel level and code level, encryption protocols in transmission, and permission granularity.

One main objective within this control set is minimizing the development of covert channels. VMware conducts peer reviews during each development cycle to secure all potential back door entry points for attackers. VVD requirements demand adequate levels of encryption, logging specifically through separating vRealize Log Insight from vRealize Network Insight and pushing security groups through NSX.

All pieces of VMware software include digital signatures and 256 MAC hashing.

Particularly important for this control family is that security requirements can be met during the acquisition process. For organizations looking to secure all levels of their infrastructure, the SDLC extends out into the supply chain and products that are acquired by VMware to deliver virtual solutions to the marketplace. Through Cloud Foundation (including both the vSAN Encryption feature in vSAN and ESXi VM Encryption feature), all elements of your virtualized environment are encrypted and secure throughout internetwork transit.

The VMware Compliance and Cyber Risk Solutions (CCRS) team develops whitepapers and other documentation to show the mapping between VMware product capabilities and compliance requirements. CCRS designed the VMware Compliance Capable Platform framework. On an ongoing basis, CCRS provides product engineering with feedback to further solidify product capabilities in support of compliance controls and cyber risk requirements. VMware product mappings and design architecture in support of a compliance-capable platform augment the value of acquiring VMware products.

The VVD architecture contains specified requirements for each component's configuration. This provides a "gold standard" for deployment across the entire suite of products. This standard is developed with security requirements through the SDLC.

To further protect any adjustments to information systems configuration, micro-segmentation can be defined through either NSX or VMware NSX-T Data Center™. Routing specifications can be set and protected by tamperproof logging. Active Directory can be integrated to enforce least privilege functionality, based on requirements across the user base. Devices can be isolated to eliminate rogue device infiltration. All configuration and isolation activities can utilize REST API to deliver at scale and in real time.

Endpoints can be further protected with AppDefense, which can comprehend the state of an environment and actively monitor changes in any applications, configurations, or system behavior. AppDefense can also be configured to block individual ports or protocols. Engaging vCloud Director can provide the ability to manage traffic between VMs within an organization via distributed firewall rules, along with edge gateway firewall capabilities.

Knowing that the protection of or adherence to standards is difficult without knowing what resides in the network, vRealize Automation has features to provide a database of virtual machines, which can be updated automatically. In conjunction, vRealize Operations provides organizations with the option to deploy agents to unearth deep, network-layer intel and monitor host configurations.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 7: Restrict Access to Cardholder Data by Business Need to Know

PCI DSS Controls 7.1 – 7.3

Requirement 7 focuses on the ability of any user, across all defined permission levels, to reach key elements of the environment. It looks at coverage across subjects such as remote access as well as the integrity of the entire authentication process.

Applicable Security Lens:

- System Access
- Endpoint Protection
- Data Encryption & Protection
- System Monitoring
- Data Segmentation

Applicable VMware Product(s):

- AppDefense
- Cloud Foundation
- ESXi
- NSX
- Site Recovery Manager
- SDDC Manager
- vCenter
- vCloud Availability for vCloud Director
- vCloud Director
- vCloud Director Extender
- VMware Identity Manager
- vRealize Automation
- vRealize Log Insight
- vRealize Network Insight
- vRealize Operations
- vRealize Orchestrator
- vSAN

VMware Product Capabilities

For all products within the SDDC platform, access controls can be implemented at a granular level. This is presented through Role-Based Access Control (RBAC) mechanisms natively available. User management interfaces are provided to control password complexity and user profiles and to access review tasks. Products, for instance vCenter, enable complementary products with RBAC capabilities. This is particularly the case for Site Recovery Manager used in conjunction with vCenter.

Across all products, default passwords can be reset. vRealize Operations can be configured to force root users to reset their passwords during their initial login. All products in accordance with the VVD and SDLC are required to have minimum password standards that are stored in an encrypted fashion, never maintained in clear text format.

SDDC and VMware Cloud products across the suite allow for seamless 2FA deployment through third-party integrations.

As an elevated protection, VMware has built third-party integration capabilities to allow organizations to integrate single-sign-on (SSO) tools to strengthen authentication needs and restrict access. Organizations can also integrate their Active Directory (AD)/Lightweight Directory Access Protocol (LDAP) instance through use of VMware published Application Programmable Interfaces (API) to refine access at all levels of their virtual stack. vRealize Operations allows administrators to limit concurrent sessions and define account lockout parameters.

vCloud Usage Meter provides additional LDAP configuration and has HTTPS enabled by default, with support for SSH. vCloud Director provides the ability to administer user accounts via the administration page, the provided API, and LDAP integration. Further, vCloud Director provides multi-tenancy, isolation of tenants, and logically isolated switches. vCloud Director can be combined with vCloud Director Extender and vCloud Availability for vCloud Director to further expand the capabilities provided by vCloud Director, which further isolates, secures, and monitors the CDE.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 8: Identify and Authenticate Access to System Components

PCI DSS Controls 8.1 – 8.8

This control family establishes criteria and controls so that only authorized connections are enabled throughout an organization's environment.

Applicable Security Lens:

- System Monitoring
- Network Protection
- Data Segmentation
- Endpoint Protection
- System Hardening
- Data Protection & Encryption

Applicable VMware Product(s):

- AppDefense
- Cloud Foundation
- ESXi
- NSX
- Site Recovery Manager
- vCenter
- vCloud Automation
- vCloud Director
- vCloud Director Extender
- vCloud Usage Meter
- VMware Identity Manager
- vRealize Log Insight
- vRealize Network Insight
- vRealize Operations
- vRealize Orchestrator
- vSAN

VMware Product Capabilities

VMware products support various forms of authentication and access controls to assist with the protection of systems and cardholder data. To ensure that only trusted IPs, subnets, or IP devices are allowed into the environment, vCenter and NSX provide access restriction to an organization's East–West traffic, or VM to VM communications.

All SDDC products can prevent sessions from remaining unlocked via the use of time-outs and re-authentication which can both be set by following the standard VVD requirement. By default, all session time-outs require user re-authentication. Typically set to 15 to 20 minutes, session time-out thresholds can be configured within the product and adjusted to meet control and requirement intents. Products can harness Active Directory integration to maintain vigilance over authentications to products.

AppDefense can manage and configure unique user identifiers within the operational console for any user logged into the AppDefense console. vCloud Usage Meter can be set to use LDAP for authentication.

NSX allows access control through the implementation of micro-segmentation via security policies. The NSX Identity Firewall feature enhances the access control down to the virtual networking level, permitting only

approved users with need to access specific virtual machines. These authentication mechanisms can be managed through security groups and policies configured within the vCenter Web UI.

Within vCloud Director manage and monitor portals, various logging capabilities can be configured and reviewed. Additionally, servers can be configured into a log repository to hold logs from NSX components and hosts. The administration portal also offers the ability to configure account lockouts, devices and accounts with access control permissions based on compliance requirements. The system administrator account permissions encompass all existing rights, in addition to those associated with administrator accounts, which are immutable.

VMware Identity Manager provides additional controls for managing user access, including the ability to institute single sign on (SSO), assign unique session tokens, leverage VMware Verify for two-factor authentication, and standard account controls. VMware Identity Manager provides a standardized reporting function available to administrators to facilitate user account reviews.

vRealize Operations and vRealize Log Insight, along with the other products that compose the SDDC suite and VMware Cloud, can support the implementation of continuous monitoring. vRealize Operations gives administrators the ability to craft custom security tags that align with PCI DSS and other security frameworks to maintain real-time assessment and authorization across the environment.

Beyond product applicability, organizations are advised to perform proactive penetration tests to meet the full extent of the control area.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

Requirement 10: Track and Monitor All Access to Network Resources and Cardholder Data

PCI DSS Controls 10.1 – 10.9

The Requirement 10 controls cover the implementation, governance, and operation of an audit program and logging systems. As a function of the program, it calls for organizations to ensure the protection of any logs and additional information associated with audit procedures.

Applicable Security Lens:

- Systems Monitoring
- System Access

Applicable VMware Product(s):

- AppDefense
- Cloud Foundation
- ESXi
- NSX
- Site Recovery Manager
- vCenter
- vCloud Availability for vCloud Director
- vCloud Director
- vCloud Director Extender
- vCloud Usage Meter
- VMware Identity Manager
- vRealize Automation
- vRealize Log Insight
- vRealize Network Insight
- vRealize Operations
- vRealize Orchestrator
- vSAN

VMware Product Capabilities

Requirement 10 speaks to the need for a security program to conduct ongoing audits to maintain integrity and compliance. Implementing the SDDC through the VVD provides a reference architecture to identify security requirements throughout the virtual platform, from hypervisor through to the UI that collects audit log data.

Across all products, rich logging features exist to allow administrators to ascertain who logged in, the origin, at what time, and whether the attempt was a success or failure. Logs can be pointed to third-party management tools through API integration if desired, although VMware also provides tools such as vRealize Log Insight to support log collection and integration into a SIEM. AppDefense can deliver alerts for all changes made within the environment. This can be configured through the provided “Scopes” feature, or through the vCenter Web UI. Any logs generated by AppDefense can be calibrated using the AppDefense Manager, and access can be restricted to only an administrator.

Monitoring is done using vRealize Network Insight, vRealize Log Insight, and vRealize Operations. vRealize Log Insight strengthens access security with forensic monitoring of the virtual/physical networking and flow. This

also includes NSX stateful firewall and security group policies. Out of the box, vRealize Log Insight provides security dashboards that enable monitoring of associated VMware products.

Implementing vCloud Director can add additional benefits in the form of monitoring functionality, which produces audit logs on the environment and can be used to monitor all assets within the environment. Access to this functionality can be restricted, as administrators can restrict access to most of vCloud Director. vCloud Director can be combined with vCloud Availability for vCloud Director to guarantee functionality.

VMware Identity Manager can integrate with vRealize Log Insight or a third-party logging system to promote log storage. In a cloud environment, VMware Identity Manager defaults to 90-day log storage, but it can be configured to push logs. On-prem instances storing recently generated logs, should be regularly pushed to an appropriate log storage area for PCI compliance.

Further, vRealize Log Insight gives IT and IT security teams the ability to point all products in their stack (not only their VMware product stack) to vRealize Log Insight to help manage and correlate any incidents or perceived incidents through an audit dashboard and native log analysis. vCloud Usage Meter can store additional logs in the VMware vFabric® Postgres database of the appliance, which can be secured.

To support non-repudiation, administrators are advised to design strong access control surrounding administrator passwords. All administrative actions should be logged and reviewed on a consistent basis.

vCenter has the capability to push logs to up to three different external syslog receivers including vRealize Log Insight. vRealize Log Insight retains data based on defined storage capacity and can apply additional tamper protection. vRealize Operations assists by monitoring the datastore's health and capacity, prompting the administrator to determine how to proceed with further log archival if need be.

vRealize Network Insight contains the ability to adjust forensic data retention. ESXi affords administrators the ability to adjust the richness and frequency of audit logs.

For advancing an organizational audit process, it is recommended that a SIEM platform be coordinated through vRealize Log Insight to ingest logs to provide better alerting and log management.

To note, some controls only have partial matches but are supported across all products within the SDDC. These controls relate to authentication against a certificate authority (CA). The organization will need to identify the CA that will then be assessed against during each user session.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*

Requirement 11: Regularly Test Security Systems and Processes

PCI DSS Controls 11.1 – 11.6

Requirement 11 is driven by the creation of organizational policies that address how evolving disaster or security events will be addressed. SDDC components can assist in the research, auditing, and curtailing of those events attributed to technical elements through integration into IDS/IPS appliances or a SIEM.

In other respects, the breadth of the family is focused on developed administrative policy.

Applicable Security Lens:

- System Access
- System Monitoring
- Network Protection

Applicable VMware Product(s):

- AppDefense
- ESXi
- NSX
- Site Recovery Manager
- vCenter
- vCloud Director
- vRealize Log Insight
- vRealize Network Insight
- vRealize Operations
- vSAN

VMware Product Capabilities

To widen appliance coordination, vRealize Log Insight, vRealize Network Insight, vRealize Operations, and vRealize Orchestration can be combined to define an event occurrence–level alert. This capability will enable organizations to calibrate alerts so that critical alerts are noticed through visual dashboards and defined distribution lists. vSphere Update Manager and vRealize Operations can be configured to automate remediation on identified vulnerabilities. Third-party solutions can be inserted to combine both on-premises and cloud-based synchronization of updates.

AppDefense can, on its own, isolate threats as they appear and suspend the affected section of the environment. AppDefense actively monitors the environment from the hypervisor layer and can detect anomalies in application behavior or network traffic, as well as changes made to network configuration. Actions can be addressed automatically when alerts are triggered. It can also be integrated with the vSphere environment,

which if used in conjunction with vCloud Director can be used to establish and maintain intrusion detection and management.

Additionally, AppDefense provides continuous detection at the hypervisor level allowing it to block, suspend, or shut down malicious behavior. It can also block or whitelist other activity within the environment based on its 'Learning Mode,' which assists with identifying the desired functionality of applications to determine when malicious activity is present.

Additional product capability details can be found at the VMware Compliance IDs listed in *Appendix B*.

VMware Administrative Controls

Requirement 9: Restrict Physical Access to Cardholder Data

PCI DSS Controls 9.1 – 9.10

VMware products can support the physical security controls described in this requirement family by providing data and technical controls which can be combined with organizationally developed policies to create or support a secure physical environment.

Applicable Security Lens:

- System Access
- System Monitoring
- Network Protection

Applicable VMware Product(s):

- vCenter
- vRealize Automation
- vRealize Orchestration

Requirement 12: Maintain a Policy That Addresses Information Security for All Personnel

PCI DSS Controls 12.1 – 12.11.1

VMware products can support the controls of this family through organizationally developed policy when properly used. All SDDC platform components do provide backup and recovery capabilities, which will thus aid the employment of a policy's requirements such as data protection and being able to meet recovery time objectives (RTO) and recovery point objectives (RPO).

Applicable Security Lens:

- System Monitoring
- Network Protection
- Automated Security

Applicable VMware Product(s):

- AppDefense
- NSX
- vCenter
- vCloud Director
- vRealize Log Insight
- vRealize Operations
- vRealize Orchestrator
- vSphere Replication

Conclusion

To meet evolving regulatory needs, security programs now must define applicable controls at early stages. From ideation to design and through to the end of the product lifecycle, VMware focused on developing methodologies that set this tone.

Through the eleven (11) security lenses and in accompaniment of the VMware Validated Design, the SDDC platform components and VMware Cloud provide users with a virtualization stack that adheres to the comprehensive requirements of PCI DSS.

Organizations can seamlessly piece together full SDDC and VMware Cloud environments, or a subset made up of individual components, and be confident in the security and privacy measures employed in the products' support efforts to protect a cardholder data environment.

The considerations that VMware brings to bear on continuous compliance for clients comes from its development culture, which constructs requirements that balance functionality and security for all deployable products. These policies provide customers with the confidence to include the SDDC product suite within their architecture and PCI DSS security program.

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Appendix A: PCI DSS 3.2.1 Control Mapping

VMware Product	PCI DSS 3.2.1 Control Families Supported
VMware AppDefense	Req.1, Req.2, Req.7, Req.10, Req.11, Req.12
VMware Cloud Foundation	Req.1, Req.2, Req.6, Req.7, Req.8, Req.10
VMware Cloud Provider Platform	Req.1, Req.2, Req.3, Req.4, Req.5, Req.6, Req.7, Req.8, Req.9, Req.10, Req.11, Req.12
- vCloud Availability for vCloud Director	
- vCloud Director	
- vCloud Director Extender	
- VMware vCloud Usage Meter	
VMware Identity Manager	Req.7, Req.8, Req.9, Req.10
VMware NSX	Req.1, Req.6, Req.8, Req.12
VMware vRealize Automation	Req.1, Req.2, Req.4, Req.5, Req.7, Req.9, Req.10
VMware vRealize Log Insight	Req.2, Req.7, Req.8, Req.9, Req.10, Req.12
VMware vRealize Network Insight	Req.7, Req.8, Req.9, Req.10, Req.11
VMware vRealize Orchestration	Req.1, Req.2, Req.7, Req.8, Req.9, Req.10, Req.12
VMware vRealize Operations	Req.1, Req.2, Req.8, Req.10, Req.11, Req.12
VMware vSAN	Req.3, Req.4, Req.6, Req.7, Req.8, Req.10, Req.11
VMware Site Recovery Manager	Req.4, Req.7, Req.8, Req.10, Req.11
VMware vSphere	Req.1, Req.2, Req.3, Req.5, Req.4, Req.6, Req.7, Req.8, Req.9, Req.10, Req.11, Req.12
- VMware ESXi	
- VMware vCenter	
- VMware vSphere Replication	

Appendix B: SDDC Product Capability Relationship with PCI DSS

Product	Capability ID	Product Capability	PCI Requirement
ESXi	ESXI_001	Login attempts can be limited.	Req.8
	ESXI_002	Concurrent sessions can be limited on web clients and virtual machine consoles.	Req.7 Req.8
	ESXI_003	ESXi can be integrated with Active Directory, or LDAP to employ unique user identifiers, instead of using the root account.	Req.8
	ESXI_004	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	ESXI_005	On ESXi and VMware vCenter Server Appliance™, the SSH service is disabled by default. Remote access to ESXi via SSH, or Web Client or API over HTTPS, can be configured as the secure communication protocol. Session identifiers are invalidated after session termination.	Req.1 Req.4
	ESXI_006	ESXi supports integration with external authentication solutions, such as Active Directory. Users that are members of a group that has been granted access to ESXi can sign- in using single sign-on, and will be able to log in using their user ID with elevated root privileges. Password requirements will be managed via the external authentication solution (minimum password, account lockout, and account lockout threshold, and etc.).	Req.7 Req.8
	ESXI_007	ESXi will perform the encryption on virtual machines that have been configured by vCenter to support VM encryption. A 3rd third-party key manager solution is required to manage encryption keys. ESXi supports virtual machine encryption, but requires a 3rd third-party key manager	Req.3 Req.4 Req.8
	ESXI_008	ESXi can push logs to be stored in an external log repository that supports syslog, including vRealize Log Insight. In the event vRealize Log Insight is used, it can then apply tamper protection of logging that can be used during after-the-fact investigations without altering the event logs.	Req.10
	ESXI_009	ESXi supports the Secure Boot feature to monitor firmware to validate version control and authorization. If the violation is detected during boot, the system will not boot up. If the violation is detected during run-time, the command will be rejected and not boot.	Req.5 Req.6 Req.11

	ESXI_010	ESXi and vCenter audit quality logging in 6.5 is enabled by default. Changing logging levels is only for troubleshooting logs used by GSS.	Req.10
	ESXI_011	If ESXi has Secure Boot enabled, any attempt to execute unsigned binaries will be blocked. All shell commands are logged via syslog and the attempt to install unsigned binaries will be logged.	Req.10
	ESXI_012	ESXi can be configured to display a log-on banner before granting access to the system.	Req.8 Req.10
	ESXI_013	ESXi provides memory safeguards to protect it from executing unauthorized code.	Req.2 Req. 5
	ESXI_015	ESXi has the capabilities to establish firewalls using vLAN and deny traffic by default and, only allowing explicitly designated traffic.	Req.1
	ESXI_016	ESXi patching is performed via vCenter using VMware vSphere Update Manager (VUM).	Req.6
	ESXI_017	vSphere Hardening Guide provides support for ESXi and vCenter hardening procedures.	Req.12
	ESXI_018	Logon authentication techniques includes two-factor authentication.	Req.8
	ESXI_019	ESXi supports configuration of access control via Single Sign-On, or Active Directory services, such as: requiring new users to change password on first logon, minimum password age, account lockout threshold, or account lockout duration. Logon authentication techniques includes two-factor authentication.	Req.8
AppDefense	AD_001	AppDefense monitors all application endpoints within an environment utilizing its Intended State Engine (ISE), which is located in the virtualization layer. Since AppDefense is installed in the vSphere hypervisor, it is completely isolated, ensuring secure communication throughout the environment. AppDefense actively monitors endpoints within the environment for any changes to their intended state. It correlates the changes with a snapshot of the endpoint to discern If the changes are permitted.	Req.8 Req.11
	AD_002	Access rights, corresponding to AppDefense, can be established through vSphere, which has the ability to prevent users from accessing AppDefense Manager.	Req.7
	AD_003	The AppDefense Manager is capable of logging activity from users with root privileges via any applications monitored by AppDefense. A user can configure multiple logging methods through the AppDefense Manager.	Req.10
	AD_004	Logs and records generated through AppDefense are reliant upon functionality provided by vSphere. Event capturing can be completely fine-tuned	Req.10

		utilizing both the vSphere Web Client and the AppDefense Manager.	
AD_007		AppDefense compiles event logs through its "Alarms" tab and can be reviewed at any time.	Req.10
AD_008		AppDefense affords the user the ability to view all previous event logs, at any time, via the AppDefense Manager. This allows for the analysis of any questionable event.	Req.10
AD_009		Access to AppDefense logs can be configured to only be accessible via an admin account, and can be further secured by utilizing configuration setting through vSphere.	Req.8 Req.10
AD_010		AppDefense is integrated within the vSphere environment, which includes a full view of the ports and protocols in use. AppDefense includes a full list of application and services that are currently in use. AppDefense is capable of learning the intended state of the environment and can whitelist processes accordingly through its "Learning Mode" When malicious activity is suspected within the environment, AppDefense can suspend, or completely shut down, any application and device.	Req.2 Req.11
AD_011		Changing user identifiers is possible within the vSphere Web Client, which AppDefense heavily relies on. AppDefense can block untrusted network protocols, resulting in a secure environment.	Req.1 Req.8
AD_012		AppDefense employs the use of a continuous detection system that is capable of responsive measures when malicious actions appear to be present. AppDefense responds by suspending, shutting down, and taking a snapshot of the environment. AppDefense also utilizes a "Learning Mode" to identify the desired functionality of applications within the environment.	Req.11 Req.12
AD_014		During the course of a debilitating event, AppDefense will respond by isolating the threat and suspending that section of the environment. Fail-safe procedures take the form of snapshots of the environment, which can be utilized to restore functionality to compromised applications.	Req.11 Req.12
AD_015		AppDefense lies within the hypervisor of vSphere, affording it the ability to isolate various elements of applications.	Req.6 Req.11
AD_016		Unauthorized code execution can be mitigated via the detection capabilities of AppDefense. If anomalies are detected within the environment, such as unauthorized code execution, AppDefense will alert and respond.	Req.5 Req.6 Req.11
AD_017		AppDefense is installed within the hypervisor of vSphere (the virtualization layer,) and monitors various endpoints in the environment. These	Req.11

		endpoints are the desirable attack vector, making this the effective area to monitor.	
	AD_018	AppDefense detects any changes within the network. Any changes, such as configuration changes and suspicious anomalies, will trigger alerts that can be viewed with the AppDefense Manager.	Req.2 Req.6 Req.11
	AD_019	AppDefense can be fully automated and can issue automated responses when various anomalies are detected, such as leveraging virtualization processes such as suspending and shutting down the environment.	Req.11
NSX	NSX_V_001	Information protection can be implemented using policies that restrict access information flow based on network micro-segmentation.	Req.4 Req.12
	NSX_V_002	Within the data plane, the guest introspection framework (host based) or network extensibility (redirect network flow to 3rd third-party appliances/tools) is supported by NSX, which can be accessed by 3rd third-party tools to support Intrusion Detection System (IDS) and/or Intrusion Prevention System (IPS) systems.	Req.10 Req.11
	NSX_V_003	NSX identity firewall supports role-based access controls (RBAC) to limit permissions that restrict viewing virtual machines (VMVMs). Also, micro-segmentation can be used to manage access to specific areas of the network using RBAC and minimize attack surface by using NSX to isolate and segment workload and platform components. This includes configuring the system to restrict the development team from having access to the production environment.	Req.1 Req.7 Req.8
	NSX_V_004	A proof of maintenance log is available to report on archived maintenance activity. These logs are captured at key components: NSX Manager (management plane) and vCenter (data plane). For a consolidated view, logs can be pushed to a syslog server, or vRealize Log Insight.	Req.10
	NSX_V_005	Remote access to products can be restricted to just SSH, or other desired and secure communication protocols. Manually, the configuration files can be altered in NSX to further restrict access to specific components such as: NSX Manager, NSX Edge, or NSX Controller. By default, SSH access is disabled. This includes controlling remote access through an existing access control and authentication solution, and invalidating session identifiers upon session termination.	Req.1 Req.4 Req.8
	NSX_V_006	Session lockouts are enforceable and require users to re-authenticate after a session time-out.	Req.8
	NSX_V_007	Account lockout threshold can be altered.	Req.8

NSX_V_008	NSX can push logs to be stored in syslog audit repositories, including vRealize Log Insight. NSX supports multiple log repository servers to enhance tamper protection of logging that can be used during after-the-fact investigations without altering the event logs.	Req.10
NSX_V_009	NSX can be used to monitor the network using logging of firewalls, and other traffic. This can be used to support monitoring the system for inappropriate usage and other security violations. Use of the NSX Application Rule Manager can monitor enforcement of security rules and firewall policies. NSX Endpoint Monitoring enables Guest Introspection Framework capabilities to monitor endpoint processes specifically on Windows .virtual machines.	Req.10 Req.11
NSX_V_010	NSX provides monitoring of the system using event logs and other security logs to identify abnormal activity. The NSX NetX feature can redirect network traffic flow to be redirected to 3rd third-party Intrusion Detection System (IDS) solution on a per security policy basis to support granular event logging.	Req.10
NSX_V_011	NSX can deny access to rogue devices that have not been approved using SpoofGuard. Also, a default deny with a list of approved devices can be established to further prevent rogue devices.	Req.7 Req.8 Req.12
NSX_V_012	NSX can isolate any devices that are out of compliance and restrict their access to the network, if the device is tagged as rogue and a policy defined to isolate devices that have this tag. NSX can quarantine any devices identified as rogue devices using the Guest Introspection Framework.	Req.8 Req.12
NSX_V_013	NSX can use micro-segmentation to establish processing domains based on access rights and user privileges. Granularity around trust can be defined as a virtual NIC, or more broadly as a region, for both static infrastructure and dynamic logical objects.	Req.1 Req.6 Req.7 Req.10
NSX_V_014	NSX can restrict network traffic based on system security classification, which can be defined using static objects and dynamic objects. Access control for objects can be restricted based on security rules and tags.	Req.7 Req.8
NSX_V_015	Network access controls can be managed using NSX, which can also be integrated with 3rd third-party tools to support managing network access. Network access controls can be managed using NSX, which can also be integrated with 3rd third-party tools to support managing network access.	Req.7 Req.8
NSX_V_016	Using NetX API, NSX can support integration with third-party intrusion detection systems (IDS) to	Req.11

		support responses in network locations, or granular to VM/workflow between VMs. In addition, NSX can use Guest Introspection to further enhance IDS responses.	
	NSX_V_017	NSX can manage all internal network connections and provides documentation to describe the networking components available for deployment.	Req.1
	NSX_V_018	NSX can manage external network connections through the NSX Edge gateway, firewall, VPN, or SSL through Load Balancer. This includes establishing a boundary defense.	Req.11
	NSX_V_019	Using the NSX Edge firewall, distributed firewall, Guest Introspection (within the VM) and third-party NetX API (network enforcement), NSX can prohibit systems from connecting directly to external networks.	Req.1
	NSX_V_020	NSX can be implemented with a fault-tolerant architecture; documentation supporting this design is available.	Req.6 Req.11
	NSX_V_021	NSX can restrict inbound internet traffic inside the DMZ using ESG FW, NSX Edge services gateway firewall, distributed firewall, and the principles of DMZ Anywhere.	Req.1
	NSX_V_022	All capabilities of NSX can be programmatically created by Rest API to segregate applications and databases that can restrict information in an internal network zone.	Req.1 Req.7
	NSX_V_023	NSX can apply configuration standards and remove unnecessary functionality using Rest API, Guest Introspection, and distributed firewall specifically to protocols, ports, applications, and services in the firewall and router configuration standard.	Req.1 Req.2
	NSX_V_024	NSX can be used to configure traffic including firewall deny all traffic by default, explicit exceptions for designated traffic, restricting outbound traffic, protecting devices from outbound connections, protecting devices to deny inbound connections, managing IP addresses in DHCP, assigning or reserving static IP addresses in DHCP.	Req.1 Req.8
	NSX_V_025	NSX can leverage a Root Certification Authority to support Public Key Infrastructure within the virtualized network platform.	Req.3 Req.4
	NSX_V_026	NSX can support analytics to be used with third - party solutions to identify behavior and characterize malicious code, which would be supported via Guest Introspection.	Req.10 Req.11
	NSX_V_027	In the event of fail-safe procedures, NSX can move around machines to other recovery networks via automated quarantine actions.	Req.4 Req.6 Req.11
	NSX_V_028	NSX provides a dashboard to monitor the platform's health, which can inform users around maintenance information of the platform itself.	Req.6 Req.11

	NSX_V_029	NSX can be configured to protect against unauthorized data mining of the NSX postgres database.	Req.2 Req.7
	NSX_V_030	NSX includes some denial of service (DoS) attack prevention mechanisms, which may support detection processes but will not monitor and detect DoS before the attack occurs.	Req.6 Req.10 Req.11
	NSX_V_031	NSX provides stateful firewall capabilities that can support adding devices requiring access control based on an Access Control List.	Req.7 Req.8
	NSX_V_032	NSX supports least privilege around workloads, and provides four different roles within NSX to support the principle of least privilege (enterprise administrator, NSX administrator, security administrator, and auditor/read only).	Req.7
	NSX_V_033	NSX can be architected to place firewalls between security domains, DMZ, and other network zones.	Req.1
	NSX_V_035	The NSX appliance provides access via SSH, which can also be disabled. Access control to the NSX appliances can enforce password parameters, including: length, requiring password change upon first login, and account lockout duration.	Req.8
	NSX_V_036	NSX provides and maintains a system hardening guide.	Req.6 Req.12
SDDC Manager Cloud Foundation	SDDCMANAGERV CF_001	A proof of maintenance log is available to report on archived maintenance activity related to ESXi, vCenter, vSAN, and NSX products within the VCloud Foundation suite.	Req.10
	SDDCMANAGERV CF_002	SDDC Manager supports two types of users: read only and cloud admin. User accounts can be managed within SDDC Manager and external user authentication services such as Active Directory.	Req.7 Req.8
	SDDCMANAGERV CF_003	Session lockouts are enforceable and require users to re-authenticate after a session time-out.	Req.8
	SDDCMANAGERV CF_004	SDDC Manager enables security architecture design through the separation of the management domain and the workload domain. Designing a separation of architecture can support segregation of duties and keep environments separate based on function.	Req.7
	SDDCMANAGER VCF_005	SDDC Manager enables security architecture design through the separation of the management domain and the workload domain. Designing a separation of architecture can support segregation of duties and keep environments separate based on function.	Req.1 Req.2 Req.6
Site Recovery Manager	SRM_002	Site Recovery Manager can push logs to be stored in vRealize Log Insight. A content pack is provided to facilitate Site Recovery Manager logging and dashboard visualization of logging.	Req.10
	SRM_003	Results of test run can be included in documentation to evidence results of continuity planning exercises.	Req.6

		Recovery mode can be run within the test plan and export the results to showcase the outcome of every test run inside test mode.	
	SRM_005	Site Recovery Manager is an application that runs in Windows and relies on events and standard maintenance logs provided by Windows. Proof of maintenance and archival of reports depends on configuration of Windows event logging.	Req.10
	SRM_006	Access to Site Recovery Manager is only available via a web client using vSphere. The vSphere web client manages authentication and session handling. Upon session termination, session identifiers are invalidated.	Req.8
	SRM_007	Remote access is possible via Remote Desktop Protocol (RDP) to the Site Recovery Manager system. This can be managed through external authentication solutions. Use of Site Recovery Manager does not require RDP access mechanism, and RDP is usually allocated for administrative access only.	Req.4 Req.8
	SRM_008	Site Recovery Manager relies on vCenter to manage and assign user access and to manage user accounts, including assignment of roles to restrict functionality.	Req.7
	SRM_009	Site Recovery Manager can be configured to use Active Directory or vSphere domain accounts that adhere to organizational password standards, including forcing users to change their password upon first login.	Req.8
vCloud Usage Meter	UM_002	vCloud Usage Meter retains a list of connections that are the subject of monitoring and usage collection. vCloud Usage Meter is installed within the vSphere environment, which is capable of full LDAP integration where user accounts can be controlled even further.	Req.8
	UM_003	vSphere logs user activity and can be maintained for a set period of time. These logs can be secured via various methods, such as user account permissions.	Req.10
	UM_004	Users can be uniquely identified through different aspects via the vSphere Web Client, as well as various methods derived from LDAP integration and configuration.	Req.8
	UM_005	vCloud Usage Meter can be configured to utilize proxy services, in addition to leveraging LDAP integration to manage user IDs and passwords within a secure environment. This includes configuring the minimum and maximum password ages that can be applied to user accounts.	Req.8
	UM_007	LDAP and various parameters derived from vSphere Web Client can be employed to maintain separation	Req.8

		between user functionality and system management.	
	UM_008	Data transmission can be secured through proxy configurations and are employed during the initial setup of vCloud Usage Meter.	Req.1 Req.4
vCloud Director	vCD_001	vCloud Director has the ability to administrate user accounts, in addition to assigning those accounts various permissions, through the administration home page and LDAP integration. Account management can also be accomplished through the vCloud API.	Req.7 Req.8
	vCD_002	Logging capabilities are configured, and observed, through the vCloud Director's manage and monitor portal.	Req.4 Req.10
	vCD_003	Session lock capabilities can be employed, such as configuring the number of invalid logins before lockout occurs, through the vCloud Director's administration portal and also within the general system settings.	Req.8
	vCD_004	Configuring device and accounts that have access control permissions can be accomplished through the vCloud Director's administration portal.	Req.7 Req.10
	vCD_005	System administrator account permissions cannot be altered and encompass all existing rights, in addition to rights only associated with an administrator role.	Req.7 Req.8
	vCD_006	The administrator account associated with vCloud Director has the capability of managing the access authorization list and is the only account that can do so.	Req.7
	vCD_007	vCloud Director includes monitoring functionality, which can produce audit logs and cost reports, to provide insight regarding the overall statistics of the environment.	Req.10
	vCD_008	The administrator account associated with vCloud Director can fully manage user accounts, including properly updating accounts and their access rights.	Req.8
	vCD_009	An administrator has the ability to restrict user access to nearly all facets of the vCloud Director environment, including log management and observation.	Req.10
	vCD_010	vCloud Director has the ability to monitor all assets within its environment, as well as produce reports that can later be utilized during forensic analysis.	Req.10
	vCD_011	Authentication measures are handled through the vSphere environment, of which vCloud Director is a part of.	Req.1
	vCD_012	vCloud Director can be coupled with vCloud Director Availability to ensure proper contingency functionality within the vCloud Director	Req.12

		environment, as well as other facets of the vSphere environment.	
	vCD_013	AppDefense can be integrated into the vSphere environment, which vCloud Director relies upon, to establish and maintain intrusion detection functionality.	Req.10 Req.11
	vCD_015	Intrusion detection procedures can be implemented within the vSphere environment, with which vCloud Director is integrated with, through the addition of AppDefense.	Req.11
	vCD_017	An Incident Response program can be established within one of the cloud environments that vCloud Director is responsible for managing. Users are able to review and update the incident response procedures following the closure of such an event, while utilizing features afforded through AppDefense to vSphere, which encompasses vCloud Director.	Req.12
	vCD_018	While utilizing AppDefense within the vSphere environment, which contains vCloud Director, a user is afforded the ability of establishing and maintaining various incident response procedures.	Req.12
vCloud Availability for vCloud Director	vCA_001	vCloud Director Availability is integrated with vCloud Director, which is installed in the vSphere environment. In turn, users that are currently using vCloud Director Availability services are subject to the termination of their session if idle for too long.	Req.8
	vCA_002	It is possible to limit super user accounts to designated system administrators, if using LDAP through vSphere.	Req.7
	vCA_003	Account lockout procedures can be configured by the use of LDAP services, which can be indirectly used in conjunction with vCloud Director Availability. The procedures that can be configured are account lockout threshold and duration, in addition to the set number of consecutive login attempts before such procedures are triggered.	Req.8
	vCA_004	vSphere has its own internal log management processes that can be utilized via any user, with applicable permissions, of vCloud Director Availability. A user of vCloud Director Availability can configure logging mechanisms within the vSphere environment that can be used for later analysis.	Req.10
	vCA_006	Event logs stemming from the vSphere environment, of which vCloud Director Availability is a part of, can be stored securely and protected from unauthorized access.	Req.10
	vCA_007	A complete network overview can be reviewed via vSphere. This includes any ports, protocols, and services currently active within the environment.	Req.1

	vCA_008	When utilizing LDAP integration within the vSphere environment, uniquely identifying properties can be employed to user accounts. This includes those who have access to vCloud Director Availability through vSphere.	Req.8
	vCA_009	Proxy measures can be implemented within the vSphere environment, in turn affecting vCloud Director Availability, and can be configured to only allow access to properly identified and authenticated connections.	Req.1
	vCA_010	The "Enable Password History" feature can be enabled via the vSphere Web Client, or through LDAP integration, and affects vCloud Director Availability services due to access being derived through vSphere.	Req.8
	vCA_011	Various password settings can be configured through LDAP, which indirectly affect vCloud Director Availability services.	Req.8
	vCA_012	System management is accomplished through the vSphere Web Client, which is completely separate from vCloud Director. vCloud Director governs services such as that of vCloud Director Availability.	Req.8
	vCA_014	User privileges are dictated through configurations stemming from either vSphere, or LDAP integration, all of which affect vCloud Director Availability due to being deeply entangled with vSphere through vCloud Director.	Req.8
	vCA_015	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	vCA_016	Remote access to products can be restricted to just SSH, or other desired and secure communication protocols. Manually the configuration files can be altered in vSphere to further restrict access to vSphere. This includes controlling remote access through an existing access control and authentication solution, and invalidating session identifiers upon session termination.	Req.2 Req.7 Req.8
	vCA_017	Session lockouts are enforceable and require users to re-authenticate after a session time-out.	Req.8
	vCA_018	Configurable to push logs to vRealize Log Insight and benefit from capability to restrict modifying log data.	Req.10
	vCA_019	Account lockout threshold can be altered.	Req.8
vCloud Director Extender	vCDX_001	vCloud Director Extender is a plug-in for vCloud Director, which is integrated within the vSphere environment. vSphere is capable of establishing various access rights to the user through the vSphere Web Client.	Req.7 Req.8
	vCDX_002	Various roles and accounts can be configured through the vSphere Web Client, of which vCloud Director Extender is inherently a part of.	Req.8

	vCDX_003	The capturing of logs can be accomplished through the vSphere Web Client. Actions taken by the user with root privileges can be detailed within the vSphere Web Client.	Req.10
	vCDX_004	Account lockout procedures can be configured via LDAP integration with vCloud Director, thus affording these same traits to vCloud Director Extender.	Req.8
	vCDX_005	vCloud Director Extender retains information regarding all previously performed virtual machine migrations.	Req.10
	vCDX_006	The preservation of logs can be accomplished through the vSphere Web Client, with which vCloud Director Extender is inherently integrated with.	Req.10
	vCDX_007	A list detailing the network configuration can be viewed within the vSphere Web Client where vCloud Director Extender resides.	Req.1
	vCDX_008	vCloud Director Extender is innately a part of the vSphere environment, which has the ability to enforce uniquely identifying properties to various users.	Req.8
	vCDX_009	The enforcement of password history requirements can be accomplished through LDAP integration, which can be configured to meet organizational requirements.	Req.8
	vCDX_010	vSphere can be successfully integrated with LDAP, which enables the options of configuring minimum and maximum password age standards for its users. vCloud Director Extender will inherit these properties due to its deep integration with vSphere via vCloud Director.	Req.8
	vCDX_011	vCloud Director Extender employs the use of the Replicator, which provides the data transfer and monitoring, to protect data with encrypted TCP traffic during a virtual machine migration.	Req.1
vCenter	VCENTER_001	vCenter supports access control configuration including: session timeout, login attempts, account lockout threshold, account lockout duration, minimum password age, and requiring re-authentication.	Req.8
	VCENTER_002	Concurrent sessions can be limited on web clients, and virtual machine consoles.	Req.7
	VCENTER_003	vCenter employs unique user identifiers through Platform Services Controller (PSC),™, which manages integration with SSO. Unique user identifiers can be assigned using Platform Services Controller.	Req.8
	VECENTER_004	Access is supported using Role Based Access Control (RBAC) through local operating system access control, or integration with Active Directory and federated services. vCenter access control is established through permissions, which are assigned	Req.8

		by a combination of roles and privileges. Users are assigned to roles. Privileges are assigned to roles. Thus, access authorization is a combination of the role a user is assigned and the privilege a role is assigned.	
	VCENTER_005	Super user capabilities in vCenter are a combination of privileges, which can be assigned to administrator roles. Assignment of elevated privileges can be restricted to only those users that are approved as designated system administrators.	Req.7
	VCENTER_006	vCenter can support an organization's continuity plan by providing workload management in the event of a host system disruption. However, this capability is not a robust continuity planning solution.	Req.12
	VCENTER_007	vCenter can list all the virtual machines and support creating an inventory of technology systems.	Req.2 Req.9
	VCENTER_008	Remote access to vCenter via SSH, or Web Client or API over HTTPS, can be configured as the secure communication protocol. For the VMware vCenter Server Appliance™, it runs on Linux and can be restricted to only accept HTTPS. Session identifiers are invalidated after session termination.	Req.4 Req.8
	VCENTER_009	vCenter can be configured to log-off out inactive sessions. By default, inactivity is set to log out after 15 minutes.	Req.8
	VCENTER_010	vCenter can configure encryption parameter designation on a VM -by -VM basis. ESXi performs the actual encryption on the VM. 3rd Third-party key manager solution is required for encryption key management.	Req.4
	VCENTER_011	vCenter can push logs to be stored in an external log repository that supports syslog, including vRealize Log Insight. In the event vRealize Log Insight is used, it can then apply tamper protection of logging that can be used during after-the-fact investigations without altering the event logs.	Req.10
	VCENTER_012	vCenter supports monitoring a set of standardized settings to monitor, which may indicate inappropriate usage or security violations. Alarms and alerts can be configured to notify users via email when triggered.	Req.10 Req.11
	VCENTER_013	vCenter has inherent capabilities to log events and specify frequency. The richness of logging can be adjusted and the log retention based on disk space can be enhanced through use of a separate logging repository via syslog, or vRealize Log Insight.	Req.10
	VCENTER_014	vCenter can be configured to display a login banner to users before granting access to the system.	Req.7 Req.8
	VCENTER_015	vCenter supports enhanced logging of audit level events to support 3rd third-party integration with tools such as Introduction Detection Systems (IDS).	Req.10 Req.11

	VCENTER_016	vCenter has granular access control permissions that can be applied to virtual machines, VM clusters, and hosts. An organization can define the roles that can access these systems, such as bifurcating access between developers and production environments.	Req.1
	VCENTER_018	vCenter can be run on a Linux appliance that is configured to restrict network traffic through use of a software firewall, which is restricted to only necessary ports during the installation. However, if vCenter is run on a Windows appliance, the network traffic and firewall are inherited based on the user's configuration of the Windows appliance.	Req.1 Req.7
	VCENTER_019	vCenter can manage the encryption of virtual machines (applying encryption, or removing encryption), and matching keys using a 3rd third-party key management solution.	Req.3 Req.4
	VCENTER_020	vCenter can push audit trail logs to be archived in an external log repository that supports syslog, including vRealize Log Insight.	Req.10 Req.11
	VCENTER_021	vCenter can patch ESXi hosts through VMware vSphere Update Manager (VUM).	Req.6
	VCENTER_022	vCenter can facilitate installation of critical security updates for ESXi. VMware vSphere Update Manager (VUM) alerts vCenter of any firmware issues that affect ESXi and can be used to install patches, and also automate installation of updates. vCenter has a manual feature to check to see if there are any updates available for vCenter without specifying the nature of the update (security, or operational).	Req.6
	VCENTER_023	vSphere Hardening Guide provides support for ESXi and vCenter hardening procedures.	Req.2 Req.12
	VCENTER_025	vCenter natively can provide two-factor authentication techniques such as CAT Card and RSA 2FA.	Req.8
VMware Identity Manager	VIDM_001	Access controls to objects and users are supported using Role Based Access Control (RBAC) through integration with Active Directory and federated services. This includes limiting super user accounts, requiring unique user identifiers, and authentication methods. VMware Identity Manager supports Single Sign-On (SSO) and serves as a Platform Services Controller instance for other VMware products.	Req.7 Req.8
	VIDM_002	VMware Identity Manager supports VMware Verify, a two-factor authentication product. In addition, VMware Identity Manager can be integrated with 3rd third-party two-factor authentication solutions.	Req.8
	VIDM_003	Maintenance logs are generated during upgrades and patches. However, logs are not automatically archived and should be stored in a logging repository to preserve the maintenance logs. For VMware Identity Manager in the cloud, the system	Req.10

		is set to store event data for 90 days. For VMware Identity Manager on-prem, only the most recent log is maintained and this should be pushed to a log repository to preserve data according to each organization's policy.	
	vIDM_004	Remote system management of VMware Identity Manager is bifurcated into Operational Access via SSH and administrator access via HTTPS. In both instances, session identifiers are invalidated upon session termination.	Req. 7
	vIDM_005	VMware Identity Manager issues session tokens (default value of 8 hours), which can be configured to force users to re-authenticate after the token expires.	Req.8
	vIDM_006	VMware Identity Manager can push logs to vRealize Log Insight, or a 3rd third-party logging system that supports syslog. For VMware Identity Manager in the cloud, the system is set to store logs for 90 days. For VMware Identity Manager on-prem, disk size may require recycling of logs. Therefore, for both cloud and on-prem instances, pushing log files to a proper log repository is recommended.	Req.10
	vIDM_007	VMware Identity Manager supports configuration of access control setting such as: requiring new users to change password on first login, minimum password age, account lockout threshold, account lockout duration.	Req.8
	vIDM_008	User Account reviews is supported through a standardized reporting function available to VMware Identity Manager administrators.	Req.7 Req.8
	vIDM_009	VMware Identity Manager access can be assigned to roles such as operator, administrator, and user.	Req.7
vRealize Automation	VRA_001	Security and protection software can be installed using NSX Rest API and Guest Introspection.	Req.5
	VRA_002	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	VRA_003	Remote access to products can be restricted to just SSH, or other desired and secure communication protocols. Manually the configuration files can be altered in vSphere to further restrict access to vSphere. This includes controlling remote access through an existing access control and authentication solution, and invalidating session identifiers upon session termination.	Req.1 Req.4
	VRA_004	Unnecessary system functionality can be configured by using vRealize Automation to disable unwanted service catalog template items by default.	Req.2
	VRA_005	vRealize Automation can push logs to syslog supported logging solutions, or vRealize Log Insight. vRealize Log Insight can then apply tamper protection of logging that can be used during after-	Req.10

		the-fact investigations without altering the event logs.	
	VRA_006	vRealize Automation can provide configuration management input to an asset inventory database using 3rd third-party tools. This includes adding devices to the Access Control List, recording the owner for applicable assets, and maintaining an asset inventory database. vRealize Orchestrator can update a control management database updating assets, but does not create the database itself.	Req.9
	VRA_007	vRealize Automation can restrict settings and services for new infrastructure and virtual machines created through the portal, which could by default launch secure, pre-defined virtual instances.	Req.2
	VRA_008	vRealize Automation supports multiple roles to separate user functionality from system management functionality, as well as the capability to support the principle of least privilege user access control.	Req.7
	VRA_009	vRealize Automation can automate log capturing and transmission to logging solutions.	Req.10
vRealize Log Insight	VRLI_001	Using 3rd third-party software vRealize Log Insight can be configured to support non-repudiation of log entries and monitor access to logs to ensure transactions are reputable. The access restriction would be applied at the operating system and restrict access to the underlying file system/database, since super users administering the operating system would be able to access log information.	Req.7 Req.10
	VRLI_002	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	VRLI_003	Session lockouts are enforceable and require users to re-authenticate after a session time-out.	Req.8
	VRLI_004	Search queries can be configured to monitor the system for inappropriate usage, security violations, and other defined events. Monitoring tools include alerts and dashboards. Dashboards and interactive analytics are provided out-of-the-box, which can also be configured to enhance system monitoring.	Req.10 Req.11
	VRLI_005	vRealize Log Insight supports standard syslog and secure syslog. In addition, when using an internal vRealize Log Insight agent, a secure, encrypted protocol is enforceable.	Req.10
	VRLI_006	Audit Dashboard is provided to analyze log data and support after-the-fact investigations. In addition, vRealize Log Insight can provide tamper protection by deploying a log system architecture configured to support multiple storage locations to minimize the risk of a central location from being corrupted or altered.	Req.10

VRLI_007	vRealize Log Insight can gather event logs across any device within the virtualized, or physical environment. Log data is stored in a centralized database. The logging database can be used to correlate system-wide audit trails. Security -related queries, dashboards, and alerts use time- stamps to support event log correlation.	Req.10
VRLI_008	vRealize Log Insight has a dashboard export feature to help distribute logs. In addition, a read-only view is available for designated users to log in and view the reports.	Req.10
VRLI_010	Backups of logs can be performed for all products using vRealize Log Insight. Remote archival of vRealize Log Insight logging data is supported.	Req.10
VRLI_011	Hosts can use a vRealize Log Insight agent, or send logs via syslog to the centralized vRealize Log Insight log database to manage storage, retention, and protect logs from unauthorized activity.	Req.10
VRLI_012	Remote access to vRealize Log Insight is by default set to HTTPS. Session identifiers are discarded upon session termination.	Req.4 Req.8
VRLI_013	vRealize Log Insight allows access control settings to be configured to manage sessions, including the following parameters: account lockout threshold, account lockout duration, and password policies. vRealize Log Insight can integrate authentication with the vCenter Platform Services Controller instance to enable enforcement of authentication parameters from Active Directory directly.	Req.7 Req.8
VRLI_014	vRealize Log Insight provides management of user accounts through the Access Control panel, including managing users configured locally, as well as accounts created through an external authentication solution.	Req.8
VRLI_015	vRealize Log Insight allows users to be assigned to roles. The roles can be assigned granular access based on the organization's assignment of least privilege, or job responsibilities within the groups. VMware Identity Manager or an external authentication solution is required to administer this capability. vRealize Log Insight can integrate authentication with the vCenter Platform Services Controller instance to enable enforcement of authentication parameters from Active Directory directly.	Req.7 Req.8
VRLI_016	vRealize Log Insight can manage an Access Control List via agent and host listings to manage devices, as well as restricting the logs a device can access. Role - based access can limit access to specific log devices and log data.	Req.7 Req.8 Req.10

	VRLI_017	If local accounts are created in vRealize Log Insight, users can be required to change their password upon first login.	Req.8
	VRLI_018	Alerts are generated when agents are unresponsive, or offline after a defined period of time.	Req.5 Req.11
	VRLI_019	vRealize Log Insight collects logs in real time. Content packs to enhance dashboards and provide custom queries tailored to many VMware products.	Req.10
vRealize Network Insight	VRNI_001	vRealize Network Insight receives NetFlow from VMware vSphere Distributed Switch (VDS), instances, which connect virtual machines. This can be used to monitor information flows and network flows.	Req.10
	VRNI_002	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	VRNI_003	Remote access to administrative features can be restricted to just SSH, or other desired and secure communication protocols. Manually the configuration files can be altered in vRealize Network Insight to further restrict access to vSphere. This includes controlling remote access through an existing access control and authentication solution, and invalidating session identifiers upon session termination.	Req.7
	VRNI_004	After fifteen15 minutes of inactivity, users are locked out and required to re-authenticate.	Req.8
	VRNI_005	vRealize Network Insight can push logs to syslog, or vRealize Log Insight. vRealize Log Insight can then apply tamper protection of logging that can be used during after-the-fact investigations without altering the event logs.	Req.10
	VRNI_006	vRealize Network Insight can be used to monitor data center traffic and provide visibility to support monitoring activities.	Req.11
	VRNI_007	vRealize Network Insight can be used to review network paths and troubleshoot components that are not communicating properly, such as a web server not reaching a database. This feature can also help in establishing distributed firewalls.	Req.11
	VRNI_008	vRealize Network Insight logs network traffic with a default retention period of thirty30 days, which can be extended to thirteen13 months. This log data can provide audit trail support.	Req.10
	VRNI_010	The vRealize Network Insight administrator can manage User Interface (UI) users. Users connect via a web portal UI. These user accounts can be reviewed, access control can be managed using roles (administrator, or read-only Member User)member user), and password complexity can be configured.	Req.7 Req.8

	VRNI_011	vRealize Network Insight traffic between the platform and proxy servers can be encrypted using certificates.	Req.4
vRealize Orchestrator	VRO_001	Remote access to products can be restricted to just SSH, or other desired and secure communication protocols. Manually, the configuration files can be altered in vSphere to further restrict access to vSphere. This includes controlling remote access through an existing access control and authentication solution, and invalidating session identifiers upon session termination.	Req.1 Req.4
	VRO_002	vRealize Orchestrator can provide user information responsible for creating or modifying the virtual machine, virtual infrastructure asset information, or other information. This can be used to trace ownership, if the creation or modification are appropriate parameters to assist in deciphering ownership.	Req.9 Req.10
	VRO_003	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	VRO_004	vRealize Orchestrator supports multiple roles to separate user functionality from system management functionality, as well as the capability to support the principle of least privilege user access control.	Req.7 Req.8
vRealize Operations	VROPS_001	A proof of maintenance log is available to report on archived maintenance activity.	Req.10
	VROPS_002	Remote access to vRealize Operations is restricted by default. vRealize Operations appliance remote access can only be enabled to use SSH via the vCenter VM Console. vROPS user console. vRealize Operations UI is only accessible via a secure URL. Upon session termination, session identifiers are invalidated.	Req.1 Req.4
	VROPS_003	Session lockouts are enforced by default and require users to re-authenticate after a session time-out.	Req.8
	VROPS_004	Using a management pack, specific to the compliance area (PCI and HIPAA only at this time), vRealize Operations can be used to support a configuration management program. The content pack relies on vSphere to evaluate technical configurations and settings based on the compliance pack's baseline.	Req.6
	VROPS_005	vRealize Operations has a maximum of concurrent sessions (6); this setting cannot be altered.	Req.8
	VROPS_006	Using a management pack, vRealize Operations can store information that is collected by agents via the use of plug-ins to collect data from guest operating systems running in virtual machines.	Req.10

	VROPS_007	vRealize Operations can perform capacity planning, forecasting, and reporting. An input into this planning process can include comparing capacity between production and backup sites.	Req.12
	VROPS_008	Initial login with the root account requires users to change the password. New users logging in for the first time can also be required to change their password upon initial login.	Req.8
	VROPS_009	vRealize Operations can monitor the storage of vSAN (or another database) and upon running low, it can provide an alert and recommendation to adjust the storage capacity. The storage capacity data and alerts can be archived to support retaining records in accordance with applicable regulations.	Req.11
	VROPS_010	vROPS vRealize Operations can be configured to support account lockout duration, number of failed attempts, and password length and complexity.	Req.8
	VROPS_011	vRealize Operations can push audit trail logs to be archived in an external log repository that supports syslog, including vRealize Log Insight.	Req.10
	VROPS_012	vRealize Operations permits creating roles and groups using Role Based Access Control (RBAC). Granularity can be applied to view or edit objects, run reports, and other functionality.	Req.7 Req.8
	VROPS_013	vRealize Operations provides metrics and system performance reports that users can compare against organizational standards or industry benchmarks. The metrics include capacity planning, virtual machine sizing, and behavioral analysis.	Req.8
vSAN	vSAN_001	Access to data storage in vSAN is managed by roles within vCenter. vSAN 6.5 introduced a new role to manage enabling/disabling encryption that can be further applied to restrict non-cryptographic user access to configuration of this feature.	Req.7 Req.8
	vSAN_002	Logging capabilities can be enabled and customized to capture event information.	Req.10
	vSAN_003	Logging can be synchronized to system clocks (NTP) and also capture a date and time stamp.	Req.10
	vSAN_004	vSAN can push logs to be stored in vRealize Log Insight. A default vSAN dashboard is available in vRealize Log Insight as a content pack.	Req.10
	vSAN_005	Session lockouts are enforceable and require users to re-authenticate after a session time-out, which are controlled by vCenter or ESXi.	Req.8
	vSAN_006	Encryption at rest can be performed for objects residing on the vSAN datastore (both in cache and long-term capacity storage media). However, a 3rd third-party key manager will be required to store and rotate keys.	Req.3 Req.4
	vSAN_007	vSAN can be patched via the vSphere Update Manager patching capabilities in vCenter. In	Req.6

		addition, vSAN 6.6 has the ability to patch firmware controller drivers for participating vendors.	
	vSAN_008	Maintenance activity is logged and can be accessed via reports, which can be archived for historical reference. The maintenance logging information is captured at each component vCenter, ESXi, and vSAN instance, which can be holistically analyzed via vRealize Log Insight or custom API log reporting tool.	Req.10
	vSAN_009	Storage size can be adjusted to prevent exceeding capacity. This can be adjusted by adding physical devices, or adding vSphere hosts, without a limit to file or block storage size.	Req.6
	vSAN_010	Cryptographic management features supported include: rotation of keys via UI or API integration, changing key management system (KMS) providers, and broadly enabling or disabling encryption. These capabilities can be used to support cryptographic procedures.	Req.3 Req.4
vSphere Replication	VSPHEREREPLICATION_001	Replication of virtual machine object and its data can be used to support continuity planning and can provide a virtualization technology alternative to offsite vSphere environment storage using electronic media.	Req.12

About VMware

VMware, a global leader in cloud infrastructure and business mobility, accelerates our customers' digital transformation journey by enabling enterprises to master a software-defined approach to business and IT.

With the VMware Cross-Cloud Architecture™ and digital workspace solutions, organizations are creating exceptional experiences by mobilizing everything; differentiating and responding faster to opportunities with modern apps hosted across hybrid clouds; and safeguarding brand and customer trust with a defense-in-depth approach to security.

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For more information on VMware security, visit security.vmware.com.

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Tevora is a leading management consulting firm specializing in enterprise risk, compliance, information security solutions, and threat research. We offer a comprehensive portfolio of information security solutions and services to clients in virtually all industries and also serve institutional and government clients.

Tevora's leaders are professionals with years of experience and records of accomplishments in technology as well as business. This dual background means that we understand the importance of growth and profitability and our solutions are designed to enhance both.

As a consulting firm that has the ability to fully implement whatever it recommends, Tevora works with all of the industry's top vendors, yet is beholden to none. We are completely vendor-independent and select best-of-breed products tailored exclusively to our clients' needs. Security is our only business and our single-minded focus on anticipating and solving client problems has been described as "obsessive." We consider this a fair assessment.

Our hard work and dedication has established us as a reliable partner CTOs, CIOs, and CISOs can depend on to help protect against threats, both internal and external. With Tevora as a partner, business leaders can devote their energies to enhancing the overall value of information technology to their enterprise.

Tevora is a Qualified Security Assessor (QSA) and Payment Application Qualified Security Assessor (PA-QSA) in good standing with the PCI Security Standards Council. Tevora is also a DVBE (Disabled Veteran Business Enterprise) certified by the California General Services Department (Cert REF# 32786).

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