FOR LOWEST TCO AND MAXIMUM AGILITY CHOOSE *VMWARE CLOUD FOUNDATION*, THE SDDC PLATFORM FOR HYBRID CLOUDS

OCTOBER 2016

The race is on at full speed. What race? The race to bring public cloud agility and economics to a data center near you. Ever since the first integrated systems came onto the scene in 2010, vendors have been furiously engineering solutions to make on-premises infrastructure as cost effective and as easy to use as the public cloud, while also providing the security, availability, and control that enterprises demand. Fundamentally, two main architectures have evolved within the race to modernize data centers that will create a foundation enabling fully private and hybrid clouds. The first approach uses traditional compute, storage, and networking infrastructure components (traditional 3-tier) overlaid with varying degrees of virtualization and management software. The second more recent approach is to build a fully virtualized data center using industry standard servers and networking and then layer on top of that a full suite of software-based compute, network, and storage virtualization with management software. This approach is often termed a Software-Defined Data Center (SDDC).

The goal of an SDDC is to extend virtualization techniques across the entire data center to enable the abstraction, pooling, and automation of all data center resources. This would allow a business to dynamically reallocate any part of the infrastructure for various workload requirements without forklifting hardware or rewiring. VMware has taken SDDC to a new level with VMware Cloud Foundation. VMware Cloud Foundation is the only unified SDDC platform for the hybrid cloud, which brings together VMware's compute, storage, and network virtualization into a natively integrated stack that can be deployed on-premises or run as a service from the public cloud. It establishes a common cloud infrastructure foundation that gives customers a unified and consistent operational model across the private and public cloud.

VMware Cloud Foundation delivers an industry-leading SDDC cloud infrastructure by combining VMware's highly scalable hyper-converged software (vSphere and VSAN) with the industry leading network virtualization platform, NSX. VMware Cloud Foundation comes with unique lifecycle management capabilities (SDDC Manager) that eliminate the overhead of system operations of the cloud infrastructure stack by automating day 0 to day 2 processes such as bring-up, configuration, workload provisioning, and patching/upgrades. As a result, customers can significantly shorten application time to market, boost cloud admin productivity, reduce risk, and lower TCO. Customers consume VMware Cloud Foundation software in three ways: factory pre-loaded on integrated systems (VxRack 1000 SDDC); deployed on top qualified Ready Nodes from HPE, QCT, Fujitsu, and others in the future, with qualified networking; and run as a service from the public cloud through IBM, vCAN partners, vCloud Air, and more to come.

In this comparative study, Taneja Group performed an in-depth analysis of VMware Cloud Foundation deployed on qualified Ready Nodes and qualified networking versus several traditional 3-tier converged infrastructure (CI) integrated systems and traditional 3-tier do-it-yourself (DIY) systems. We analyzed the capabilities and contrasted key functional differences driven by the various architectural approaches. In addition, we evaluated the key CapEx and OpEx TCO cost components. Taneja Group configured each traditional 3-tier system's hardware capacity to be as close as possible to the VMware Cloud Foundation qualified hardware capacity. Further, since none of the 3-tier systems

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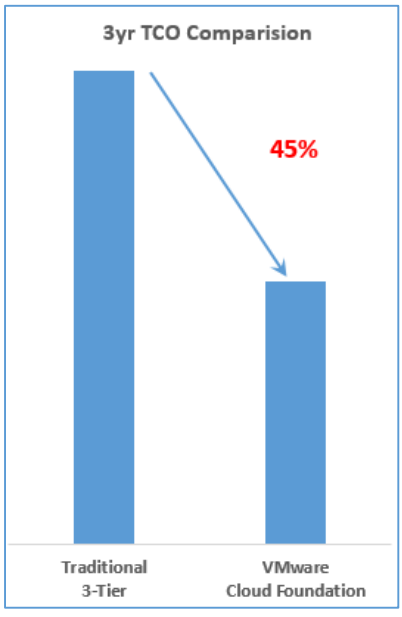
had a fully integrated SDDC software stack, Taneja Group added the missing SDDC software, making it as close as possible to the VMware Cloud Foundation software stack. The quantitative comparative results from the traditional 3-tier DIY and CI systems were averaged together into one scenario because the hardware and software components are very similar.

Our analysis concluded that both types of solutions are more than capable of handling a variety of virtualized workload requirements. However, VMware Cloud Foundation has demonstrated a new level of ease-of-use due to its modular scale-out architecture, native integration, and automatic lifecycle management, giving it a strong value proposition when building out modern next generation data centers. The following are the five key attributes that stood out during the analysis:

- **Native Integration of the SDDC:** VMware Cloud Foundation natively integrates vSphere, Virtual SAN (VSAN), and NSX network virtualization.
- **Simplest operational experience**: VMware SDDC Manager automates the life-cycle of the SDDC stack including bring up, configuration, workload provisioning, and patches/upgrades.
- **Isolated workload domains**: VMware Cloud Foundation provides unique administrator tools to flexibly provision subsets of the infrastructure for multi-tenant isolation and security.
- **Modular linear scalability:** VMware Cloud Foundation employs an architecture in which capacity can be scaled by the HCI node, by the rack, or by multiple racks.
- **Seamless Hybrid Cloud:** Deploy VMware Cloud Foundation for private cloud and consume on public clouds to create a seamless hybrid cloud with a consistent operational experience.

Taneja Group's in-depth analysis indicates that VMware Cloud Foundation will enable enterprises to achieve significant cost savings. Hyper-converged infrastructure, used by many web-scale service providers, with natively integrated SDDC software significantly reduced server, storage, and networking costs. This hardware cost saving more than offset the incremental SDDC software costs needed to deliver the storage and networking capability that typically is provided in hardware from best of breed traditional 3-tier components. In this study, we measured the upfront CapEx and 3 years of support costs for the hardware and software components needed to build out a VMware Cloud Foundation private cloud on qualified Ready Nodes. In addition, Taneja Group validated a model that demonstrates the labor and time OpEx savings that can be achieved through the use of integrated end-to-end automatic lifecycle management in the VMware SDDC Manager software.

By investing in VMware Cloud Foundation, businesses can be assured that their data center infrastructure can be easily consumed, scaled, managed, upgraded and enhanced to provide the best private cloud at the lowest cost. Using a pre-engineered modular, scale-out approach to building at web-scale means infrastructure is added in hours, not days, and businesses can be assured that adding infrastructure scales linearly without complexity. VMware Cloud Foundation is the only platform that provides a natively integrated unified SDDC platform for the hybrid cloud with end-to-end management and with the flexibility to provision a wide variety of workloads at the push of a button.



In summary, VMware Cloud Foundation enables at least **five** unparalleled capabilities, generates a **45% lower 3-year TCO than the alternative traditional 3-tier approaches,** and delivers a tremendous value proposition when building out a modern hybrid SDDC platform. Before blindly going down the traditional infrastructure approach, companies should take a close look at VMware Cloud Foundation, a unified SDDC platform for the hybrid cloud.

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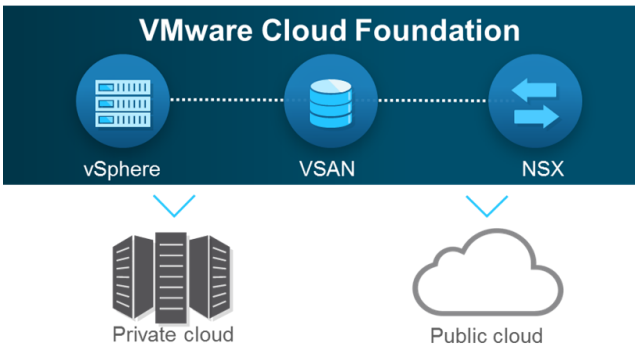
OVERVIEW OF THE CONTRASTING APPROACHES TO BUILDING A PRIVATE CLOUD

Existing approaches to building a private cloud require specialized hardware, prescriptive integration of missing SDDC software components, and extensive ongoing manual administration. Given the current resource burdens on IT managers, existing approaches only reduce some complexity, but, still require integration, additional ongoing administrative overhead, and expose applications to risks, which can all negatively impact business performance. The following summarizes the different approaches evaluated in this study.

VMware Cloud Foundation

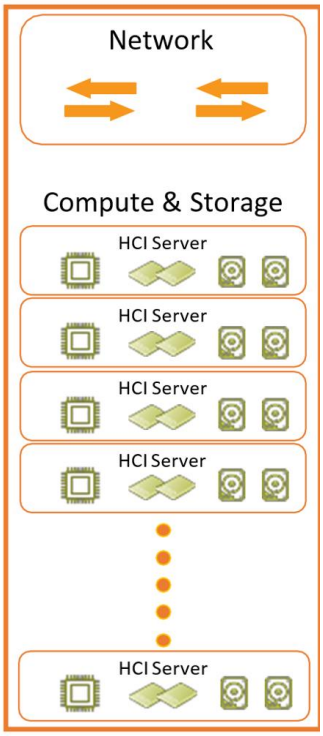
VMware Cloud Foundation software establishes a unified SDDC platform for the hybrid cloud. In the context of private cloud, customers can deploy VMware Cloud Foundation software on top qualified Ready Nodes from HPE, QCT, Fujitsu, and others in the future, with qualified networking. VMware Cloud Foundation has been designed from the start to be the simplest path to an SDDC private cloud, enabling certified VMware partners or customers to build SDDC clouds based on VMware Cloud Foundation for use at the time of delivery or build. Once a VMware Cloud Foundation system is delivered, customers simply need connect it to a network and, in a matter of hours, they have a complete SDDC cloud with compute, storage, networking, security, and management.

Figure 1: VMware Cloud Foundation Overview



VMware Cloud Foundation integrates logical and physical compute, storage, and networking into a unified solution. It brings together VMware's compute, storage, and network virtualization into a natively integrated stack that combines hyper-converged software (vSphere plus Virtual SAN) with network virtualization (NSX). A typical deployment contains x86-based HyperConverged (HC) Ready Nodes with Direct Attached Storage (DAS), top of rack (ToR) switches, a management switch, and Power Distribution Units (PDU). The second rack contains spine switches to interconnect racks in a highly resilient, scale-out, spine-leaf architecture. Figure 2 depicts the layout of a single rack.

Figure 2: Ready Nodes and Ready Networking



- **Networking:** Spine, Leaf, and management switches are provided by qualified hardware partners. VMware NSX provides network virtualization, load balancing, and security.
- **Management Cluster:** The management cluster uses 3+ hyper-converged servers and hosts the SDDC management software and necessary components.
- **Workload Clusters:** The hyper-converged servers are Ready Nodes from qualified partners with virtualization and software defined storage from VMware vSphere and VSAN.

The key difference from other partial SDDC architectures is that VMware Cloud Foundation virtualizes and abstracts every infrastructure layer – networking, compute, storage – using a natively integrated SDDC stack that embeds all layers as virtualized

services directly within the vSphere hypervisor kernel. The VMware Cloud Foundation SDDC platform can be optimized for various workload such IaaS private clouds or enterprise grade VDI. Finally, because the unified and natively integrated SDDC stack can be run as a service from the public cloud, VMware Cloud Foundation enables powerful hybrid cloud capabilities.

VMWARE CLOUD FOUNDATION INTEGRATED INFRASTRUCTURE MANAGEMENT

VMware Cloud Foundation includes VMware SDDC Manager, a new tool for the cloud operator to automate Day 0 to Day 2 workflows of the entire unified SDDC software stack. SDDC Manager automates the bring up and configuration process of the VMware Cloud Foundation stack, including VMware infrastructure VM deployment, management cluster creation, VLAN configuration, storage configuration, physical network configuration, cluster creation and provisioning, and more. Next, SDDC Manager enables a one-click patching/upgrading process of the complete VMware Cloud Foundation software stack. Cloud admins have the flexibility to choose the timing and scope of the updates and can apply updates/upgrades on a per workload domain basis. SDDC Manager simplifies resource allocation to individual workloads by automating cluster creation through policy-based provisioning. SDDC Manager provides REST-based API's to enable programmability and to integrate with the existing data center management and monitoring tools.

In summary, SDDC Manager provides:

- Automated, simplified, and rapid setup of the entire SDDC-based private cloud.
- Automated lifecycle management of the entire SDDC Platform including day 0 to day 2 processes such as bring-up, configuration, provisioning, and patching/upgrades.
- Workload Domain abstraction for isolating pools of resources into private cloud capacity with different availability, performance, and security attributes.
- Integrated management of servers/switches and virtualized resources from a single pane.
- Operational simplicity and automation for health monitoring of both physical and virtual infrastructures.
- Simplified IaaS and VDI service deployment and operations similar to a public cloud.

As a result, the VMware Cloud Foundation solution significantly improves agility and reduces TCO, enabling a simpler and cheaper way to deliver an SDDC private cloud.

Traditional 3-Tier Architecture-based Private Cloud

The alternative approaches involve using traditional 3-tier systems with several software components added in order to achieve a partially integrated SDDC solution. We analyzed several leading traditional 3-tier integrated systems (or converged infrastructure, CI) and several 3-tier DIY reference architecture derived systems. We based evaluations on external shared storage and blade-based computing infrastructure along with the appropriate VMware virtualization technology needed to build a solution. The reference architecture solutions were designed based on vendor designed and certified reference architecture solutions. Figure 3 shows the basic approach to the rack design using a traditional 3-tier architecture.

- **Networking:** Spine and Leaf based on networking provided by industry leaders. Hardware-based load balancing and security was used when needed in lieu of software-based.
- **Management Cluster:** A dedicated set of isolated servers forms a compute cluster which is sized to host all dedicated management software for operating both the hardware and virtualization software infrastructure.

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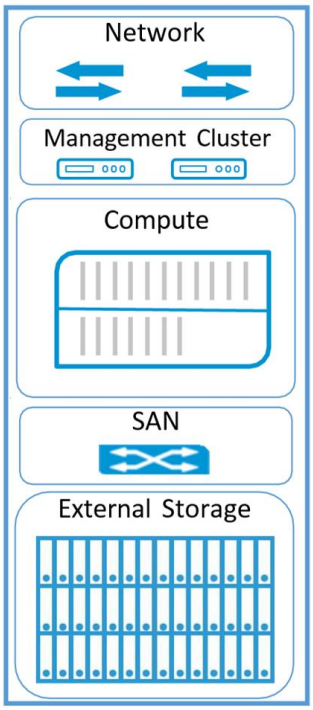
- **Compute Cluster:** A dedicated set of servers reserved exclusively for hosting private cloud workloads. All servers were based on blade servers with necessary components.
- **Storage Cluster:** External hybrid storage arrays and storage controllers were evaluated. The storage area network (SAN) was based on dedicated network components.

Figure 3: Traditional 3-Tier



Each of the traditional 3-tier architecture based systems that we evaluated supported a virtualized private cloud on top of their pre-built or reference architecture based systems. The vendors typically shipped VMware capable systems with pre-installed vSphere and vCenter components. The creation of a SDDC-like environment will require either a professional services engagement or significant customer-led customization and will result in limited integration, automation, and lifecycle management capabilities.

TRADITIONAL 3-TIER ARCHITECTURE INFRASTRUCTURE MANAGEMENT

An additional overhead of 3-tier systems is that each system component comes with its own management software. This makes sense, given that each device stands on its own, however, it leads to a complex set of individual tools with varying degrees of overlap and unique capabilities. For instance, most vendors support vCenter plug-ins but typically not all functionality and troubleshooting is available through these plug-ins. This adds complexity and the customer must be fully trained on and understand each tool. Several 3-tier companies have been trying to mitigate this by creating their own uber-tool to manage each of the 3 tiers as if they were one. While this is a good first step, these tools have yet to eliminate the need for individual tools. The bottom line: traditional 3-tier based architectures require a more complex system management toolset.

Summary of Key Components

	VMware Cloud Foundation	Traditional 3-Tier DIY or CI
SOFTWARE		
Compute Virtualization	*VMware vSphere Ent+*	*VMware vSphere Ent+*
Network Virtualization or Software Defined Networking	*VMware NSX Adv.*	*VMware NSX Adv. or Cisco ACI*
Storage Virtualization	*VMware VSAN Adv.*	*None*
SOFTWARE for MANAGEMENT		
Virtualization Management	*vCenter (if needed)*	*vCenter (if needed)*
Lifecycle Management	*VMware SDDC Manager*	*Software products from multiple vendors*
Infrastructure Management & Automation	*VMware SDDC Manager*	*Individual element manager plus vCenter plug-ins*
HARDWARE		
Network	*Spine switches (second rack)* *Leaf switches (each racks)* *Management switch (each rack)*	*Spine switches* *Leaf switches* *Management switch*
Security and Load Balancing	*None*	*Physical firewalls and load balancers required with Cisco ACI*

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	(all within NSX)	
Storage Area Network	*None* *(all within VSAN)*	*Independent FC SAN switches*
Compute for workloads	*Modular scale-out HCI servers (qualified Ready Nodes)*	*Blade servers* *Blade chassis* *Additional components*
Compute for management cluster	*Modular scale-out HCI servers*	*Management cluster built with standard rackmount servers*
Storage and Controllers	*Modular scale-out HCI servers and within VSAN*	*External hybrid arrays and storage controllers*

COST COMPARISON METHODOLOGY AND APPROACH

For the cost comparison analysis, the systems were configured and optimized for workload use cases where the quantitative hardware metrics could be calculated and compared to reference architectures from the vendors. As a result, each 3-tier system was tuned to meet similar CPU, memory, and storage criteria such that comparative study was possible while staying within the reference architecture guidelines. This allowed us to compare VM density fairly, not handicapping a product configuration with too little memory or storage capacity. The following are the guiding principles used in this comparative research:

- Optimize system sizing around a single 42-U rack deployment of infrastructure.
- Use a vendor's reference architecture (when available) for sizing and best practices.
- Optimize each solution with similar compute, storage and networking resources to make the comparison as fair and balanced as possible.
- Focus on the key CapEx components and associated 3 years of ongoing support costs. Ignore smaller areas that were insignificant. (e.g. no significant difference in power consumption or floor space density was found).
- Taneja Group validated a VMware OpEx savings study and model. VMware conducted the study in its own data center and in VMware Cloud Foundation customer datacenters by comparing labor and time savings versus the traditional 3-tier systems that the customers were using.

Assumptions and Configurations for each Scenario

As discussed above, each traditional 3-tier scenario was configured to be as close as possible to the VMware Cloud Foundation scenario. Further, since none of the traditional 3-tier systems had a fully integrated SDDC software stack, Taneja Group added the missing SDDC software, making it as close as possible to the VMware Cloud Foundation integrated software stack. The cost for professional services or for integration was not included for any of the 3-tier systems. The quantitative comparative results from each of the traditional 3-tier DIY and CI systems were averaged together into one scenario because the hardware and software components are essentially the same. Since a common load testing tool is not widely recognized for VM density, the approach to calculating VM density was to first normalize all the available CPU capacity dedicated to guest VMs, and to then give each solution the same density based on the same vCPUs per VM approach. The goal was to have each comparative solution approximate the same equivalent VM density per system rack. The following table gives the high-level configurations for each scenario:

System Configuration Comparison Matrix		
Component	**VMware Cloud Foundation**	**Traditional 3-Tier DIY or CI**
Cloud Platform	VMware Cloud Foundation	vSphere and additional SDDC software

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Compute Platform	HCI Rack Mount Servers (all nodes the same)	Blade Servers (8/16 nodes per chassis)
Cores per CPU	12	12
Memory per Node	384 GB	384 GB
CPU Speed	2.6 GHZ	2.6 GHZ
Dedicated Management Nodes in Solution	3 (from HCI servers above)	4 (isolated rack-mount servers)
Available Compute Nodes in Solution	21	20
Storage Technology	Virtual SAN	External hybrid array, SAN switches, and storage controllers
SSD for Caching	34 TB	35 TB
Raw Storage Capacity	230 TB	122 TB
Raw to Effective Capacity Overhead Estimate	50%	80%
Effective Capacity	115 TB	125 TB

Assuming the above configurations, the VM density numbers were calculated based on the following formula and outlined in the table below:

VM Density Calculation		
Item	VMware Cloud Foundation	Traditional 3-Tier
Total CPU Cores in Solution	576	576
Dedicated Cores for Management	72	96
Compute Cores Available for Customer VMs	504	480
Overcommit Ratio	4.0	4.0
Available vCPUs	2,016	1,920
VM Supported (based on 2vCPUs per VM)	**1,008**	**960**
Estimated Memory Available per VM (GB)	8.0	8.0
Estimated Usable Storage per VM (GB)	100	130

HARDWARE AND SOFTWARE COST ANALYSIS

The approach used to calculate the cost metrics for each of these scenarios was to build solutions that matched the characteristics above. When possible, for the 3-tier systems, the HW and SW BOM structure exactly matched those provided by a vendor's own reference architecture. The list prices were obtained from vendor pricing tools, vendor reseller quotes, and pricing databases. Because of the constraints on building real systems based on real pricing, not every dimension in the area of compute/storage/memory ratios could be matched exactly. Instead of trying to force fit the ratio, it is left up to the readers to gauge the importance of each variable when comparing the scenarios. The costs of the solutions were calculated in the following categories:

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Hardware CapEx

- For compute/server/networking, the actual prices of components were used based on current vendor pricing and vendor reseller quotes.
- All hardware-specific management packages (those provided by hardware vendor or the software bundled with the hardware specifically to run on that appliance) were included in the hardware CapEx section. In many cases, software was bundled with an appliance and could not be separated – these were included with the hardware.
- The cost of racks, cables, and installation were excluded for simplicity, but would likely increase the cost for the traditional 3-tier DIY and CI scenario.

Hardware Support

- The actual maintenance pricing was used when available and, if a three-year quote was not available, the maintenance was extended on a per year basis. If a particular hardware component maintenance quote could not be found, a 5%-8% per year hardware maintenance cost was used which fit within the range of the actual maintenance quotes received.

Software CapEx

- All perpetual software components that were not specifically tied to the hardware vendor were included based on research methods described above.
- Miscellaneous software components that were deemed similar across all scenarios were not included. For example, costs of Microsoft Windows software for the management cluster or client VM hosted software were not included.

Software Support

- Annual software support was included and calculated for three years.

Cost Comparison Results – Upfront Costs for HW, SW, and Support

The table below summarizes the upfront cost attributes of each system for a private cloud.

Upfront Costs for HW, SW, Support (list price)		
Cost Item	**VMware Cloud Foundation**	**Traditional 3-Tier**
HW CapEx	$556,625	$1,854,227
SW CapEx	$647,040	$311,600
HW Support (3 Years)	$83,494	$445,014
SW Support (3 Years)	$485,280	$233,700
Total Upfront Cost	**$1,772,439**	**$2,844,541**
Savings using VMware Cloud Foundation	**38%**	

Our in-depth analysis indicates that using VMware Cloud Foundation results in a significant upfont cost savings over using traditional 3-tier systems. The costs of the server and networking hardware were significantly reduced by using hyper-converged infrastructure similar to what's used in large web-scale service provider datacenters. The resulting hardware cost savings help to offset the incremental SDDC software costs needed to provide storage and networking capability that leading 3-tier component vendors typically provide within hardware.

COMPARING THE KEY TECHNICAL CAPABILITIES AND BUSINESS BENEFITS

In this fast-paced global economy, companies must be able to perform with agility, flexibility, and speed. Building a private cloud infrastructure goes a long way in fulfilling that promise, but only if it is built to scale dynamically and can evolve with the ever-changing business requirements.

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With that in mind, the following key attributes were considered and evaluated with each of the contrasting private cloud deployments. As each attribute is described we also contrast the capabilities of VMware Cloud Foundation versus several industry-leading traditional 3-tier CI and DIY systems.

Scalability

When scaling at a data center level, repeatability and time to deploy oftentimes are more valuable than a highly customized "tuned to a specific application" approach. This becomes more evident when building a private cloud to support legacy workloads, modern applications, hybrid systems, and applications with high churn and high scale behavior. With the advent of hyper-scale computing, ever increasing cores per CPU-socket, and the now ubiquitous flash acceleration for storage, an SDDC platform can support a broader set of application workloads. There is still a case for a highly tuned customized design, but the number of business workloads needing such infrastructure continues to shrink. With this in mind, we considered the following:

- What is the modular granularity of the infrastructure building blocks when capacity needs to be added incrementally? What is the minimum size deployment that can still meet cost goals?
- What is the level of complexity when adding capacity? Does the new capacity need to be custom made or is it easy to add new capacity in a modular fashion?
- Does the architecture chosen for scalability aid in improving the "time to deploy" when scaling up the system?
- Does the solution scale linearly in performance across all vectors (compute, networking, storage, and management)?
- Does the scalability approach flexibly allow you to refresh hardware and/or introduce new HW/SW technology without isolating the previous version?

Time to Value

Time to value is the time required to design, build and deploy a complete private cloud solution. Building a private cloud using a DIY or CI approach can consume precious time and resources when the integration work needed among the various software and hardware components is not done in advance or not fully tested and validated up front. Also, the necessary integration at the factory can lead to delays in delivering the infrastructure to the on-premises data center. The level of customization and number of multi-vendor components that the DIY or CI approach utilizes typically leads to a longer manufacturing or on-site integration time before the product is fully deployed. The time to value metric is not only important for the initial deployment but also for any incremental capacity additions. With this in mind, the following was considered:

- How complex is the design and quoting process of infrastructure (prior to placing an order)?
- What is the true lead time from "order to floor" for both the initial deployment and a future capacity expansion?
- How completely integrated is the infrastructure prior to arriving on the data center floor versus having to be integrated on-premises?
- How many hours of professional services are required to get the system up and running and prepped for initial VM deployment?

Integrated Provisioning and Life-Cycle Management

The goal of building an SDDC private cloud is to try to make the infrastructure as invisible as possible and push as much of the work to a self-service portal as possible. In order to do that, it is critical that the provisioning of the infrastructure match the workloads deployed. In addition, it must easily adapt to various workloads and keep the environment updated to the latest software versions, security updates, and patch levels. As the software and hardware go through various revisions over the life of the infrastructure, it is important to have tools that ensure compatibility at various levels. With that in mind, we considered the following attributes:

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- Do infrastructure management tools seamlessly provision workload specific domains with unique attributes customized for that workload domain?
- Do infrastructure management tools work across the entire SDDC stack by deploying the software and configuring the hardware at the same time?
- Do management tools ensure that the various components of the SDDC stack have been tested together?
- Is there a centralized tool for managing the patches and upgrades of all software components?
- How easy is it to cycle infrastructure and move to new infrastructure?

Support Experience

The quality of support is key as companies seek to shift human resources currently dedicated to maintaining infrastructure to instead focus on business innovation. Support complexity is reduced by reducing the complexity of design, reducing the number of vendors involved, and providing integrated tools that work across the entire infrastructure. With that in mind, we considered the following attributes:

- Is there a clear process to follow when something is not working?
- Are vendors cooperating with each other throughout the support experience?
- Is there a single tool that can be used to diagnose tough technical issues?
- How solid is the relationship between your vendors of choice? Is it likely to remain that way in the future?

Comparison of the Key Technical and Business Value Attributes

The following table measures and compares each scenario across the attributes discussed previously.

Comparison Matrix of Key Technical Capabilities and Business Benefits		
Vendor Compared	**VMware Cloud Foundation SDDC**	**Traditional 3-Tier DIY or CI**
SCALABILITY		
Scalability granularity?	One additional HCI server at a time or rack at a time.	Rack(s) at a time once initial footprint is exceeded
Full SDDC virtualization across network, storage, and compute?	Yes	No
TIME TO VALUE		
Time to size solution based on customization?	Low	Medium (CI) – High (DIY)
Completeness of integrated solution upon delivery?	High	Medium (CI) - Low (DIY)
INTEGRATED PROVISIONING AND LIFE-CYCLE MANAGEMENT		
Can update software components and apply security updates with one tool?	Yes	No
Can provision workload specific clusters?	Yes	Yes (CI) - No (DIY)
Number of tools to manage software patching and upgrades?	One integrated tool	Typically 3 or more
Can cycle portions of infrastructure automatically?	Yes	No
SUPPORT EXPERIENCE		

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One vendor to call initially?	Yes	Yes (CI) - No (DIY)
Centralized tool for troubleshooting and debug?	Yes	No
Complexity in solving problems?	Low	Medium – High
Coordination between vendors in solving problems?	Yes	Yes (CI) - No (DIY)

Key Takeaways: Technical Capabilities and Business Benefits

Our analysis concluded that both types of systems are more than capable of handling a variety of virtualized workload requirements. However, VMware Cloud Foundation technology has brought SDDC to new levels of ease-of-use and when combined with a virtualized scale-out architecture, giving it a strong value proposition for building out modern SDDC data centers. The following are the key attributes of VMware Cloud Foundation that stood out during the analysis:

- **Native Integration of the SDDC:** VMware Cloud Foundation brings together VMware's compute, storage, and network virtualization into a natively integrated stack that combines hyper-converged software (vSphere plus Virtual SAN) with network virtualization (NSX).
- **Simplest operational experience**: VMware SDDC Manager automates the entire life-cycle of the SDDC stack including bring up, configuration, workload provisioning, and patches/upgrades. In contrast, traditional 3-tier systems typically require multiple management tools and none of them can manage a complete SDDC software stack in addition to hardware.
- **Isolated workload domains**: VMware Cloud Foundation provides unique tools that enable administrators to flexibly provision subsets of the infrastructure for workload specific use cases. Since every part of the stack - networking, storage, and compute - is fully virtualized, workload domains can be built at almost any scale with multi-tenant isolation and security.
- **Modular linear scalability** of the architecture means the infrastructure can be acquired by the server node, by the rack, or by multiple racks. This flexible granularity of scaling means businesses only need to buy what they need when they need it.
- **Flexibility of choice** on qualified hardware for private cloud or through service providers for the public cloud with consistent operational experience across clouds.
- **Enterprise-grade functionality:** VMware delivers complete and advanced enterprise functionality for compute, storage and networking management making it the ideal platform to also run virtualized mission critical apps such as databases, web apps, VDI, etc.
- **Storage elasticity and high performance:** VMware Cloud Foundation supports the latest VSAN 6.2 with all-flash performance and enterprise-class storage services including deduplication, compression and erasure coding. Virtual SAN implements hyper-converged storage architecture, delivers elastic storage, and drastically simplifies storage management.
- **Network and security:** Through VMware NSX network virtualization, VMware Cloud Foundation drastically simplifies network management delivering the operational model of a VM and improves security by leveraging micro-segmentation.
- **Automated lifecycle management:** VMware Cloud Foundation includes VMware SDDC Manager, new management software that automates day 0 to day 2 operations of cloud infrastructure software stack, including, when deployed, vRealize Suite and Horizon.
    - **Rapid deployment:** SDDC Manager automates the bring up process of VMware Cloud Foundation stack, including VMware infrastructure VMs deployment, management cluster creation, VLAN configuration, storage configuration, physical network configuration, cluster creation and provisioning, etc.

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- **One-click, zero-downtime patching and upgrades:** SDDC Manager enables a one click patching/upgrading process of the VMware Cloud Foundation stack. Cloud admins have the flexibility to choose the timing and scope of the updates.
- **Policy-based provisioning:** SDDC Manager simplifies resource allocation to individual isolated workloads by automating cluster creation based on unique policies.

- **Flexible deployment choice:** Customers consume VMware Cloud Foundation software in three ways: factory pre-loaded on integrated systems, deployed on top qualified Ready Nodes from HPE, QCT, Fujitsu, and others in the future, with qualified networking, and finally run as a service from the public cloud through IBM, vCAN partners, vCloud Air, and more to come.

OPEX LABOR COSTS SAVINGS ANALYSIS

As we have discussed above, most virtualized datacenters worldwide are based on a traditional 3-tier architecture (either DIY or Converged Infrastructure integrated systems) with virtualization, limited cloud management, and scattered system management. Compared to traditional 3-tier DIY, traditional 3-tier CI integrated systems simplify upfront integration efforts and operations. However, neither approach supports the efficiency, scalability, and agility that business teams require to compete and succeed in their markets. The complexity of the traditional approach forces IT organizations to spend up to 80% of budgets and labor activities on keeping the lights on, preventing them from delivering strategic IT services that their business partners desperately need. Under business partner pressure, CIOs quietly implant public cloud apps or emerging datacenter appliances in an attempt to deploy systems that will help business teams capture fleeting market opportunities or run more efficiently. These hasty approaches introduce heterogeneity and security vulnerabilities, which increase complexity and OpEx costs, quickly offsetting any initial benefits. It should not be surprising that VMware Cloud Foundation offers a better path forward from the operational perspective, in addition to upfront CapEx. Compared to traditional approaches, VMware Cloud Foundation can save IT organizations up to 58% in OpEx costs over 3 years by increasing IT staff productivity.

Let's start by considering an IT team running a virtualized datacenter based on the traditional 3-tier architecture model covered in this study. The IT team carries out activities such as planning & build up, system configuration, provisioning capacity, life cycle management, and many others (i.e. back-up, monitoring, integration, application architecture, and more). For simplicity, we'll consider a team of 4 IT engineers in which each engineer works 1,760 hours per year, enabling the 4-person team to work 21,120 hours over 3 years. A typical 4-person IT team consists of a network specialist, storage specialist, server specialist, and a virtualization specialist, as well as a shared project manager resource, whose labor is excluded. Interviews with Fortune 500 traditional datacenter organizations and datacenter research from leading consultants indicate that it is not uncommon for 21,120 hours over 3 years to be executed as shown below (on average). For example, Buildup & Planning occurs regularly due to datacenter growth and churn but occurs less frequently than Life Cycle Management or Other.

IT Labor Activity	% of total labor hours per activity	Labor hours, 3 yrs, Traditional 3-Tier
Buildup & Planning	10%	2,112
Configuration	10%	2,073
Provision Capacity	17%	3,684
Life Cycle management	28%	5,859
Other	35%	7,392
Total	**100%**	21,120 hr

- Source: VMware Cloud Foundation customers & industry analyst data.
- Scenario: 4-person FTE team over 3 years
- Annual hr/FTE: 1,760 hr
- Labor rate: $75/hr
- Note: These averages may differ across IT teams

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Let's now consider VMware Cloud Foundation results in real datacenters. VMware has deployed Cloud Foundation at several Fortune 500 companies worldwide who currently run virtualized datacenters using traditional 3-tier architectures. Taneja Group reviewed and validated the findings that these companies reported back to VMware. The resident IT teams reported that, compared to their traditional 3-tier systems, VMware Cloud Foundation enabled more efficient datacenter operations, resulting in the average labor savings shown below. Simply put, each IT team spent less time in the first four IT labor activity categories when using VMware Cloud Foundation technology compared to the time they spent on the same activities using their existing traditional 3-tier datacenters. The percentage of hours saved is an average across all participating companies with each company saving more or less time than the average percentage. For example, on average, compared to their traditional 3-tier datacenters, VMware Cloud Foundation enabled each IT team to spend only ~2% of the time usually spent on Buildup & Planning, only ~4% of the time usually spent on Configuration, only ~20% of the time usually spent on Provisioning Capacity to business partners, and only ~13% of the time usually spent on Lifecycle Management. Further, each IT team was delighted at the possibility of spending the freed up time (~58%) on long-delayed strategic activities and innovative high-value IT projects.

IT Labor Activity	Average % hours saved compared to Traditional 3-Tier
Buildup & Planning	98.2%
Configuration	96.3%
Provision Capacity	80.0%
Life Cycle management	87.5%
Other	0.00%

- Source: VMware Cloud Foundation customer trials at global Fortune 500 companies.
- Note: Savings compared to traditional 3-tier architectures will be lower. The "Other" category is unchanged until future VCF capabilities are announced. These are averages across many trial customers.

If we return to our 4-person IT team that is running a virtualized datacenter based on a traditional 3-tier architecture, we can apply the average percentage hours saved to each IT labor activity. As you can see, on average in our model, the 4-person IT team can achieve a 58% total time saving over 3 years or around $ 910,525. This 4-person IT team can now spend that time on projects that deliver the efficiency and agility that its business partners have long been demanding.

IT Labor Activity	# of labor hours (Traditional 3-Tier)	3 yr labor cost Traditional 3-Tier	% Hours saved compared to Traditional 3-Tier	# of hours VMware Cloud Foundation	3 yr labor cost VMware Cloud Foundation
Buildup & planning	2,112	$158,400	98.2%	38	$2,880
Configuration	2,073	$155,439	96.3%	77	$5,784
Provision Capacity	3,684	$276,336	80.0%	737	$55,267
Life Cycle management	5,859	$439,424	87.5%	735	$55,143
Other	7,392	$554,400	0.00%	7392	$554,400
Total	**21,120 hr**	**$1,584,000**	**57.5%**	**8980 hr**	**$673,475**

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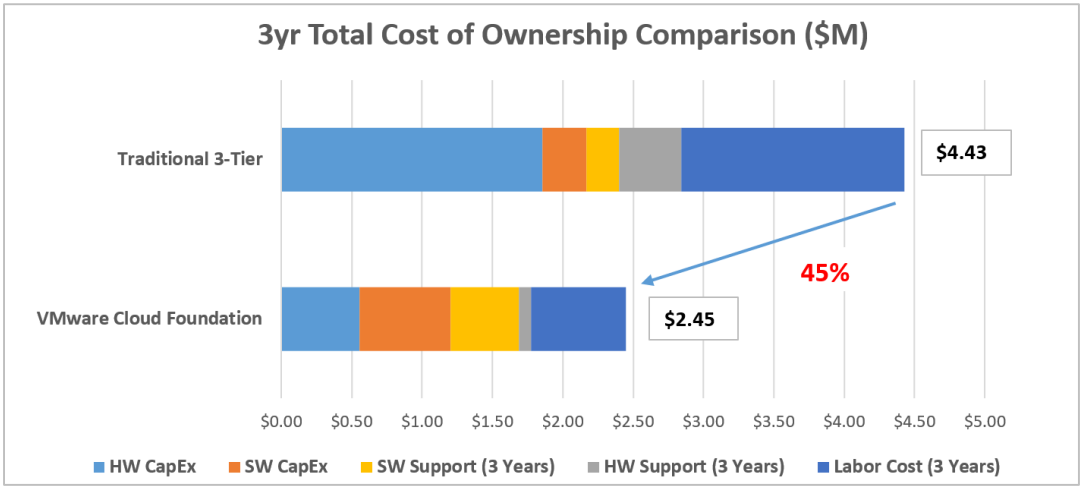
In summary, VMware Cloud Foundation on average enables IT teams to spend 58% less time on routine IT labor activities, time that IT teams can instead spend on more impactful activities, such as system enhancements and application innovation, which make IT organizations more agile and efficient. Agile and efficient IT organizations have the capacity to respond rapidly to business partner demands, enabling them to capture market opportunities faster and to run business operations more effectively.

Total Cost of Ownership (TCO) Savings Comparison: CapEx and OpEx

When looking at total cost of ownership savings over three years, the following graph gives an example of what can be saved when using VMware Cloud Foundation over alternative traditional 3-tier architectures. The following graph and table combines all the costs associated with deploying both architectures.



3yr Total Cost of Ownership Comparison (TCO)

Cost Item	VMware Cloud Foundation	Traditional 3-Tier
HW CapEx	$556,625	$1,854,227
SW CapEx	$647,040	$311,600
HW Support (3 Years)	$83,494	$445,014
SW Support (3 Years)	$485,280	$233,700
Labor Cost (3 Years)	$675,572	$1,584,000
3yr Total Cost of Ownership	**$2,448,010**	**$4,428,541**
Savings using VMware Cloud Foundation	**45%**	

TANEJA GROUP OPINION

Innovations in SDDC technology continue in a dramatic fashion, driven by an overarching need for IT shops to do much more with less. SDDC systems lower costs while dramatically improving ease of use. Companies should be able to deploy on-premises private cloud infrastructure that approaches the ease of use and scalability of a public cloud with an even more predictable quality of service. With the release of VMware Cloud Foundation, VMware significantly raises the bar by delivering the only unified SDDC platform for the hybrid cloud with flexible qualified on-premises deployment options.

Through an investment in VMware Cloud Foundation, companies can be assured that their data center infrastructure can be easily consumed, managed, upgraded, and enhanced to provide the best private cloud at the lowest cost. Using a modular, scale-out approach means infrastructure is added in hours, not days and businesses can be assured that infrastructure scales linearly without any added complexity. VMware Cloud Foundation is the only product that provides a comprehensive SDDC

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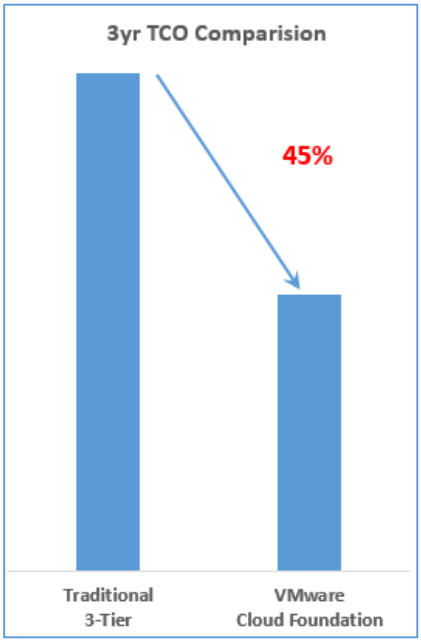
environment with end-to-end management and the flexibility to provision a wide variety of workloads at the push of a button. Perpetual hardware and software refresh capabilities mean an investment today is well protected in the future.



Through the comprehensive evaluation of traditional 3-tier DIY and CI alternatives, Taneja Group has demonstrated that VMware Cloud Foundation is not only dramatically more cost-effective, but is also the most integrated and automated solution. Unlike other versions of converged and hyperconverged systems, VMware Cloud Foundation dramatically increases integration by natively integrating an SDDC stack, with attributes such as a full set of networking, security, software defined storage, and private cloud automation software included up front. Other alternatives can force businesses to either integrate these functions on-premises themselves, pay for expensive services to completely build out an SDDC private cloud, or rely on hardware or 3-rd party software to approximate an SDDC with seamless hybrid capabilities.

The majority of enterprises run VMware virtualization technology. If a business is looking for a private cloud or a hybrid cloud, then it makes tremendous sense to maintain compatibility with their existing virtualized infrastructure. A VMware Cloud Foundation solution will enable a seamless transition to an SDDC private cloud at a **45%** reduction in TCO over the traditional 3-tier alternatives. As businesses continue to drive toward on-premises infrastructure with cloud-like agility and economics, Taneja Group recommends a full evaluation of VMware Cloud Foundation whether adding to existing infrastructure or starting from scratch.

When it comes to private cloud mainstream virtualized workloads, the linear modular scale-out approach that VMware Cloud Foundation provides is very compelling. Before blindly going down the traditional infrastructure approach, businesses should first take a close look at VMware Cloud Foundation.

Taneja Group Note: This paper contains ideas on calculating real-world TCO for the presented solutions. However, differences in customer environments, skill sets, and related services will drive differences in TCO analyses. Further, the supported business outcomes and especially the automation level of the compared offerings vary. You will need to conduct an analysis tailored to your own environment to develop TCO numbers consistent with your environment. Finally, the analysis presented in this paper is designed to raise awareness about how to evaluate solutions. The analysis is not about proving which solution is the best for specific circumstances. Each solution covered in this analysis has its own proven merits.

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