

VMware Cloud Foundation on Dell VxRail

Accelerating the Journey to VMware Software-Defined Data Center and Hybrid Cloud

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Abstract

VMware Cloud Foundation on Dell VxRail, the foundation for APEX Hybrid Cloud, delivers a simple and direct path to the hybrid cloud and Kubernetes at cloud scale with one complete, automated platform. By deploying VMware Cloud Foundation on VxRail HCI, customers get full-stack integration with both the infrastructure layer and VMware Cloud software stack. Automated life cycle management is provided as a single complete turnkey hybrid cloud experience that greatly reduces risk and increases IT operational efficiency. VxRail HCI System Software's unique integration between SDDC Manager and VxRail Manager combines operational transparency with automation, support, and serviceability capabilities not found when VMware Cloud Foundation is deployed on any other infrastructure.

White Paper

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Revisions

Date	Part number/ revision	Description
July 2019		Initial version
October 2019		Updated to cover VMware Cloud Foundation on VxRail version 3.8.1 feature set
September 2020		Updated to cover VMware Cloud Foundation 4.0.1.1 on VxRail 7.0.010 feature set
December 2020		Branding updates
February 2021		VxRail integrated rack updates
July 2021		Updated to cover VMware Cloud Foundation 4.2 on VxRail 7.0.131 feature set
December 2021		Updated to cover VMware Cloud Foundation 4.3.1 on VxRail 7.0.241 feature set
February 2022	H17854	Minor edits
April 2023	H17854.1	Updated to cover VMware Cloud Foundation 4.5.0 on VxRail 7.0.400 feature set and subscription licensing options

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Executive summary

VMware Cloud Foundation on Dell VxRail hyperconverged infrastructure (HCI) provides a simple path to the hybrid cloud and Kubernetes at a cloud scale. It is a fully integrated platform that leverages native VxRail hardware and VMware Cloud Foundation software capabilities. It includes unique features jointly engineered by Dell Technologies and VMware to deliver a turnkey user experience with full-stack integration. With full-stack integration, customers experience both the infrastructure layer and cloud software stack in one complete, automated life cycle, turnkey experience.

VMware Cloud Foundation on Dell VxRail provides a consistent hybrid cloud experience unifying customer public and private cloud platforms under a common operating model and management framework. Customers can operate both their public and private platforms using one set of tools and processes with a single management view and provisioning experience across both platforms. Customers can build, run, and manage a broad set of workloads from traditional and legacy applications to virtual desktops, as well as next generation workloads from artificial intelligence and machine learning to cloud native and container-based workloads. VMware Cloud Foundation with Tanzu, available since version 4.0 of the platform, is a major architectural upgrade thanks to integration of Kubernetes directly into the vSphere hypervisor.

The SDDC Manager and VxRail HCI System Software integration allows VMware Cloud Foundation to build a complete software-defined data center on VxRail. SDDC Manager orchestrates the deployment, configuration, and life cycle management of vCenter, NSX, and some of the Aria Suite (formerly vRealize Suite) components above the ESXi and vSAN layers of VxRail. It enables VxRail clusters to serve as a resource platform for workload domains or as multicluster workload domains. It can also automatically enable VMware Tanzu for container-based and VM-based workloads with integrated native Kubernetes orchestration. Integrated with the SDDC Manager management experience, VxRail Manager is used to deploy, configure, and life cycle manage ESXi, vSAN, and HCI infrastructure hardware firmware. VxRail life cycle management is accomplished using fully integrated and seamless SDDC Manager orchestration that leverages VxRail Manager APIs to perform it natively.

Through the standardized hardware and software architecture that is integrated into VMware Cloud Foundation on VxRail, customers can build and run heterogeneous workloads on a common hybrid cloud infrastructure. Infrastructure building blocks based on native VxRail clusters are created using SDDC Manager which enables customers to scale up and scale out incrementally.

VxRail Manager delivers automation, life cycle management, support, and serviceability capabilities that are integrated with SDDC Manager and vCenter to extend the VMware Cloud Foundation management experience and simplify operations. VxRail management functionality is available in vCenter through a VxRail Manager vCenter plug-in.

All VMware Cloud Foundation on VxRail life cycle updating and upgrade operations are orchestrated using SDDC Manager. As a part of this monitoring, SDDC Manager automatically discovers when new VxRail and VMware Cloud Foundation updates are available for download and proactively notifies the administrator accordingly within the user interface. All updates are scheduled and orchestrated by SDDC Manager but may be

performed by either SDDC Manager directly or by VxRail Manager using SDDC Manager integrated VxRail APIs.

Dell delivers the top hyperconverged (HCI) infrastructure portfolio purpose-built for HCI with the latest generation Dell PowerEdge server platform. This portfolio delivers tailor-made performance and reliability powerful enough for any workload, combined with an advanced approach to intelligent deployment and operations that simplify and accelerate IT. Dell HCI on the latest generation of PowerEdge servers are powerful and purpose-built platforms that provide the ideal foundation for software-defined data center initiatives.

VxRail nodes are available with different compute power, memory, and cache configurations to closely match the requirements of new and expanding use cases. As requirements grow, the platform easily scales up or out in granular increments.

VMware Cloud Foundation on Dell VxRail can be delivered as either a cluster of nodes that leverages the customer's existing network infrastructure, or as a custom integrated rack system with or without integrated networking. With rack assembly services from Dell, VxRail rack-integrated systems can be delivered with customer-chosen rack and networking component options.

Dell Services accelerate the deployment of VMware Cloud Foundation on VxRail with a full range of integration and implementation services. Dell Services helps IT organizations quickly realize the value of their investment both by deploying the hardware and software components of VMware Cloud Foundation on VxRail. Dell Services also helps organizations achieve IaaS through integration of this integrated cloud platform into their application portfolio, operating model, and enterprise infrastructure.

Customers have a choice of support and maintenance options that can align to their business model. Options range from a single-vendor Dell Support experience to obtaining support from Dell, VMware, and third parties for network switches and racks. Dell Support is recognized with an over 95 percent customer satisfaction rating¹ and has received multiple awards.

For additional details, see [Appendix B: Business IT challenges and trends](#), [Appendix C: VMware SDDC](#), and [Appendix D: VMware Cloud Foundation](#).

¹ <http://i.dell.com/sites/doccontent/business/solutions/brochures/en/Documents/prosupport-enterprise-suite-brochure.pdf>

Introduction

Information Technology (IT) departments are under significant pressure to deliver new applications to market, to innovate with technology to beat competitors, and to do it faster with +more choice. At the same time, there are requirements for stricter compliance, improved security, controlled costs, and increased efficiency. To solve these problems, the modern data center is trending towards converged and hyperconverged infrastructures, virtualization, and software-defined infrastructures and public and hybrid cloud solutions. For a more detailed discussion of these issues, see [Appendix B: Business IT challenges and trends](#).

The VMware vision of the modern data center is a software-defined, standardized architecture. It is a fully integrated hardware and software stack that is simple to manage, monitor, and operate. The VMware architecture for the software-defined data center (SDDC) empowers companies to run hybrid clouds and to leverage unique capabilities to deliver key outcomes that enable efficiency, agility, and security. The VMware SDDC is based on VMware vSphere, VMware vSAN, and VMware NSX. It provides compute, storage, and networking virtualization to the SDDC, as well as the VMware Aria Suite (formerly vRealize Suite) for additional cloud management, self-service, automation, intelligent operations, and financial transparency. For more information see [Appendix C: VMware SDDC](#).

VMware Cloud Foundation provides integrated cloud infrastructure (vSphere compute, vSAN storage, NSX networking, and security) and cloud management services (with the Aria Suite) to run many types of enterprise applications in both private and public environments. Applications range from traditional applications deployed as virtual machines and VMware Horizon virtual desktops, to Kubernetes-powered containerized cloud native applications. VMware Cloud Foundation helps break down the traditional administrative silos in data centers, merging compute, storage, network provisioning, and cloud management to facilitate end-to-end support for application deployment. VMware Cloud Foundation's SDDC Manager component automates the life cycle management of a complete software-defined data center on standardized hyperconverged architecture. VMware Cloud Foundation can be deployed on premises on a broad range of supported hardware or consumed as a service in the public cloud. See [Appendix D: VMware Cloud Foundation](#) for more information about the native software platform architecture, key features and capabilities, SDDC Manager, resource management with workload domains, support for dual-region and multiple availability zones, and path to the hybrid cloud details.

Dell Technologies shares VMware's vision of the modern data center and extends that to the infrastructure. For customers that choose VMware as the primary technology for modernizing their data center or building a multicloud IT environment, Dell offers an accelerated path to the VMware SDDC by jointly developing a fully automated and turnkey cloud infrastructure platform.

VMware Cloud Foundation on Dell VxRail delivers a simple and direct path to the hybrid cloud and Kubernetes at cloud scale while allowing customers to maintain flexibility of networking and topology. VMware Cloud Foundation on VxRail builds on native VxRail and VMware Cloud Foundation capabilities. It provides additional unique integration features that are jointly engineered by Dell and VMware that no other VMware Cloud Foundation infrastructure offer can provide. These features simplify, streamline, and automate SDDC operations from deployment through Day 2 operations (including support and serviceability capabilities).

VMware Cloud Foundation on Dell VxRail

VMware Cloud Foundation on Dell VxRail is an integrated VMware Cloud Foundation stack running on top of a VxRail HCI system. It provides automated hardware and software life cycle management and fully automated deployments of the VMware SDDC and HCI infrastructure while still providing customers with flexible topologies and networking in one complete, seamless user experience.

VMware Cloud Foundation leverages Dell VxRail APIs to consume the value-added capabilities in VxRail. VMware has made architectural updates to the platform that pair well with core VxRail functionalities, such as networking flexibility, enabling Dell integration benefits, and deployment options ranging from a cluster of nodes to integrated rack offerings.

Operational hub for hybrid cloud

VMware Cloud Foundation on Dell VxRail provides a simple and direct path to the hybrid cloud. It is a fully integrated platform that leverages native VxRail hardware and software capabilities and other VxRail unique integrations, such as vCenter plug-in, SDDC Manager and VxRail Manager integration. VxRail architecture awareness is engineered into VMware Cloud Builder to deliver a turnkey hybrid cloud user experience with full-stack integration.

Full-stack integration means that customers get both the infrastructure layer and cloud software stack that leverages native VxRail hardware and software capabilities and other VxRail unique integrations (such as vCenter plug-in) in one complete, automated life cycle, turnkey experience. The platform delivers a set of software-defined services for compute (with vSphere and vCenter), storage (with vSAN), networking (with NSX), security, cloud management (with Aria Suite), and container-based cloud native platform services (with VMware Tanzu) in both private or public environments. These features make it the operational hub for customers' hybrid clouds, as shown in Figure 1.

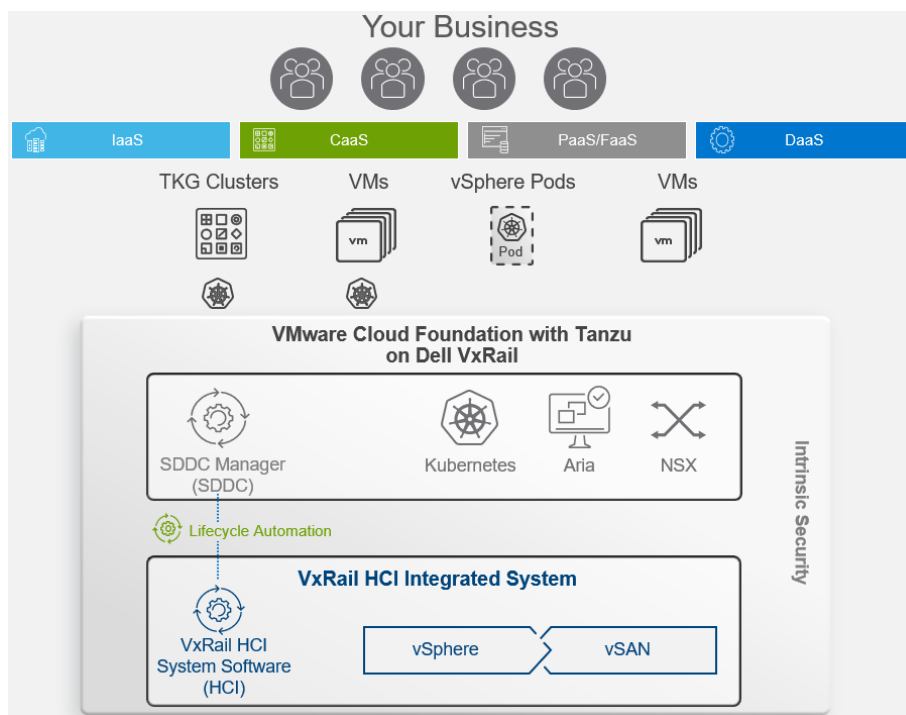


Figure 1. Operational hub for customers' hybrid cloud

Consistent hybrid cloud platform

The consistent hybrid cloud is a paradigm that has emerged in the market, as a response to the complexity of multicloud raised in [Transforming from legacy to modern applications and multicloud](#).

VMware Cloud Foundation on Dell VxRail provides a consistent hybrid cloud unifying customer public and private cloud platforms under a common infrastructure, operating environment, and management framework. Customers can operate both their public and private platforms using one set of tools and processes, with a single management view and provisioning process across both platforms. This consistency allows for easy portability of applications and IT operations.

An April 2019 IDC White Paper² described how the consistent hybrid cloud platform (Dell Technologies Cloud, rebranded as APEX Hybrid Cloud) achieved savings of up to 47 percent over a 5-year period compared with a native public cloud, when evaluated for typical applications being deployed on cloud infrastructure by enterprises today.² The TCO is based on platform built with VMware Cloud Foundation on Dell VxRail. VxRail is built upon mature Dell PowerEdge server hardware and the pervasive VMware software stack and management tools and allows a nondisruptive path to adoption of multiple cloud platforms within an organization. This consistency across cloud platforms is the key differentiator defining the next generation of hybrid cloud—the consistent hybrid cloud platform.

How Dell VxRail complements VMware's SDDC and hybrid cloud vision

Dell VxRail is the foundation for the APEX Hybrid Cloud. APEX Hybrid Cloud is a part of the Dell APEX Cloud Services portfolio that offers integrated compute, storage, networking, and virtualization resources that enable consistent, secure infrastructure and operations for workloads across public and private clouds. With a simple way to order and manage cloud resources, customers can easily build the cloud of their choice with solutions that are tailored to their most pressing business needs.

VxRail delivers the fastest and simplest path to achieving IT outcomes, from modernizing data center at the core with new platforms and faster network connectivity, to automated and accelerated hybrid cloud deployment with VMware Cloud Foundation on VxRail.

The Dell VxRail turnkey experience starts with full-stack integration of software and hardware, for a consistent and deeply integrated VMware environment. VxRail goes even further to deliver even more highly differentiated features and benefits based on the VxRail HCI System Software. The software automates deployment, delivers complete life cycle management, and facilitates key upstream and downstream integration points. The result is a better-together experience for hybrid cloud infrastructure use cases, with VxRail as the foundation. VxRail is the only jointly engineered HCI system with VMware and supports synchronous releases with VMware. This means that the latest HCI and cloud software updates are available to customers sooner.

VMware Cloud Foundation on Dell VxRail

VMware Cloud Foundation on VxRail builds upon native VxRail and VMware Cloud Foundation capabilities with additional unique Dell and VMware jointly engineered

² <https://www.dell EMC.com/en-us/collaterals/unauth/analyst-reports/products/dell-technologies-cloud/idc-cost-benefits-analysis-of-dell-technologies-cloud-solution.pdf>

integration features. These features simplify, streamline, and automate the operations of your entire SDDC from deployment through Day 2 operations, including support and serviceability capabilities that no other VMware Cloud Foundation infrastructure offering can provide.

Full-stack integration with VMware Cloud Foundation on VxRail means both the HCI infrastructure and VMware cloud software stack life cycle are managed as a single automated turnkey hybrid cloud experience that reduces risk and increases IT operational efficiency. VMware Cloud Foundation on VxRail delivers a consistent infrastructure and consistent operations experience with edge, private, and native public cloud workload deployment options for a true hybrid cloud solution.

VMware Cloud Foundation on Dell VxRail can be delivered several ways while providing customers with the flexibility to use their own or Dell networking systems:

- A cluster of nodes where customers can integrate it into their own racks with their choice of existing networking components.
- A customized integrated rack system with integrated networking built and delivered to a customer's site, saving hours of building and testing the infrastructure themselves.

Based on VMware SDDC best practices, VMware Cloud Foundation on VxRail ensures that customers are future-proofed for next generation VMware cloud technologies that will be innovated around the same architectural design principles.

Full-stack integration

VMware Cloud Foundation on VxRail makes operating the data center fundamentally simpler. It brings the ease and automation of the public cloud in-house by deploying a standardized and validated network flexible architecture with integrated life cycle automation for the entire cloud infrastructure stack, including hardware. As shown in Figure 2, full-stack automation is in place for Day 0, Day 1, and Day 2 operations. Day 0 operations consist of automating deployment and installing VxRail clusters and SDDC software. Day 1 operations include automating the environment configuration and resource provisioning. Finally, Day 2 consists of automating end-to-end infrastructure updating, upgrading, and the serviceability and support experience.

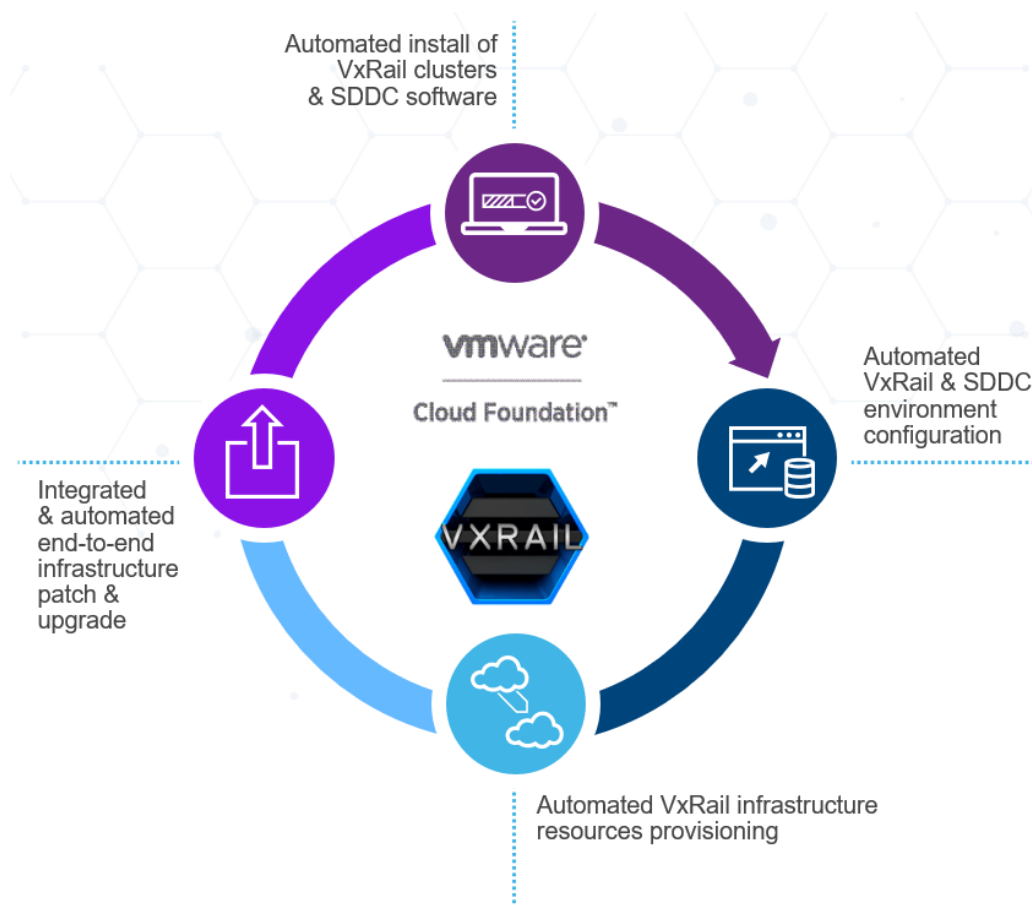


Figure 2. VMware Cloud Foundation on VxRail delivers end-to-end stack life cycle automation

Core components for VMware Cloud Foundation on VxRail come from VxRail and VMware Cloud Foundation. VxRail provides the base HCI hardware, ESXi, vSAN, VxRail Manager, and Dell Secure Remote Gateway appliance. VMware Cloud Foundation provides SDDC Manager, vCenter, and NSX. Optional add-on components include the VMware Aria Suite (formerly vRealize Suite: VMware vRealize Operations, VMware vRealize Log Insight, and VMware vRealize Automation). VMware Tanzu is also an optional add-on component.

To learn more about the VMware SDDC components listed above, see [Appendix D: VMware Cloud Foundation](#) and [Appendix E: VMware SDDC common component details](#).

Every VxRail provides the benefits of a jointly engineered HCI system that is built for VMware and is powered by vSphere, vSAN, and VxRail HCI System Software (which includes VxRail Manager) according to standardized HCI designs. With VxRail, a customer gets several highly valuable integrated features that are driven by the capabilities of VxRail HCI System Software. These features include scalable VxRail deployments, VxRail cluster creation, node addition and removal capabilities, and serviceability and support creation in vCenter, vCenter plug-in for VxRail workflow automation, and more.

Every VMware Cloud Foundation on VxRail deployment is based on a standardized VMware best practices architecture. VMware has validated the suite of components (vSphere, vSAN, NSX, Aria Suite, Tanzu, and others), that when used together, provide

all the data center virtualization and cloud management services that a customer must build to have a full-stack HCI private cloud. VMware takes these components and performs interoperability testing on them, but also develops a set of standardized component-level designs for how they should be configured with each other according to these VMware best practices. Combining the component qualification with a standardized SDDC-level architecture creates a fully validated SDDC design.

The following figure shows how Dell Technologies joint engineering efforts for VMware Cloud Foundation on VxRail fit together and the unique value-added features are introduced by each component.

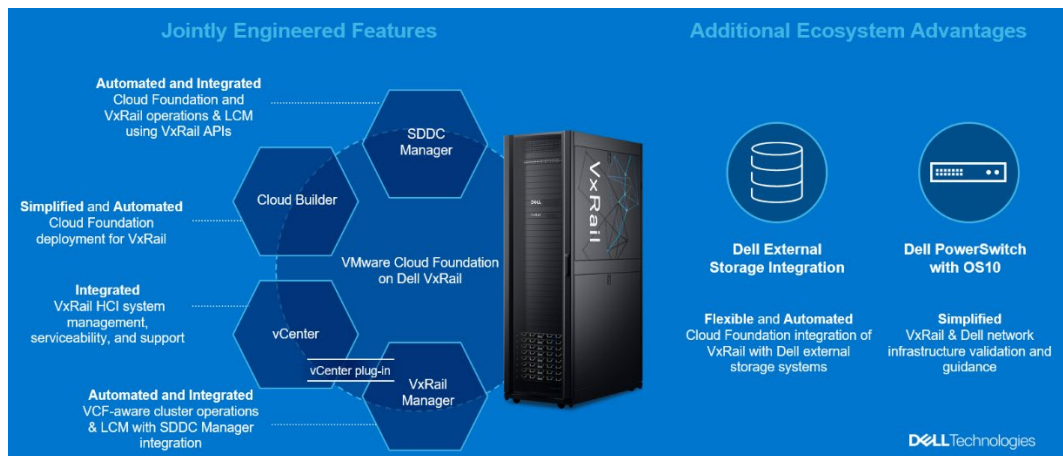


Figure 3. VMware Cloud Foundation on VxRail deep integration features and ecosystem advantages

The following list provides details of the VxRail integration features:

- Dell VxRail Manager**
VxRail Manager is the primary management and automation tool used for VxRail cluster operations. It features end-to-end life cycle management of HCI software and hardware (optionally including FC HBAs and GPUs). It also features automated cluster deployment and configuration, and an integrated serviceability and support experience. Examples of these serviceability features are the native integration with VxRail Manager and Dell Secure Remote Gateway proactive phone-home support system and capabilities to automate serviceability tasks such as proactive drive replacements. VxRail Manager extensibility is a key enabler to how VMware Cloud Foundation and VxRail are integrated.
- VMware vCenter**
The VxRail HCI System Software is integrated with vCenter through the VxRail Manager vCenter plug-in. This integration provides operational transparency that enables customers to manage 100 percent of VxRail Manager HCI system management tasks from within the familiar vCenter console. It also provides additional serviceability and support capabilities, also from within the vCenter console. These capabilities essentially eliminate any friction for customers who want seamless management of their VxRail from the vCenter interface. Examples of some of these management capabilities include: Physical and logical detailed graphical node views with integrated physical geo-location tags, centralized HCI system events and alerting, eServices access, automated failed disk drive serviceability automation, and VxRail dashboards.

- **VMware Cloud Builder**

This is a standardized automation tool for deploying and configuring VxRail according to VMware's SDDC best practices and standardized architecture. This tool has been exclusively engineered to be "VxRail Aware" and integrate with VxRail to deploy the additional VMware Cloud Foundation components that have not already been deployed by VxRail Manager. This aligns the VMware Cloud Foundation deployment to existing VxRail deployment operating models.

- **VMware SDDC Manager**

This feature is responsible for the automated configuration and life cycle management of the SDDC software components. SDDC Manager is integrated with VxRail Manager. They work together to streamline how the layers of the stack are managed, leveraging a consistent operating experience that VxRail customers are already used to and extending that to include an end-to-end full-stack experience. SDDC Manager leverages the VxRail API to natively perform VxRail cluster management operations such as cluster deployments and LCM workflows, all from within the SDDC Manager UI.

In addition, VMware Cloud Foundation on VxRail enables customers to take advantage of VxRail Additional Ecosystem Advantages, which include:

- **Dell PowerSwitch with OS10**

VxRail has been qualified with Dell PowerSwitch with OS10 Enterprise Edition networking switches. For information about deploying Dell network switches for VMware Cloud Foundation on VxRail, see [Appendix A: References](#). In addition, tools such as the Dell Networking Fabric Design Center are available to help create the right network architecture based on a customer's requirements.

- **Dell External Storage Integration**

VMware Cloud Foundation on VxRail deployments can inherit the benefits of integration efforts engineered between VxRail and Dell external storage systems with the support of VxRail dynamic nodes with Dell PowerMax, VMAX, PowerStore-T, and Unity XT systems. This enables administrators to leverage existing Dell external storage investments in their VMware Cloud Foundation on VxRail environments while maintaining a simple and consistent operations experience. In a VMware Cloud Foundation on VxRail use case, the integration of VxRail dynamic nodes with Dell external storage is taken to the next level with the co-engineered integration between VMware Cloud Foundation, VxRail, and external storage configuration support. With the introduction of VxRail dynamic nodes, Dell PowerMax, VMAX, PowerStore-T, and Unity XT storage can be used as a VxRail cluster's principal storage. VMware Cloud Foundation is now aware of these dynamic nodes with external storage. It can automate the creation of a VI Workload Domains (VI WLDs) and the addition of VxRail dynamic node-based clusters into existing VI Workload Domains using the Dell external storage as the principal storage for those workload domain VxRail clusters. Customers now have additional flexibility on which type of storage (VxRail nodes with vSAN or VxRail dynamic nodes with VMFS on FC) they would like to use for their VI WLD clusters' principal storage that best meets their workload requirements.

Integrated platform management

The SDDC Manager and the VxRail Manager software integration allows the VMware Cloud Foundation to build a complete SDDC on VxRail. The SDDC Manager orchestrates the deployment, configuration, and life cycle management of vCenter, NSX, and VMware

Aria (formerly vRealize Suite, resulting from integration with VMware vRealize Suite Lifecycle Manager) above the ESXi and vSAN layers of VxRail. It unifies multiple VxRail clusters as workload domains or as multicloud workload domains. Integrated with the SDDC Manager management experience, VxRail Manager is used to deploy, configure, and life cycle manage ESXi, vSAN, and hardware firmware. It takes advantage of the native VxRail Continuously Validated State update bundle framework, which is only available through the VxRail HCI System Software. The deployment of VxRail clusters uses the native VxRail Manager first run cluster creation process. VxRail life cycle management is integrated into the SDDC Manager orchestrated LCM workflows that use the VxRail Manager to perform it natively. VxRail Manager also monitors health of hardware components and provides remote service support.

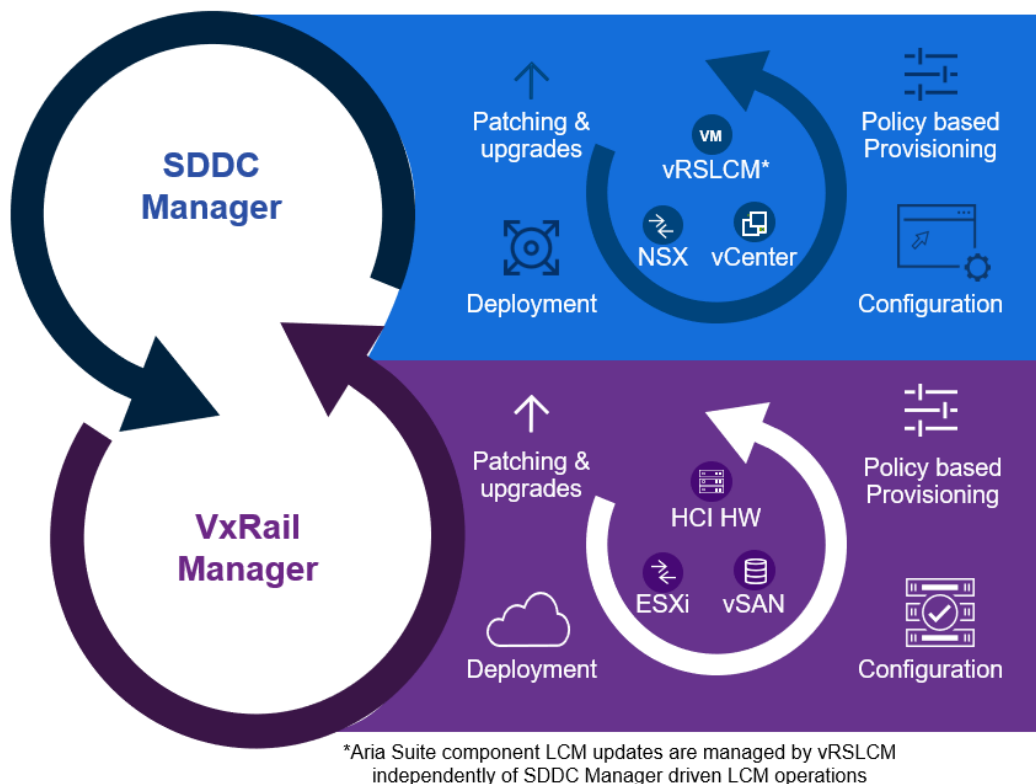


Figure 4. VxRail Manager and SDDC Manager integration

Scalable and flexible platform for heterogeneous workloads

Through the standardized hardware and software architecture integrated into VMware Cloud Foundation on VxRail, customers can build heterogeneous workloads. Using the SDDC Manager, infrastructure building blocks based on native VxRail clusters are created that can incrementally scale up and out.

Starting with four nodes, customers can scale up leveraging the flexible hardware configurations available within a VxRail node to increase storage capacity or memory. Similarly, customers can scale out by adding nodes in single node increments to a cluster. The physical compute, storage, and network infrastructure becomes part of a single shared pool of virtual resources that is managed as one cloud infrastructure ecosystem using the SDDC Manager. From this shared pool, customers can organize separate pools of capacity into workload domains, each with its own set of specified CPU, memory, and storage requirements to support various workloads. As new VxRail physical capacity is added, he

SDDC Manager recognizes the added capacity and makes it available for consumption as part of a workload domain.

In VMware Cloud Foundation, two types of workload domains can be deployed: a VxRail virtual infrastructure (Virtual Infrastructure) workload domain and a special workload domain called the Management domain. VI workload domains can be created using the SDDC Manager UI or API. This VCF automated process has been co-engineered by design to integrate SDDC Manager with the VxRail API to automatically deploy VxRail HCI clusters and maintain a consistent operational experience for VxRail customers. Each workload domain can have administrative tasks that are performed against it such as create, expand, and delete. All of which are fully integrated into the VxRail API to drive a consistent HCI infrastructure operations experience using native VCF management tooling. (Note: The management domain is the only one that is not allowed to be deleted; and it is created during initial system install, also known as “VCF Bring Up”). Figure 5 displays the SDDC Manager UI Workload Domain details screen after clicking the **+ WORKLOAD DOMAIN** button in the upper right, with the option showing the VxRail integration to create a **VxRail Virtual Infrastructure Setup**.

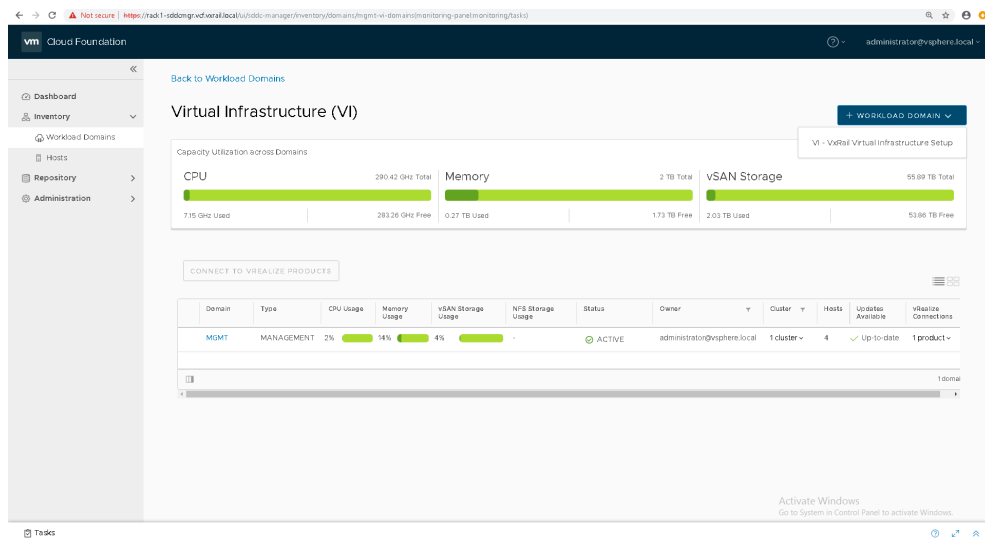


Figure 5. Launching the create VxRail VI workload domain dialog in SDDC Manager

The platform also supports the deployment of what is known as a VCF consolidated architecture. This is an attractive proposition for customers who value reduced footprint of the cloud platform rather than clear separation of management infrastructure from workloads. In the consolidated architecture, customer’s workloads co-exist within the management workload domain, reducing the entry point to as little as four nodes at the expense of physical separation of management and flexibility of life cycle management upgrades. Conversion from the consolidated to the standard architecture is supported as the need for environment expansions arises. Currently, the conversion process requires a Dell Professional Services engagement.

Customers may choose to enable VMware Cloud Foundation with Tanzu functionality on both VxRail virtual infrastructure workload domain and the Management Domain.

Support for Kubernetes-based cloud native platform services

VMware Cloud Foundation 4.0 on VxRail 7.0 introduced a major architectural upgrade to the platform. The biggest innovation in this version is VMware Cloud Foundation with Tanzu, providing native integration of Kubernetes directly into the vSphere hypervisor. This integration delivers a new set of VMware Cloud Foundation services, including VMware Tanzu Runtime Services and Hybrid Infrastructure Services, providing the basis for the cloud infrastructure and container ecosystems to accelerate developer productivity.

On VMware Cloud Foundation 4.0, virtual infrastructure administrators get unified visibility of virtual machines (VMs), containers, and Kubernetes clusters directly in vCenter Server, which is also the standard management console for VxRail, they are familiar with. Containers and Kubernetes are managed alongside VMs from the same console and the concept of Kubernetes namespace is integrated into vSphere, becoming the unit of management. Resource objects, such as VMs and containers can be grouped into logical applications using namespaces, simplifying the management of cloud-native workloads at scale. Administrators can set policies, quota, and role-based to a namespace, allowing developers to access the namespace within the predefined boundaries.

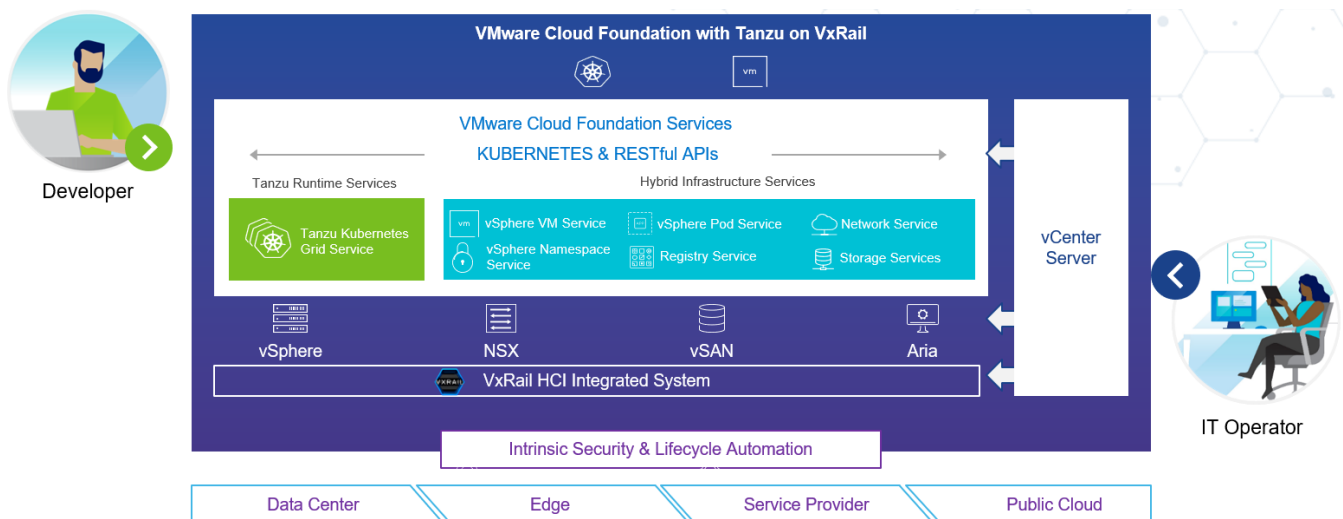


Figure 6. VMware Cloud Foundation with Tanzu on VxRail (services view)

Developers can also create Supervisor Clusters and Guest Clusters. Supervisor Clusters run Kubernetes natively on ESXi for better container performance and integration, while Guest Clusters run Kubernetes in Tanzu Kubernetes Grid (TKG) clusters on VMs. Similar to VMware administrators who can manage Kubernetes environment in vSphere using their native management tools (such as vCenter), developers can consume cloud resources such as Kubernetes clusters, disks, and networks using familiar Kubernetes CLI and API tools (see Figure 6).

The following list summarizes the key benefits of VMware Cloud Foundation with Tanzu functionality that is introduced in VMware Cloud Foundation 4.0:

- **Application-focused management brings VMs and containers onto the same platform:** Using the same platform enables unified visibility of VMs, containers, and Kubernetes clusters in vCenter and integrates Kubernetes namespace concept as the management entity into vSphere.

- **Enterprise-class resiliency, QoS, security, and access control for both VMs and containers:** Administrators can define QoS, security policies, firewall rules, encryptions settings, availability and backup rules, and access rules at namespace level; also, NSX integration with Kubernetes enables context-aware security policies with namespace isolation.
- **Developer self-service APIs to boost productivity:** Developers can create and consume cloud resources such as Kubernetes clusters, volumes, and networks with VMware Cloud Foundation Services using Kubernetes and RESTful APIs.
- **Rapid application deployment with full-stack agility:** VMware Cloud Foundation automates deployment not only of the underlying infrastructure (workload domain), but also Kubernetes components.
- **Enhanced infrastructure life cycle management:** Automated life cycle management on a per-workload domain basis enhances functionality.
- **Full-stack networking and intrinsic security at every layer of the stack:** For example, container registry from Tanzu Kubernetes Grid has integrated vulnerability scanning, image signing, and auditing (container image layer). It also has vSphere comprehensive security for protecting data, infrastructure, and access (compute layer) and NSX delivering micro-segmentation and granular security to the individual VM or pod workload (network layer).
- **Cloud operating model extending across private and hybrid cloud:** The same SDDC stack that is leveraged in private cloud deployments of VMware Cloud Foundation is also the underpinning technology of VMware-based public cloud offerings, resulting in consistent infrastructure and operations. These offerings include VMware Cloud on AWS, other VMware Cloud Provider Program partners, and VMware Cloud on Dell.

VMware vSAN as a core component of VMware Cloud Foundation on VxRail includes a CSI driver that enables developers to provision persistent storage for Kubernetes on vSphere on-demand in an automated fashion. VMware administrators can manage container volumes through the Cloud Native Storage UI within VMware vCenter as if they were VM volumes. Developers and IT administrators can have a consistent view of container volumes and troubleshoot at the same level.

Cloud Native Storage through the CSI driver on vSAN is natively integrated into the vCenter and provides comprehensive data management for both stateless and stateful applications. Customers using cloud native storage can create containerized stateful applications capable of surviving container restarts and outages. Stateful containers leverage storage exposed by vSphere that can be provisioned using Kubernetes primitives such as persistent volume, persistent volume claim, and storage class for dynamic provisioning.

NSX, another key component of VMware Cloud Foundation stack, removes the need for end users to understand underlying network architecture. Networking can be easily managed with Kubernetes clusters—deployment, upgrade, and scaling out. NSX can automatically create load balancers, routers, and switches to be used by Tanzu. It also provides end-to-end security by firewalls, namespace isolation, and more.

To learn more about the VMware Tanzu portfolio, see [Appendix E: VMware SDDC common component details](#).

Support for cloud-native stateful services with Dell ObjectScale

ObjectScale is the next evolution in object storage. It is essentially Dell ECS software-defined object storage that has been refactored into a Kubernetes-native microservices architecture to accelerate application innovation and lower TCO. It has been designed to run on infrastructure platforms such as VMware Cloud Foundation with Tanzu or vSphere with Tanzu, which can then be run on infrastructure such as VxRail HCI integrated systems or PowerEdge servers. Customers can manage S3-compatible modern application stateful services such as ObjectScale and link IT policies to it as part of its integration with the VMware vSAN Data Persistence Platform framework.

ObjectScale is built with a software-defined, containerized architecture in a Kubernetes-native package. It is designed for shared infrastructure and multitenant environments. It is a software bundle of management services that contains everything required to deploy and consume Dell object storage. ObjectScale is deployed in a Kubernetes cluster, allowing Kubernetes to handle the necessary orchestration. One ObjectScale instance with one or more object stores is deployed per Kubernetes cluster.

The following figure shows the high-level architecture of ObjectScale running within VMware Cloud Foundation on the VxRail environment.

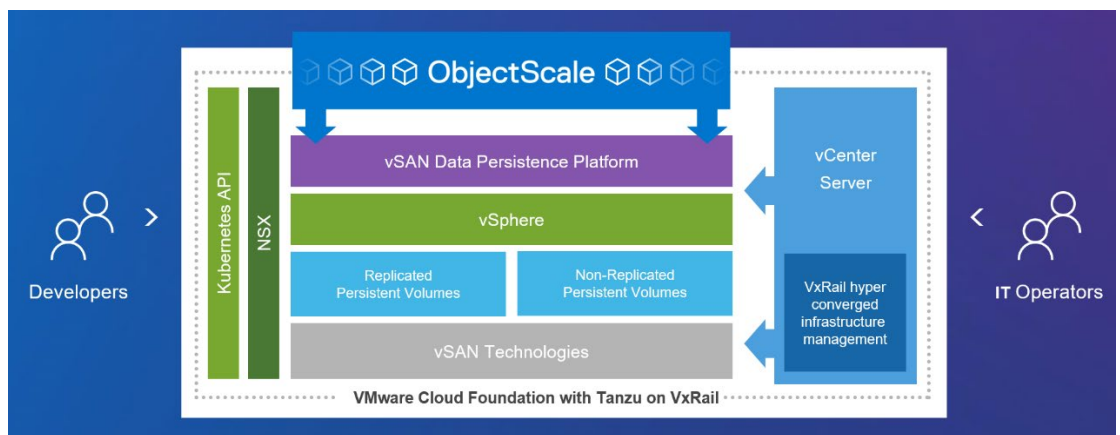


Figure 7. High-level architecture of ObjectScale running within VMware Cloud Foundation on VxRail environment

Use cases

With rich S3 compatibility, enterprise-grade data protection features, and a globally scalable architecture, ObjectScale supports several modern and traditional use cases. ObjectScale is designed to support data-intensive applications and workloads:

- **Cloud-native web and mobile applications**—ObjectScale is purpose-built for cloud-native applications. With rich S3 compatibility for data access and Kubernetes APIs for container management, developers can integrate object stores into their continuous integration and continuous delivery (CI/CD) pipelines in a self-service manner, accelerating application development. ObjectScale replication capabilities enable data to be distributed across any number of sites to promote fault tolerance and low-latency access.
- **Dev/Test**—ObjectScale serves as an ideal platform for modern application development that requires S3. Automated provisioning and an integrated workload sizer provide for easy deployment of object stores and buckets. Multitenancy

provides resource isolation, while identity and access management (IAM) policies enable secure data access.

- **Consolidated data lake**—ObjectScale can serve as a centralized data lake storing sensor telemetry, machine-generated logs, and application data. Federate multiple sites to eliminate data silos and provide anywhere access to data from edge to core. Objects are tagged to enhance analysis and make data more discoverable.
- **AI and ML**—ObjectScale delivers performance at scale to support next-generation machine learning and artificial intelligence workloads. ObjectScale can deliver datasets at high transfer rates to the most demanding CPU and GPU servers, exposing AI training algorithms to more data without introducing the complexity of HPC storage. Clusters can be scaled-out with ease to linearly scale performance and capacity.
- **Analytics**—Run rapid queries on a performant ObjectScale data lake to generate operational insights at the speed the business demands. With the ability to deploy analytics on NVMe-based, all-flash drives, storage performance is no longer a bottleneck. Custom tags add context to data for greater discoverability and faster results. S3a enables Hadoop workloads to directly read and write data to ObjectScale, replacing the need for complex HDFS cluster management.
- **Backup and archive**—ObjectScale is a TCO-optimized S3 backup target and long-term archive. Featuring ObjectScale Lock for data immutability, data-at-rest encryption (D@RE), global replication, and erasure-coding protection schemes, ObjectScale safeguards data from ransomware attacks and ensures resiliency from node or disk failures.

VxRail HCI System Software and VxRail Manager

VxRail HCI System Software consists of multiple, integrated software elements. They extend VMware native capabilities to deliver a seamless and automated operational experience, keeping the infrastructure in a prevalidated configuration to ensure that workloads are consistently up and running. VxRail HCI System Software is preinstalled on the VxRail system as a single virtual machine, the VxRail Manager VM.

The software services in VxRail HCI System Software can be grouped into three main areas: life cycle management (LCM) for predictable outcomes, management flexibility and extensibility, and simplified services and support experience.

Life cycle management for predictable outcomes

- Intelligent LCM functionality automatically updates clusters with prevalidated, pretested software and firmware components, ensuring that the HCI stack is in a Continuously Validated State.
- The electronic compatibility matrix serves as a compliance asset, providing validation that all possible configuration and update path permutations are sound. Customers can choose the Continuously Validated State of their choice to optimize each cluster for its respective workloads.
- Ecosystem connectors tightly integrate with infrastructure components, including vSAN, PowerEdge server components, and networking. This integration enables automation and orchestration services across the entire stack for simple cluster software and firmware updates.

Management flexibility and extensibility

- VxRail Manager, which is natively integrated with and accessed through vCenter, is the overall management engine for all VxRail operations. VxRail Manager is used to deploy, manage, update, patch, and add nodes to a cluster.
- SaaS multicloud management is designed to provide centralized multi-cluster management powered by AI-driven operations insights through a software-as-a-service delivery model. The continuous innovation and continuous delivery approach allows for frequent, incremental updates to introduce new capabilities. SaaS multicloud management provides detailed health checks and predictive analytics. SaaS multicloud management further simplifies the VxRail cluster update process with on-demand pre-update health checks, update bundle download and staging, and cluster updates at scale.
- A broad set of publicly available RESTful APIs are provided to customers to deliver greater cloud and IT automation extensibility.

Simplified services and support experience

Customers always have access to Dell Secure Remote Services for all included hardware and software within VxRail throughout the entire life cycle of the infrastructure.

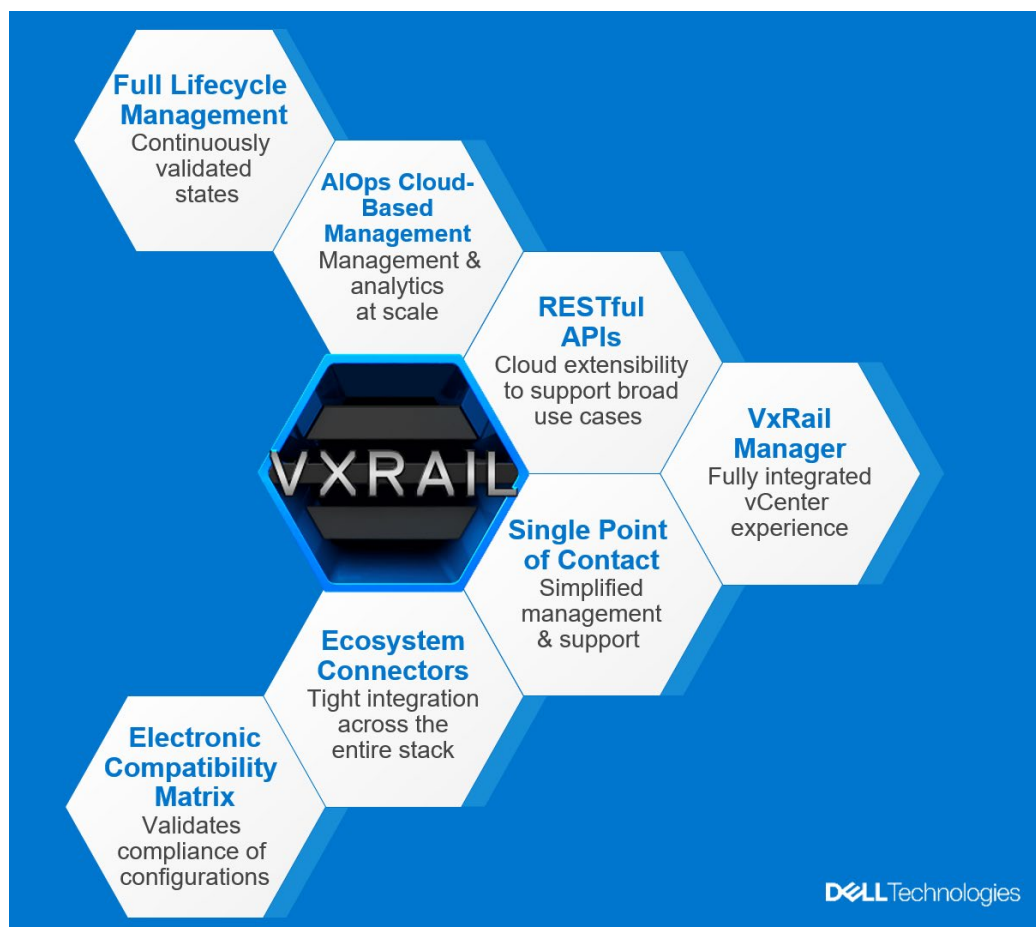


Figure 8. Core components of VxRail HCI System Software

When used for a cloud deployment use case, the VxRail HCI System Software sits in between the infrastructure layer and cloud orchestration software. Local management features include vCenter Plug-ins, life cycle management, serviceability using eServices and Secure Remote Gateway, and health alerts. The extensibility of VxRail HCI System Software is available to VMware SDDC solutions like VMware Cloud Foundation including backend APIs, SaaS multicluster management, and open REST APIs for configuration management solutions such as Puppet and Ansible.

VxRail Manager

VxRail Manager features user-friendly workflows for automating VxRail deployment and configuration and for monitoring the health of individual systems in the entire cluster. VxRail Manager also incorporates functionality for hardware serviceability and system platform life cycle management. For instance, it guides system administrators through the process of adding systems to an existing cluster, and it automatically detects new systems when they come online. VxRail Manager is also used to replace failed disk drives without disrupting availability to generate and download diagnostic log bundles and apply VMware updates or software patches nondisruptively across VxRail nodes.

With the VxRail Manager plug-in for vCenter Server, all VxRail Manager features are integrated with and accessible from the vCenter Server so that users can benefit from them on a familiar management interface. With the VxRail Manager plug-in, the vCenter Server can manage physical hardware of the VxRail cluster.

VxRail HCI System Software simplifies system platform life cycle management by delivering patch software and update notifications that can be automatically installed without interruption or downtime.

The VxRail Manager functionality visible through the HTML5 vCenter plug-in is illustrated in the following screenshots. Figure 9 displays a vCenter view showing the VMware Cloud Foundation management domain and workload domain that is built on VxRail clusters.

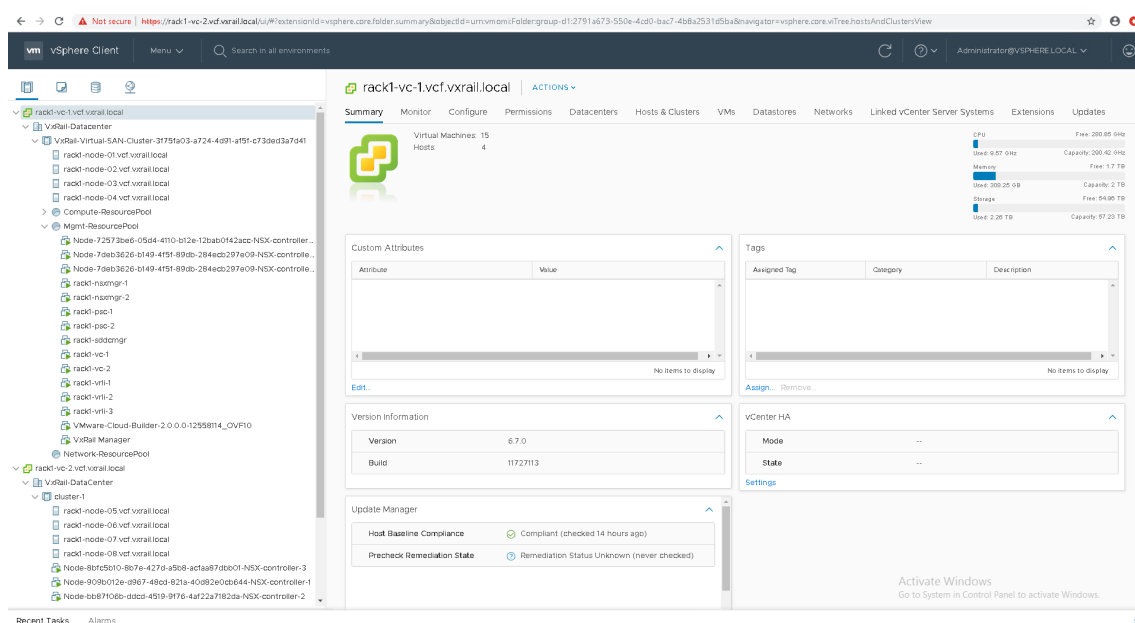


Figure 9. vCenter view showing VMware Cloud Foundation management domain and workload domain

Figure 10 displays going to the vSAN cluster level, choosing the Monitor tab and selecting Appliances to get to the link to open the VxRail Manager provided physical view for this cluster.

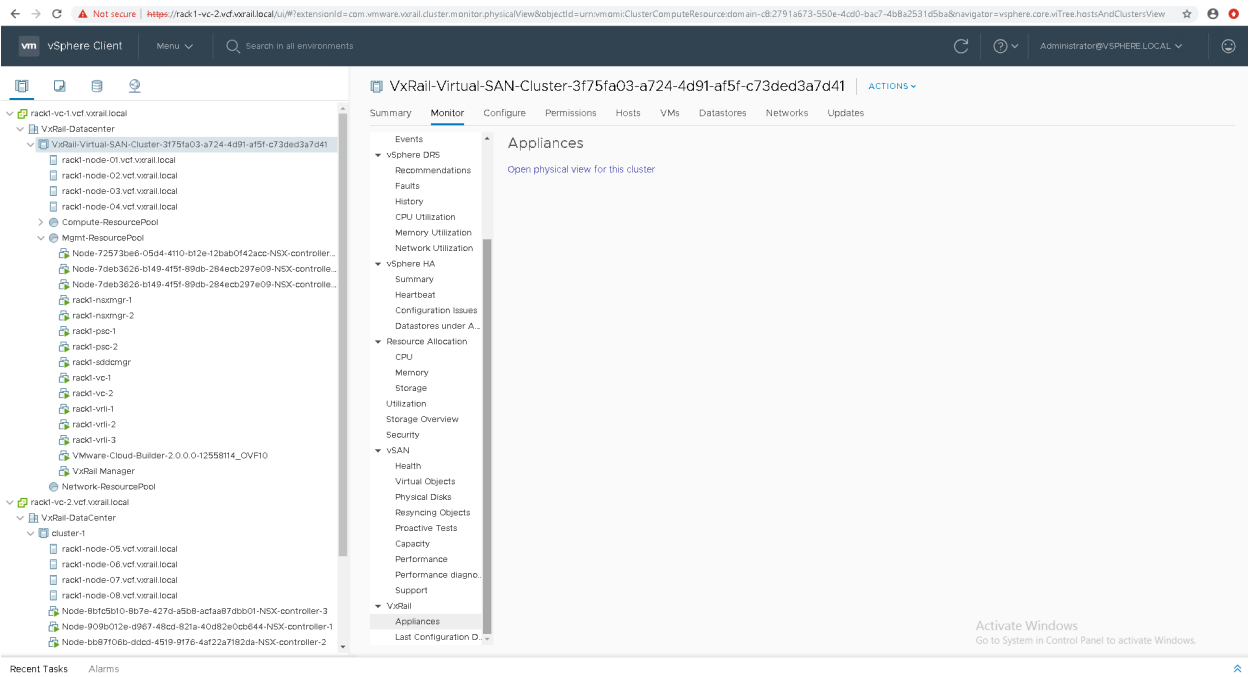


Figure 10. Open the cluster VxRail physical view

Figure 11 shows the top level four node management cluster VxRail hardware view.

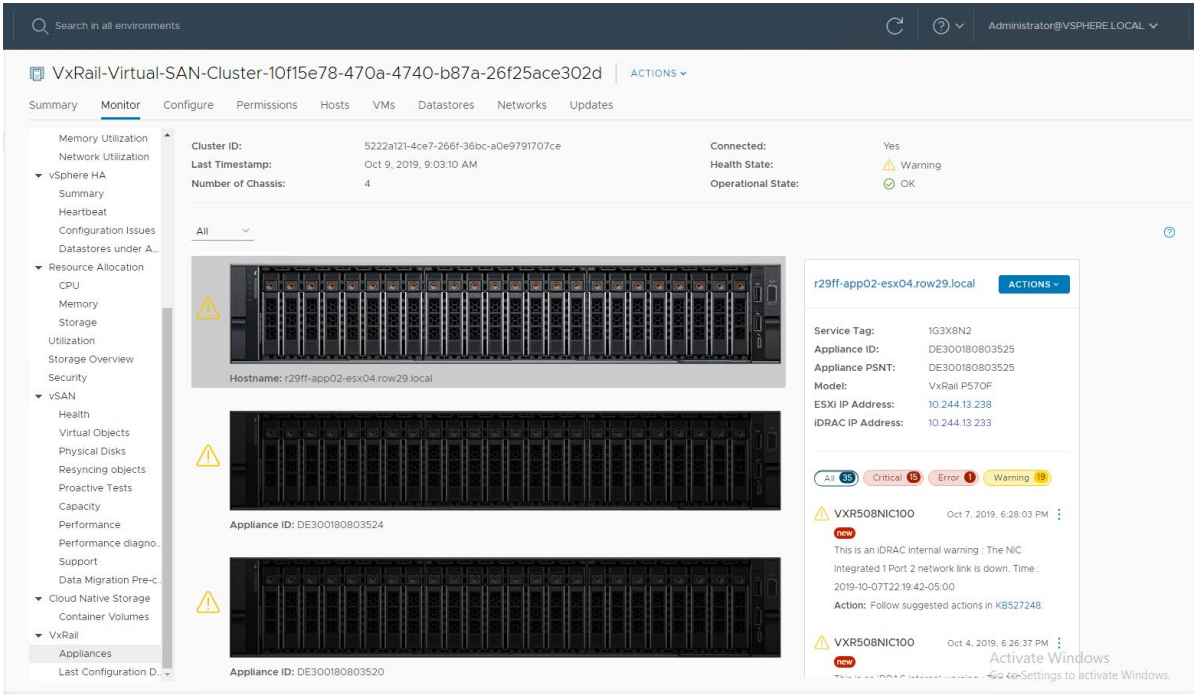


Figure 11. VxRail cluster physical view

Drilling down on the physical views can display additional details. For example, Figure 12 shows a hardware view used for disk hardware replacement.

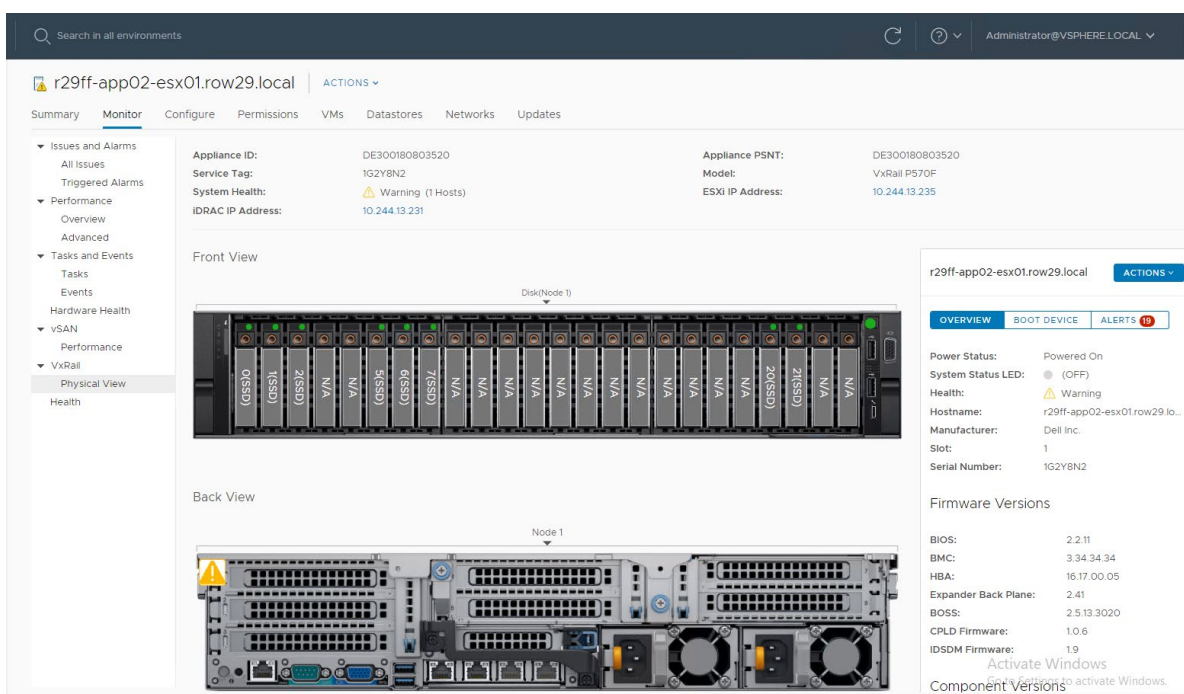


Figure 12. VxRail disk hardware replacement screen

Detailed VxRail hardware component level events and alerts are collected by the VxRail Manager and displayed in vCenter as part of the integrated vCenter HTML5 plug-in. This provides holistic, system-level health awareness within the SDDC management framework. Failure events are passed to vCenter. Alarms from VxRail start with the prefix 'VXR.' Figure 13 shows an example in vCenter that displays VxRail hardware alarms.

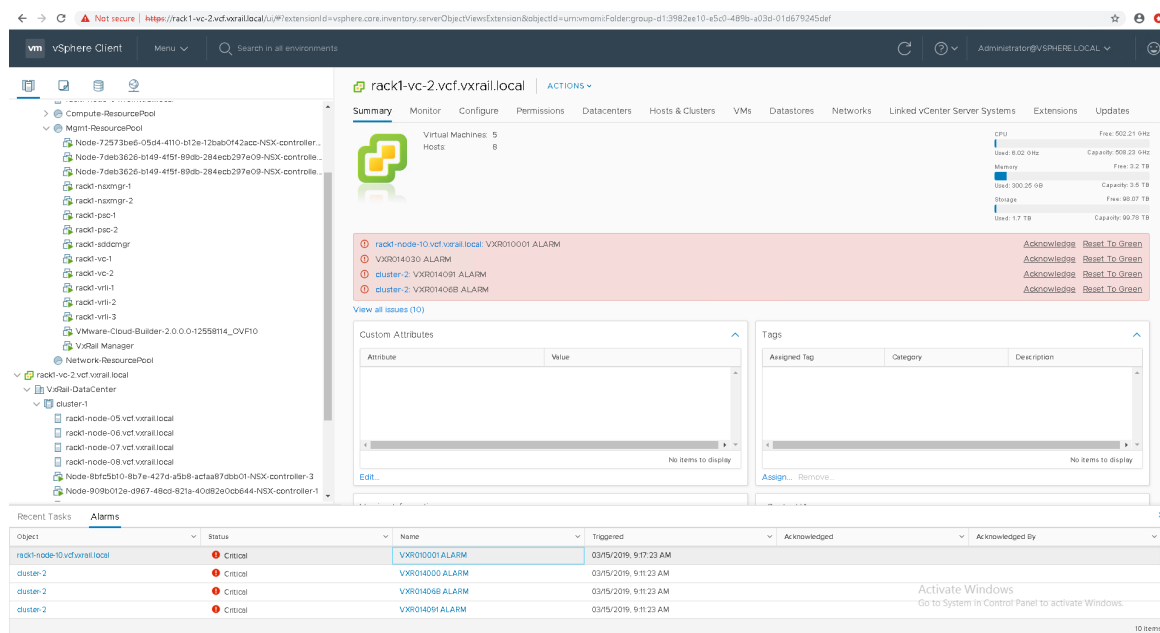


Figure 13. Example of VxRail hardware alarms in the vCenter HTML5 plug-in

VxRail HCI version 7.0.010 introduced support for geographic location tags for VxRail nodes. The capability allows for important user-defined node metadata that can assist many customers in gaining greater visibility of the physical location mapping of the HCI infrastructure that makes up their cloud. Customers can leverage this data to choose the node/host order to be displayed in the VxRail Manager vCenter plug-in Physical View. These geo location host attribute tags can be applied during VxRail Day 1 cluster installation or during node expansion and host edit Day 2 operations (see Figure 14).

This functionality provides customers with full-stack physical-to-virtual infrastructure mapping to help further extend the VMware Cloud Foundation management experience and simplify operations only available with VMware Cloud Foundation on VxRail.

In addition, VMware Cloud Foundation 4.5 on VxRail 7.0.400 (and higher) allows customers to add user-defined tags to VCF objects within SDDC Manager. For instance, administrators can add user-defined tags to cluster objects for a logical grouping based on location, type of environment, workload, and so on.

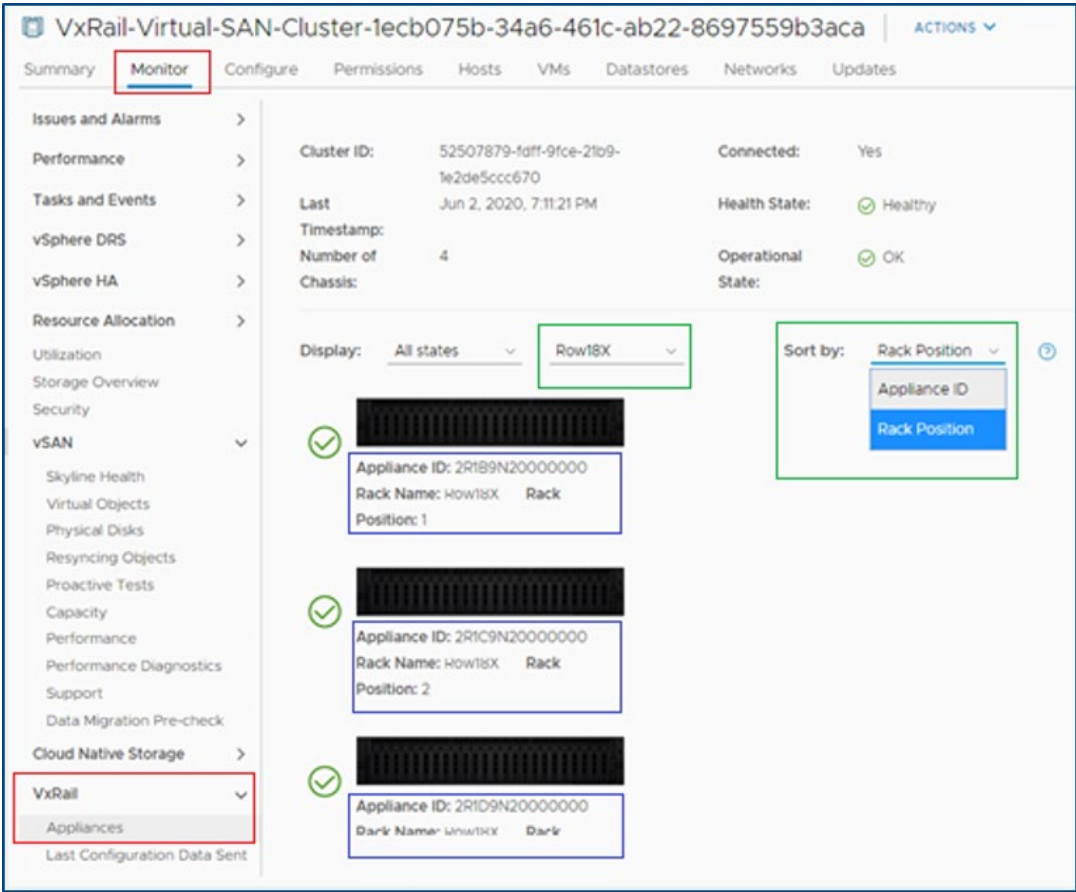


Figure 14. Example of VxRail geo_location host tags in the vCenter plug-in

REST APIs

VxRail HCI System Software includes APIs that enables customers to leverage the full power of automation and orchestration services across data centers. This extensibility allows infrastructure to operate with cloud-like scale and agility and streamlines the

integration of the infrastructure into your IT environment and processes. Instead of manually managing environments through the user interface, repeatable operations can be triggered and performed programmatically by software. More customers are embracing DevOps and Infrastructure as Code (IaC) models as they need reliable and repeatable processes to configure the underlying infrastructure resources required for applications. IaC leverages APIs to store configurations in code, making it repeatable and reduces error risk.

VxRail API is a feature of VxRail HCI System Software that exposes management functions with a RESTful application programming interface. It is to simplify VxRail customer and ecosystem partner experiences, who would like to integrate third-party products with a VxRail system.

VxRail API was designed to complement VMware REST APIs, such as vSphere Automation API, and focuses on the underlying infrastructure and unique automated life cycle management capabilities. VxRail API can be used with VMware Cloud Foundation on Dell VxRail API, which is supported since version 4.0 of the platform. Most of the operations that required SDDC Manager UI can now be performed using API. This is an area of extensive development with new capabilities growing over time important especially for service providers, who are leveraging VMware Cloud Foundation on VxRail as a platform to deliver cloud-based services for their customers.

To learn more about VxRail API, see this [solution overview](#). For more information about VMware Cloud Foundation on VxRail API, see the API [reference guide](#).

SaaS multi-cluster management

VxRail HCI System Software works with SaaS multicluster management, which is a centralized data collection and analytics platform. SaaS multicluster management streamlines the monitoring and management of a customer's multiple VxRail clusters, improves serviceability, and helps the customer make better decisions to manage their HCI performance and capacity. It is a cloud-based analytics platform that uses advanced telemetry collected from the VxRail clusters for its infrastructure machine learning to provide reporting and actionable insight. Its infrastructure machine learning uses onboard knowledge of Dell best practices and more than 700 common issues. SaaS multicluster management provides aggregate health scores for the entire HCI stack to enable customers to quickly identify areas to troubleshoot and to address areas to efficiently scale based on projected growth of IT resources.

SaaS multi-cluster management functionality is entirely consumed through a Dell-hosted web portal, called CloudIQ, which provides a single global view of the customer's VxRail environment. Note, VCF on VxRail supports the monitoring and capacity aspects of CloudIQ and not active cluster management LCM capabilities.

To learn more about VxRail SaaS multicluster management and CloudIQ, check the [Dell VxRail System Tech Book](#).

Integrated life cycle management

Data center upgrades and patch management are typically manual, repetitive tasks prone to configuration and implementation errors. Validation testing of software and hardware firmware to ensure interoperability among components when one component is upgraded requires extensive quality assurance testing in staging environments. IT must sometimes make the difficult decision to deploy new patches before they are fully vetted or to defer

new patches, which slow down the roll-out of new features, security, and fixes. Both situations increase risk for the customer environment.

Learning about the VMware Cloud Foundation concept of a Workload Domain can help customers better understand life cycle operations details. A Workload Domain is a policy-based resource container with specific availability and performance attributes that combines compute (vSphere), storage (vSAN), and networking (NSX) into a single consumable entity. In the case of running VMware Cloud Foundation on VxRail, these workload domains are built using VxRail clusters and leverage the native VxRail operations experience for tasks such as automated cluster builds and cluster expansions as examples.

Infrastructure building blocks can be created based on native VxRail clusters that can scale up and out incrementally. Customers can scale up leveraging the flexible hardware configurations available within a VxRail node to increase storage capacity or memory. Customers can similarly scale out by adding nodes in single node increments to a cluster. The physical compute, storage, and network infrastructure becomes part of a single shared pool of virtual resources that is managed as one cloud infrastructure ecosystem using the SDDC Manager.

From this shared pool, customers can organize separate pools of capacity into workload domains, each with its own set of specified CPU, memory, and storage requirements to support various workload types such as cloud native, VDI, or business critical applications, such as databases. As new VxRail physical capacity is added, it will be recognized by the SDDC Manager and be made available for consumption as part of a workload domain. Scaling workload domains beyond a single cluster gets even easier with the ability to add multiple VxRail clusters within a workload domain.

As mentioned previously, Workload Domains can be created, expanded, and deleted. They can also be upgraded independently, providing customers with the flexibility to align workload domain infrastructure requirements to the applications running on them. This can be done even at the individual cluster level within a domain. With VMware Cloud Foundation, all life cycle management occurs at the workload domain level, enabling flexibility to mix and align workloads to the appropriate underlying infrastructure dependencies.

Life cycle management end-to-end process details

VMware Cloud Foundation on VxRail leverages both the native VMware Cloud Foundation and VxRail HCI System Software update bundles for its updates. This allows customers to take advantage of new platform features faster. There is no proprietary package that must be generated to run VMware Cloud Foundation on VxRail that would delay the availability of these updates from being published for customer consumption when the updates are available. This allows both VMware and Dell to innovate faster within their respective layers asynchronously, updating the features without affecting the other layers of the platform stack. It also means that VMware and Dell can continue to leverage their respective streamlined development and release processes for both VxRail and VMware Cloud Foundation independently.

VxRail life cycle management is built on ecosystem connectors to integrate vSAN cluster software and PowerEdge server hardware so that the ESXi host can be managed as a single system. This system integration enables the automation and orchestration

necessary to deliver nondisruptive, streamlined HCI stack upgrades. VxRail life cycle management delivers a differentiated value on its ability to deliver a prevalidated set of software and firmware that ensures compatibility and compliance of the entire configuration on HCI stack. It does that while maintaining the performance and availability required of the virtualized workloads running on the clusters.

Continuously Validated States describe the ability to test, validate, and produce a VxRail software bundle to support every vSphere release, any-to-any version upgrade path, and the millions of VxRail configurations. These Continuously Validated States are recorded on the Electronic Compatibility Matrix. The VxRail team's \$60 million in equipment investment with a team of more than 100 members dedicated to testing and quality makes this possible.

All VMware Cloud Foundation on VxRail life cycle updating and upgrade operations are orchestrated using SDDC Manager. It is responsible for monitoring the respective VMware and Dell support repositories where the VMware Cloud Foundation and VxRail update bundles are published. The various VMware Cloud Foundation update bundles include bundles for vCenter updates, NSX, SDDC Manager, and vRealize Suite Lifecycle Manager (vRSLCM). Aria Suite (formerly vRealize Suite) components (vRealize Automation, vRealize Operations, and vRealize Log Insight) are then updated by applying respective component update bundles using vRSLCM. Aria Suite has been engineered to be VMware Cloud Foundation aware, and VMware Cloud Foundation is Aria Suite aware. Each VMware Cloud Foundation release includes a qualified version of the vRSLCM in the release software bill of materials (BOM). The SDDC Manager can be used to optionally deploy the vRealize Suite Lifecycle Manager (vRSLCM) and, in doing so, establish a two-way communication channel between these two products. vRSLCM is then "VMware Cloud Foundation aware" and reports back to the SDDC Manager what vRealize components are installed.

The native VxRail update bundle includes ESXi, vSAN, VxRail Manager, hardware firmware and drivers. As a part of this monitoring, SDDC Manager automatically discovers when new VxRail and VMware Cloud Foundation updates are available for download and proactively notifies the administrator accordingly within the user interface.

SDDC Manager will also ensure that all update bundles are automatically curated, guaranteeing visibility and access to only the updates that have been qualified and supported for the system configuration it is managing. For example, an update cannot be accessed for a workload domain until first applied to the management domain. SDDC Manager even controls the ordering of life cycle management updates to ensure that a bundle version cannot be applied without first verifying that all update pre-requisites are met first. This helps mitigate risk so that the system is always at a known good state from one version to the next. This removes any need for the administrator to guess about valid releases or to cross-reference support matrixes to ensure update bundle compatibility across the system.

All updates are scheduled, performed, and orchestrated by SDDC Manager but may be performed by SDDC Manager or VxRail Manager using integrated APIs as shown in Figure 15.

Once a set of updates has been downloaded, SDDC Manager is used to schedule the updates to be applied to each of the workload domains in the environment independently.

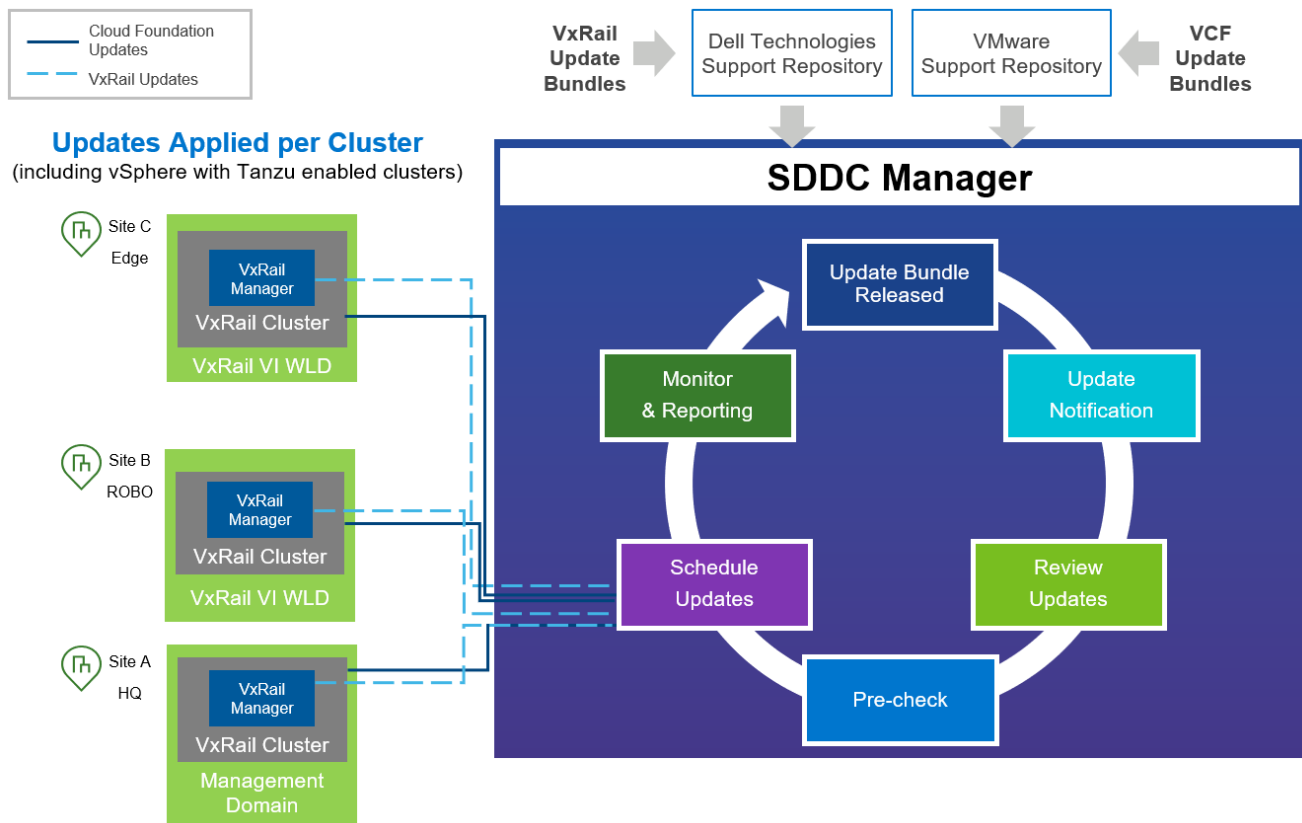


Figure 15. SDDC Manager orchestrated life cycle management integrated with VxRail

Lifecycle management in SDDC Manager can be applied to the Management Domain, which contains SDDC software stack or to individual workload domains and does not disrupt tenant virtual machines (VMs). Using live VM migration together with vSphere Dynamic Resource Scheduler (DRS), SDDC Manager can update software to improve infrastructure security and reliability. VMware and Dell perform extensive validation testing of the software stack before releasing software updates, which reduces risk and helps to instill confidence.

The SDDC Manager Lifecycle Management view provides notification of update availability and download of the update bundle. The SDDC Manager interface also provides for selecting update targets and scheduling the update. It is highly recommended to schedule updates at a time when the SDDC Manager is not in heavy use and avoid any changes to the domains until after the upgrade completes.

Before starting the update, there are prerequisite tasks to ensure that the system is in a healthy state. The precheck utility can be manually triggered in the SDDC Manager update screen as shown in Figure 16.

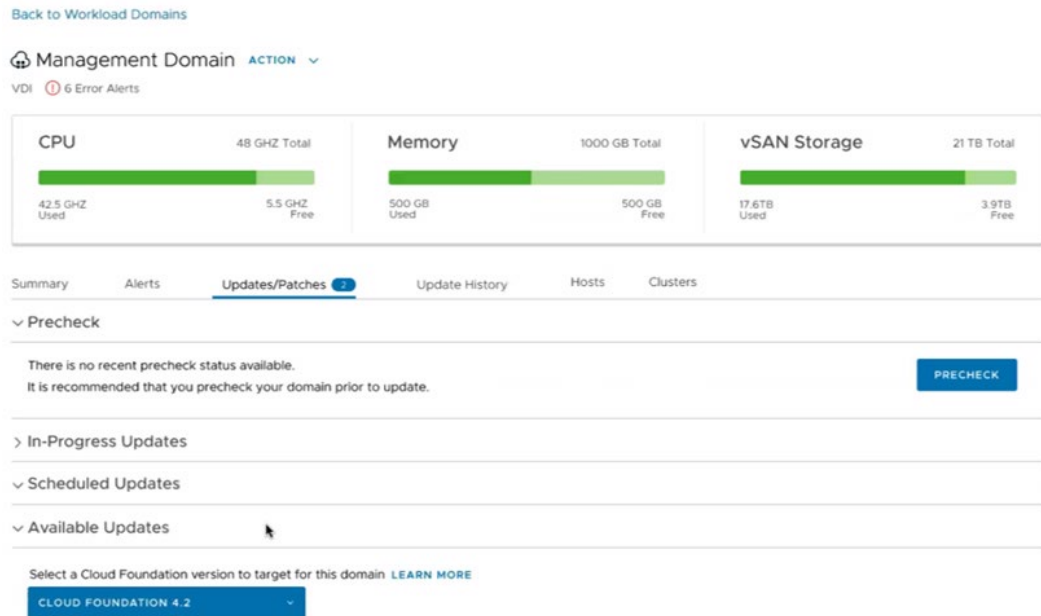


Figure 16. SDDC Manager Update screen example

These VMware Cloud Foundation prechecks also natively integrate with VxRail Health Check APIs to capture native VxRail cluster-specific hardware and software health.

The update bundles can be scheduled for automatic installation which can be applied to any cluster within any workload domain across data centers and across the edge. Administrators can select and schedule which clusters in a multicluster WLD they want to update, essentially allowing for control over the order of which clusters get updated first in LCM operation. This allows the cloud administrator to target specific workloads or environments (development vs. production, for example) for updates independently of the rest of the environment.

For native VMware Cloud Foundation software updates, SDDC Manager performs the automated workflows that are required to apply those updates to the clusters within a workload domain.

For native VxRail updates, SDDC Manager orchestrates the LCM process for a given workload domain but leverages the native VxRail Manager that runs on each VxRail cluster in that workload domain to apply the VxRail update using integrated VxRail Manager REST API calls in the background. As VxRail Manager performs the cluster update, SDDC Manager monitors its progress, and the VxRail Manager will notify the user when the process is complete. In a multicluster workload domain example, this process of SDDC Manager automatically calling out a VxRail cluster's VxRail Manager APIs occurs automatically. It involves no administrator input until all clusters in the workload domain have been updated.

All these co-engineered features drive the full-stack integration life cycle management experience only available with VMware Cloud Foundation on VxRail. This integration offers a true better together experience to help Dell customers simplify and accelerate their IT transformation.

VMware and Dell Technologies constantly strive to improve the automated life cycle management experience that is integrated in the platform. Starting with VMware Cloud Foundation 4.0.1 on VxRail 7.0, customers can upgrade specific clusters within a workload domain. This provides administrators with more flexibility in planning maintenance windows. VMware Cloud Foundation also supports NSX Edge cluster-level and parallel upgrades that offer more flexibility and efficiency in updating this critical component of the platform and better alignment with maintenance windows. VMware Cloud Foundation skip levels are also supported and can be performed from the SDDC Manager web-based UI. This provides additional efficiency by eliminating the requirement to install intermediate stepwise upgrades for customers who are performing LCM operations of the platform less often. The updated SDDC Manager LCM Manifest architecture also allows VMware and customers to respond more quickly to potential changes introduced in upgrade sequencing to provide more agility and further reduce risks related to software and hardware firmware upgrades.

To avoid any potential issues during LCM activities, VMware Cloud Foundation administrators can run SDDC Manager prechecks to weed out any issues before any LCM operation is run. VMware Cloud Foundation on VxRail includes an extensive set of integrated SDDC and VxRail specific health prechecks that have been integrated with the native SDDC Manager precheck workflows to identify many of the common system states that could cause LCM operations issues. Prechecks include password validity (including expired passwords), file system permissions, file system capacity, CPU reservation for NSX Managers, hosts in maintenance mode, and DRS configuration mode, among others. The following figure illustrates some examples of what these prechecks look like from the SDDC Manager UI.

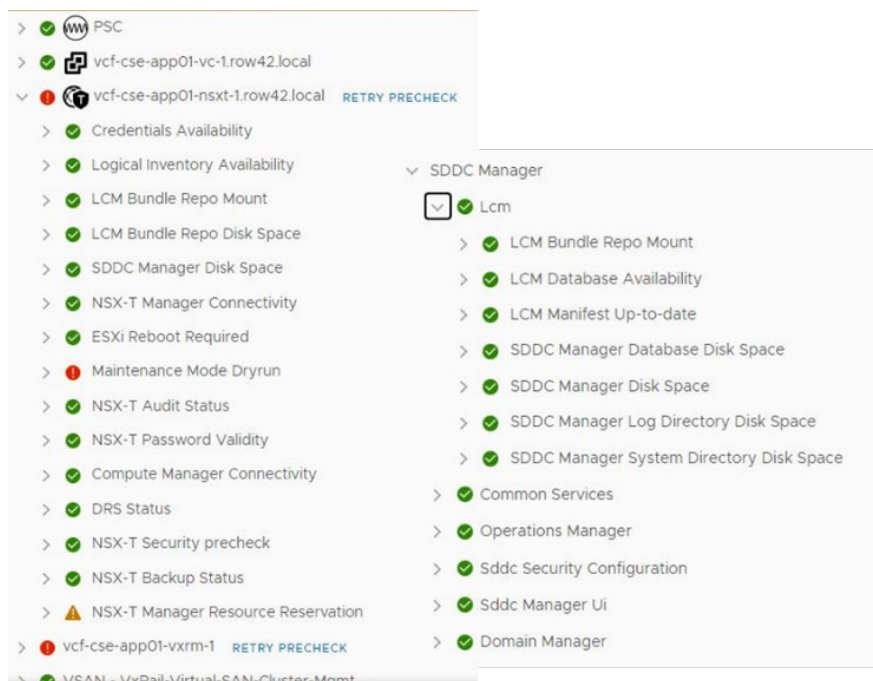


Figure 17. SDDC Manager precheck

Recent VMware Cloud Foundation enhancements include the concept of flexible cloud management LCM operations. In VMware Cloud Foundation 4.4 and later, Aria Suite component updating and upgrading operations are managed independently from VMware Cloud Foundation using vRealize Suite Lifecycle Manager (vRSLCM) directly. Thus, administrators can upgrade Aria products independently from the core VMware Cloud Foundation upgrade to better align with business requirements. This functionality also helps simplify the core VMware Cloud Foundation upgrade process. Aria Suite upgrades do not have to be performed for a VMware Cloud Foundation upgrade if existing components are still compatible with the version being upgraded to. Thus, administrators have more flexibility on which Aria Suite components are updated and when they are updated.

Reducing maintenance window timelines is always a design goal for VMware Cloud Foundation on VxRail engineering teams to deliver on for IT teams. This is especially true in circumstances where an LCM operation has not fully completed for all hosts in a cluster. It would be inefficient, adding unnecessary time to maintenance windows, to have to start an LCM process from the beginning on hosts where an update was already successful. To avoid this situation, VMware Cloud Foundation on VxRail implements a jointly engineered LCM method that is available through the VxRail Retry API and is fully integrated with SDDC Manager. It adds logic that allows the new cluster LCM update retry function to target only the failed nodes. This enhancement drastically reduces LCM upgrade times and helps IT teams meet their maintenance windows, especially for VMware Cloud Foundation on VxRail deployments with many large workload domain clusters. It also demonstrates close collaboration and commitment from Dell and VMware engineering teams for continuous improvements of the platform based on customer feedback, and deep integration between VMware Cloud Foundation software and VxRail engineered system.

VMware Cloud Foundation Async Patch Tool support

The VMware Cloud Foundation Async Patch Tool is a CLI-based tool that allows cloud administrators to apply individual component out-of-band security patches to their VMware Cloud Foundation on VxRail environment, separate from an official VMware Cloud Foundation LCM update release. This enables organizations to address security vulnerabilities faster without having to wait for a full VMware Cloud Foundation release update. It also gives administrators control to install these patches without requiring the engagement of support resources.

VMware Cloud Foundation on VxRail supports the ability to use the VMware Cloud Foundation Async Patch Tool for ESXi, vCenter, NSX, and VxRail Manager security patch updates. Once patches have been applied and a new VMware Cloud Foundation BOM update that includes the security fixes is available, administrators can use the tool to download the latest VMware Cloud Foundation LCM release bundles. They can then upgrade their environment to an official in-band VMware Cloud Foundation release BOM. Administrators can then continue to use the native SDDC Manager LCM workflow process to apply additional VMware Cloud Foundation on VxRail upgrades.

For information and interactive demonstrations on the LCM process and more, see [Interactive Demo: VMware Cloud Foundation on Dell VxRail](#).

External storage for VMware Cloud Foundation on VxRail

VMware Cloud Foundation on VxRail supports the use of external storage to complement the use of vSAN storage that can be included with VxRail as principal storage. This is important for customers who have investments that are already made in existing external storage systems or have a use case in which external storage systems are required.

VMFS on FC external storage (such as Dell PowerMax, VMAX, PowerStore-T, and Unity XT) is supported as principal storage for VxRail VI workload domains. This capability has been integrated with SDDC Manager as part of VI WLD provisioning workflows allowing customers a choice in storage type that they would like to use when deploying VxRail dynamic node-based clusters into VI WLDs.

Customers can leverage their existing investments in IP, FC, or vVol based external storage and extend VMware Cloud Foundation on VxRail with additional capacity for use cases such as:

- Storage for applications that require particular data services that an external storage array can provide to meet workload requirements
- Data protection (file/image backups)
- Data at rest (templates, backups, archives)
- Workload and data migrations to VMware Cloud Foundation on VxRail from legacy environments
- General-purpose application storage

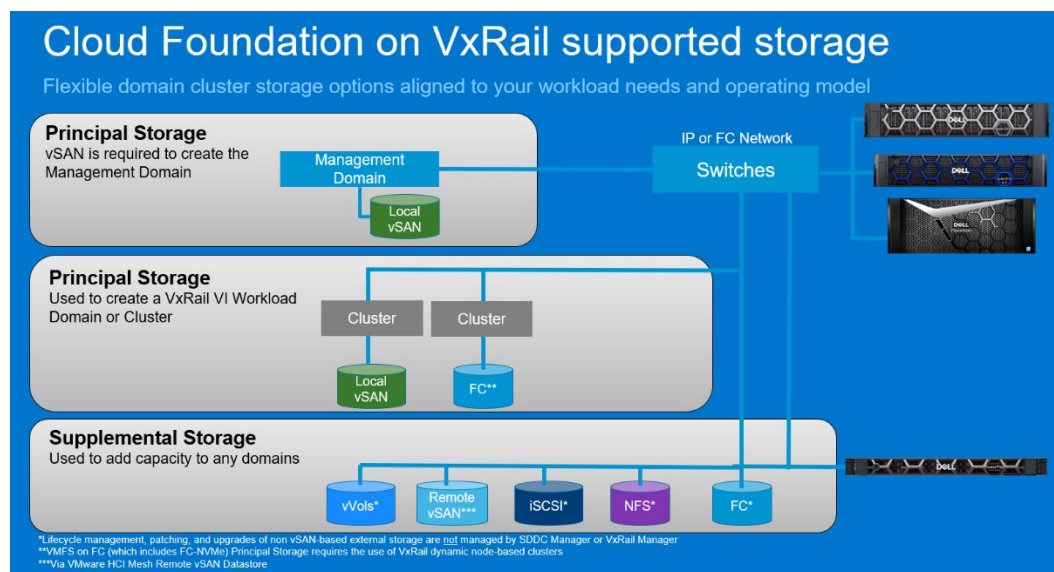


Figure 18. VMware Cloud Foundation on VxRail supported storage

The use of VMFS on FC Principal Storage (which includes FC-NVMe when using PowerMax and PowerStore-T systems) for VI workload domains is supported as of VMware Cloud Foundation 4.3.1 on VxRail 7.0.241 and higher. It supports PowerStore-T, PowerMax, VMAX, and Unity XT Primary FC storage systems only. Since this feature leverages FC, VxRail nodes must be configured with Dell VxRail qualified FC HBAs. Check the E-Lab Support Matrix and VxRail hardware compatibility documentation for the

latest supported firmware and software versions and supported VxRail hardware available.

The external storage as principal storage for VMware Cloud Foundation on VxRail feature is currently supported only with VxRail dynamic node-based clusters. Administrators can use IP, FC, and vVol external storage as supplemental cluster storage in all VMware Cloud Foundation domains to complement vSAN principal or VMFS on FC principal storage. In this case, VxRail dynamic node-based clusters or VxRail HCI node-based clusters can be leveraged.

Note: Use of third-party FC storage systems for VMFS over FC Principal Storage in VMware Cloud Foundation on VxRail is not supported. However, third-party FC Storage Systems can be used as Supplemental storage. In all cases when FC storage systems are used, life cycle management of those systems is the responsibility of the administrator. It is not performed or managed by SDDC Manager or VxRail Manager.

VxRail flexible hardware configurations

VxRail nodes are available with different compute power, memory, and cache configurations to closely match the requirements of new and expanding use cases. As requirements grow, the system easily scales out and scales up in granular increments.

Dell delivers top of the line HCI portfolio purpose-built for HCI with the newest Dell PowerEdge server platform. This portfolio delivers tailor-made performance and reliability powerful enough for any workload, which is combined with an advanced approach to intelligent deployment and operations that simplify and accelerates IT. Dell HCI on next-generation PowerEdge servers provides the ideal foundation for software-defined data center initiatives.

With up to 150 integrated customer HCI requirements, PowerEdge servers are designed for and tailored to HCI workloads that depend on servers and storage. This results in a more consistent, predictable, and reliable high-performing HCI that can meet any use case. With a comprehensive portfolio, Dell can deliver the best fit for organization-specific HCI needs—from workload requirements, to customer environment, to deployment preferences.

Dell Technologies leads in hyperconverged sales with over 30 percent market share according to IDC.³

VxRail environments are configured as a cluster, with each node containing internal storage drives (VxRail with vSAN node cluster) or connected to an external storage (VxRail dynamic node cluster). VxRail systems are delivered with the software loaded, ready to attach to a customer-provided network. The system can be configured to match unique site and networking requirements by using a simple wizard at the time of install.

VxRail with vSAN node cluster

VxRail nodes are enclosed in a one-node, single-server system, with each node having one, two, or four multi-core processors and either all-flash solid-state disks (SSDs) or a hybrid mix of flash SSDs and hard disk drives. The nodes form a networked cluster with a minimum of two or three nodes for scale-out clusters with a maximum of 64 nodes.

³ Based on IDC converged Tracker Q1 2018, June 2018

VxRail dynamic node cluster

VxRail dynamic nodes are VxRail systems that are compute-only nodes used to form a vSphere cluster. Dynamic node clusters rely on external storage resources for their primary storage. External storage resource types can be remote datastores from vSAN clusters using VMware vSAN HCI Mesh or datastores from storage on Dell storage arrays such as PowerStore-T, PowerMax, Unity XT, and PowerFlex.

Dynamic node clusters further extend the workload types that VxRail can address. Customers can deploy VxRail for workloads that might require enterprise storage-level data protection and resiliency or that can benefit from independent scaling of compute and storage for better cost economics. Customers can continue to store the workloads on an enterprise array while benefitting from the VxRail simplified LCM. For applications that might be compute-intensive or storage-intensive, with VMware vSAN HCI Mesh, customers can use a mix of compute clusters and vSAN clusters that can result in better resource utilization and optimized license costs. When VxRail is used to form vSphere and vSAN clusters, customers can benefit from a common operating model with VxRail HCI System Software.

VxRail dynamic nodes are compute-only nodes running ESXi. Internal storage is not supported, so a vSAN license is not required. VxRail HCI System Software is responsible for the LCM of the node. LCM of the storage array is separate. VxRail dynamic nodes are available with the E660F, P670F, and V670F VxRail models. All configuration options that come with these models, except for cache and capacity drives, are available.

All Dell VxRail systems offer a choice of Dell PowerEdge servers, powered by new Intel® Xeon® Scalable and AMD EPYC processors, variable RAM, and storage capacity, allowing customers to make immediate purchases based on their specific needs. Single-node scaling and storage capacity expansion provide a predictable, “pay-as-you-grow” approach for future scale up and out as business and user requirements evolve.

Figure 19 shows the comprehensive set of options available across the PowerEdge family. Customers can be assured that their VxRail system is configured to best match their workload requirements, with millions of possible configuration combinations in the VxRail model series family. Available configuration options are different between standard VxRail nodes and VxRail dynamic nodes. For more information about VxRail hardware configurations, see the [Dell VxRail System TechBook](#).

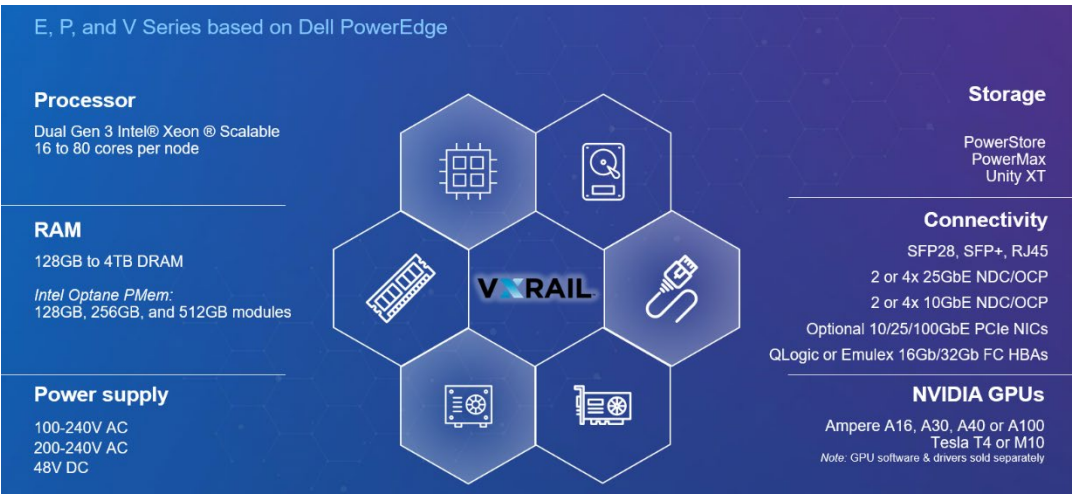


Figure 19. Component options available across the VxRail System

VxRail automated life cycle management enables scale out where new nodes can be added nondisruptively and different models can be mixed within a VxRail cluster. By adding the latest technology nodes into existing clusters and decommissioning aging nodes, an evergreen HCI environment can be obtained which removes necessity of costly SAN data migrations. Flexible storage options also allow a node to start with a few drives and add drives as capacity requirements grow. Nodes may also be scaled-up where the VxRail nodes can be nondisruptively upgraded with additional memory, GPU, NIC cards, cache SSD, and capacity drives to meet changing requirements.

VxRail delivery options

VMware Cloud Foundation on VxRail can be delivered as either a cluster of nodes (platform) that leverages the customer's existing network infrastructure, or an integrated rack system with optionally included networking as shown in Figure 20.

These delivery packaging options can be used for all different customer use cases such as VxRail with vSAN HCI, VMware Cloud Foundation on VxRail, or VxRail edge use cases.

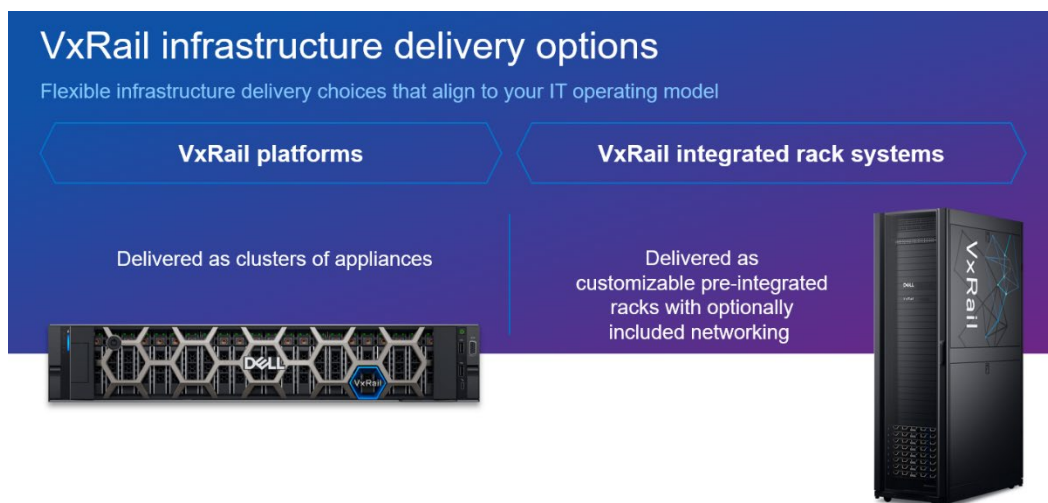


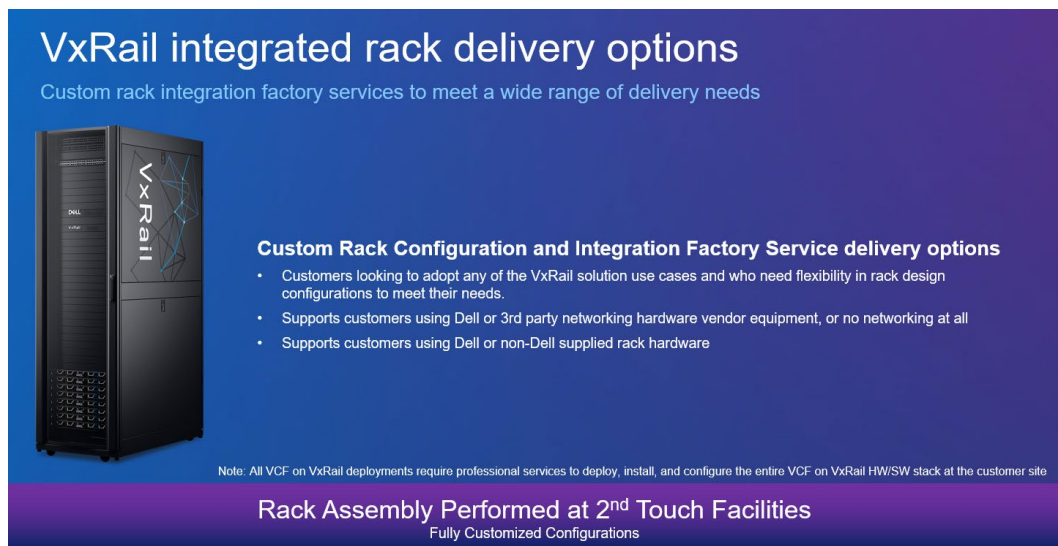
Figure 20. VxRail delivery options

VxRail integrated rack delivery services options

Custom rack design configuration and integration services for VxRail integrated deployments are available for all customers looking to adopt any of the VxRail solution use cases and who need flexibility in rack design configurations to meet their needs. These services support customers using Dell or third-party networking hardware vendor equipment, or no networking at all. These services also support customers using Dell or third-party-supplied rack hardware.

Flexible Dell Technologies 2nd Touch Facility factory services give customers options on the rack and networking components they would like used. Customers can purchase from Dell Technologies, a rack from our Dell Technologies partner, APC, or supply their own consigned third-party rack. Customers also have a choice of network switches. Customers can purchase Dell PowerSwitch with OS10 EE switches from Dell Technologies or supply their own third-party switches. Any third-party consigned items supplied by the customer must be purchased separately by the customer outside of Dell Technologies. Support for those components would be provided by the component vendor. Depending on which

components are used for the system, customers can choose the specific support experiences for their infrastructure.



VxRail integrated rack delivery options
Custom rack integration factory services to meet a wide range of delivery needs

Custom Rack Configuration and Integration Factory Service delivery options

- Customers looking to adopt any of the VxRail solution use cases and who need flexibility in rack design configurations to meet their needs.
- Supports customers using Dell or 3rd party networking hardware vendor equipment, or no networking at all
- Supports customers using Dell or non-Dell supplied rack hardware

Note: All VCF on VxRail deployments require professional services to deploy, install, and configure the entire VCF on VxRail HW/SW stack at the customer site

Rack Assembly Performed at 2nd Touch Facilities
Fully Customized Configurations

Figure 21. VxRail integrated rack delivery options

Customers who choose the VxRail nodes deployment option maintain the responsibility for defining the networking and rack configuration as well as performing the work of physically racking and cabling the nodes and non-Dell, third-party product. In this option, VxRail nodes are shipped directly to the customer who will perform further rack integration work in their own data center.

A custom VxRail rack integration service option is available for customers who want a factory-integrated rack configuration delivery engagement in which they can define the networking and rack components in addition to VxRail node hardware and rack design configuration. This includes the use of third-party products performed in a Dell Technologies 2nd Touch Facility before shipping it to the customer.

Note: For third-party components, the customer will be responsible for procuring and sending the products to a Dell Technologies 2nd Touch Facility for racking. This option supports all the available VxRail solution use cases.

Customers who want specific turnkey VxRail cloud solution outcomes and who value fast delivery, within 14 days, can purchase one of the cloud solution offerings available within the APEX Cloud Services portfolio. These solutions are turnkey and are designed and packaged to provide the fastest time to value. They are delivered with prevalidated configurations and delivered in a rack whose rack components, VxRail node configurations, and rack configuration design are predefined by Dell Technologies to optimize delivery speed. For these solution offerings, customers have a choice of different pre-defined VxRail node hardware configurations that will be pre-racked as part of solution delivery. Available offerings include VMware Cloud Foundation on VxRail and VMC on Dell.

VMware Cloud Foundation on VxRail financial consumption models

VMware Cloud Foundation on VxRail offers flexible financial consumption models that can align with how customers choose to consume their private cloud technologies. This includes traditional CAPEX, Instance-based configurations with APEX, and Dell Technologies On Demand.

- **VMware Cloud Foundation on VxRail (CAPEX):** Customers can purchase VMware Cloud Foundation on VxRail using traditional CAPEX consumption models. This model requires an upfront payment.
- **VMware Cloud Foundation-S on VxRail (OPEX):** Consume on-premises VCF hybrid cloud infrastructure through a term subscription OPEX model. Ideal for customers who want a subscription that supports secure air gapped environments that cannot have cloud connectivity. In this model, the VxRail HW remains CAPEX.
- **VMware Cloud Foundation+ on VxRail (OPEX):** This is a metered subscription OPEX model with connection to VMware cloud services that transforms on-premises infrastructure with a new class of VMware hybrid services. In this model, the VxRail HW remains CAPEX.
- **APEX Hybrid Cloud (OPEX):** VMware Cloud Foundation on VxRail is the foundation for APEX Hybrid Cloud. In a few clicks, you can subscribe to instances designed for your workloads through the APEX Console and get it deployed in your data center, co-location facility, and edge locations in as few as 14 days. With a simplified ordering process enabled by the APEX Console, pick instance types based on your workload requirements, capacity needed, and subscription term. Intuitively select from preconfigured hybrid cloud solutions aligned to your enterprise workloads.
- **APEX Flex On Demand (OPEX):** Payment solutions for VxRail include APEX Flex On Demand, a pay-per-use consumption model that enables customers to scale capacity up or down, with payments that rise and fall accordingly. Customers simply choose their baseline capacity, which they pay for at an agreed-upon rate each month, as well as buffer capacity.

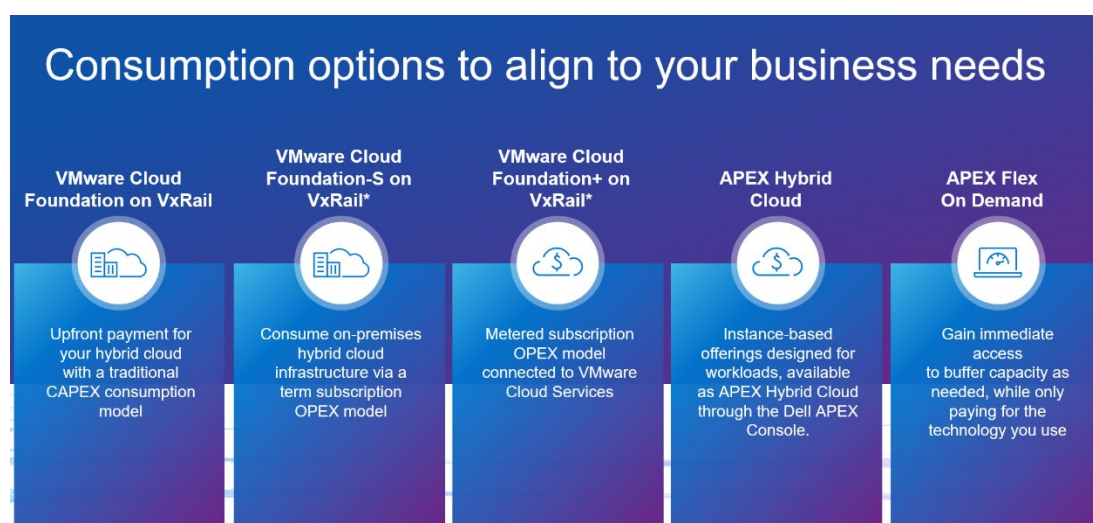


Figure 22. VMware Cloud Foundation on VxRail financial consumption options

VMware Cloud Foundation on VxRail subscription licensing options

Customers can purchase and apply perpetual or subscription-based licensing when deploying VMware Cloud Foundation on VxRail.

VMware software perpetual licenses

The perpetual licensing model (VMware Cloud Foundation on VxRail) has been the default on-premises deployment approach with VMware Cloud Foundation on VxRail historically and remains unchanged. It is suitable for customers who want to maintain a CAPEX-based licensing cost model. With this approach, VMware Cloud Foundation components require license key inputs at the time of deployment and during environment expansion.

VMware software subscription-based licenses

In 2022, VMware introduced new subscription offerings for vSphere, vSAN, and VMware Cloud Foundation. These subscription offerings fall into two categories: cloud-connected metered subscriptions and on-premises term subscriptions.

The cloud-connected metered subscriptions are known as vSphere+, vSAN+, and VMware Cloud Foundation+. These are multicloud workload platform subscription offerings that bring the benefits of cloud-connected VMware Cloud services to customers with on-premises workloads and who want to consume VMware software using OPEX subscription financial models.

The on-premises term subscription offers are known as vSphere-S, vSAN-S, and VMware Cloud Foundation-S. VMware introduced these subscription offerings to meet the needs of organizations that cannot connect or do not want to connect their on-premises infrastructure to the cloud but still want to consume infrastructure using an OPEX subscription financial model.

All these subscription options are supported with VxRail and VMware Cloud Foundation on VxRail offerings.

Using VMware Cloud Foundation+ with VMware Cloud Foundation on VxRail

This section describes VMware Cloud Foundation on VxRail deployment architecture and requirements for using VMware Cloud Foundation+ with VMware Cloud Foundation on VxRail. It also describes the relevant VMware Cloud Foundation+ component architecture and networking requirements associated with deploying the vCenter Cloud Gateway Appliance used to connect to VMware Cloud Services. In particular, it introduces the VMware Cloud Console for metering and hybrid cloud services features. Finally, it provides an overview of Day 2 operational considerations related to LCM and how, with VxRail, the VMware Cloud Foundation+ life cycle service complements the on-premises cluster LCM experience delivered through VxRail HCI System Software.

VMware Cloud Foundation+ on VxRail offers best-in-class on-premises and cloud-connected infrastructure in a single solution. As a true hybrid cloud platform, VMware Cloud Foundation+ on VxRail delivers new administrator, developer, and hybrid cloud services to new and existing VMware Cloud Foundation on VxRail deployments.

A range of high-value cloud-connected services provides administrators and developers access to a comprehensive workload platform that can span multiple VMware Cloud Foundation+ on VxRail deployments. The VMware Cloud Console offers global visibility and centralized management of all VMs and container-based workloads.

VMware Cloud Foundation+ delivers a simple and flexible subscription model. Customers can leverage their existing capital expense (CAPEX) investments and easily shift to an operational expense (OPEX) model with a pay-as-you-grow subscription without needing to refactor workloads.

By transforming existing on-premises VMware Cloud Foundation on VxRail deployments into a SaaS-enabled infrastructure, new and powerful cloud services can be seamlessly onboarded as they are released using consumption-based economics.

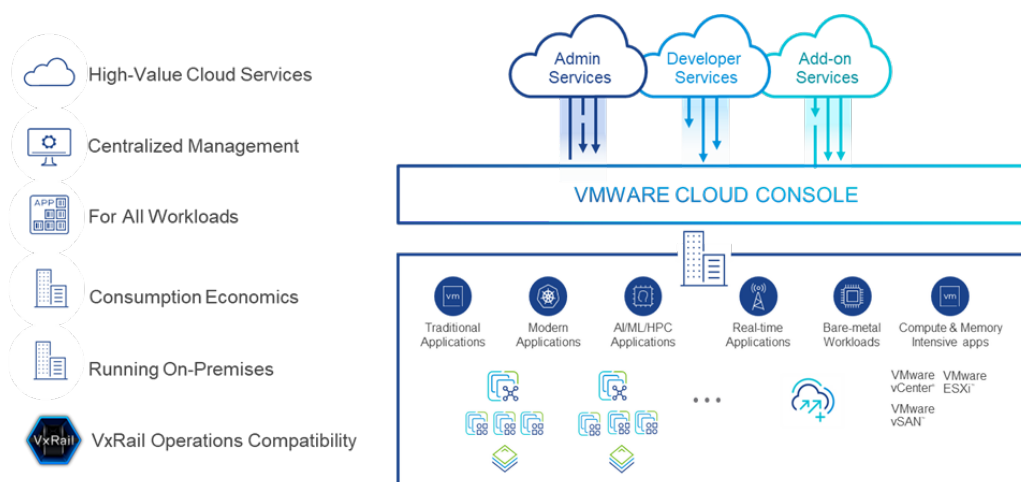


Figure 23. VMware Cloud Services with vSphere+, vSAN+ and VMware Cloud Foundation+

Figure 23 depicts the high-level architecture available with the VMware vSphere+, vSAN+, and VMware Cloud Foundation+ offerings with VxRail. High-valued VMware Cloud Services, such as Admin Services, Developer Services, and Add-on Services, will continue to be developed and enhanced and be made available over time to customers to extend the capabilities of their on-premises VxRail environment.

VMware Cloud Foundation+ on VxRail architecture

VMware Cloud Foundation+ adds a new cloud-connected architecture for managing and operating full-stack HCI in the data center.

VMware Cloud Foundation+ is powered by VMware Cloud Foundation 4.5 and later and uses vSphere+, vSAN+, and a Cloud Gateway Appliance to provide access to the VMware Cloud Console as part of the full-stack architecture.

The vCenter Cloud Gateway Appliance is at the core of the solution. Each vCenter Cloud Gateway is a VM appliance that the cloud administrator installs into the VMware Cloud Foundation on VxRail environment. The vCenter Cloud Gateway Appliance securely establishes the communication between on-premises VMware Cloud Foundation instances and VMware Cloud, facilitating the monitoring and management of all VMware Cloud Foundation+ instances from the VMware Cloud Console (VMC).

The VMware Cloud Console delivers new cloud-connected services, providing a global inventory, alerts, capacity management, and critical security vulnerabilities awareness for each VMware Cloud Foundation+ on VxRail instance. Virtual machines can be deployed directly from the VMware Cloud Console, allowing users to choose where to deploy a given workload and the best-suited infrastructure to run workloads on.

Empowered with these new capabilities, organizations can achieve greater operational efficiencies by enabling simplified, global management of VM-based and container-based enterprise workloads across VMware Cloud Foundation on VxRail instances. Also, customers can streamline maintenance windows, improve security posture, and gain immediate access to new features and cloud services.

The following figure illustrates the high-level architecture of VMware Cloud Foundation+ on VxRail.

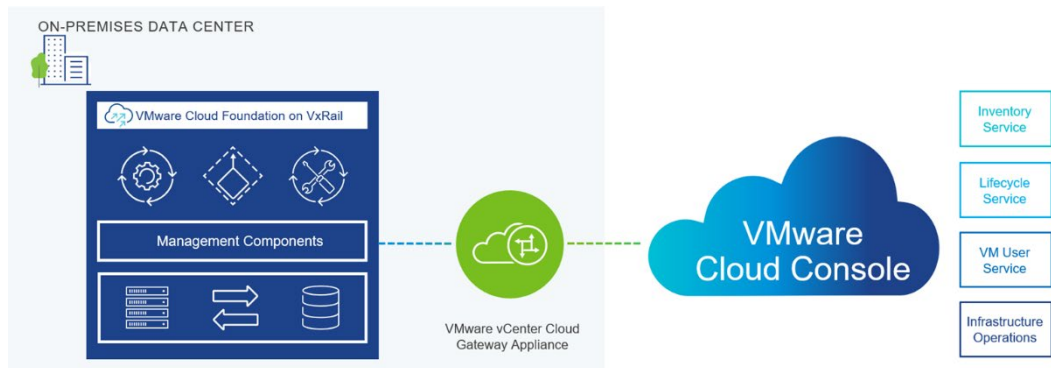


Figure 24. VMware Cloud Foundation+ on VxRail high-level architecture

VMware Cloud Foundation+ on VxRail deployment considerations

To benefit from the VMware Cloud Foundation+ offering, customers must deploy a minimum supported version—VMware Cloud Foundation 4.5 on VxRail 7.0.400 with vCenter 7.0 U3h. The enablement of VMware Cloud Foundation+ on VxRail currently requires a conversion performed as a Day 2 operation after initially deploying VMware Cloud Foundation on VxRail. VMware Cloud Foundation+ includes vSphere+, vSAN+, and a required embedded NSX term subscription license as a part of the subscription offering.

All on-premises vCenter and SDDC Manager instances are never configured to connect to the VMware Cloud directly. Instead, the on-premises infrastructure that hosts all customer workloads connect to the VMware Cloud Console through deployed virtual Cloud Gateway Appliances that securely communicate with on-premises vCenter instances and SDDC Managers. These Cloud Gateway Appliances transmit the metered infrastructure usage to the VMware Cloud, enabling a pay-for-what-you-use level of consumption economics. All this is delivered with VMware Cloud Foundation on VxRail operations compatibility in mind. VMware Cloud Services and VMware Cloud Console interactions complement the value-added on-premises infrastructure management environment that VMware Cloud Foundation on VxRail offers through Dell CloudIQ and the VxRail HCI System Software, and the System Software integrations with VMware Cloud Foundation SDDC Manager.

VMware Cloud Console does not replace existing on-premises VxRail infrastructure operations tools when vSphere+, vSAN+, and VCF+ are used with VxRail. Together, they deliver a complementary management experience for VMware Cloud Foundation+ on VxRail environments, simplifying customer operations.

For the vCenter Cloud Gateway Appliance to work correctly in VMware Cloud Foundation on VxRail environments that use VMware Cloud Foundation+, the following prerequisites must be met:

- **Internet Connection**—Although the vCenter server or servers do not (and should not) be connected to the Internet, the Cloud Gateway Appliance requires Internet access to be able to communicate with VMware Cloud Foundation.
- **Firewall Ports**—Certain ports should be open (primarily, port 443) for proper communications to and from the Cloud Gateway Appliance.
- **Resources**—There should be enough resources (memory, CPU, storage) in the cluster where the Cloud Gateway Appliance will be deployed.

The following figure illustrates these networking considerations for deploying the vCenter Cloud Gateway Appliance.

Connecting on -prem to the cloud

Cloud Gateway

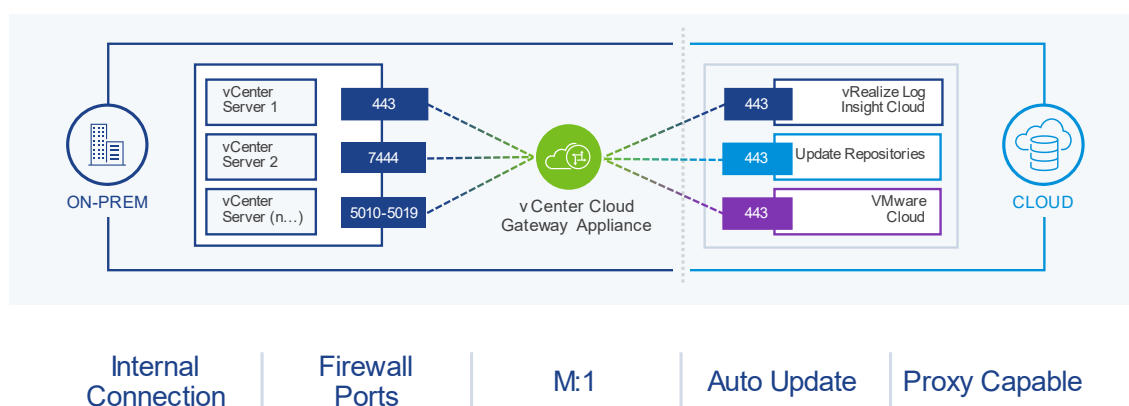


Figure 25. Network considerations when deploying vCenter Cloud Gateway Appliance

VMware Cloud Foundation+ on VxRail helps customers deliver the benefits of the cloud to on-premises workloads. IT teams can begin supercharging productivity with admin services designed to enhance operational efficiency and centralize management with the VMware Cloud Console. VMware Cloud Foundation+ helps by enabling customers to monitor global inventory and alert status easily, and even allow customers to provision VMs to any subscribed VMware Cloud Foundation on VxRail workload domain cluster from a centralized SaaS-based portal. It helps customers accelerate innovation with integrated developer services, allowing them to take advantage of integrated VMware Tanzu component services and features in available VMware Cloud Foundation+ offerings. As a result, it enables customers to manage, operate, and run VM and container workloads on a common on-premises, modern full-stack cloud HCI. Finally, it allows customers to transform their on-premises infrastructure with cloud integration by extending on-premises workloads with add-on hybrid cloud services when needed and gain the flexibility of OPEX-based consumption while improving ROI from existing investments.

Networking

VMware Cloud Foundation supports a network flexible architecture. Customers can choose switches that meet their organization's standard and scalability requirements. There is also increased flexibility in network configurations permitting customers to configure VLANs and other settings without fear of disrupting SDDC Manager's

automation or configuration. SDDC Manager does not require access to the physical network layer. Switches are manually configured by the customer's network team or by the professional services engineer, if this part of implementation is also covered with a custom services engagement.

There are multiple VMware Cloud Foundation on VxRail network topology options. The choice of topology design depends on preferred outcomes. The most common network topology for VMware Cloud Foundation on VxRail follows a standard spine-leaf architecture. Decisions are required to determine where VLANs from the platform's workload domains will terminate in the supporting physical network layer. Users must also determine the Layer 2 and Layer 3 boundary in multirack deployments.

For more detailed documentation on network design options, see the VxRail Network Planning Guide and Architecture Guides and the Dell Networking Guides on the VxRail Knowledge Center and Dell support portal. For more information, see [Appendix A: References](#).

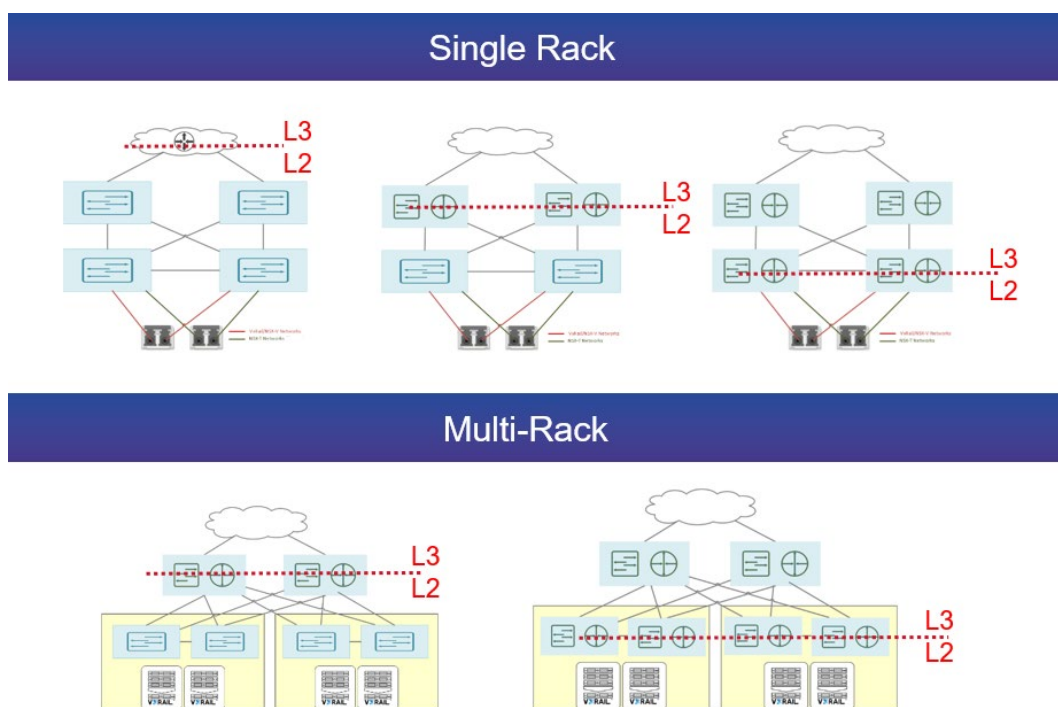


Figure 26. VMware Cloud Foundation on VxRail example network topology options

VxRail node networks for a cluster spanning additional racks can share same IP subnet (nonroutable) or assigned a different IP subnet (routable). This provides even more network configuration flexibility for customers.

VMware introduces Application Virtual Networks (AVN) in version 4.0 of the VMware Cloud Foundation platform. The AVN enables linkage for the Aria Suite (formerly vRealize Suite) cloud management components and enables connectivity to the upstream external network. The vRealize components, including vRealize Log Insight, vRealize lifecycle management (LCM), vRealize Operations Manager, and vRealize Automation, connect to the AVN when deployed (AVN deployment is optional).

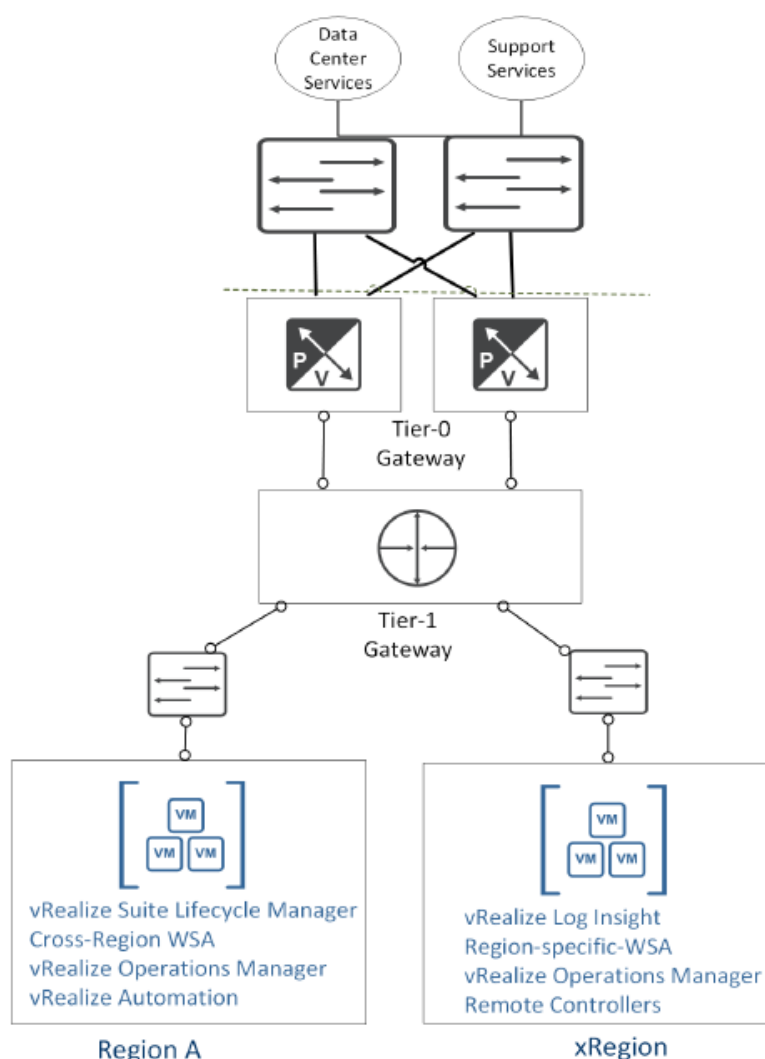


Figure 27. Application Virtual Network (AVN) Overview – Regions and Logical Segments

AVN provides the following benefits:

- The application virtual network is highly secured by using an NSX Edge device as the distributed firewall to isolate applications from each other and external users. Direct access to application virtual networks is controlled by distributed firewall rules.
- AVN prepares for future use of a single IP network address space that provides application mobility between data centers.
- AVN provides simplified future disaster recovery procedures.
- Applications that need failover support across regions now have an overlay backed subnet that spans across regions.
- During failover, applications retain their IP addresses, resulting in faster RTO.

Network virtualization

NSX provides the foundation of the network virtualization layer for VMware Cloud Foundation on VxRail. It provides a software-defined networking approach that delivers Layer 2 to Layer 7 networking services, such as switching, routing, firewalling, and load balancing, in software. These services can be programmatically assembled in any combination, producing unique, isolated virtual networks in a matter of seconds. NSX provides native support for Kubernetes, VMware Tanzu, and cloud-native applications.

To learn more about VMware Cloud Foundation on VxRail network architecture, including NSX, see the *VMware Cloud Foundation on VxRail Architecture Guide*.

Multisite use cases

With flexible network architecture, VMware Cloud Foundation on VxRail systems can support multi-site use cases. Deployment in these cases is not automated. By leveraging additional guidance contained in the VMware Validated Solutions, customers can deploy VMware Cloud Foundation environments in multiple availability zones topologies to support variety of multisite and stretched cluster use cases.

Availability zones enhance resiliency of the SDDC and improve SLAs by:

- Allowing identification of separate fault domains within the primary region.
- Leveraging the stretch-clustering capabilities of vSAN to distribute workloads across the availability zones.

VMware Cloud Foundation supports NSX Federation. NSX Federation is the foundational building block used to support a multisite, dual-region deployment of VMware Cloud Foundation. This allows connection of two separate VMware Cloud Foundation instances deployed in data centers at two different geographically distanced regional locations. It provides centralized networking management, consistent networking data services, and centralized network security policy configuration along with enforcement and a synchronized operational state. With NSX Federation, VMware Cloud Foundation can leverage stretched networks and unified security policies across multiregion VMware Cloud Foundation deployments providing workload mobility and simplified disaster recovery. The deployment and configuration are done following the prescriptive guidance and automation scripts outlined in the VMware VVS documentation.

To learn more about the supported multisite use cases, see [Appendix D: VMware Cloud Foundation](#).

Expanded platform capabilities with VMware Validated Solutions

VMware Validated Solutions (VVS) are technical validated implementations built and tested by VMware and VMware Partners. These solutions are designed to help customers solve common business problems using VMware Cloud Foundation as the foundational infrastructure.

VMware Validated Solutions are designed to help customers build secure, high-performing, resilient, and efficient infrastructure for their applications and workloads deployed on VMware Cloud Foundation. Each VMware Validated Solution comes with detailed design, with design decisions, implementation guidance consisting of manual UI-based step-by-step procedures, and, where applicable, automated steps using infrastructure-as-code. Individual VMware Validated Solutions might be supplemented with code samples and how-tos, customer success stories, and links to other published assets to provide a one-stop experience for our customers.

The benefits of VMware Validated Solutions are as follows:

- **Validated**—VMware Validated Solutions are designed by VMware architects to help customers build secure, high-performing, resilient, and efficient infrastructure.
- **Scalable**—Customers can easily scale infrastructure and applications running on VMware Cloud Foundation with technically validated, repeatable, and automated solutions.
- **Secure**—Security-centric designs offer prescriptive guidance and enhance postdeployment hardening of VMware Cloud Foundation infrastructure.
- **Lower costs**—Infrastructure as code accelerates deployments through automated workflows that reduce manual labor and rework.
- **Faster time to value**—VMware Validated Solutions help customers rapidly implement solutions on top of VMware Cloud Foundation.

Types of solutions currently available include:

- Developer Ready Infrastructure for VMware Cloud Foundation
- Site Protection and Disaster Recovery for VMware Cloud Foundation
- Advanced Load Balancing for VMware Cloud Foundation
- Private Cloud Automation for VMware Cloud Foundation
- Cloud-Based Automation for VMware Cloud Foundation

The qualification of VVS with VMware Cloud Foundation on VxRail was introduced with VMware Cloud Foundation 4.4.1 on VxRail 7.0.371; the VVS solutions qualified with VMware Cloud Foundation on VxRail are marked with a “VxRail” tag.

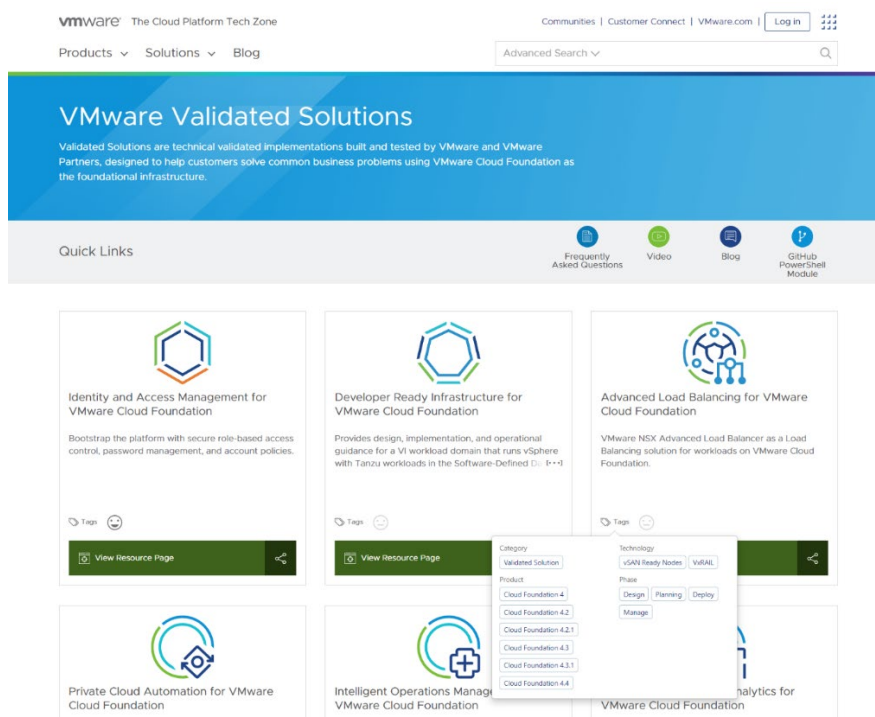


Figure 28. VMware Validated Solutions portal

These solutions get updated asynchronously from VMware Cloud Foundation releases. For the latest updates on existing solutions and to see new solutions and learn more, see the [VMware VVS portal](#).

Services and support

Dell Secure Connect Gateway

VxRail support includes Dell Secure Connect Gateway for call-home and proactive two-way remote connection for remote monitoring, diagnosis, and repair through the entire life cycle process to ensure maximum availability. VxRail is constantly introducing product enhancements to improve serviceability by streamlining support experience. For example, VxRail is improving the log capture and bundling to ensure that Dell technical support has the necessary information to perform troubleshooting without extensive back-and-forth with customers.

VxRail systems now use the next-generation secure remote service connectivity agent and the Secure Connect Gateway to connect to the Dell Cloud for dial-home serviceability. This new connectivity agent running within VxRail will also be used on all Dell infrastructure products.

The Secure Connect Gateway is the 5th generation gateway that acts as a centralization point for Dell products in the customer environment to manage the connection to the Dell Cloud. This remote connectivity enables bi-directional communication between the product and Dell Cloud. Products can send telemetry data and event information to the Dell Cloud. That data and information can be used to facilitate remote support by Dell services as well as to deliver cloud services such as CloudIQ, MyService360, Licensing Portal, and Service Link.

The latest-generation remote service connector is intended to provide a uniform telemetry experience across all Dell ISG products. By providing standardization, customers can reduce redundant infrastructure used to provide remote services for all their Dell products. The connectivity agent also introduces a simpler setup experience by streamlining and automating the setup process of the secure remote service for new VxRail cluster deployments.

New nodes that are shipped with VxRail 7.0.350 or later now include a unique connectivity key for the secure remote gateway. Dell manufacturing embeds this key into the iDRAC of the VxRail nodes. Users do not have to log on to the Dell Support portal to retrieve the access key to enable secure remote services. Instead, the enablement process automatically retrieves the unique connectivity key from iDRAC for the connectivity agent to enable the connection. This feature is designed to simplify and streamline the secure connect gateway serviceability setup experience.

Customers can also have a direct connection to Dell Cloud instead of having a gateway deployed. This option is available for any clusters running VxRail 7.0.350 and later.

VxRail dial-home payload improvements have been introduced to help provide Dell Support with additional key cluster information in the dial-home payload itself and capture more system error conditions. These improvements further enhance VMware Cloud Foundation on VxRail serviceability and reduce time to resolution of any VxRail related issues.

Dell Professional Services

Dell Services must be used to successfully install VxRail and the VMware Cloud Foundation software platform. Dell networking hardware installation and multisite or stretched cluster configuration initial installation are also optionally available services. Any Day 2 customization work (for example NSX customization, vRealize Automation customization, data protection customization) that is needed would be performed using additional services engagements with VMware or Dell.

Dell Services accelerates the deployment, reduces downtime, and simplifies operations of VMware Cloud Foundation on VxRail with a full range of integration, implementation, support, and consulting services. Dell Services helps IT organizations quickly realize the value of their investment by deploying the hardware and software components of VMware Cloud Foundation on VxRail. Dell Services also helps customers achieve IaaS by integrating the cloud platform into their application portfolio, operating model, and enterprise infrastructure.

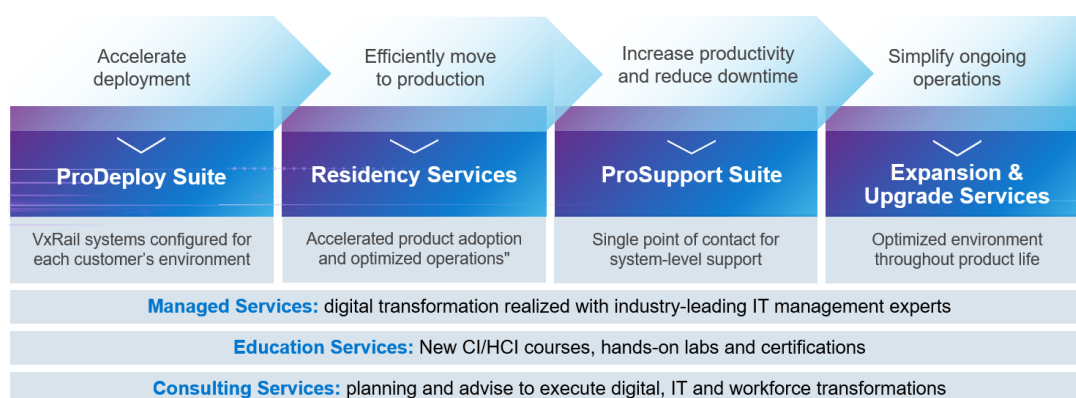


Figure 29. Dell Services for VMware Cloud Foundation on VxRail

Consulting services complement the platform integration with services to hasten realization of IaaS:

- For application integration, target applications are profiled to determine their suitability and priority for VMware Cloud Foundation on VxRail deployment, and then assistance is provided to migrate these applications while minimizing downtime and risk.
- For operating model integration, help is provided to refine operational processes for more automated and agile-as-a-service operations, while also optimizing the roles and skills of customer teams for service-based operations.

Dell Support

Customers have a choice of support and maintenance options that aligns with their business model.

Customers that purchase all components from Dell Technologies are provided with a single vendor support experience. For customers using VMware Cloud Foundation software, Dell provides the initial support levels and coordinates advanced level support

from VMware. Similarly, for Dell supplied APC Racks, Dell provides the initial support and engages advanced support from APC.

Exclusively for VMware Cloud Foundation on VxRail, Dell Technologies offers single source of support for VMware Cloud Foundation software on both ProSupport and ProSupport Plus, even if customers bring their own VMware Cloud Foundation licenses.

Remote system software code upgrades performed by Dell are also in both ProSupport and ProSupport Plus.

PROSUPPORT	PROSUPPORT PLUS
<ul style="list-style-type: none">• 24X7 remote technical support• Onsite hardware support: next business day or 4hr mission-critical• 3rd party collaborative assistance• Automated issue detection and proactive case creation• Self-service case initiation and management• Access to software updates• Support for VCF software• System software code upgrades for VCF on VxRail*	<p>All the features of ProSupport, as well as:</p> <ul style="list-style-type: none">• Priority access to specialized support experts• Eligible 3rd party software support (find list here)• Assigned Technology Services Manager• Personalized assessments and recommendations• Semiannual systems maintenance

Figure 30. VMware Cloud Foundation on VxRail support options

Dell and VMware have partnered to develop and deliver VMware Cloud Foundation on VxRail, providing an optimized, premium end-user experience for customers. The following figure shows the characteristics that differentiate this offering from alternative VMware Cloud Foundation deployments:

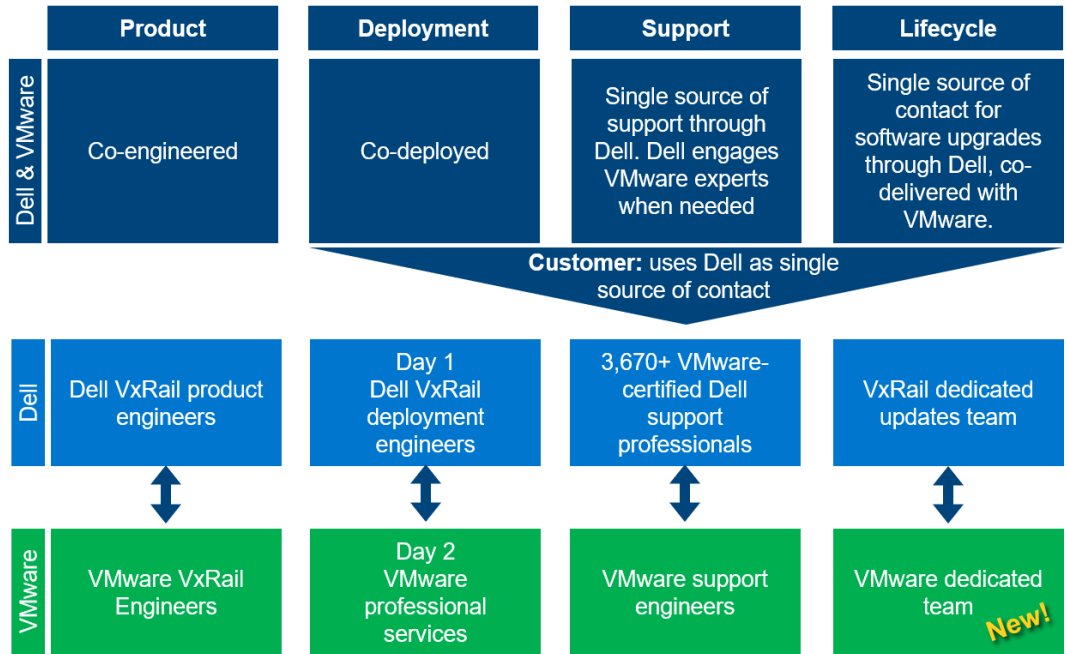


Figure 31. VMware Cloud Foundation on VxRail premium support experience

- **Co-engineered:** Dell VMware Cloud Foundation on VxRail is jointly engineered between Dell and VMware to deliver a market-leading, multicloud platform.

- **Co-deployed:** Dell conducts day-1 deployment of the fully integrated solution; day-2 activities are performed by VMware.
- **Single source of support:** While Dell is the single source of system-level support for VMware Cloud Foundation on VxRail, we work closely with VMware to resolve complex issues for customers.
- **In-version VMware Cloud Foundation software upgrades:** Dell and VMware collaborate to perform in-version VMware Cloud Foundation code upgrades (that is, from 3.x to 3.y or from 4.x to 4.y); Dell remains the single source of contact and project management for our customers.

Customers can choose to do their own VMware Cloud Foundation system software code upgrades. Alternatively, they can have code upgrades performed by the Dell Technologies Remote Proactive Team if they have an active ProSupport Suite for VMware Cloud Foundation on VxRail contract (ProSupport, ProSupport Plus or ProSupport One – Next Business Day or 4 hour Mission Critical). This simplifies their overall full-stack support experience.

Customers who purchase network switches or rack/PDUs from third parties are provided support for those components only from the third-party vendor.

Dell ProSupport Plus offers a single source with the expertise, know-how, and capabilities to deliver world-class support.

ProSupport Plus provides global support from highly trained experts to address IT needs, minimize disruptions, and maintain a high level of productivity. ProSupport Plus enables businesses to:

- Maximize productivity by leveraging Dell scale and skill
- Minimize disruptions with around the clock access to highly trained experts
- Gain efficiency through a single source for all support needs

Single source, 24x7 global support is provided for VxRail appliance hardware and software (including VMware Cloud Foundation software) using phone, chat, or instant message. Support also includes access to online support tools and documentation, rapid on-site parts delivery and replacement services, access to new software versions, assistance with operating environment updates, and remote monitoring, diagnostics, and repair with Dell Secure Remote Services.

Dell 12 Centers of Excellence and Joint Solution Centers deliver in-house collaboration and industry-leading levels of support, leveraging Dell's alliances with leading application providers such as Oracle and Microsoft. Dell has 87 technical support sites that include 71 Dell Technologies Support Sites and 16 Dell Technologies Customer Service Centers.

Conclusion

VMware Cloud Foundation on VxRail provides the simplest path to the hybrid cloud through a fully integrated platform that leverages native VxRail hardware and software capabilities and other VxRail unique integrations.

Dell enables organizational IT transformation and hybrid cloud adoption by providing flexible modern cloud infrastructure solutions that can transform IT at the pace our customers are ready for. Cloud transformation is a journey. It does not happen overnight. Dell Technologies is looking to be our customers' strategic partner to help them on their journey.

IT and cloud transformation can be accomplished using a phased approach that aligns with where our customers are in their journey. First, customers can modernize their infrastructure by taking advantage of scale-out, software-defined, and cloud-enabled technologies across servers, storage, and core HCI systems, and full-stack HCI private-cloud-ready infrastructure. This helps break down infrastructure management silos to enable a more streamlined IT operations experience.

Second, customers can begin to automate their services and create a self-service experience for the business to interface with IT. This activity could happen in parallel with the third phase, which is when customers transform the way they operate and recognize the need for new roles, skills, and organizational structures to best use and optimize these new technology capabilities.

Businesses that can successfully navigate through these phases are poised for success in the new digital era.

Adoption phases

Customers who are just getting started can look to modernize their traditional three-tiered infrastructure by adopting HCI to help simplify compute and storage operations. No longer do they have to manage compute and storage in silos, and use hardware-based infrastructure to provide compute and storage services. They can simplify their operations by consolidating compute and storage management using native VMware tools. They can leverage the power of automation and compute and storage virtualization to provide IT with more agility in provisioning infrastructure and life cycle management.

Instead of taking days or weeks to provision compute and storage infrastructure, they can now do the provision in minutes to hours by deploying VxRail HCI. VxRail includes vSphere for Compute Virtualization, vSAN for Storage Virtualization, and VxRail HCI System Software, which includes Manager software for HCI Infrastructure Lifecycle Management and Automation. If needed, VxRail can be augmented with a customer's existing external storage infrastructure so the customer can maintain investment protection for those existing assets or leverage them for specific workloads as needed.

Some customers might plan to implement hybrid or multicloud in the future for their core data centers and the edge but want to start with just the foundational pieces needed to get there over time. Those customers can start by implementing a standardized VMware full-stack HCI private-cloud-ready infrastructure architecture with VMware Cloud Foundation on VxRail that includes NSX for network security and optional network virtualization and SDDC Manager for full-stack HCI LCM and automation. Here, a customer deploys a

VMware full-stack HCI private-cloud-ready SDDC infrastructure on-premises with the benefit of automated full-stack HCI life cycle management and automation while still maintaining IT control over resource provisioning and infrastructure management.

By incorporating technologies that allow for virtualizing all their infrastructure, customers can take advantage of what a fully virtualized infrastructure can provide, such as resource utilization, workload and infrastructure configuration agility, and advanced security. With SDDC software life cycle automation provided by VMware Cloud Foundation (specifically SDDC Manager which is a part of VMware Cloud Foundation on VxRail), customers can streamline the life cycle management experience for the full-stack HCI software and hardware stack. Customers no longer need to worry about performing updates and upgrades manually using multiple tools for all the SDDC SW and HW components of the stack. These processes are streamlined through a common and integrated management toolset in SDDC Manager along with VxRail Manager.

Also at this stage, customers can begin to leverage the advanced network security that software-based networking tooling can deliver. This security goes beyond what core HCI includes without requiring a full transition to a full virtualized network implementation. For example, customers can take advantage of NSX microsegmentation and distributed firewalling, which was nearly impossible to implement using physical networking tools.

When they are ready, customers can then begin to leverage the data services benefits that a fully virtualized infrastructure can offer along with SDDC infrastructure LCM automation. For example, customers use the software-defined networking features from NSX, such as logical overlay network virtualization. Another important aspect is the introduction of VMware Cloud Foundation for deployment of these SDDC components. With this standardized design incorporated as part of the platform, customers are guaranteed that these components have been certified with each other and are backed by Dell Technologies. Customers can then be assured of an automated and validated path forward to get from one Continuously Validated State to the next across the end-to-end stack.

Also during this phase, customers can look to consolidate multiple application workloads to run on a common infrastructure platform. Customers have the optional flexibility to incorporate virtual desktop workloads to run on top of this fully virtualized infrastructure with VMware Horizon. To help accelerate modern application transformation, customers can also optionally leverage native modern application platform runtime and control plane services. They can also take advantage of additional developer services using VMware Cloud Foundation with Tanzu and other Tanzu portfolio offerings.

As their cloud readiness grows, customers might have needs for better operational management of their newly virtualized full-stack HCI private-cloud-ready infrastructure. Here they can incorporate additional cloud infrastructure operations management capabilities into the environment—SDDC operations management capabilities provided by Aria Operations, Aria Log Insight, and Aria Network Insight. These capabilities can be added seamlessly in alignment with best practices standardized architecture guarantees. In this stage, customers can begin transforming how they operate to better manage and monitor a fully virtualized full-stack HCI private-cloud-ready infrastructure. Customers now can gain more insight into the SDDC abstractions across compute, network, and storage and their associated costs. They can use the power of integrated analytics to become smarter and more efficient when performing capacity planning or troubleshooting. These

cloud infrastructure operations management tools can be automatically deployed. They can then be life cycle managed using vRSLCM, which has been natively integrated into VMware Cloud Foundation to easily extend cloud infrastructure operations management capabilities and prepare IT teams for full cloud operating model transformation.

After attaining a comfort level in managing, operating, and automating the infrastructure, a customer might then be ready to transform how the infrastructure is delivered to the business by adopting a cloud operating model. Adoption of this model provides the business with services such as Infrastructure as a Service and Desktop as a Service using IT-governed self-service portals and catalogs to business users. This stage in the cloud transformation journey would involve a combination of people and process changes within an IT organization as well as the technology to support it. Here, customers can introduce cloud management, automation, and governance with Aria Automation. At this stage, a customer would have a full private cloud with self-service catalogs.

For many customers, the target destination is a hybrid cloud and multicloud. In this stage, customers extend on the capabilities that they have built with their private cloud. They begin to incorporate public cloud and edge cloud services to enable workload mobility, portability, and location independence for deciding where workloads should run, all while leveraging a common operating model across both private and public cloud resources. Here they can leverage public cloud services such as VMware Cloud on AWS services and HCX workload mobility solutions. With these services and solutions, they can align to business priorities—whether for cost purposes or governance requirements—and build out hybrid cloud use cases. They can extend this to other VCPP powered or native public cloud providers and leverage cloud-based multicloud security with Carbon Black. Thus, they can take advantage of SaaS-based Tanzu Mission Control for multicloud K8s cluster management and Aria SaaS services to incorporate cloud native infrastructure services and applications into their strategy. All this allows IT to be a strategic business enabler for new digital transformation initiatives.

VMware Cloud Foundation on VxRail makes data center operations simpler by bringing the ease and automation of the public cloud in-house. It deploys a standardized and validated flexible network architecture with integrated life cycle automation for the entire cloud infrastructure stack including hardware. It enables a true hybrid cloud based on a common and compatible VMware Cloud Foundation platform that stretches from on-premises to off-premises. The platform combines the speed and flexibility of a public cloud with the security and control of on-premises infrastructure. It provides simplicity, consistency, and peace-of-mind to customers and empowers organizations to deliver business innovation and differentiation.

Appendix A: References

- [Dell VxRail Hyperconverged Infrastructure](#)
- [VMware Cloud Foundation on VxRail Interactive Demo](#)
- [VMware Cloud Foundation on VxRail Architecture Guide](#)
- [VMware Cloud Foundation on VxRail Planning and Preparation Guide](#)
- [Dell VxRail Network Planning Guide](#)
- [Dell Networking Guides for VxRail](#)
- [Dell VxRail Appliance TechBook](#)
- [VMware Cloud Foundation documentation](#)
- [VMware Software-Defined Data Center \(SDDC\) Solutions](#)
- [VMware Aria Suite \(formerly vRealize Suite\)](#)
- [VMware Tanzu](#)
- [VMware Tanzu on Dell VxRail](#)
- [Dell Technologies APEX](#)
- [Dell PowerProtect Data Manager: Protection for VMware Cloud Foundation on Dell VxRail](#)
- [VMware Validated Solutions](#)

Appendix B: Business IT challenges and trends

Business IT challenges

Business IT departments are under significant pressure to rise to present IT demands. This means that IT is no longer responsible only for keeping the lights on; rather, it is now treated as a cost center and is responsible for playing a significant role in digital transformation.

As more of our daily lives and business opportunities shift into the digital world, there is a corresponding demand to prioritize IT activities within an organization. This shift has been disruptive for organizations with existing systems and operational models that failed to adapt quickly enough to meet business needs.

There is an imperative to deliver new modernized applications to market, to innovate with technology, and beat competitors, and to do it faster with more options. There are also requirements for stricter compliance, improved security, controlled costs, and increased efficiency. Lowering risk with disaster recovery (DR) and business continuity solutions is more critical than ever.

Traditional IT infrastructure is custom designed to fit particular needs of a business using any solution from any vendor. This flexibility comes with drawbacks, including the extensive time required for research and initial or expanded infrastructure ordered, installed, and ready to deploy applications. Infrastructure from multiple hardware and software vendors leads to separately managed operational silos, which rely on many IT staff members with different areas of expertise. Without centralized management, achieving security and compliance is much more difficult. When a problem occurs, support issues might result in circular finger pointing where vendors blame one another. Even with careful planning, upgrades run into complications and increased risk from interactions between products from different vendors.

Each product in this type of legacy stack is likely to be grossly overprovisioned, using its own resources (CPU, memory, and storage) to address the intermittent peak workloads of resident applications. The value of a single shared resource pool, offered by server virtualization, is still generally limited to the server layer. Low utilization of the overall stack results in a ripple effect of high acquisition, space, and power costs. Too many resources are wasted in traditional legacy environments.

Physical IT infrastructure consists of complex hardware silos that are difficult to manage or automate. Regular maintenance tasks and hardware outages require expensive downtime. Mitigating the problem using dedicated standby hardware is expensive. The hardware-centric architecture results in operational inefficiencies because of factors such as the limited capacity of the CPUs in running applications, a single operating system image per machine and inflexible infrastructure that is difficult to troubleshoot.

These problems can be mitigated by trading off a highly flexible choice of vendors and applications for building the infrastructure with a more standardized infrastructure that is easier to support and maintain. Traditional IT can use product compatibility lists to help alleviate multivendor support issues by reducing the scope of solutions that can be considered for use to only those products included in the compatibility list. However, without easy automation solutions and limited IT staff, achieving compliance is still challenging.

Trend to hyperconverged infrastructures

Hyperconverged infrastructures help IT organizations standardize multi-vendor product options, reducing the time, cost, and risk of deploying, configuring, and managing hardware and software components separately.

HCI uses software-defined technologies to provide compute, storage, and networking infrastructure services, rather than using traditional purpose-built hardware components. HCI software defines the storage that is installed inside individual servers into a single, shared pool of storage and then runs workloads on those servers. HCI is usually deployed on standard server components, providing a simplified scale-out architecture with intelligence and rich data services moved to the software layer. With a much narrower set of potential hardware and software combinations, HCI vendors more thoroughly test their hardware and software stack, providing easier software and hardware upgrades.

Organizations are shifting from traditional do-it-yourself infrastructure to HCI solutions to address their business IT challenges. With HCI, multiple pre-engineered and pre-integrated components operate under a single controlled architecture with a single point-of-management and a single source for end-to-end support. HCI provides a localized single resource pool that enables a higher overall resource utilization than can be achieved with legacy infrastructure. Overall total cost of ownership (TCO) is lower with operational savings from simplified management. In the data center, HCI typically has a smaller footprint with less cabling and can be deployed much faster and at lower total cost than traditional infrastructure.

Industry infrastructure deployment is transforming as customers begin to shift from a “build” to a “consume” approach. This deployment shift is being driven by the need for IT to focus limited economic and human capital resources on driving business innovation, resulting in fewer resources available for infrastructure. While a “build-your-own” deployment strategy can achieve a productive IT infrastructure, this strategy can be difficult and lengthy to implement. It can also make customers vulnerable to higher operating costs and susceptible to greater risk related to component integration, configuration, qualification, compliance, and management. A “consume” deployment strategy for HCI provides the benefits of previously integrated, configured, qualified, and compliant components. Purchasing an HCI system provides a single optimized IT solution that is quick and easy to deploy. A “consume” deployment strategy for HCI provides a simple and effective alternative to “build-your-own” and has been widely adopted.

Defined infrastructures

Virtualization transforms physical systems into a virtual environment by creating a logical version of a device or resource. This includes anything from a server to an operating system. Virtualization helps solve problems with utilization and rapid scalability. Without virtualization, traditional server utilization is typically in only the 6 percent to 12 percent range.

Traditional hardware comes in fixed sizes and is difficult to scale and fully use. Virtualization allows organizations to purchase more powerful equipment with better performance and put many optimally sized virtualized resources on it. Technologies such as overprovisioning, automatic load balancing, clustering and parallel processing optimize resources and improve uptime. Virtualization technology emulates hardware by using software that hides details of the underlying physical hardware. Multiple hardware components and the functionality of that hardware can be efficiently emulated on less expensive, nonspecialized hardware.

Server virtualization has high adoption rates in data centers of all sizes. Storage virtualization groups physical storage from multiple storage devices so that it looks like a single storage device. Software-defined storage (SDS) includes storage virtualization and goes further to abstract all storage services from hardware devices using software to create, deploy, and manage storage resources and infrastructure. SDS replaces expensive proprietary storage solutions with software-defined storage that uses x86 technology. By using industry-standard x86 technology, SDS helps eliminate the need for storage area networks (SANs) and proprietary storage expertise. Organizations can also reduce their storage footprint, which lowers hosting and cooling costs.

Software-defined networking (SDN) is a system networking architecture that separates the data plane from the control plane through routers and switches. The control plane is implemented in servers using software and is separate from networking hardware. The data plane is implemented in networking hardware. In traditional networking, when a data packet arrives at a switch or router, the firmware tells the hardware where to forward the packet and sends all packets to that destination using the same path. All packets are treated the same. More advanced smart switches equipped with application-specific integrated circuits recognize different types of packets and treat them differently based on the ASIC programming. These switches, however, are expensive.

SDN decouples networking control from the hardware's firmware. The network administrator can centrally configure network traffic without changing the settings of individual switches. The administrator can change network rules, prioritization, and selectively block packets with greater control. SDN provides better control of network traffic and offer better security options while using less expensive commodity switches as the underlying hardware layer.

Software-defined data center (SDDC) solution

Combining server, storage, and network virtualization together leads to a completely software-defined infrastructure. *The Why, the What and the How of the Software-Defined Data Center* (Osterman Research, May 2017) identifies the business benefits of the SDDC solution:

- **Improved speed and productivity of IT staff**
With the right tools, SDDC is easier to configure, reconfigure, and secure, resulting in IT operations that are more responsive to change and more efficient. SDDC also permits frequent service updates and rapid standup and teardown of test environments.
- **Improved security**
SDDC's software-defined nature enables consistently enforced policies that act on logical, abstracted characteristics of the workload and its data. Traditional data center operations must distribute rules across a range of different hardware devices that require manual updates with inevitable hardware and configuration changes. In an SDDC, relevant policies remain in place and automatically adjust to changes in the underlying physical environment of SDDC workloads.
- **Improved reliability**
Traditional IT operations are inherently error-prone, even when using a centralized management console. SDDC's ability to automate operations reduces repetitive tedium and error, which maximizes security and minimizes unplanned downtime.

Trending to public and hybrid cloud

- **Improved utilization of hardware**

Virtualization increases the hardware utilization, allowing organizations to make more efficient use of their capital expenditures. For example, it allows several workloads to share software-defined computing, storage and network resources. SDDC unifies networking functions using nonspecialized hardware avoiding lock-in to specific networking equipment.

- **It enables an interoperable cloud**

SDDC helps organizations realize the benefits of hybrid clouds without vendor or technology lock-in. The combination of automation, abstraction, visibility, and control fosters consistency that will ease the placing of workloads into public or private clouds to an even greater extent than virtualization alone would permit.

The benefits of cloud computing drive more organizations to use cloud computing as a key part of their IT infrastructure.

The National Institute of Standards and Technology (NIST) provides the following definition of cloud computing:

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models.”⁴

The essential characteristics of cloud computing are:

- On-demand self-service
- Broad network access
- Resource pooling
- Rapid elasticity
- Measured service

A public cloud is formed when a cloud provider makes computing resources publicly available over the Internet or other broad network channels. In a public cloud, setup for a consumer is usually quick and easy. Users pay for the resources they use, rather than for direct hardware. Some providers also charge a subscription fee. The cloud can also provide more resources, meaning customers do not have to install additional software or hardware.

One major concern for many organizations using the public cloud is data security and governance. A private cloud resolves this issue. A private cloud describes a computing infrastructure privately held by an organization. It has capabilities similar to a public cloud but is completely internal and so could be considered more secure based on an organization's regulatory and compliance requirements. Virtualization provides many cloud-like resource allocation features. Additional cloud management tools can be used to build a private cloud.

⁴ <https://csrc.nist.gov/publications/detail/sp/800-145/final>

Various studies conducted by IT analyst firms show that organizations want to use multiple cloud platforms across both public and private clouds resulting in a potentially complex multicloud strategy. As Jeff Clarke, vice chairman of products and operations of Dell Technologies, said, “Cloud is not a destination; it’s an operating model.”⁵

Transforming from legacy to modern applications and multicloud

IT departments are responsible for managing their application portfolio. That portfolio is typically split into two categories: existing applications and new applications. For existing applications, customers may be responsible for managing costs and maintaining a reliable, secure environment that will keep an existing portfolio of applications extended through its logical lifespan. At the same time, they are prioritizing new built-in-the-cloud applications focused on differentiating their business from their competition.

Customers have several choices they can make about how to support legacy applications in a dual portfolio, as shown in Figure 32. For example:

- Customers can choose to maintain applications unchanged, but in an increasingly virtualized and enhanced environment;
- They can also choose to move applications to the cloud and re-platform;
- They can refactor or rebuild applications for the cloud, build brand new applications in the cloud, or replace them with a set of SaaS applications.

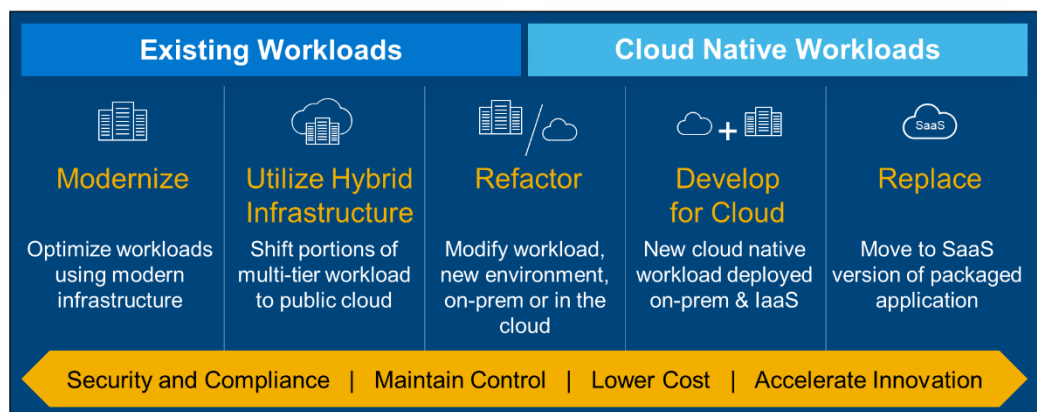


Figure 32. Matching cloud strategies to the needs of each workload

For many organizations, this increasingly diverse application landscape can complicate IT functions. Over 93 percent of organizations now deploy their workloads across two or more clouds.⁶ This multicloud approach can become increasingly complex due to multiple operational silos, resulting from disparate management and operations tools, increasingly complex application and infrastructure life cycle management, ultimately delivering inconsistent service level agreements (SLAs). Solving this complexity is one of the biggest IT challenges.

⁵ <https://www.livemint.com/technology/tech-news/why-michael-dell-is-betting-big-on-multi-cloud-strategy-1556592666769.html>

⁶ IDC White Paper, sponsored by Cisco, Adopting Multicloud — A Fact-Based Blueprint for Reducing Enterprise Business Risks, June 2018

Customer workload needs evolve, meaning customers starting with a private cloud may want to extend to a public cloud, or conversely bring their resources back on-premises. Various studies show that organizations want to use various cloud platforms across both public and private clouds. When ESG surveyed CIOs, 91 percent of respondents reported that their company's cloud strategy would include on-premises data centers where many have found some workloads realize 2-4x savings compared to the public cloud alone.

Customers want future proof cloud decisions and flexibility through a hybrid cloud strategy. To do so effectively, however, requires customers to simplify the multicloud complexity challenge. Customers value a hybrid cloud strategy, which addresses the biggest issue regarding extension across on-premises and off-premises, with 83 percent of customers stating that they value consistency of infrastructure from data center to cloud.⁷

⁷ VMware Cloud Market Study, January 2018

Appendix C: VMware SDDC

Introduction

VMware is a leader in providing both virtualization and management products that support an SDDC and integrates them into a cohesive solution.

VMware SDDC vision

The VMware vision of the modern data center starts with a foundation of software-defined infrastructure and is based on the value customers realize from a standardized architecture. VMware SDDC provides a fully integrated hardware and software stack that is simple for customers to manage, monitor, and operate. The VMware approach to the SDDC delivers a unified platform that supports any application and provides flexible control. The VMware architecture for the SDDC empowers companies to run private and hybrid clouds and to leverage unique capabilities to deliver key outcomes that enable efficiency, agility, and security.

The fully virtualized data center is automated and managed by intelligent, policy-based data center management software, which simplifies governance and operations. A unified management platform enables centralized monitoring and administration of all applications across physical geographies, heterogeneous infrastructure, and hybrid clouds. Workloads can be deployed and managed in physical, virtual, and cloud environments with a unified management experience.

The VMware SDDC is based on well-established products from VMware. vSphere, vSAN, and NSX to provide compute, storage, and networking virtualization to the SDDC. The Aria Suite (formerly vRealize Suite) provides additional management, self-service, automation, intelligent operations, and financial transparency to the system. This forms a solid foundation to host both traditional and cloud-native application workloads.

IT service delivery automation

Organizations that are running traditional hardware data center architectures are forced to rely on manual processes, scripting, and complicated communication between teams to get new applications to market. They experience lengthy and costly challenges provisioning networks, and troubleshooting manual process configuration errors. By transforming to an SDDC, organizations can automate and manage IT processes in software. A fully automated environment can dramatically reduce the production-ready infrastructure and application component provisioning time from days or weeks down to a matter of minutes.

As part of the VMware SDDC cloud management platform, VMware Aria Automation (formerly vRealize Automation), can solve the challenges observed in traditional data center architectures with comprehensive and extensible automation capabilities, providing a self-service cloud experience. The ability to integrate into existing processes maximizes the SDDC platform return on investment (ROI) and ensures that it is not just an island in the environment.

Service architects use a convenient visual interface to design service blueprints that can span one or multiple VM templates, logical networks, load balancers, security policies, software components, and scripts. Using this approach, they can model comprehensive IaaS and application services, which can be exposed to end users through the customizable self-service catalog, as shown by the example in Figure 33. Provisioning and LCM of these standardized services (scaling out of the application components,

change requests, de-provisioning) can be fully automated. This automation accelerates IT service delivery and eliminates error-prone operations, resulting in reduced operational costs and improved end-user experience.

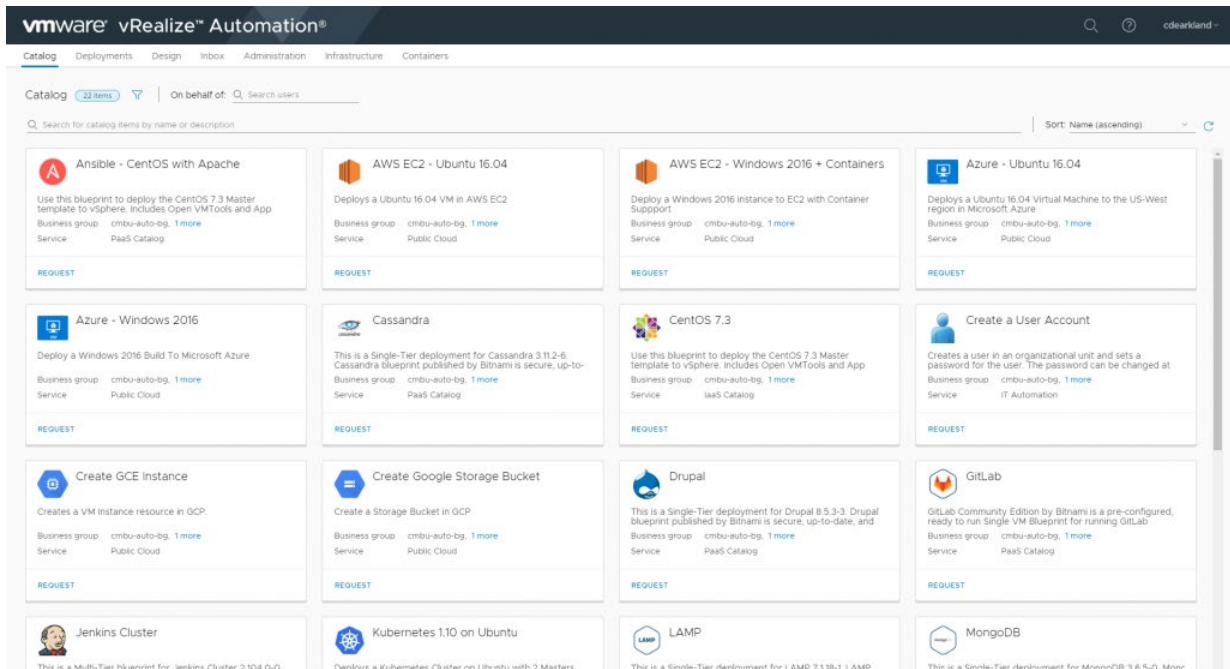


Figure 33. Sample self-service catalog configured within vRealize Automation

With integrated orchestration and several choices for predefined plug-ins, automated workflows can be built to integrate the platform with the external environment, including backup, configuration management, CMDB, service desk systems, and other ITSM tools. By leveraging orchestrator workflows, it is possible to define and expose XaaS (anything-as-a-service) in the self-service catalog. All these services can be consumed by end users through a web-based portal or by developers through the API or CLI.

vRealize Automation policies provide governance for the IT services being offered using the platform. The service catalog can be customized, making sure that the services are only exposed to appropriate users and groups. Reservation policies can be used to prioritize the assignment of infrastructure resources and stay below quotas and to alert administrators when approaching defined thresholds. Multiple levels of approval policies can be defined for request approval from both business (cost) and technical (configuration) perspectives, eliminating potential VM-sprawl enabled by the self-service automated consumption.

Note: The orchestration capabilities provided by vRealize Automation are focused more on workloads and integration with the external environment, enabling end users to consume these as services and at scale.

Security

Security tends to be a top concern for organizations adopting a cloud operating model. VMware SDDC provides a holistic approach to security that exceeds the capabilities typically found in a traditional data center architecture which often depends on perimeter security. In a diverse traditional infrastructure environment, it is challenging to maintain

consistent operations and compliance. vRealize Automation, used with NSX, automates an application's network connectivity, security, performance, and availability.

Network virtualization provided by NSX decouples the workloads from the underlying physical infrastructure by leveraging a network overlay technology and moves the intelligence of the network from hardware to software. A key innovation of NSX is the ability to provide network and security functions, such as switching, routing, and firewalling in a distributed fashion across all hosts and within the kernel-level module of the hypervisor.

A major benefit to this approach is an enhanced distributed security model, where security policies are applied closer to the workload, using virtualization-aware, higher-level security constructs, and where security policies move with the workload. NSX helps to segment the environment, decreasing risk and the attack surface while increasing the security.

NSX microsegmentation is a specific security function that decreases the level of risk and increases the security posture of a data center. It is achieved with a distributed stateful firewalling that is implemented at the kernel-level of the hypervisor and distributed across all hosts in the environment. Security policies are applied at the vNIC level, independently from the underlying physical network topology, with per-workload granularity. A grouping construct called Security Group can be leveraged to dynamically identify workloads based on matching criteria, such as VM name, Security Tag, operating system type, Active Directory group, and more. This means when workloads are moved between hosts the security policies automatically move with the workloads. The IT administrator can define vRealize Automation application blueprints that specify NSX security policies that contain firewall rules, intrusion detection integration, and agentless anti-virus scanning at each application tier to allow application and per-tier security. Deploying network security at the application level or between application tiers to ensure that firewall rules are placed as close to the virtual machine as possible provides a true defense-in-depth solution. Such a solution was too expensive and difficult to implement for a transitional hardware-based infrastructure.

vRealize Automation provisions, updates, and decommissions network and security services in lockstep with virtualized applications. Network and security services are deployed as part of the automated delivery of the application, consistent with its connectivity, security, and performance requirements.

NSX provides advanced security features, including microsegmentation, to cloud native applications. It supplies Kubernetes clusters with advanced container networking and security features, such as microsegmentation, load balancing, ingress control, and security policies. NSX furnishes the complete set of Layer 2 through Layer 7 networking services that are needed for pod-level networking in Kubernetes. Customers can quickly deploy networks with microsegmentation and on-demand network virtualization for containers and pods.

VMware SDDC security is not limited to NSX and microsegmentation. Encryption protects the confidentiality of information by encoding it to make it unintelligible to unauthorized recipients. In VMware SDDC, data on the datastore can be encrypted using native vSAN encryption, individual VMs can be encrypted using vSphere Encryption, and VMs in motion can be encrypted using vMotion encryption. Additional levels of encryption may be configured based on the application requirements.

vSAN encryption is the easiest and most flexible way to encrypt data at rest because the entire vSAN datastore is encrypted with a single setting. This encryption is cluster-wide for all VMs using the datastore. Encrypted data does not benefit from space-reduction techniques such as deduplication or compression. But with vSAN, encryption is performed after deduplication and compression, so it takes full advantage of these space reduction techniques.

Hybrid cloud ready

VMware SDDC can be deployed as a private cloud on premises or offsite using secure infrastructure-as-a-service (IaaS) operated by VMware or VMware certified partners.

Customers can build a true hybrid cloud, by integrating their private cloud with VMware Cloud on AWS. Using a Hybrid Linked Mode a VMware Cloud on AWS vCenter Server instance can be linked with an on-premises VMware vCenter Single Sign-On domain. Once linked the inventories of both vCenters can be viewed and managed from a single vSphere Client interface, and workloads can be easily migrated between them.

Multiple public cloud providers can be connected to vRealize Automation as endpoints. In this case, the automated service provisioning and basic life cycle management operations can be extended to popular public cloud IaaS services by using the same self-service portal, while maintaining the same governance principles as in the private cloud. This provides greater transparency, increases internal control, and eliminates “shadow IT.” The organization IT department can become a service broker agent for their internal customers, enabling a multicloud experience. The VMware vRealize Business for Cloud component, integrated into the same self-service portal, can be used to provide cost transparency and showback.

Additionally, the inclusion of an optional VMware HCX component can provide workload mobility between enterprise sites and VMware Cloud on AWS. It enables large-scale application mobility between sites with secure live migration enabling customers to transform their applications and data centers more rapidly and securely.

To learn more about VMware HCX, see the [product website](#).

Appendix D: VMware Cloud Foundation

Introduction

VMware Cloud Foundation is an integrated software stack. It bundles compute virtualization (VMware vSphere), storage virtualization (VMware vSAN), network virtualization (VMware NSX), cloud management and operations (VMware Aria Suite, formerly VMware vRealize Suite) and Kubernetes-based container services (VMware Tanzu) into a single platform. The platform can be deployed on premises as a private cloud or run as a service within a public cloud. VMware Cloud Foundation can be a common platform for running traditional and next-generation containerized applications. It helps to break down the traditional administrative silos in data centers, merging compute, storage, network provisioning, and cloud management to facilitate end-to-end support for application deployment.

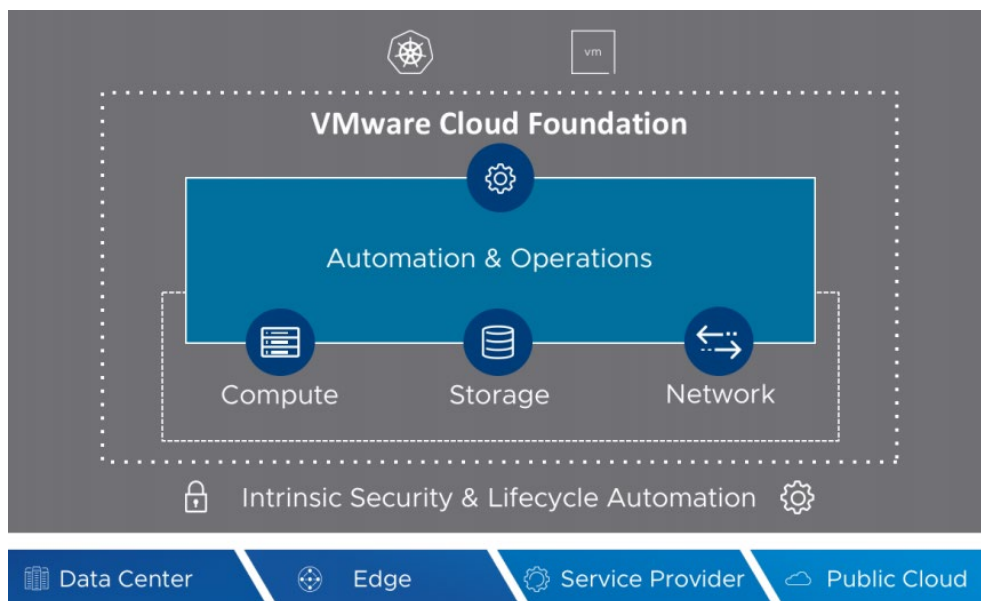


Figure 34. VMware Cloud Foundation software stack

VMware Cloud Foundation is an integrated software platform. Its SDDC Manager component automates the life cycle management of a complete SDDC on standardized hyperconverged architecture. It can be deployed on premises on a broad range of supported hardware or consumed as a service in the public cloud. With integrated cloud management capabilities, the result is a hybrid cloud platform that spans private and public environments. It offers a consistent operational model, based on well-known vSphere tools and processes, and freedom to run applications anywhere without the complexity of rewriting applications.

Key features and capabilities

Key features of VMware Cloud Foundation include:

- **Integrated stack:** An engineered solution that integrates the entire VMware software-defined stack with guaranteed interoperability, freeing organizations from dealing with complex interoperability matrixes.
- **Enterprise-grade services,** based on VMware technologies: vSphere, vSAN, NSX, and Aria Suite (formerly vRealize Suite) delivering enterprise-ready cloud infrastructure services for both traditional and containerized applications.

- **Integrated intrinsic security** delivers network-level microsegmentation, distributed firewalls and Virtual Private Network (VPN), compute-level encryption for VM, hypervisor and vMotion, and storage-level encryption for data at rest and clusters.
- **Self-driving operations** enable self-driving health, performance, capacity, and configuration management to scale and manage the environment efficiently.
- **Self-service automation** automates the delivery of IaaS and application services using blueprints (templates) that bind compute, storage, networking, and security resources through policies.
- **Standardized architecture** automatically deploys a hyperconverged architecture based on a VMware Validated Designs for SDDC, ensuring quick, repeatable deployments while eliminating risk of misconfiguration.
- **Storage elasticity and high performance** provide a hyperconverged architecture with all-flash performance and enterprise-class storage services, including deduplication, compression, and erasure coding.
- **Automated life cycle management** includes unique life cycle management services that automate Day 0 to Day 2 operations. These operations range from deployment to configuration of the cloud environment, to on-demand provisioning of infrastructure clusters (workload domains), to upgrades of the complete software stack.
- **Automated deployment** automates the bring-up process of the entire software platform, including creation of the management cluster, configuration of storage, deployment of platform components/management VMs, and provisioning using standardized architecture designs.
- **Workload domain and cluster provisioning** enables on-demand provisioning of isolated infrastructure clusters to separate workloads.
- **Simplified updating and upgrades** enable simplified updating and upgrading of the software platform (including VMware vCenter Server). Cloud administrators have the flexibility to choose the timing and scope of the updates.
- **Simple path to hybrid cloud** dramatically simplifies the path to hybrid cloud by delivering a common platform for private and public clouds. It enables a consistent operational experience and the ability to quickly and easily move workloads at scale across clouds without rearchitecting applications, leveraging VMware HCX.
- **Tanzu Runtime Services and Hybrid Infrastructure Services** that provide the basis for the cloud infrastructure and container ecosystems to accelerate developer productivity.

SDDC Manager

SDDC Manager automates configuration, provisioning, and life cycle management of the entire SDDC stack. This automation helps administrators build and maintain the SDDC. It also automates the installation and configuration of Aria Suite (formerly vRealize Suite) components due to integration with vRealize Suite Lifecycle Manager. SDDC Manager complements well-known VMware management tools such as vCenter Server and vRealize Operations that are available for advanced administration tasks and integration with third-party software tools.

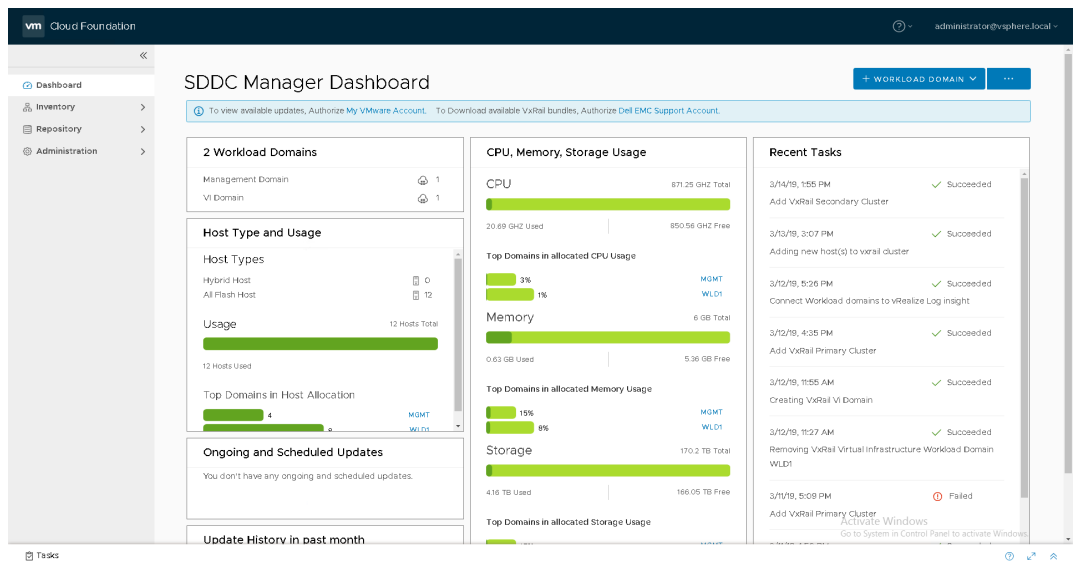


Figure 35. SDDC Manager main dashboard

The automated deployment of VMware Cloud Foundation is performed with the help of Cloud Builder, which manages the orchestration of the initial deployment and configuration of an SDDC platform ensuring that it adheres to the architecture best practices. Cloud Builder creates the management domain with the VMware SDDC components. Cloud Builder has been uniquely engineered to integrate with VxRail. When Cloud Builder is deployed with the VxRail profile enabled, it deploys and configures only the platform components that VxRail Manager has not already deployed and configured as part of standard VxRail cluster creation (such as deploying and configuration SDDC Manager and NSX, and more).

Simplified resource management with workload domains

VMware Cloud Foundation can scale up from a set of four or seven initial nodes, in increments as small as one server, up to thousands of servers in a single VMware Cloud Foundation environment. The physical compute, storage, and network infrastructure becomes part of a single shared pool of virtual resources that is managed as one system using SDDC Manager, removing any physical constraints of a single physical server or rack. From this shared pool, customers can carve out separate workload domains, each with its own set of specified CPU, memory, and storage requirements to support various workloads.

Workload domains are a policy-driven approach for defining performance, availability, and security parameters. SDDC Manager automatically implements a deployment workflow to translate the workload domain specifications into the underlying pool of resources. Through the automation of tasks and workflows, SDDC Manager simplifies provisioning, monitoring, and ongoing management of both logical and physical resources of VMware Cloud Foundation.

Support for multiple instances and availability zones

Customers can deploy VMware Cloud Foundation environments in various locations to support various multisite, stretched cluster, and cloud edge use cases by leveraging additional guidance contained in the VMware Validated Solutions.

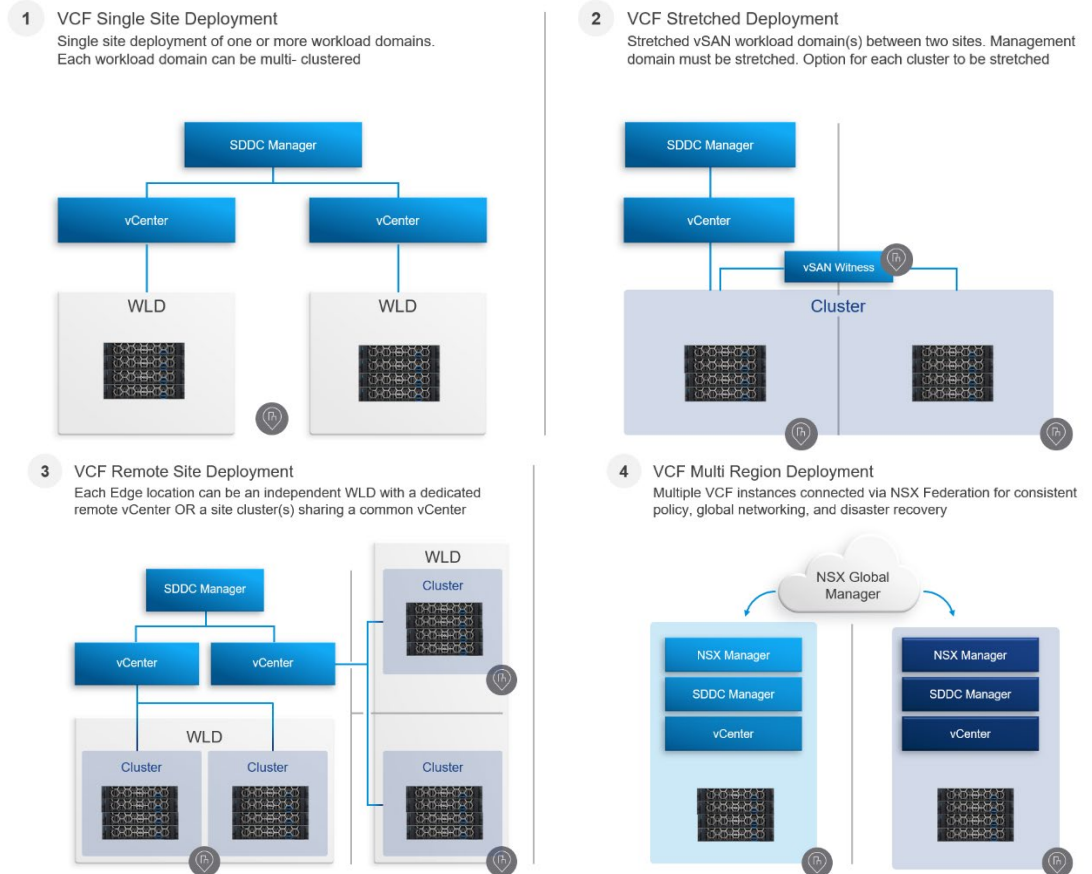


Figure 36. VMware Cloud Foundation multisite architectures

Expanding to public cloud to deliver a true hybrid cloud experience

VMware Cloud Foundation dramatically simplifies the path to hybrid cloud adoption by delivering a common platform for private and public clouds. It enables a consistent operational experience and the ability to quickly and easily move workloads at scale across clouds without rearchitecting applications, leveraging VMware HCX.

For simplified management, VMware Cloud Foundation, you can take advantage of Hybrid Cloud Linked Mode capabilities in vCenter to connect to a vCenter instance in a VMware powered public cloud such as VMC on AWS. This provides centralized visibility of the on-premises SDDC infrastructure and workloads along with the SDDC infrastructure and workloads running in the VMC on AWS instance.

Leveraging Cloud Management with VMware Aria Automation (formerly vRealize Automation), you can develop a centralized IT self-service catalog for the business to consume that is sourced from on-premises and public cloud infrastructure services. vRealize Automation has integration not just with VMware Cloud Foundation based public cloud services but also other native clouds such as AWS EC2 and Microsoft Azure. This allows IT teams to determine which clouds make the most sense to source the catalog services their business can consume using self-service.

For example, when a user requests a new Windows operating system based virtual machine, IT can determine if it is more valuable to automatically deploy that VM in the public cloud on a VMC on AWS service or deploy on premises in the VMware Cloud Foundation on VxRail private cloud. The public cloud integration makes businesses more

agile and flexible to align the physical location of where a workload should run based on business needs all while still maintaining control and visibility.

The other areas of hybrid cloud operations include the workload mobility capabilities available through HCX, which allows customers to perform online VM migrations to VMware powered public clouds nondisruptively. This function allows customers to vMotion their virtual machines to the public cloud and back to on premises.



Figure 37. Building a hybrid cloud with VMware Cloud on AWS and other partner clouds

Appendix E: VMware SDDC common component details

VMware vSphere The VMware vSphere software suite delivers an industry-leading virtualization platform to provide application virtualization within a highly available, resilient, efficient on-demand infrastructure. ESXi and vCenter are components of the vSphere software suite. ESXi is a hypervisor installed directly onto a physical server node, enabling it to be partitioned into multiple virtual machines (VMs). VMware vCenter server is a centralized management application that is used to manage the ESXi hosts and VMs.

vCenter Server is the centralized console for managing a VMware environment. It is the primary point of management for both server virtualization and vSAN. vCenter Server is the enabling technology for advanced capabilities such as VMware vSphere vMotion, VMware vSphere Distributed Resource Scheduler (DRS), and VMware vSphere High Availability (HA). vCenter supports a logical hierarchy of data centers, clusters, and hosts, which allows resources to be separated by use cases or lines of business and allows resources to move dynamically as needed. This is all performed from a single interface.

VMware ESXi is an enterprise-class hypervisor that deploys and services VMs. Figure 38 illustrates the basic ESXi architecture.

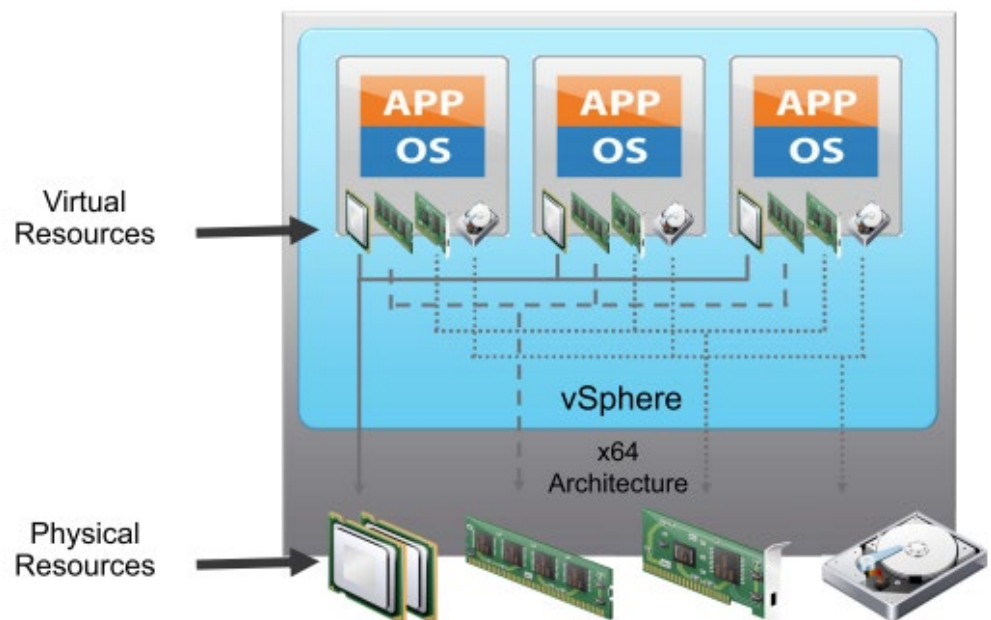


Figure 38. vSphere ESXi architecture

ESXi partitions a physical server into multiple secure, portable VMs that can run side by side on the same physical server. Each VM represents a complete system with processors, memory, networking, storage, and BIOS. Guest operating systems and software applications can be installed and run in the VM without requiring modification.

The hypervisor provides physical-hardware resources dynamically to VMs as required to support the operation of the VMs. The hypervisor enables VMs to operate with a degree of independence from the underlying physical hardware. For example, a VM can be moved from one physical host to another. Also, the VM's virtual disks can be moved from one type of storage to another without affecting the functioning of the VM.

ESXi also isolates VMs from one another. When a guest operating system on a host fails, other VMs on the same physical host are unaffected and continue to run. VMs share access to CPUs and the hypervisor is responsible for CPU scheduling. In addition, ESXi assigns VMs a region of usable memory and provides shared access to the physical network cards and disk controllers associated with the physical host. Different VMs can run different operating systems and applications on the same physical system.

VMware vSAN

vSAN is VMware's software-defined storage solution specifically engineered for vSphere VMs. It abstracts and aggregates locally attached disks in a vSphere cluster to create a storage solution that can be provisioned and managed from vCenter and the vSphere Web Client. vSAN integrates with the entire VMware stack, including features like vMotion, HA, and DRS. VM storage provisioning and day-to-day management of SLAs can all be controlled through VM-level policies that can be set and modified on-the-fly. vSAN delivers enterprise-class features, scale, and performance, making it the ideal storage platform for VMs.

The figure below shows an example of a hybrid configuration where each node contributes storage capacity to the shared storage vSAN datastore. The SSD drive provides caching to optimize performance and hard disk drives for capacity. All-flash configurations (not shown) use flash SSDs for both the caching tier and capacity tier.

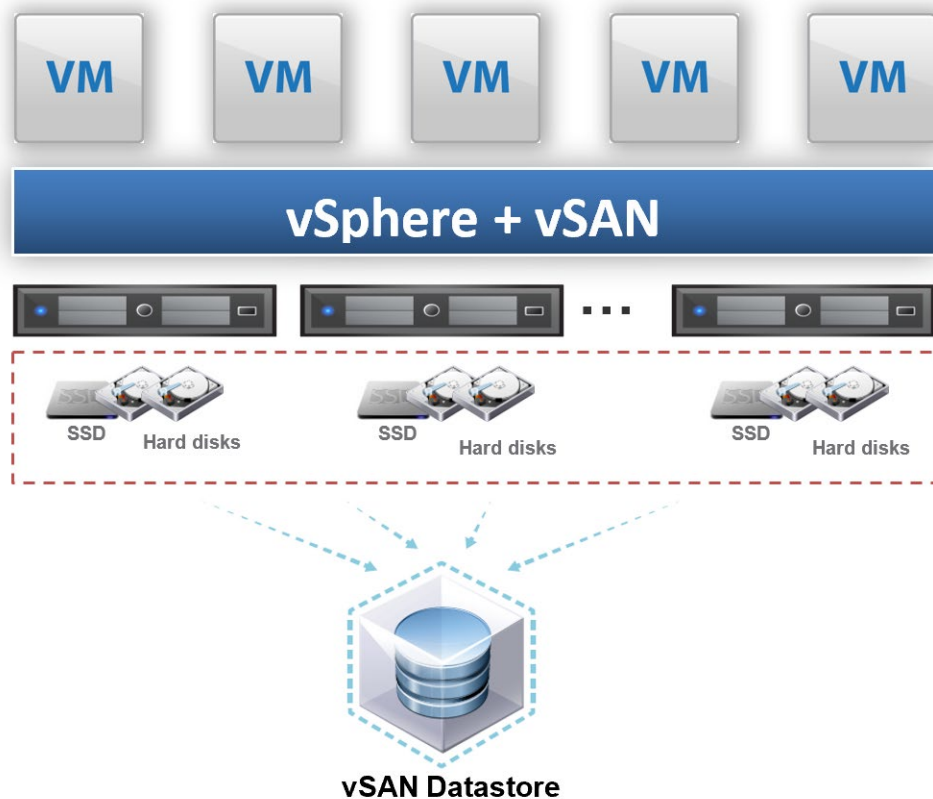


Figure 39. vSAN datastore

VMware NSX

VMware NSX is the network virtualization and security platform that enables VMware's cloud networking solution with a software-defined approach to networking that extends across data centers, clouds, and application frameworks. With NSX, networking and security are brought closer to the application wherever it is running, from virtual machines (VMs) to containers to physical servers. Like the operational model of VMs, networks can be provisioned and managed independent of underlying hardware. NSX reproduces the entire network model in software, enabling any network topology—from simple to complex multitier networks—to be created and provisioned in seconds. Users can create multiple virtual networks with diverse requirements, leveraging a combination of the services offered through NSX or from a broad ecosystem of third-party integrations, ranging from next-generation firewalls to performance management solutions, to build inherently more agile and secure environments. These services can then be extended to various endpoints within and across clouds.

VMware NSX delivers a new operational model for networking defined in software, forming the foundation of the software-defined data center (SDDC) and extending to a cloud network. Data center operators can achieve levels of agility, security, and economics that were previously unreachable when the data center network was tied solely to physical hardware components. NSX provides a complete set of logical networking and security capabilities and services. These include logical switching, routing, firewalling, load balancing, virtual private network (VPN), quality of service (QoS), and monitoring. These services are provisioned in virtual networks through any cloud management platform leveraging NSX APIs. Virtual networks are deployed nondisruptively over any existing networking hardware and can extend across data centers, public and private clouds, container platforms, and physical servers.

The main use cases of VMware NSX are as follows:

- **Security**
NSX makes operationalizing Zero Trust security for applications attainable and efficient in private and public cloud environments. Whether the goal is to lock down critical applications, create a logical demilitarized zone (DMZ) in software, or reduce the attack surface of a virtual desktop environment, NSX enables microsegmentation to define and enforce network security policy at the individual workload level.
- **Multicloud networking**
NSX delivers a network virtualization solution that brings networking and security consistently across heterogeneous sites to streamline multicloud operations. As a result, NSX enables multicloud use cases ranging from seamless data center extension to multi-data-center pooling to rapid workload mobility.
- **Automation**
By virtualizing networking and security services, NSX enables faster provisioning and deployment of full-stack applications by removing the bottleneck of manually managed networking and security services and policies. NSX natively integrates with cloud management platforms and other automation tools, such as VMware Aria Automation, Terraform, Ansible and more, to empower developers and IT teams to provision, deploy, and manage applications at the speed that business demands.
- **Networking and security for cloud-native applications**
NSX provides integrated, full-stack networking and security for containerized

applications and microservices, delivering granular policy on a per-container basis as new applications are developed. This enables native container-to-container L3 networking, microsegmentation for microservices, and end-to-end visibility of networking and security policy across traditional and new applications.

To learn more about NSX architecture in the context of VMware Cloud Foundation on VxRail, see the *VMware Cloud Foundation on VxRail Architecture Guide*.

VMware Aria Suite (formerly VMware vRealize Suite)

Most SDDCs are hybrid, with a mix of traditional and modern application architectures. They are provisioned in an increasingly virtualized mix of physical and virtual environments, managed both on-premises in private clouds and off-premises in public clouds. The concept of a cloud management platform has evolved as a response to this complex set of management requirements. VMware Aria Suite (formerly vRealize Suite) is a cloud management solution. It integrates VMware Aria (vRealize cloud management) products that together provide automation, operations, and log analytics in a hybrid IT environment.

The VMware vRealize cloud management platform includes the following features:

- **vRealize Automation** automates the delivery of IaaS or application services using blueprints (templates) that bind compute, storage, networking, and security resources through policies.
- **vRealize Business for Cloud** automates costing, usage metering and service pricing of virtualized infrastructure and cloud services.
- **vRealize Operations** provides intelligent health, performance, capacity, and configuration management. vRealize Operations offers performance and health monitoring and capacity planning as well as custom dashboards, capacity modeling and customized alerting. These insights help administrators maintain compliance and efficiently detect and resolve any issues that may arise.
- **vRealize Log Insight** provides real-time log management and log analysis. vRealize Log Insight lets administrators monitor physical and virtual infrastructure to avoid failures and performance issues. vRealize Log Insight provides centralized log aggregation and analysis with search and filter capabilities. This provides the ability to monitor all workloads from a single place.
- **vRealize Suite Lifecycle Manager** provides automated installation, configuration, upgrade, patch, drift remediation, health, and content management of vRealize products.
- **vRealize Network Insight** provides intelligent operations for software-defined networking and security. It accelerates microsegmentation planning and deployment, enables visibility across virtual and physical networks, and provides operational views to manage and scale VMware NSX deployments.

VMware Tanzu

VMware Tanzu is a portfolio of products, solutions, and services for building, running, and managing modern applications on any cloud. It simplifies multicloud operations while freeing developers to move faster with easy access to the right resources. VMware Tanzu enables development and operations teams to work together in new ways that deliver transformative business outcomes. VMware Tanzu is a modular cloud-native application platform that enables vital DevSecOps outcomes in a multicloud world.

The prominent use cases include:

- **Modernize existing business-critical applications**—VMware Tanzu with VMware Tanzu Labs can help you create and deliver on an application modernization strategy. Customers can replatform and rearchitect existing software to be resilient and continuously delivered, all while running in cloud environments. They can also modernize their infrastructure to simplify how their clouds, clusters, and applications operate, with security, stability, and scale in mind.
- **Streamline the developer experience for any Kubernetes**—VMware Tanzu offers a superior developer experience for building and deploying software quickly and securely on any compliant public cloud or on-premises Kubernetes cluster. Developers can access preconfigured cloud-native application templates and a rich set of rapid tooling to jump-start development and debug code straight from their IDE. Developers can also maintain visibility of applications at runtime to troubleshoot and improve their applications.
- **Enable a modern DevSecOps practice**—VMware Tanzu helps improve customers' security posture as they build and deploy containers to any cloud continuously. Automate security and compliance tasks through preapproved paths to production, logging and tracking the provenance of their code. They can also automate updates when they become available. VMware Tanzu enables operations and security teams to customize software supply chains to model their security processes and use compliant container images.
- **Centrally manage, secure, and monitor Kubernetes estate**—VMware Tanzu provides a set of capabilities that empowers platform operations teams to provision, manage, connect, secure, and observe a multicloud Kubernetes platform. From a centralized software-as-a-service (SaaS) management hub, customers can manage security and access policies for all compliant Kubernetes distributions. Customers can impose networking and security measures at multiple layers to meet the strictest security and compliance requirements. Customers can also gather and analyze platform and application metrics to proactively detect and fix anomalies, as well as fine-tune their infrastructure and applications for best performance.
- **Enrich public cloud strategy and reduce risk of vendor lock-in**—By abstracting applications from infrastructure, VMware Tanzu offers a consistent developer experience on any Kubernetes. It also offers the ability to operate all Kubernetes as one for maximum efficiency and security—whether it is in the public cloud or on VMware vSphere. This model allows customers to choose the best landing zones for their applications and can provide more flexibility in public cloud adoption. It lets business needs dictate cloud usage and avoids lock-in to any single cloud vendor or set of tools.

VMware Tanzu portfolio (Figure 40) consists of three main solutions and services:

VMware Tanzu Application Platform

VMware Tanzu Application Platform is a modular, application-aware platform. It provides a rich set of developer tooling and a pre-paved path to production to build and deploy software quickly and securely on any compliant public cloud or on-premises Kubernetes cluster. It helps jump-start application development, boost developer velocity, and accelerate the path to production.

VMware Tanzu for Kubernetes Operations

VMware Tanzu for Kubernetes Operations provides the foundation for building a modern Kubernetes-based container infrastructure at scale across all clouds. It helps simplify container management with tools, automation, and data-driven insights that boost developer productivity, secure applications and data, and optimize infrastructure performance across all your clouds.

VMware Tanzu Labs

Technology is only part of any modernization initiative. Customers might need support and expertise on their journey to deliver the outcomes they want in at the time they need them. VMware Tanzu Labs services can empower customers' teams to respond faster to their business needs and deliver the results that drive their business. With Tanzu Labs, customers can:

- Build and modernize applications, and quickly assess business-critical applications so they can start migrating existing software immediately.
- Develop a Kubernetes-based application platform and run it at scale, making life better for developers along the way.
- Adopt modern practices and culture changes necessary for meaningful transformation and sustained success.

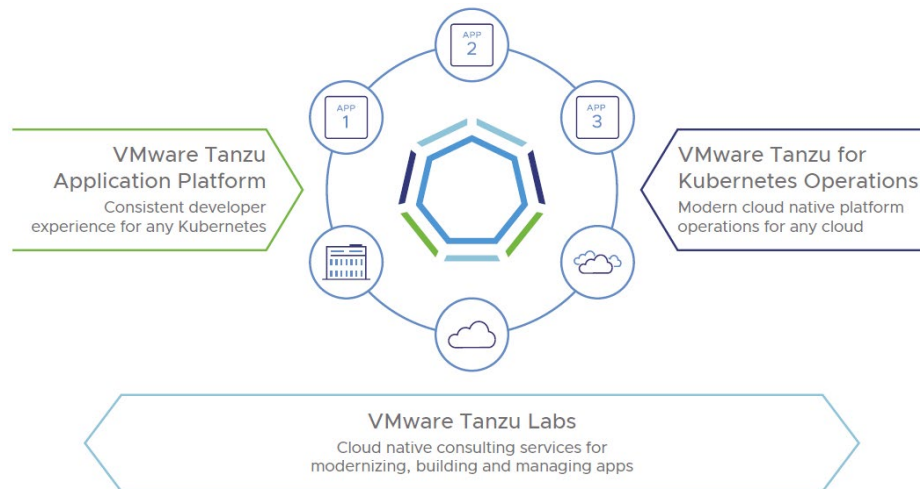


Figure 40. VMware Tanzu portfolio

For the latest information about VMware Tanzu, see the [VMware Tanzu website](#).