Infrastructure Roadmap

Virtual and Physical Infrastructure Planning

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1 Executive Overview

The State of Connecticut has engaged SHI Professional Services to develop an overall Data Center Infrastructure Roadmap for the state's Department of Administrative Services/Bureau of Enterprise Services (DAS/BEST). This document focuses on the planning and deployment of the overall infrastructure as follows:

- Virtual Infrastructure
  - Network
  - Server
  - Storage
- Backup and Recovery
- Disaster Recovery
- Automation
- Configuration Management
- Security
- Billing System

This roadmap is based on the strategy initially created and provided to DAS/BEST and is intended to provide a plan for designing, building and deploying the overall infrastructure successfully at the two sites identified by DAS/BAST.

This roadmap will allow DAS/BEST to deploy an infrastructure that can support all virtual workloads while at the same time reducing the overall effort to manage the infrastructure – including servers, storage and networking. The roadmap outlines an integrated approach to deploying this infrastructure so that, when complete, DAS/BEST will have a converged infrastructure solution. This approach includes the implementation of components to help reduce the overall administration effort and to achieve a framework for providing a self-provisioning environment.

The overall implementation roadmap follows this sequence:

- Deploy the virtual infrastructure at both sites and start migration of workloads to new infrastructure.
- Deploy backup and recovery solution at both sites and start backing up the applications immediately following migration.
- Once the infrastructure and backup have been started, begin implementing any new security products and or procedures.
- Start automation of the major repetitive tasks undertaken within the entire infrastructure, particularly provisioning of new environments for agency customers. This would be the top 10% of those tasks typically done by the IT staff.
- Start configuration management integration into various agency environments for the major platform applications and services.
- As the virtual infrastructure and backup/recovery infrastructure reach completion, start disaster recovery implementation for those applications that require it.
- Towards the end of the overall deployment, implement a billing system for the services being provided to the agencies.

The state will realize over a million dollars in savings over the course of the next five years by undertaking the implementation of a tightly integrated converged infrastructure, particularly with greater emphasis on virtualization to provide a more flexible infrastructure with greater utilization of computing resources. By following an integrated approach to deploying the infrastructure, and implementing a major portion of each layer of the infrastructure before moving on to the next layer, will allow DAS/BEST to acquire a converged infrastructure in less time and with greater integration.

If these recommendations are followed, the primary benefit is the reduction in time required by the staff to complete the deployment of the overall computing environment. In addition, they should be able to free up time to pursue activities that would lead to potential innovation and further cost reduction. Additional benefits are an infrastructure capable of providing more services to their customers at an overall lower cost.

2 Project Goals

The overall project goal is the implementation of converged infrastructure that reduces the effort and cost to support and maintain environments for agency customers of DAS/BEST. Ultimately, DAS/BEST wants the operational costs and labor effort to support the infrastructure reduced and the implementation of tools that allow for more automation of customer environments. This primary goal suggest several short and long term goals that should be met – milestones that need to be reached so that the overall project will be successful.

The short-term goals are related to implementation of the base infrastructure and the implementation of products and tools that will allow DAS/BEST to better manage, at lower cost, the many environments they support on behalf of their customers. The long-term goals are farther reaching and are related to achieving a more efficient organization and operational model for the overall DAS/BEST agency.

2.1 Short-Term Goals

Because the short-term goals are directly related to implementation of the overall infrastructure and the components, it is important to list the specific short-term goals for the various aspects of the infrastructure. Since the implementation includes virtual infrastructure, backup infrastructure, disaster recovery implementation as well as automation and change management, it is necessary to list the short-term goals related to each.

For the virtual infrastructure, the short-term goals are the initial implementation and subsequent replacement or re-configuration of the virtual infrastructure to include the server platform, storage array and network switching needed to support the virtual guests and operating environments.

For the backup infrastructure, the short-term goals are the initial implementation and complete replacement of the current backup infrastructure and complete integration of the backup infrastructure into the virtual infrastructure, and testing of the backup and recovery of those environments.

Disaster recovery, because it is based on hardware already implemented for other infrastructures, does not require any significant implementation beyond the initial software installation. However, because disaster recovery is complex to implement, due to the complexity of the applications that need to be recovered, the primary short-term goals are identifying and understanding the business requirements for the various applications of the agency customers. The review, analysis and inventory of those applications that agency customers want protected are the immediate short-term goal, the long-term goal is the implementation of a suitable product and the actual protection against disaster of various mission-critical applications as identified by customers.

The next two areas, automation and change management, have only a few immediate short-term goals since these will be implemented within the infrastructure last. By definition, the implementation would be a long-term goal; however, to implement these goals properly, several short-term goals exist for the final implementation to be successful. These goals are the determination of the specific products/tools that will be used and the reorganization and re-orientation of the teams involved with actual delivery of application development and platform services for DAS/BEST customers. The other short-term goal for automation is the identification of those tasks most suitable for automation – the top 20% of effort that, if automated, would yield the greatest reduction in staff labor and effort.

The last area, billing/chargeback, has a few immediate short-term goals which include determining the actual application to be used, but more importantly, determining the actual costs for various services and the components and staff that will become part of the cost model for a particular service.

Functional Area	Components	Short-Term Goals	Pre-Requisite
Virtual Infrastructure	Servers, Storage, Network	▪ Design and Implementation of Infrastructure components ▪ Begin migration of customer environments	▪ Determination of components and budget
Backup/Recovery	Backup Application, Storage, Network	▪ Design and Implementation of Infrastructure components ▪ Begin integration of customer environments for backup	▪ Determination of components and budget ▪ Partial completion of virtual infrastructure rollout
Disaster Recovery	Data Replication Application	▪ Identify candidate applications that require DR ▪ Document recovery process (run-book) for candidate applications	▪ Determination of components and budget
Automation	Automation software/application	▪ Identification of suitable tasks for automation (top 20%)	N/A
Configuration Management	Config. Mgmt. software/application	▪ Re-organization of application service teams ▪ Identification of major software platforms suited to configuration management	N/A
Billing/Chargeback	Billing software/application	▪ Identification of team ▪ Identification of components involved in each service cost model	N/A

Table 1 - Project Roadmap Short-Term Goals

2.2 Long-Term Goals

The long-term goals are focused on meeting large-scale requirements for the DAS/BEST infrastructure, such as Active/Active data centers capable of providing DR capabilities and a converged infrastructure that reduces the overall effort of the IT organization to support. These long-term goals are directly related to automation, configuration management and disaster recovery.

The other important long-term goal is the implementation of a billing system. Although DAS/BEST is not allowed to charge their customers directly, it is important that there be a clear method for measuring the overall success of their efforts, financial metrics are the clearest method most easily understood. This approach allows DAS/BEST to show their customers the costs for supporting an application environment and the cost reduction or improved service levels from initiatives aimed at improving efficiency.

Long-Term Goal [Requirement]	Functional Areas Affected	Pre-Requisite	Notes
Active/Active Data Centers	▪ Virtual Infrastructure ▪ Disaster Recovery	▪ Almost complete implementation and migration of virtual guests (workloads) to new infrastructure ▪ Purchase and implementation of software to allow for application recovery	This requirement is intended to keep all virtual environments in use and to reduce wasted computing power.
Converged Infrastructure	▪ Virtual Infrastructure ▪ Automation ▪ Configuration Management	▪ Almost complete implementation and migration of virtual guests (workloads) to new infrastructure ▪ Initial determination of tasks to be automated ▪ Initial determination of application services to manage	The primary goal is the use of automation to reduce labor effort to manage, maintain and provision infrastructure.
Billing/Chargeback (IT-as-a-Service)	▪ Virtual Infrastructure ▪ Automation ▪ Configuration Management	▪ Complete implementation of new infrastructure ▪ Automation of a significant portion of environment ▪ Configuration Management partially implemented ▪ Service Catalog defined	The final goal of the entire strategy effort is to provide IT services to DAS/BEST customers, this is the last milestone in the entire project.

3 Objectives, Tasks and Timelines

The objectives and tasks are related to the short and long-term goals as outlined above. The major objectives based on these goals are:

- Completion of new virtual infrastructure at the DAS/BEST primary and secondary sites
- Implementation and integration of a new backup infrastructure
- Implementation of a DR solution for mission-critical customer applications
- Automation and configuration management implementation, and
- A billing/chargeback software application implementation

There are five major objectives. The first three have to do with infrastructure and include an infrastructure capable of supporting any potential customer workloads, a complete backup solution for the entire infrastructure, and a functioning DR capability for customer's mission-critical applications. The last two major objectives are related to the software implementations and include the automation of the virtual infrastructure and management of the various platforms to reduce labor effort and the ability to provide pricing and costs for billing. The last two objectives are the key to reducing costs, since the first item helps reduce labor effort and the second tracks those results over time. Each of these objectives also has high-level tasks and milestones that need to be completed. These tasks and milestones are listed and described in detail in the sections that follow.

3.1 Virtual Infrastructure

The virtual infrastructure timeline is shown in Figure 1. The entire project may take approximately a year, with the majority of the work being the migration of current virtual workloads and the virtualization of current physical workloads. For those workloads (applications) that cannot be virtualized, a plan to move the infrastructure will need to be created. The overall project breaks down into three major sub-tasks. The first is the design, purchase, implementation of the virtual infrastructure, the second is the migration of the virtual environments (or workloads), and the final major task is the virtualization of all remaining physical workloads. Each of these major tasks has many sub-tasks, of which the next level of detail is presented below in Table 2.

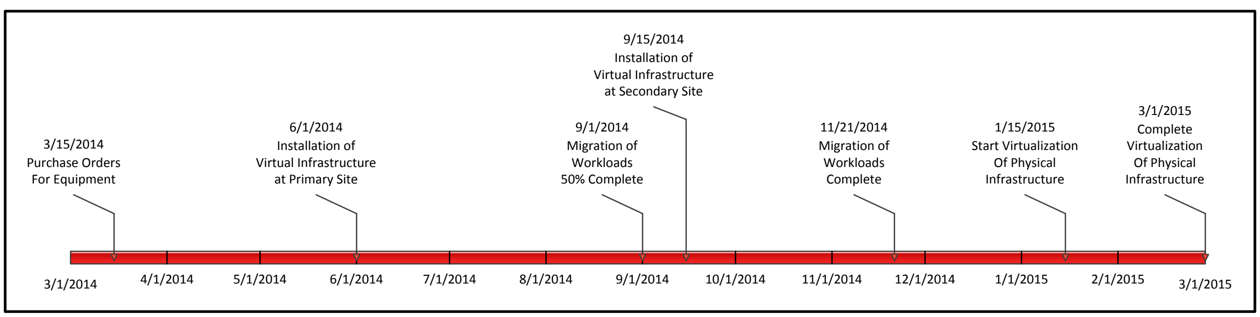

Figure 1 - Virtual Infrastructure Deployment Timeline

Major Tasks	Sub-Tasks	Duration	Overall
Implement Virtual Infrastructure	Design virtual infrastructure	1 Week	2 Months
	Purchase hardware	1 Day	
	Deliver/Install hardware	2 Weeks	
	Build virtual infrastructure	1 Month	
	Test functionality	1 Week	
Migrate Virtual Workloads	Determine virtual guest and application dependencies	1 Month	3 Months
	Develop migration schedule	1 Week	
	Determine tool for migration	1 Week	
	Migrate virtual guests	2 Months	
Virtualize Physical Workloads	Determine physical application dependencies	2 Weeks	3 Months
	Develop schedule for physical servers	1 Week	
	Determine tool for migration	2 Days	
	Virtualize physical servers	2 Months	

Table 2 – Major Tasks for Virtual Infrastructure Deployment

3.2 Backup Infrastructure

The backup infrastructure should take only a few months to deploy. Since the final step, integrating the backup with the application within the virtual infrastructure, takes place after the virtual infrastructure is completed and the migrations are undertaken, this aspect of the project is concerned only with implementing the base infrastructure and backup software. Final deployment/integration occurs during the migrations of virtual and physical workloads. Figure 2 shows the overall backup infrastructure deployment timeline. Table 3 lists the major tasks and their associated sub-tasks necessary for completing this project.

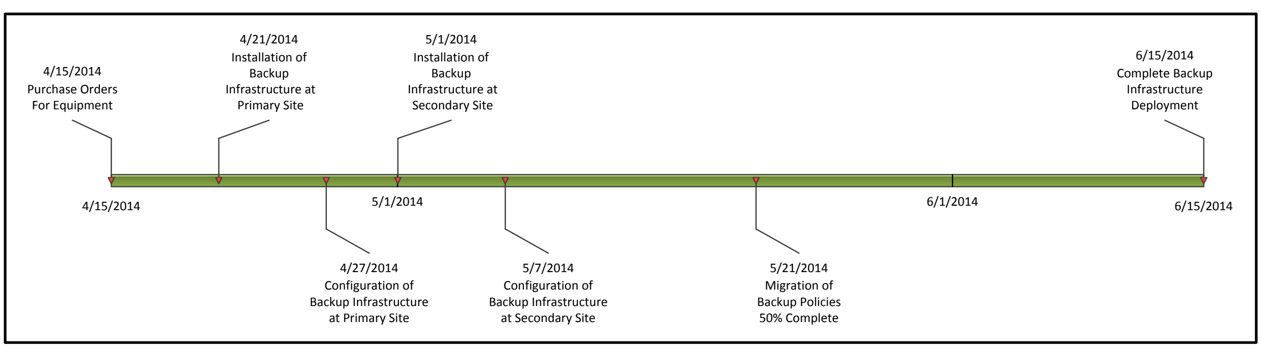

Figure 2 - Backup Infrastructure Deployment Timeline

Major Tasks	Sub-Tasks	Duration	Overall
Implement Backup Infrastructure	Design backup infrastructure	1 Week	2 Months
	Purchase hardware	1 Day	
	Deliver/Install hardware	2 Weeks	
	Build/configure backup infrastructure	4 Weeks	
	Test functionality	3 Days	
Configuration of Backup Policies	Determine application dependencies and integrations	2 Weeks	2 Months
	Develop migration schedule	1 Week	
	Migrate policies for physical servers	4 Weeks	
	Create new polices for virtual infrastructure	1 Week	

Table 3 – Major Tasks for Backup Infrastructure Deployment

3.3 Disaster Recovery (Active/Active) Implementation

The disaster recovery implementation is concerned with enabling two capabilities. First is to deploy a solution capable of providing disaster recovery capabilities to the virtual infrastructure and therefore available to customers. The second is to take advantage of the primary and secondary data centers in an active/active manner where each site runs active production applications and uses spare capacity at the alternate site for recovery. The complete implementation of disaster recovery capabilities and the necessary procedures could take several years and may always be in progress; however, the initial project to identify major mission critical applications and implement the basic tools to accomplish disaster recovery should take a year or less.

The major tasks are first to identify the mission-critical applications that should be protected first, and then develop a schedule for protecting them. Several other important tasks must be completed including identifying the DR software used for replication and recovery and developing the necessary DR processes for each mission-critical application. Figure 3 shows the overall timeline; Table 4 lists the major tasks and their sub-tasks.

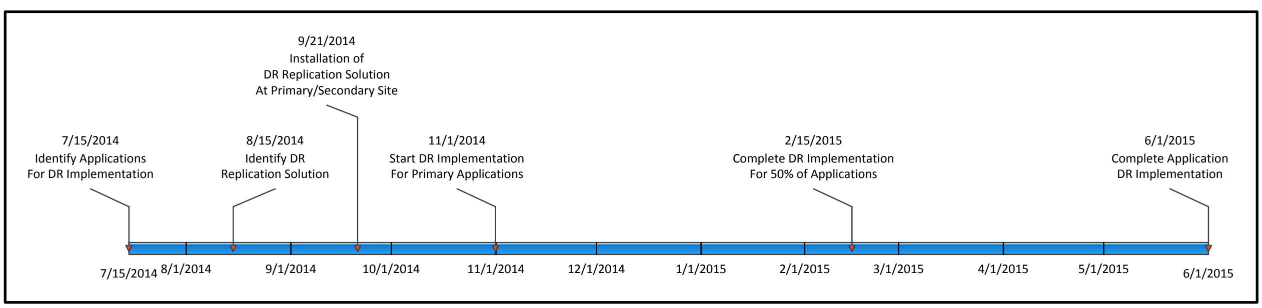

Figure 3 – Disaster Recovery Implementation Timeline

Major Tasks	Sub-Tasks	Duration	Overall	Notes/Comments
Identify Applications and Solution	Identify Mission Critical Applications for Customers	4 Weeks	2 Months	Both of these tasks could run concurrently (in parallel)
	identify DR Replication Solution	4 Weeks		
Implement DR solution for Applications	Determine application dependencies	6 Weeks	8 Months	Some overlap of these tasks is possible depending on the involvement of the customer and the staff time constraints
	Develop schedule	2 Weeks		
	Document Process for Applications	1 Month		
	Implement DR solution	5 Months		

Table 4 – Major Tasks for Disaster Recovery Implementation

3.4 Infrastructure Automation

The infrastructure automation will always be an ongoing effort requiring new tasks to be automated and old tasks that are already automated to be reviewed and updated with new steps. However, for the purposes of this project, the automation that will initially be undertaken is the automation of the 20% most executed tasks as they relate to maintaining the overall virtual infrastructure. These tasks are generally associated with provisioning the virtual infrastructure. This sub-project has focus to recursively automate the top 20% of the manual effort in managing and maintaining the overall environment at least three times – eventually this should be close to automation of 50% of the overall tasks, though final results will vary depending on the initial tasks chosen. Although 50% of the tasks might be automated, this will not be 50% of the overall effort. This could be either more or less depending on the actual effort of each task.

The tasks identified in the timeline (see Figure 4) can be broken down into four major phases: 1) identify the initial tasks, 2) identify the product to use, 3) implement the product, 4) automate the tasks (recursively the top 20% of those manual tasks remaining). The ongoing effort, once the automation software is fully in use, will be the ongoing maintenance, support, and enhancement of the overall automation solution once the initial project is complete.

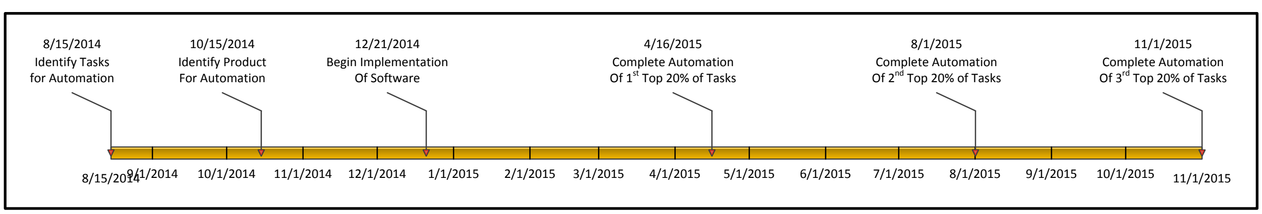

Figure 4 – Infrastructure Automation Timeline

Major Tasks	Sub-Tasks	Duration	Overall	Notes/Comments
Initial Identification	Tasks for Automation (top 20%)	2 Months	4 Months	The project is weighted towards identification first
	Product to Use	2 Months		
Automating Infrastructure	Automate top 20% of Tasks	3 Months	9 Months	The majority of the project effort is in automating the tasks
	Automate next top 20% of Tasks	3 Months		
	Automate last top 20% of Tasks	3 Months		

Table 5 – Major Tasks for Infrastructure Automation

3.5 Platform Services Configuration Management

The two sub-projects, Infrastructure Automation and Configuration Management, are very similar in that both seek to automate what are typically labor-intensive tasks. The primary difference between the two is that automation takes the various tasks associated with provisioning a VM and automates all of those tasks into a single workflow, while configuration management seeks to automate the deployment and configuration of a component within a platform or “stack” that provides services to the application. Because these two are so similar, the timelines and tasks associated with completing the project are also similar. Figure 5 displays the overall timeline for completing the implementation.

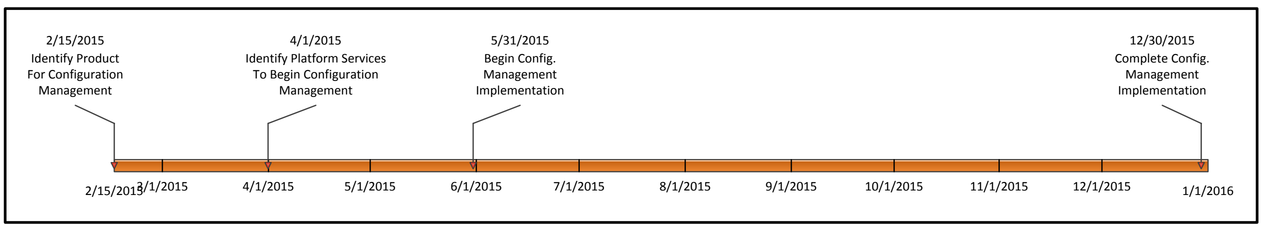

Figure 5 – Configuration Management Implementation Timeline

Instead of automating 20% of the top most required tasks, automation is of the first, second and third component in a particular platform stack – in this particular case, Microsoft, since it represents the largest part of the infrastructure would be the primary candidate for placing the components under control of a configuration management tool (see Table 6 below).

Major Tasks	Sub-Tasks	Duration	Overall	Notes/Comments
Initial Identification	Components for Config. Mgmt.	6 Weeks	3 Months	The project is weighted towards identification
	Identify product to use	2 Months		
Automating Infrastructure	Automate management of first component in Microsoft Platform	3 Months	9 Months	The majority of the project effort is in creating the configuration management templates for each component
	Automate management of second component in Microsoft Platform	3 Months		
	Automate management of third component in Microsoft Platform	3 Months		

Table 6 – Major Tasks for Configuration Management Implementation

3.6 IT Services Pricing and Billing

IT Services and Billing are the final sub-projects in the overall deployment of the virtual infrastructure for DAS/BEST. These two aspects together define the overall service offering provided by the DAS/BEST organization. This is broken down into two major phases. The first phase is the identification and implementation of billing/chargeback software to be used to track the costs associated with supporting each individual customer and their application. The second major phase is the identification of the major services being offered to agency customers and the costs for those services captured in the billing application.

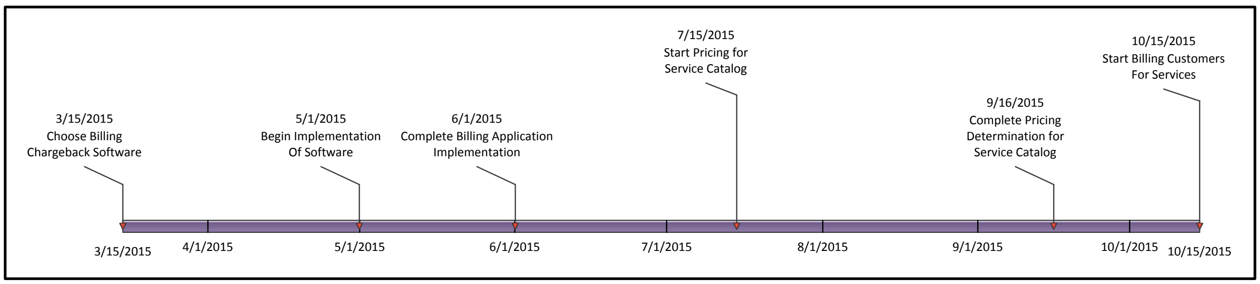

Figure 6 – IT Services & Billing Implementation Timeline

Major Tasks	Sub-Tasks	Duration	Overall	Notes/Comments
Billing Application	Choose/Identify Billing Application	4 Weeks	2 Months	This is the initial determination on the application
	Implement Billing Application	4 Weeks		
Services Offered	Identify Services that will be offered	2 Weeks	4 Months	This is the identification of those services that will be offered and at what cost
	Determine Costs for Services	2 Months		
	Implement Pricing/Costs for Services	6 Weeks		

Table 7 – Major Tasks for Billing Implementation

The process for determining the actual services and their costs has been discussed previously in the overall strategy. Briefly, the process requires that each service being offered (once identified) includes all of the costs for supporting that service, including hardware, software, facilities and labor and then the total cost broken out by the actual component use. For virtual infrastructure this is the cost to deploy a virtual guest, for the backup infrastructure it is the cost to backup this virtual guest, and for disaster recovery, it is the cost to protect the virtual guest and replicate to a secondary site.

3.7 Overall Project Timeline

The overall project timeline is given in Figure 7, Figure 8, Figure 9, and Figure 10 below. This is simply another view of the information presented in the figures already shown, though with all of the sub-projects and their respective milestones shown together in one timeline. The overall timeline is roughly two years long. If the entire project is undertaken, the total effort and final duration may vary based on potential unknowns and the staff resources available to work on the various tasks within the overall project. DAS/BEST should estimate that the project will take from 2 to 3 years to complete with ongoing maintenance and improvements continuing for the life of the virtual infrastructure.

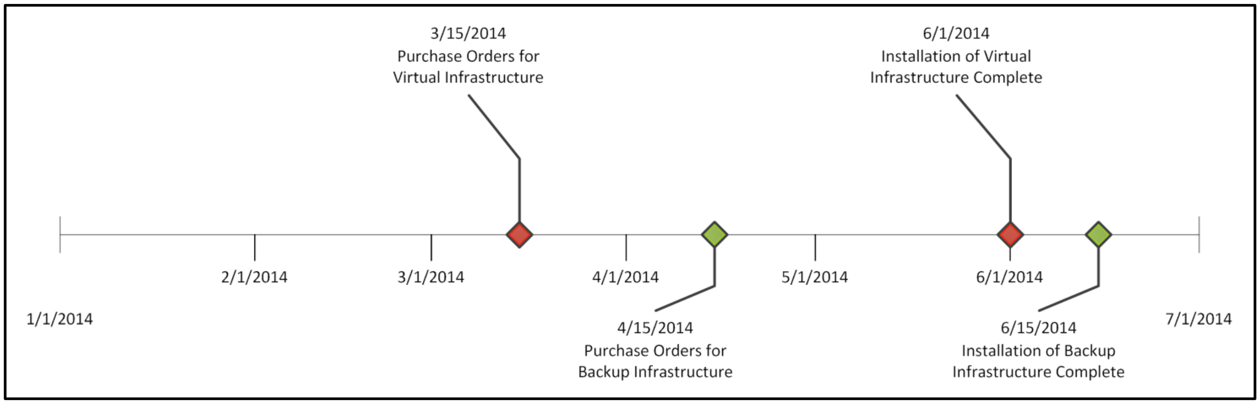

Figure 7 - First Quarter of Project

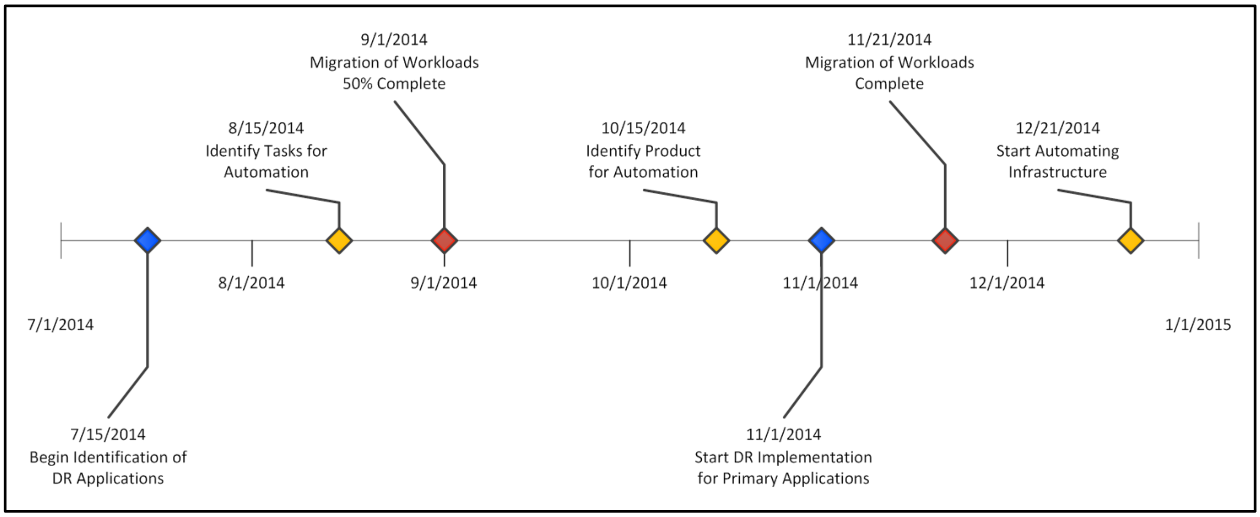

Figure 8 – Second Quarter of Project

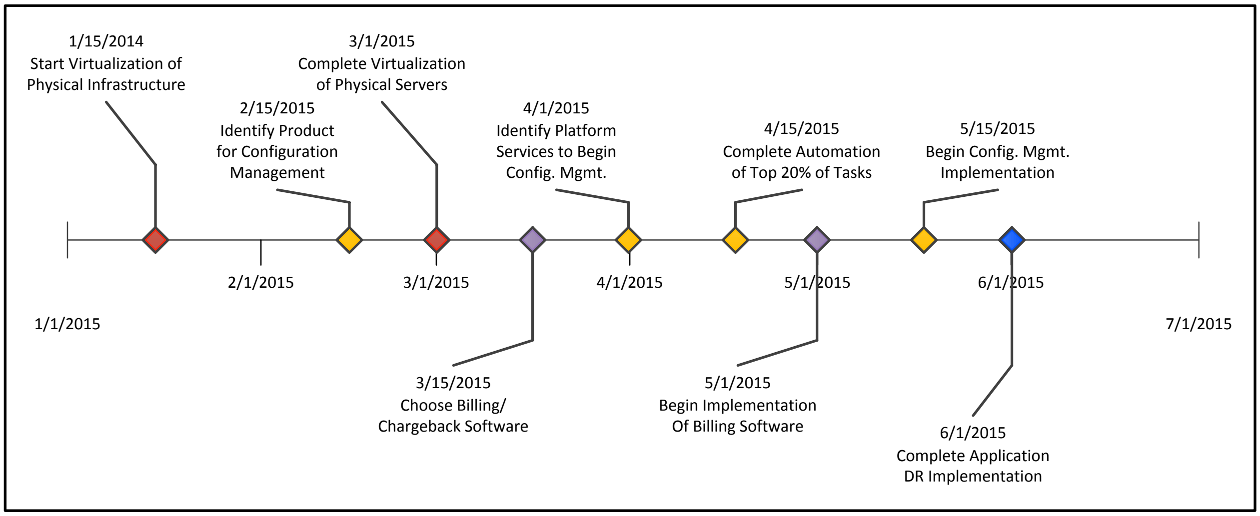

Figure 9 – Third Quarter of Project

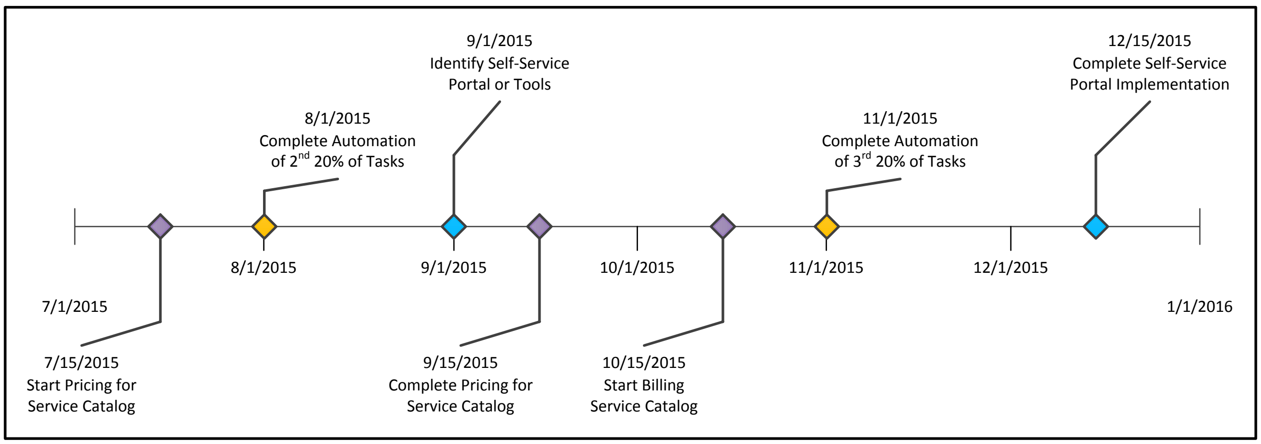

Figure 10 – Fourth Quarter of Project

The final figure below (Figure 11) shows the six sub-projects and their relative start and end dates and overall duration relative to each other. The single most important sub-project is the implementation of the new virtual infrastructure (shown in red). This implementation lasts almost a year and ends with all (or almost all) of the physical workloads virtualized. Shortly after this implementation is started, the backup infrastructure is implemented. It would not be prudent to have operating environments that were not being protected against potential loss or corruption. However, once the backup implementation is complete, virtual guests are simply backed up as they are migrated to the new infrastructure.

The disaster recovery implementation/replication sub-project would start after a significant number of applications have been migrated to new infrastructure. This phase of the overall project would continue until all of the virtual guests were protected that were identified by the customers.

Slightly after the Disaster Recovery implementation starts, implementation of the infrastructure automation would begin, with the primary goal the automation of the most executed tasks completely automated first. Several months later the configuration management implementation would be begin.

After the first year, DAS/BEST should begin investigating the use and implementation of billing/chargeback software to help understand the costs incurred to support each customer.

Each of the sub-projects is staggered so that the IT organization has a chance to get the next sub-project underway before beginning another one. Although, different groups might undertake each of these sub-projects, staggering these sub-projects allows the organization to adjust to the increased effort required.

The overall project is shown at a two year duration; this may need to increase based on the current workload and staff resources available for the project and could extend out to 3 or 4 years. The initial focus and effort should be spent on deploying the base virtual infrastructure as well as backup and disaster recovery.

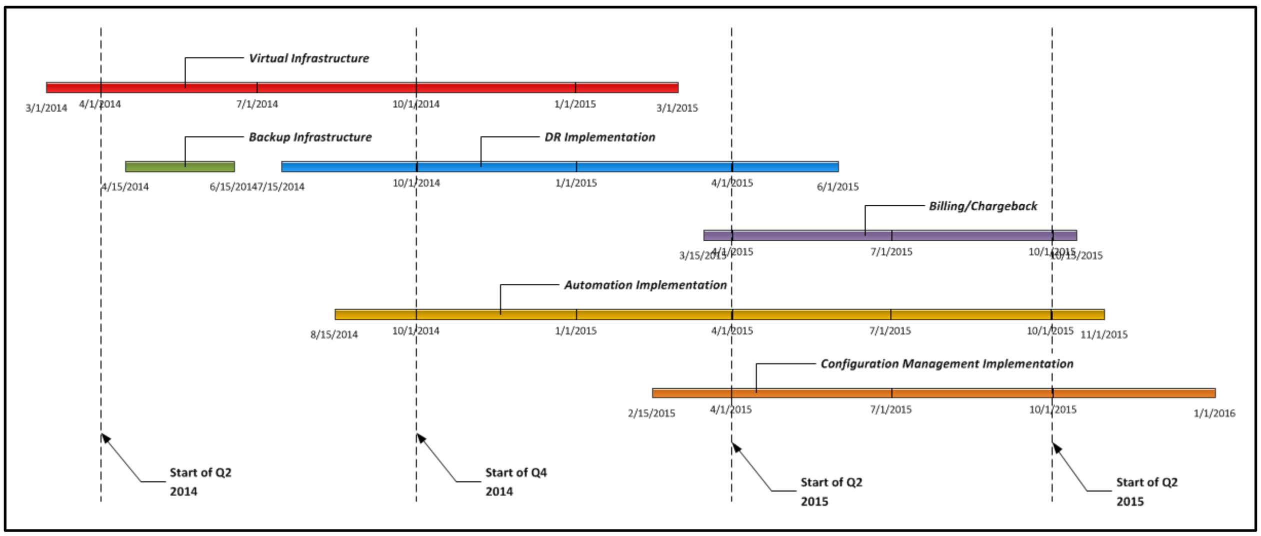

Figure 11 - Overall Timeline Parallel Projects

Assumptions used for creating the overall timeline:

- The overall environment should be built in layers, with lower layers installed and configured first before adding automation and management at higher layers.
- The start of sub-projects should be staggered so that the IT organization is not overwhelmed with multiple project starts.
- Protecting the virtual environment is more important than automation, therefore backup and disaster recovery should be implemented first.
- Each sub-project has a period of time devoted to identification, planning, and some design, before actual implementation is started.
- Given the size of the overall project, this will be a multi-year project and therefore should have a single dedicated project manager assigned to manage the deadlines, milestones and resources.

4 Technology Forecasting

Technology forecasting deals with the characteristics of technology such as levels of performance or improvements in features and functions, but is not concerned with how these characteristics are achieved. For the purposes of this roadmap, technology forecasting refers to the forecasting of future performance improvements and feature/function enhancements of current technology. It is not concerned with attempting to predict new, currently unknown technologies, as that would be impossible. However, by closely watching the IT industry overall, some trends that might suggest the advent of currently unknown technologies is possible. Furthermore, the concern is creating a process for producing technology forecasts within the DAS/BEST organization, but not producing a forecast as part of this roadmap.

There are many approaches to technology forecasting including the use of pattern analysis, extrapolation, goal analysis, intuition and others. This roadmap will not attempt to choose the best one, or analyze these methods on their merits, but to offer the DAS/BEST IT organization a collection of methods and an overall process along with some basic rules to help identify future trends for use in their own forecasting efforts.

The first step is to incorporate technology forecasting into the overall activities of the IT organization. This requires a process repeated periodically so that forecasting becomes part of the ongoing effort to manage, maintain and improve the infrastructure supporting customers. DAS/BEST should hold, at least, quarterly technology review meetings with senior technology staff from all of the disciplines within the organization. This would include senior technical members supporting virtual infrastructure, storage infrastructure, backup infrastructure and network infrastructure. Meetings should focus on forecasting the future of the technology that DAS/BEST will use over the next 5 years with some forecasts as far in to the future as 10 years, though this would be an extreme upper limit.

These quarterly meetings should focus on those technologies currently in use and a forecast of their future state over several time-periods and also on what types of technologies might become available for use by DAS/BEST in maintaining their environment. Obvious examples are new technologies that do not currently exist, but might be predicted with the use of the forecasted mentioned above. There may also be new implementations of technologies already in use, but due to a significantly different approach in design and construction, represent a significant improvement or change in the state of those technologies being offered. These forecasts should be documented and at the beginning of each meeting a review of prior forecasts over the last several quarters and years should be conducted. This provides much needed feedback into the technology forecasting process. Initially, the forecasts submitted by the team will be poor relative to later results; the use of feedback will serve to improve the forecasts much faster than simple repetition of the process.

In addition to the process, there are the methods that need to be used that will make the forecasts more accurate. The first method that can be used is simple extrapolation; the past can be used to predict the future, performance of CPU's have doubled every 18 months[1] and the capacity of hard drives have doubled every 24 months. Therefore, technology forecasting would predict that the size of a specific type of drive (FC, SCSI, SAS, SSD, and NL) would double in about two years. The bandwidth

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[1] Refered to as Moore's Law - the number of transistors on integrated circuits doubles approximately every two years. This "law" is now used in its own way for to guide long-term planning and to set targets for R&D. Other laws or conjectures exist for network capacity and hard disk storage.

available on network switch ports seems to follow an order of magnitude increase after every new release. First there was 1 Mbit, then 10 Mbit, followed by 100 Mbit, then 1 Gbit, and lately 10 Gbit, with the cost to manufacture these switches decreasing over time. The 10 GbE switch sold next year will cost less than the 10 GbE switch sold last year. This simple type of extrapolation applies to most of the data center components within data center infrastructure.

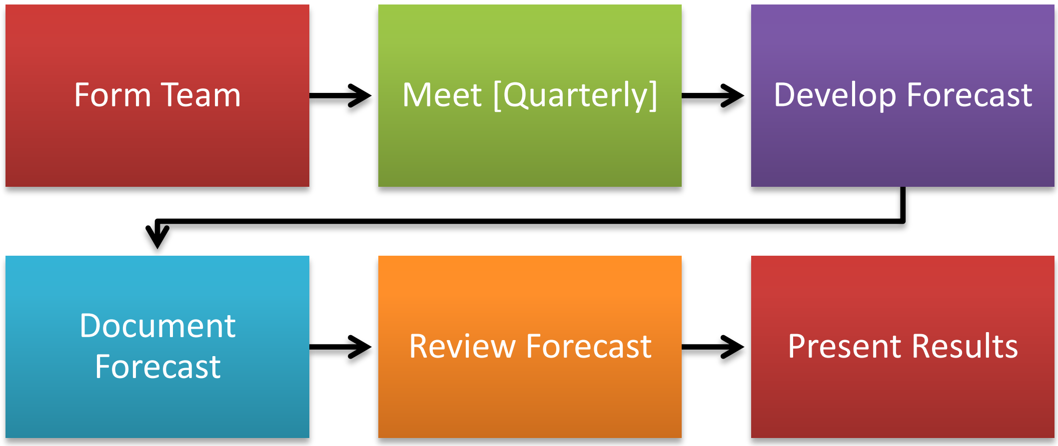
The next method would be the use of pattern analysis – analyzing the patterns of data center infrastructure for common features across disparate types of components. For example, there has been a growing trend to use embedded Linux in appliance-like devices to create simple to use devices. This has been done with most security appliances, some storage arrays and now is being used on network switches, such as Arista Network's family of switches. Another example of a pattern prevalent in most datacenter infrastructure is the use of modular components to scale out hardware infrastructure instead of scaling up or scale horizontally, instead of vertically[2]. Another pattern that exists is the use of virtualization to create virtual resources or pools out of physical resources. This was first done with network switches using VLAN(s), then with Storage using LUN(s) and finally with servers using hyper-visors. This type of virtualization attempts to create an abstract resource or pool out of physical components.

Another method that could be used (there are several others available) would be the use of intuition. The most obvious implementation of this method is the Delphi-scenario writing (DSW) method - a complex eight-step process first used by Toshiba Corporation in 1978 for developing the facsimile innovation. A full description and implementation of this method is outside the scope of this document, but is certainly recommended given the useful insights garnered as a result of using the method. However, the use of the full method is extensive, comprehensive and exhaustive and should only be undertaken provided there is a commitment from DAS/BEST leadership and there are enough staff resources available.

Steps to conduct technology forecasting:

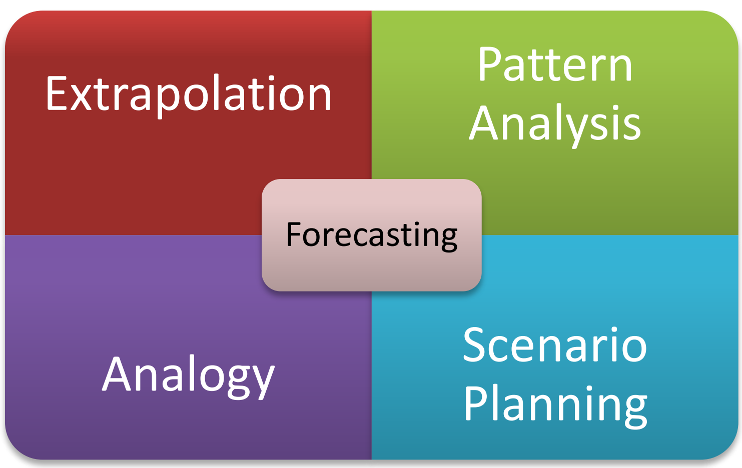
- Setup a team of senior technical staff
- Meet at least quarterly
- Using at least 3 methods, develop forecast for a set time-period
- Document forecast – share with DAS/BEST leadership
- Review prior forecasts older than at least one year
- Review results with DAS/BEST leadership

[2] Scaling horizontally means to add more nodes to a system, scaling vertically means to add more resources to a single node in a system.



Methods for Forecasting:

- Extrapolation
- Pattern Analysis
- By analogy
- Delphi Scenario



5 Critical Factors for Roadmap

5.1 Success Factors

For DAS/BEST to have a successful implementation there are some key factors that must be incorporated into the overall plan and roadmap for the project. Most of these critical success factors are the standard factors associated with any large complex project and primarily focus on clear and timely communication, though in different aspects.

The first critical factor is agreement among management, project sponsors and other stakeholders on the purpose and goal of the project and ultimately what problem the project is intended to solve, that is what the desired result is. So far, in the strategy outlined, the primary goal is the implementation of converged infrastructure achieved with automation and configuration management. The problem as understood is that DAS/BEST needs to achieve greater efficiency and utilization of their current staff resources, since no budget is available for hiring. During the course of the implementation of the strategy, clearly defined goals for each portion of the overall project and a final overall goal should be stated, defined and measured.

The second critical success factor is a clearly defined plan with assigned responsibility and accountability. Developing a plan for the strategy will require more than just assigning tasks to staff; in addition, clearly defined deliverables for each portion of the project must be defined along with the tasks necessary to produce them. Also important are listing any potential risks.

Next, the scope of the project must be managed. The project scope is defined in the goal setting and planning stages. During the course of the project the scope or work effort requested will change. The goal is to manage these changes and to understand are the changes necessary. It is also necessary to understand how these changes will affect the overall project budget.

The fourth success factor is the need to communicate constantly among management, the stakeholders and the staff. The best approach used is to provide weekly status reports with monthly review meetings. In addition, an issues log should be kept that highlights any exceptions or deficiencies with assignment to someone responsible for resolving the issue. The staff assigned to work on the overall project will also need task assignments and regular briefings on short and long-term goals.

The final success factor is the need for management support. This is directly related to agreement on project goals, since management must agree that the project is important, but also that it will provide value and solve an important problem[3]. During the course of the overall project as outlined in this roadmap, it is clear that the entire organization will be consumed with this work for several years. Management support will be critical for the completion and success of the project.

5.2 Project Prerequisites

5.2.1 Define the problem

The single most important goal for this roadmap is the definition of the problem that the DAS/BEST organization must solve. The first step is identify the problem to solve (this has been done with the strategy presented earlier). The second step is to make sure it is the right problem to solve. Historically, most projects and products designed and delivered to the marketplace fail because they did not solve the right problem. The single most important goal is for the DAS/BEST IT organization to agree that this is right problem to solve.

DAS/BEST should also avoid stating the problem is solved too soon. It is quite possible that the problem has currently defined is wrong and therefore the solution proposed will fail. Vendors may also attempt to define the problem and therefore the solution to their advantage. Vendor solutions should be examined carefully. Finally, the agency customers may clamor for a solution to their problems that represents only a temporary solution (Band-Aid), while the organization must focus on a strategic solution that makes them more efficient, less costly and more responsive.

[3] It is this author's understanding that all of this is currently true.

Internally, the DAS/BEST organization should pursue their own, even cursory, analysis to further define their strategy and the potential scope for this initiative. The steps are:

- Define Goals and Mission
- Assess Needs and Review Performance
- Gap Analysis
- Define Strategy
- Detail the Scope of the Project

5.2.2 Manage Requirements

It is important to develop detailed plans, requirements, and documentation before implementing the solution. Any impulse to reduce this planning effort will eventually lead to cost overruns and delays – ultimately a disappointing outcome.

After upfront planning, there are critical issues of change control. Modifying one requirement may have a domino effect on various dependencies within the project or the deliverables. It will be important to track the relationships between requirements, and it will be an invaluable tool in determining the cost and schedule consequences of making changes that, on the surface, appear innocent and small. Processes for defining requirements and managing their change over time provide an important means to managing costs, schedule, risk, and product quality.

5.2.3 Choose the Team

Even the best plan and strategy will fail without the proper team. Major projects require an effective team to be successful; project management and planning alone are not enough.

The right team consists of several parts: the core project staff, the experts who serve as resources, the suppliers, and the organization-wide stakeholders that including business, technical, management, and agency customers. The team should have the necessary skill, experience, and commitment to make the program or project work. Finally, the team members should be committed to the group, the collective vision, and the overall success.

The importance of the team is obvious, but programs and projects often get into trouble because the team is incomplete, some members are unprepared or inexperienced, or the group dynamics are uncoordinated. If a project has a high priority, leadership must commit to making the right people and resources available.

5.2.4 Maintain a Common Understanding

Although a considerable amount of effort will be expended to communicate all the relevant information to everyone within the organization, it is still possible for misunderstandings to occur and for some aspects of the project to be overlooked. This is the reverse of "ensure proper communication", since the information may have been communicated, but not properly understood. It is also important that understanding among all of the various disciplines within the DAS/BEST organization has the same understanding and that this understanding matches that of management. For example, if the network team all have the same understanding, to build the network according to best practice, but they do not understand that additional VLAN(s) must be created or that the network must be integrated with the hyper-visor, then the overall design and goal – to create a converged infrastructure, will fall short.

It is also possible for the different teams to have the same understanding, build the "best" possible infrastructure, when management has actually meant, build the lowest cost with the most features and best integration. The need to over-communicate and to check the understanding of the various groups within the organization cannot be stressed enough. Some method for real-time feedback from each group will be very useful at preventing the activities of the team from straying too far from the final goal.

5.3 Application to Roadmap

It is not enough to be aware of success factors and necessary project prerequisites; these must also be applied to each portion of the overall roadmap and each sub-project. For the key success factors: management agreement, a clearly defined plan, managing the project scope managed, constant communication, and management support, there is a point during the project when these items must be addressed, and in the case of communication many times during the course of the project.

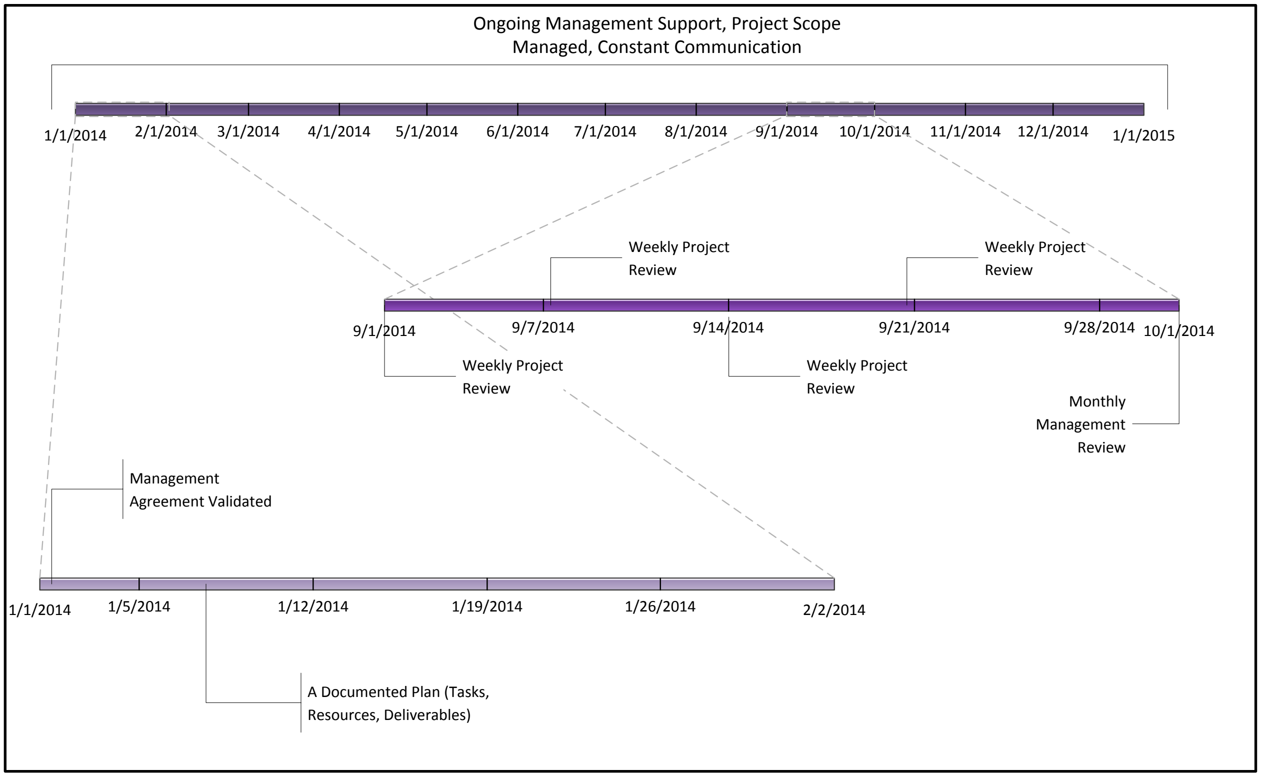


Figure 12 - Project Breakdown

Figure 12 depicts a yearlong project time-line with the initial project start shown expanded as well as a typical month. Shown at the project start are two milestones, the point when agreement on the project goals, budget and problem definition have been validated, along with agreement on the proposed solution. The next milestone is the document project plan that includes tasks with assigned resources and deliverables identified. The expanded month shown shows the frequency of weekly project status reviews along with a monthly management review of progress and issues.

The ongoing factors of managing project scope and constant communication can be addressed with the use of documentation. For project scope, this is the use of change control to communicate the impact to the project, goals and budget for any requested changes. For communication among the team and management, weekly status reports and monthly reviews will be important. Also necessary is that an issues log be maintained during the course of the project so that all team members and management are aware of issues and their relative priority and that these are addressed as quickly as they surface.

Several key items need to be determined before the project starts. These are a clearly defined problem statement and an agreed upon solution by management and the project team. A clear list of documented requirements that the completed solution must meet and finally, the actual team identified that will work on the project.

6 Implementation Planning

An implementation plan describes how the system will be deployed, installed and transitioned into an operational system. The plan should contain an overview of the system, brief description of major tasks, overall resources required to include hardware, software, facilities, materials and personnel and any site specific implementation requirements. For the purposes of the DAS/BEST implementation some of this has already been documented as part of the initial strategy. However, additional detail is required to identify the major tasks and assignment of resources.

6.1 System Overview

The goal is the implementation of an automated virtual infrastructure capable of some limited self-service by agency customers. The overall system should be capable of providing disaster recovery protection for agency applications. This implies additional goals to include:

- Active/active datacenters at two different sites
- Billing system for determining charges for agency customers
- Converged infrastructure accomplished with automation and configuration management

System organization and description have been described in detail as part of the strategy. However, to repeat those again briefly, they are:

- Virtual infrastructure composed of:
  - VMware Hyper-Visor and management components (vCenter)
  - Intel-based Rack-mount server (HP, DELL, IBM or equivalent)
  - Brocade Ethernet switches
  - Tintri Storage (or equivalent hybrid modular storage array)
- Backup Infrastructure composed of:
  - CommVault Simpana software (backup)
  - ExaGrid (or equivalent backup storage target)
- Disaster Recovery Infrastructure composed of:
  - Zerto BC/DR software

There is also a need to implement software components that automate the provisioning of application environments. These apply to two areas of the infrastructure. The first is the automation of the base hardware to include the hyper-visor. The second area requiring automation is the use of configuration management software for application components to include databases, web servers, and middleware.

The last component of the overall system is the use of billing software to track usage by each agency customer whether an invoice is issued or not. This last component allows the DAS/BEST IT organization to track the actual costs associated with each agency customer as a method for determining changes in usage of the overall infrastructure.

6.2 Management Overview

The overall converged infrastructure as outlined above would be deployed over the course of several years in phases that build each major underlying infrastructure. In order of implementation these would be: Virtual, Backup, DR, Automation, Configuration Management, and finally Billing. Installation for each major sub-component will occur at two sites as determined by the organization. Each will have a substantial period of deployment (1-2 months) before the next phase is started. This approach staggers the implementation and allows the staff and organization each subsequent project without excessively burdening the staff; though implementing this infrastructure still represents a considerable effort on the part of the entire DAS/BEST organization.

Prior to starting the implementation of the system, a list of contacts broken down into groups responsible for implementing each major system component is necessary. These should the manager responsible for that area and associated component(s). A sample contact list (shown in Table 8) includes columns for the phase of the overall project, the group responsible for managing that subset of the infrastructure, contacts within the group responsible for the infrastructure, their respective responsibilities and contact information to include e-mail address and phone number.

Project Phase	Group	Contact	Responsibility	E-mail	Phone #

Table 8 - Sample Contact List

Also, the major tasks should be listed in a format that is organized by major phase. This will become the initial start of the final project plan. The information required for this is the phase the task is associated with, the name of the major task, a description of the task, what the task is expected to accomplish, resources required to accomplish the task, key persons responsible for completing the task, and criteria for successful completion. Table 9 lists some of the initial major tasks for the overall project as outlined in the project planning section for the deployment of virtual infrastructure.

Project Phase	Major Task	Description	Expected to Accomplish	Resources	Personnel	Criteria for Success
Virtual Infrastructure	Complete General Design	High Level Design of virtual infrastructure	Description of infrastructure	Visio, Vendors, Resellers	Solution Architects, Technical Leads	Complete and accurate BOM and Quotes
	Issue P.O.	Purchase equipment and licenses	Purchase of necessary components	Accounting P.O.	Chief Financial Officer, Director IT	Equipment ordered with delivery dates provided
	Complete detailed design	Detailed design of entire virtual infrastructure	Detailed description of component integration	Visio	Solution Architects, Technical Leads	Completed design with sufficient detail to fully describe how infrastructure will be configured

Project Phase	Major Task	Description	Expected to Accomplish	Resources	Personnel	Criteria for Success
	Build infrastructure	Install, rack, cable and configure components	Operating virtual infrastructure	Hardware and software components as purchased	Technical leads and staff	Fully functional virtual infrastructure Tested as specified
	Migrate Virtual Guests	Move/migrate virtual guests from current to new infrastructure	Virtual guests will be running in new environment	Migration tools as needed network links between sites	Technical leads and staff	Virtual guests moved. Current infrastructure decommissioned
	Migrate Physical Servers	Virtualize physical server workloads	Complete virtualization of remaining physical servers	Migration tools, network links between sites	Technical leads and staff	Physical servers running properly in virtual infrastructure Physical servers decommissioned

Table 9 – Major Task List Sample

A similar major task list should be completed for every sub-project within the overall strategy to include backup, disaster recovery, and automation and configuration management. The next step is the creation of a task completion schedule that includes the start and end dates for each major task. Dependencies on other tasks should be noted, unless the predecessor task is the one immediately prior. The amount of duration for the task (different than effort) and the effort required should be noted if known. The sample given below in TAB provides an example, the values given for dates, duration and effort are only intended as an example and do not indicate actual dates, duration or effort.

Project Phase	Major Task	Description	Start Date	End Data	Duration	Effort
Virtual Infrastructure	Complete General Design	High Level Design of virtual infrastructure	3/1/2014	4/1/2014	1 month	9 days
	Issue P.O.	Purchase equipment and licenses	4/5/2014	Milestone	1 day	1 hour
	Complete detailed design	Detailed design of entire virtual infrastructure	4/1/2014	6/1/2014	2 months	4 weeks
	Build infrastructure	Install, rack, cable and configure components	6/1/2014	8/1/2024	2 months	7 weeks
	Migrate Virtual Guests	Move/migrate virtual guests from current to new infrastructure	8/1/2014	10/1/2014	2 months	8 weeks
	Migrate Physical Servers	Virtualize physical server workloads	10/1/2014	2/1/2015	4 months	12 weeks

Table 10 – Major Task Schedule Sample

6.3 Implementation Support

Implementation support section of an implementation plan is a schedule of the hardware, software, material and resources needed at specific points in the project to support the ongoing project efforts, not strictly site specific. Hardware would include testing equipment; software might include software needed to support the project though not specifically part of the actual implementation. An example might be project planning software or resources schedule/planning software. Material needed for support might include tapes, cable labels, and access badges for consultants or contractors.

Finally, personnel requirements should be determined. These requirements include the number of personnel, length of time needed, and skill levels needed. Based on this information, an analysis should be conducted to determine what training if any, is needed and when it should be scheduled. In addition, if it is clear that not enough staff is available for the project, personnel will either need to be hired or consultants/contractors brought in to temporarily staff to level consistent with support the project and ongoing operations efforts.

6.4 Implementation Requirements

This section of the implementation plan describes site requirements and procedures. If these differ by site, describe the requirement for each site. Define requirements that must be met for careful and orderly implementation of the infrastructure at each site. This would include hardware, software and site-specific facilities requirements to include racks, cables, power distribution, cable trays and labeling.

Subsections should be added that address site-specific hardware and software requirements necessary to support the implementation. Facilities requirements may also include additional office space, working areas, staging areas, specific areas completed in the data center.

A section of the plan that addresses the specifics of the implementation of the infrastructure for a site should also be completed. Information would include:

- **Team**: If an implementation team is required, describe its composition and the tasks to be performed at this site by each team member.
- **Schedule**: Provide a schedule of activities, including planning and preparation, to be accomplished during implementation at this site. Describe the required tasks in chronological order with the beginning and end dates of each task. If appropriate, charts and graphics may be used to present the schedule.
- **Procedures**: Provide a sequence of detailed procedures required to accomplish the specific hardware and software implementation at this site. If necessary, other documents may be referenced. If appropriate, include a step-by-step sequence of the detailed procedures. A checklist of the installation events may he provided to record the results of the process.

In addition to the above, site operations startup is an important factor in implementation; therefore startup procedures should be addressed. If a period of parallel operation will occur while the current migrations occur then operations will need to occur for both infrastructures simultaneously and plans for personnel and other materials should be determined prior to the start of the project.

The last two important sections for the infrastructure implementation are a back out plan that specifies how to revert to the current infrastructure if there are issues with the new infrastructure and a process for verifying through tests of the function, performance and resiliency of the infrastructure. The back out plan should include a list of steps and actions that will revert to the current infrastructure.

Verification requires that any discrepancies be rectified – i.e. performance issues be addressed, and any single points of failure be corrected. Given the nature of the infrastructure, verification should be completed before the actual migration of virtual and physical servers begins.

7 Project Planning

Although the goal is not to present a formal project plan as part of this roadmap, it is important to review a high-level project plan and to discuss certain tasks that need to be completed in order to create a viable and useful project plan. The first step is the creation of a work breakdown schedule – simply a list of all the tasks that need to be completed for the project down to an appropriate level of detail, grouped hierarchically based on logical delineation of phases within the project. The level of granularity depends on the need by project management, though in general tasks should be broken down to the point where a single resource can complete the task in some fraction of a day. A task that takes too long and is too vague is difficult to complete, however too much detail and too granular and the team is consumed with updating the project plan instead of doing real work.

The initial work breakdown schedules for the major sub-projects are show below in diagrams [Figure 13, Figure 14, Figure 15, Figure 16, and Figure 17]. These are not complete and only show the major headings and phases with the major sub-tasks. The next step that the DAS/BEST organization should take is the completion of these schedules to far more granular level.

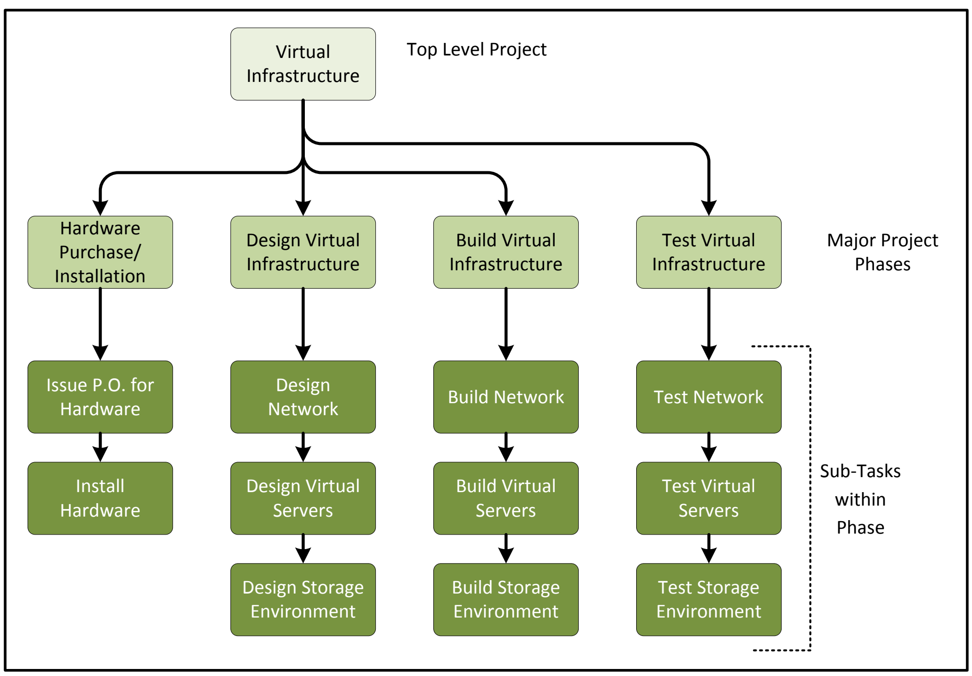


Figure 13 - Virtual Infrastructure Work Breakdown

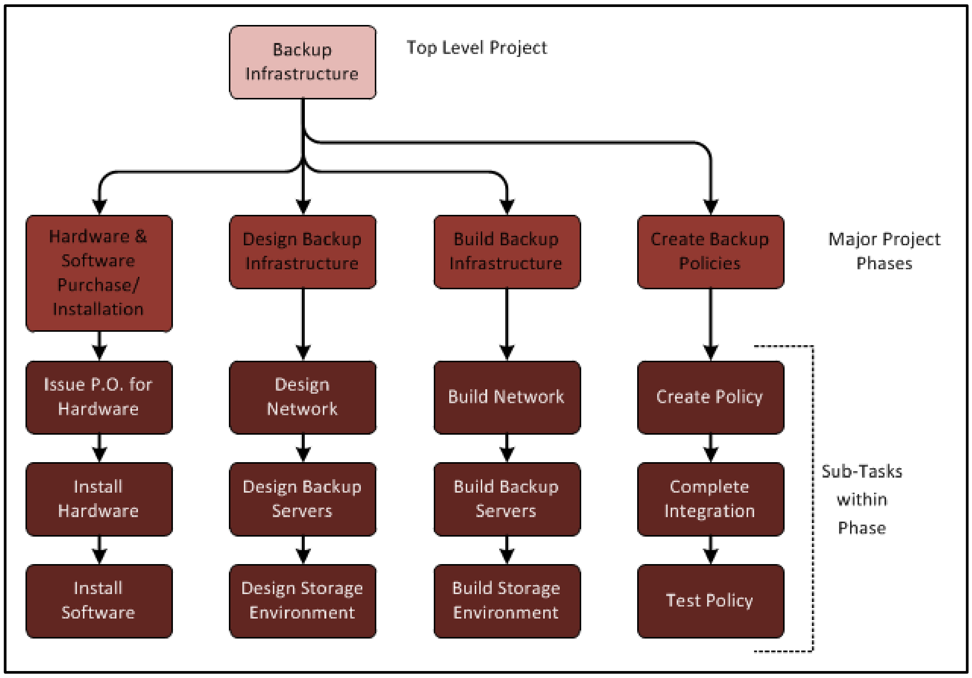


Figure 14 – Backup Infrastructure Work Breakdown

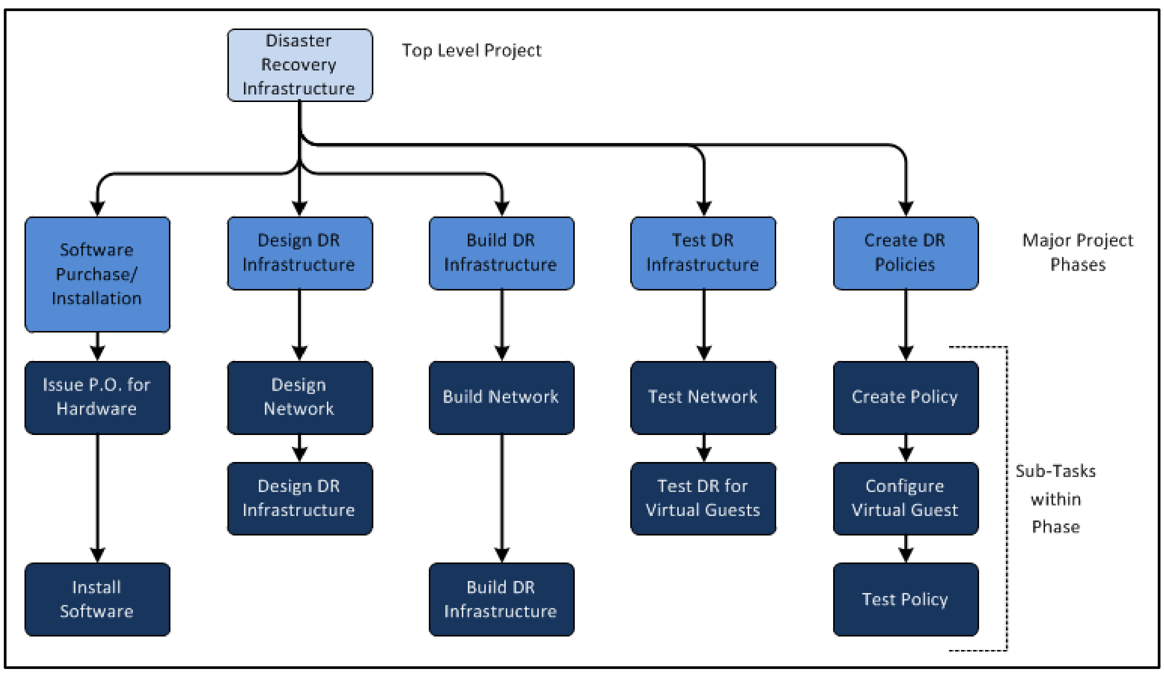


Figure 15 – Disaster Recovery Infrastructure Work Breakdown

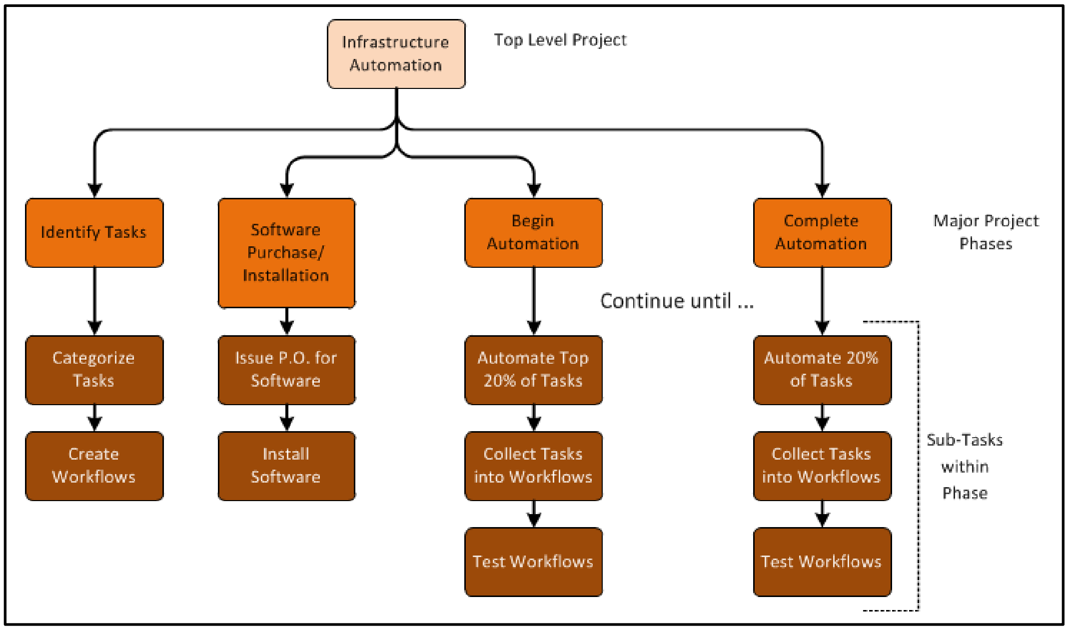


Figure 16 – Infrastructure Automation Implementation Work Breakdown

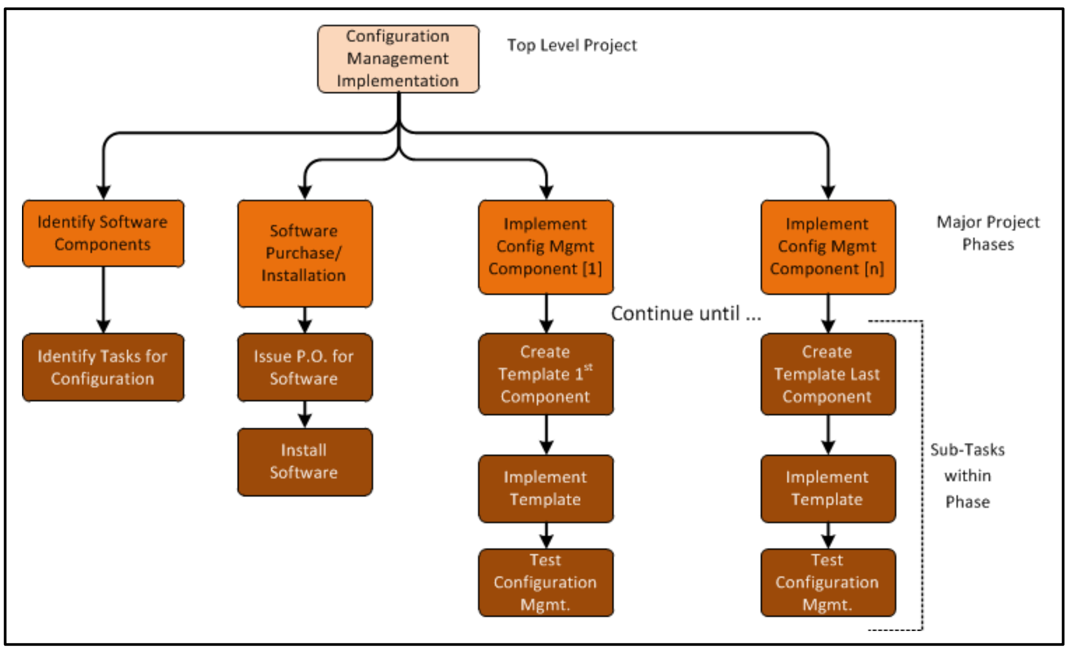


Figure 17 – Configuration Management Implementation Work Breakdown

In each case, further detail needs to be provided under each major sub-task, such that these become additional headings for tasks lists. In addition, time to complete each task (approximately) should be shown with totals included at the heading level.