A Cloud Computing Business Case Analysis for Existing Training Systems

Paul Dumanoir
PEO STRI
Orlando, FL 32826
Paul.H.Dumanoir.civ@mail.mil

Jeffery Bergenthal, Mark Hodgins, John Tamer, Rodney Yerger
The Johns Hopkins University Applied Physics Laboratory
Laurel, MD 20723
Jeffery.Bergenthal@jhuapl.edu, Mark.Hodgins@jhuapl.edu, John.Tamer@jhuapl.edu, Rodney.Yerger@jhuapl.edu

ABSTRACT

The US Army has published several documents and directives that establish the overarching strategies, guidance, and an implementation plan for the rationalization and modernization of the Army's information technology (IT) systems and applications. The guidance and implementation plan mandate a Business Case Analysis (BCA) be performed when assessing the migration of IT systems and applications to approved hosting environments, and closing or consolidating data centers. These overarching strategies, guidance, and implementation directive impact how the Army's Integrated Training Environment (ITE) will be hosted in the future. The individual training devices and simulations that comprise the ITE have existed for some time, and some of the architectures may not support effective homestation training if they are hosted in a distant enterprise data center. This paper reports on the analysis performed to assess the main systems that comprise the ITE System of Systems (SoS), and conduct a BCA in accordance with the Army guidance. The technical assessment framework that was developed for the characterization and technical assessment of training and simulation systems is described. The paper then discusses how the framework was utilized to characterize and assess each of the systems, including critical system-of-systems aspects, and generate the technical rationale for feasible cloud migration alternatives. The approach and methodology for the BCA are described, and the calculated cost and economic viability are presented for each of the feasible migration alternatives. Sensitivity analysis results are shown illustrating the extent to which alternative rankings change as a result of varying certain factors and/or assumptions. Finally, the paper discusses how the technical assessment and BCA provide PM ITE with the information necessary to support planning, budgeting, and architectural evolution for the migration of the ITE to the cloud.

ABOUT THE AUTHORS

Paul Dumanoir is the Chief Engineer for Product Manager for Warrior Training Integration, Project Manager Integrated Training Environment (PM ITE) at PEO STRI. He has 30+ years of experience in simulation and training as Product Manager, Project Director, and Systems/Software Engineer. He holds a B.S. in Electrical Engineering from the University of South Alabama and M.S. in Computer Systems from the University of Central Florida.

Jeffery Bergenthal is a Program Manager at JHU/APL, providing leadership of acquisition and training programs for Department of Defense (DoD) sponsors. Previously, he spent 26 years with the Lockheed Martin Corporation, most recently as the Director of Advanced Programs. He holds a M.S. in Operations Research from the University of California, Los Angeles, and a B.S. in Management Science from the Massachusetts Institute of Technology.

Mark Hodgins is an analyst at JHU/APL, providing cost, business, and economic analysis that facilitate resourcing decisions for DoD sponsors. Previously, he spent 6 years as a management consultant for Booz Allen Hamilton. He has also served as an economist for the Bureau of Economic Analysis. He holds a M.A. in Applied Economics and a B.A. in Economics from the Johns Hopkins University.

John Tamer is a systems engineer at JHU/APL, supporting a variety of Government sponsors on projects including cloud computing and Nuclear Command and Control. Previously, he spent 12 years with (then) Price Waterhouse as an IT consultant. He holds a B.S. in Computer Science and a MBA from Syracuse University, a B.S. in Accounting from The University of Maryland and a M.S. in Systems Engineering from The Johns Hopkins University.

Rodney Yerger is an analyst at JHU/APL, leading a team that provides affordability analysis and assessments for DoD sponsors. Previously, he spent 10 years as a civilian supervisory program analyst on the staff of the Chief of Naval Operations. He holds a M.S. in Cost Estimating and Analysis from the Naval Postgraduate School, a MBA from the University of Maryland, and a B.S. in Mechanical Engineering from the U.S. Naval Academy.

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INTRODUCTION

This paper provides an overview of a business case analysis that was performed on migrating a system of training systems to a cloud computing environment. Cloud migration strategy and guidance are discussed, followed by a description of the system of training systems. A set of technical criteria for assessing the readiness and suitability of migrating a training system are introduced, as well as proposed architectures that were guided by the technical assessment results. The methodology for conducting a business case analysis is described and the results of this analysis are presented. The paper concludes with a description of roadmap development for a cloud migration effort and a summary of the main findings of the analysis. This paper is intended for any organization that is considering the migration of training and simulation systems to a cloud computing environment or an enterprise data center.

ARMY CLOUD MIGRATION STRATEGY AND GUIDANCE

The Federal Government, Department of Defense (DoD) and the Army have published policy, strategy, plans, and technical information regarding the migration of systems and applications to enterprise data centers, and the consolidation of data centers. At the Federal Government level, a memorandum was published on the Data Center Optimization Initiative (Office of Management and Budget, 2016) that requires Federal Agencies, including the DoD, to develop strategies and report on their progress to consolidate data centers. Further, both the DoD Chief Information Officer (CIO) and the Army have published guidance requiring the development and use of a Business Case Analysis (BCA) as part of the migration decision making process (Department of Defense Chief Information Officer 2014; Department of the Army Chief Information Officer/G-6, 2015, March). The Army has published a directive on the migration of systems and applications to approved hosting environments and the closure of existing data centers (Secretary of the Army, 2016). The directive specifies that all Army Mission Training Complex (MTC) Special Purpose Processing Nodes (SPPNs) must be closed by the end of Fiscal Year (FY) 2024. While this directive excludes training simulators and simulations, weapons system specific and non-systems training aids, devices, simulators, and simulations (TADSS) from migration, it specifically states that computing and data centers at mission training centers and mission training simulation centers must be migrated, which directly impact the future hosting of the Army's Integrated Training Environment (ITE).

The Army has published policy, strategy, plans, and technical documents on the hosting environments for systems and applications that migrate. The Army's vision for delivering cloud-enabled capabilities is laid out in their Cloud Computing Strategy (Department of the Army Chief Information Officer/G-6, 2015, March), and guidance has been provided on migrating applications and the use of commercial cloud service providers (CSPs) (Department of the Army Chief Information Officer/G-6, 2015, July). The architecture for the Army's data center and cloud computing environment and architecture compliance (Office of the Assistant Secretary of the Army, Acquisition, Logistics & Technology, 2014a; 2014b) provide the technical information for building and migrating applications to this environment. Analysis of these policies, strategies, plans, and technical documents identified a number of criteria that will influence the migration of the ITE from both a process perspective and from a technical perspective.

THE INTEGRATED TRAINING ENVIRONMENT (ITE)

The ITE is a system of systems (SoS) that provides a complex Operating Environment to support brigade and below combined arms training at home station enabling commanders to train agile and adaptive leaders and versatile units.

The ITE SoS includes TADSS from the Live[1], Virtual[2], Constructive[3], and Gaming domains; Mission Command Systems, an integrating architecture, and the installation's supporting infrastructure, as shown in Figure 1.

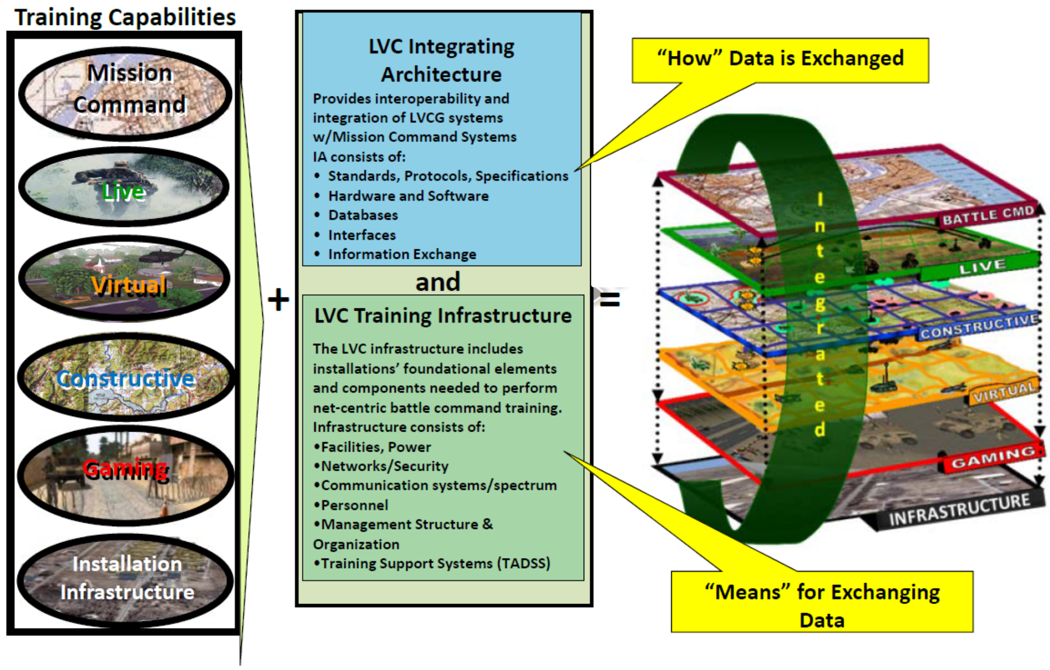

Figure 1. The Integrated Training Environment.

The ITE SoS is being used at twelve (12) homestations in and outside the continental United States. At each deployed location, the ITE uses the local homestation network infrastructure with the individual TADSS being separated by no more than a few miles.

The ITE consists of the following currently fielded live, virtual, constructive, and gaming training capabilities, and an integrating architecture:

- Aviation Combined Arms Tactical Trainer (AVCATT) - a mobile, transportable, multi-station virtual simulation device that supports unit collective and combined arms training for helicopter aircrews. Each device consists of networked manned modules that are driven by a highly specialized Image Generator that are subject to stringent system latency requirements.
- Close Combat Tactical Trainer (CCTT) – a virtual simulation device that supports the training of Infantry, Armor, Mechanized Infantry, Cavalry and Armored Reconnaissance units from squad through battalion/squadron level, to include their staffs. Like AVCATT, each device consists of networked manned modules that are driven by a highly specialized Image Generator that are subject to stringent system latency requirements.
- Games For Training (GFT) - Virtual BattleSpace 3 (VBS3) – a commercial-off-the-shelf (COTS) game-based three-dimensional (3-D), first-person platform that allows the Army to train small unit tactics, techniques and procedures in Decisive Actions. A VBS3 suite consists of a server, 52 laptop computers, and three network switches. Each laptop computer has an NVIDIA graphics processing unit (GPU).
- Joint Land Component Constructive Training Capability (JLCCTC) – a constructive simulation environment that stimulates Mission Command Systems to provide unit commanders and their battle staff

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[1] Live simulation: A simulation involving real people operating real systems. [DOD M&S Glossary, version 2013.1]

[2] Virtual simulation: A simulation involving real people operating simulated systems. [DOD M&S Glossary, version 2013.1]

[3] Constructive simulation: Simulations involving simulated people operating simulated systems. Real people can be allowed to stimulate (make inputs) to such simulations. [DOD M&S Glossary, version 2013.1]

the capability to train in an operationally relevant environment. A JLCCTC federation can consist of one - three enclaves, allowing for different classification levels to interoperate with each other by separating tasking and parametric data. JLCCTC generally runs geographically dispersed, with multiple physical sites connected by Wide Area Networks (WANs).

- Homestation Instrumentation Training System (HITS) – an instrumentation system that provides position location and weapons effects data for the real-time exercise monitoring and after action review (AAR) of force-on-force and force-on-target training conducted at homestation ranges.
- Live, Virtual, Constructive – Integrating Architecture (LVC-IA) – a system of tools, hardware and software that provides the net-centric linkage that collects, retrieves and exchanges data among the training capabilities listed above and both joint and Army Mission Command Systems. LVC-IA consists of gateway components that provide protocol translation and communication among various training capabilities; an Exercise Control component; an enterprise after-action reporting component; and a cross-domain solution to control data movement between the unclassified and classified environments.

For purposes of this ITE cloud migration technical assessment and BCA, only the synthetic (virtual, constructive, and gaming) and LVC-IA components of the ITE were considered. Although the Live component, HITS, was not part of this effort, it can certainly benefit from the results of this work.

During FY2016, a technical assessment and BCA were performed on a small subset of simulation programs of record (PORs) for migration to a cloud computing environment: LVC-IA, VBS3, and Synthetic Environment Core (SE CORE). The individual assessment and BCA of these three PORs, as currently architected, determined that no cloud migration alternative resulted in significant economic or technical benefit from the "as is" program (Johns Hopkins University Applied Physics Laboratory 2016a; 2016b; 2016c). As a result, PM ITE decided to conduct a cross-portfolio technical assessment and BCA on the ITE SoS using shared computing assets, and taking into account the planned architectural evolution of the each of the ITE's component systems.

TECHNICAL ASSESSMENT OF THE ITE SYSTEM OF SYSTEMS

Moving a system to a new environment with a fundamentally different architecture is a challenge for any organization. A determination must be made as to whether the system can be migrated as is, must be completely re-architected, or somewhere between those two extremes. In the case of the systems under consideration here, there are many complicating factors, both from a system perspective, and from a SoS perspective.

Assessment Criteria

Analysis was performed to identify the criteria that should be considered in determining which systems, or components of the systems, would be candidates for migration to a cloud computing (National Institute of Standards and Technology, 2013) environment or enterprise data center. The criteria that were identified include items that are specific to a particular system, as well as items that are relevant for SoS performance. These criteria are general in nature and can be applied in assessing training and simulation systems for migration to a cloud computing environment or enterprise data center.

- Virtualization: Virtualization involves technology in which an application, guest operating system or data storage is abstracted away from the underlying physical hardware or software. A key use of virtualization technology is server virtualization, which uses a hypervisor to emulate the underlying hardware. This may include central processing unit (CPU), memory, input/output (I/O), and network traffic. Virtualization is a key component of cloud computing that supports some of the essential characteristics of cloud computing such as rapid elasticity, on-demand provisioning and resource pooling. Systems must be virtualized before, or as a part of, a migration.
- Special Purpose Hardware: Special purpose hardware includes Government off-the-shelf (GOTS) or commercial off-the-shelf (COTS) hardware components required by the simulation. Examples include image generators, manned modules, and graphics processing units. These are considered special purpose in the sense that they are not typically available as part of a commodity server configuration. Depending on the specific system, special purpose hardware is difficult or even impossible to virtualize. Components such as graphics processing units can be shared across multiple virtual servers; however, these may not be

available as a part of the type of commodity servers found in typical cloud environments. Further, they are unlikely to be available in most commercial cloud environments. Other types of special purpose hardware may need to be re-architected.

- Mobile/Fixed: Some AVCATT and CCTT systems must be self-contained in order to be relocated. This type of system can be moved to a new location to support stand-alone training or a federated simulation. Fixed systems are permanently located at a training complex or other installation. A mobile system must either be self-contained or be able to connect to shared resources as needed. If a mobile system must connect back to shared resources, consideration must be given to the system's latency requirements and network requirements.
- Latency Requirements: Latency is the time between a user event and the system response. Network latency is created by a number of factors, including geographic distance between the user (point of need) and the system. Some simulators and simulations are particularly sensitive to latency. Since network latency, in particular, is impacted by factors such as geographic distance and the number of intermediate hops in the network path, careful consideration must be given to the geographic placement of resources. End users begin to notice latency at around 100 milliseconds (Johns Hopkins University Applied Physics Laboratory, 2016a), and some systems may only tolerate up to approximately 50 milliseconds of network latency before becoming unusable (MITRE Corporation, 2015).
- Security Impact Level: The Security Impact Level is associated with the data stored or processed by the system. The levels range from level 2, which is unclassified and publically releasable, to level 6, which is classified SECRET. The Security Impact Level is particularly relevant for Commercial Cloud Service Provides whose facilities are approved by the DoD to host data up to and including a particular level. The current DoD Security Requirements Guidance does not encompass Top Secret (TS) and Top Secret/Sensitive Compartmented Information (TS/SCI) systems. Systems that must process TS or TS/SCI information or connect to networks at those classifications are subject to the requirements and regulations of the Defense Intelligence Agency (DIA) or the intelligence community. Careful consideration must be given to the security requirements of the capabilities being migrated in light of the facilities and accreditations available at the target site. For example, TS/SCI processing must be confined to a Sensitive Compartmented Information Facility (SCIF). In addition, any change to the security architecture, including network connections and processing facilities will like require new security accreditations.
- Cross-Domain Requirement: A Cross-Domain solution (CDS) is an information assurance device that is used to support the transfer of information from one security domain to another. A CDS is typically employed when there is a requirement to transfer information between unclassified and SECRET environments. Cross-domain solutions are typically program-specific and may not be available at shared or enterprise facilities, even those, such as MilCloud, that have both unclassified and SECRET environments. There are also policy issues that prevent the use of a CDS in an enterprise facility.
- Multicast Simulation Protocols: Federated simulations typically employ multicast simulation protocols such as Distributed Interactive Simulation (DIS) or High-Level Architecture (HLA). These protocols are used for information exchange across multiple host computers. Experimentation conducted by PEO STRI in 2015 found that commercial cloud service providers are unlikely to support multicast protocols due to security concerns. Also, different systems use different protocols. These protocols are converted via LVC-IA gateways. This may necessitate the co-location of an LVC-IA gateway with a TADSS.
- Virtual Desktop Interface: Virtual Desktop Infrastructure (VDI) involves the hosting of desktop operation systems in a virtual server and then pushing the desktop system to a thin- or zero-client device. VDI can reduce the cost and support required to deploy desktop devices. The software and hardware necessary to support VDI would be required at any shared or enterprise facility. This is similar to virtualization in that while it may ultimately be a program-specific responsibility, the use of VDI should be implemented and tested prior to or as part of a migration. Further, thick clients must also be migrated to thin clients.
- Dual Use Hardware: Some systems make use of resources that are not dedicated and may be used for other purposes or to support other systems. This may limit the ability to migrate end-user devices to thin clients.

System and System of Systems Characterization

Each of the systems was assessed against the technical criteria identified above to identify their maturity and readiness for migration to a cloud computing environment or enterprise data center. Additionally, Army's published policy, strategy, plans, and technical information on the hosting environments for systems and applications that migrate were reviewed to identify additional criteria and technical compliance factors that were used to further gauge the maturity and readiness for migration. Examples of these additional technical factors include the system's support for Internet Protocol version 6 (IPv6), the system's virtualization container being in compliance with the Open Virtualization Foundation's standard.

Additional criteria were considered in characterizing the ITE SoS. One important criteria was response time and latency sensitivity of the SoS, and the resultant implications on network design and co-locating or minimizing the geographic distance between individual systems. A second criteria was SoS reliability, including the reliability of any networks connecting remote systems, as well as the reliability of the hosting environments, and the physical or virtual proximity and access to the system to facilitate the recovery. In total, these assessments provided the basis for the identification of the alternatives that were considered in the BCA.

Technical Assessment and Proposed Architectures

Each system was evaluated according to the assessment criteria, as described above. Taken as a whole, this evaluation guided the architectures to be considered. Further, certain characteristics, such as sensitivity to network latency or the use of special-purpose hardware, dictated that some systems remain located at the MTCs. In addition, systems that are, or could be, virtualized were co-located to the extent possible to make use of resource pooling and thereby reduce the physical hardware footprint.

According to the DoD Core Data Center Reference Architecture (Department of Defense Chief Information Officer, 2012), an SPPN is a data center that supports functions that cannot be supported by Core Data Centers or Installation Processing Nodes because of the need for local infrastructure or equipment. This includes the specialized requirements for modeling and simulation, and test ranges as well as other specialized systems. The proposed architectures investigated in this BCA considered designating the MTCs as SPPNs and then consolidating system resources, implementing a virtualization management layer, and implementing resource pooling among the virtualized TADSS, in effect, creating a private cloud at the MTC. Systems that are sensitive to network latency, or that utilize special-purpose hardware, will have their system resources resident in the MTC SPPNs. Two architecture variants were investigated for the remaining TADSS – co-location within the MTC SPPNs, and migration to an Army Enterprise Data Center (AEDC) or Army Private Cloud – Enterprise (APC-E). A representation of the second variant is shown in Figure 2.

BUSINESS CASE ANALYSIS

The BCA adhered generally to the DoD CIO BCA process (Department of Defense Chief Information Officer, 2014) for conducting Information Technology BCAs, so it could serve as the foundation for a formal BCA, to be authored by PEO STRI and submitted to the DoD CIO for approval per the Army Cloud Computing Strategy. The steps followed in conducting the BCA are shown in Table 1.

Table 1. Business Case Analysis Steps.

Step	Description
Define the Objective	Understand the problem; document a clear, achievable and measurable objective
Define the Scope	Define the analysis time frame; document ground rules and assumptions
Define Alternatives	Includes a status quo / baseline alternative
Develop Cost Estimate for Each Alternative	Life Cycle Cost Estimates that may include Total Ownership Costs; generate common Work Breakdown Structure
Identify Quantifiable and Non-Quantifiable Benefits	Monetary and non-monetary benefits (from technical and policy criteria)
Compare Alternatives	Via Economic Viability Metrics; test sensitivity
Report Results	Include recommendations

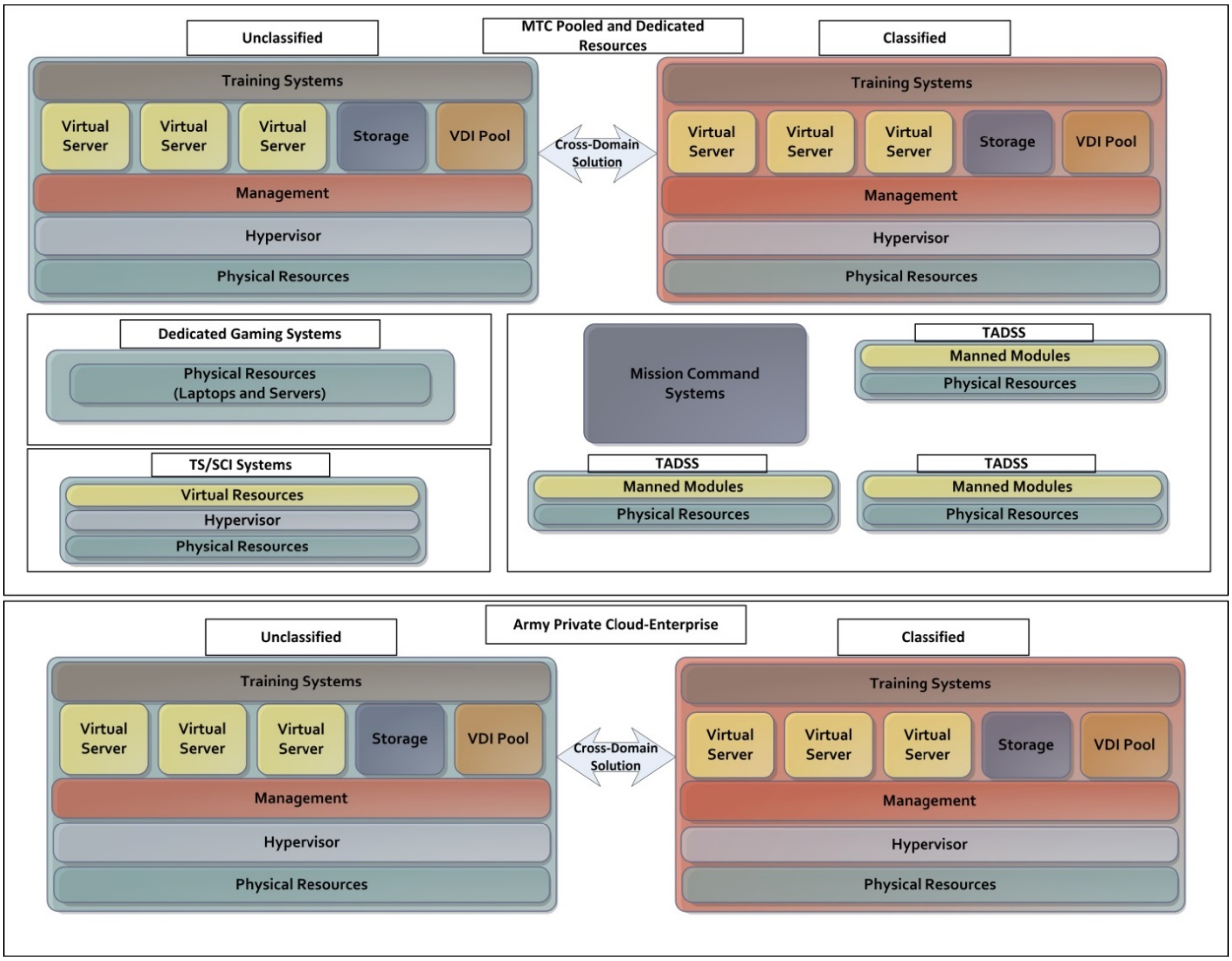

Figure 2. Representative Architecture for Variant 2.

Approach and Methodology

The BCA charter consisted of estimating both monetary benefits and costs associated with specific alternatives approved by PM ITE over a recommended analysis timeframe. This timeframe was agreed to by the study team, approved by PM ITE, and was based on a start date equivalent to the current year (i.e., FY2017) and an end date which coincided with the planned phase out of many of the PORs.

Based upon the criteria that were identified, and the technical assessment, the team went through a process of identifying and iteratively refining a set of alternatives for estimating monetary benefits and cost. These alternatives lend themselves to being practical based on the identified systems, the ITE SoS, constraints and Army directives. The alternatives represent a critical stepping stone toward a more encompassing strategic roadmap for the simulation system and ITE SoS migration to a cloud computing environment or enterprise data center. The specific alternatives are not provided as part of paper but totaled three alternatives (to include the status quo) and covered the spectrum of hosting all simulation applications at the Point of Need (PON), such as the MTCs, to hosting all simulation applications at Army enterprise data centers/cloud environments.

The cost estimating effort of the BCA relied on POR cost data to serve as the foundation for the baseline program costs. Specifically, the baseline/status quo costs were estimated using the current Program Office Estimates (POEs) for the five PM ITE PORs. The POR POEs served as the basis for a common work breakdown structure (WBS)/cost element structure (CES) that was adjusted to account for other elements that applied to the approved alternatives. The cost effort consisted of rough order of magnitude (ROM) life-cycle cost estimates conducted for each approved alternative calculated in FY 2017 and then-year dollars and reported as a point estimate with an uncertainty range reflecting confidence levels.

These estimates considered the four life-cycle categories as defined by the Defense Acquisition Guidebook (Defense Acquisition University) and DoD cost analysis guidance and procedures (Department of Defense, 2015):

- Research and development
- Investment/procurement
- Operations and support
- Disposal

Additionally, elements of Total Ownership Costs were also considered to include facilities maintenance, energy consumption, and MTC manpower.

The cost delta between each alternative and the status quo was calculated and key differences were detailed in the following areas:

- Development, Modernization, and Enhancement investments:
  - Virtual Server Procurements
  - Cloud Migration Development
  - Test and Evaluation
  - Training
  - Information Assurance
- Sustainment
  - Cloud Service Provider Hosting Costs
  - Changes to Post Deployment Software Support (PDSS) footprint
  - Changes to Contractor Logistics Support (CLS) footprint
  - Changes to the scope of technical refreshes
  - Changes to Total Ownership Cost elements (i.e., facilities maintenance, energy consumption, MTC manpower)

Business Case Analysis Results

The cost deltas were used to calculate Economic Viability metrics in accordance with the DoD CIO BCA process and leveraging methodologies from the Office of the Secretary of the Defense (OSD) Economic Viability tool, which is cited by the DoD CIO as an approved methodology for conducting BCAs. Additionally, cloud computing economic viability methodologies were applied from industry research; specifically, cloud computing return on investment strategies and methodologies published by ISACA (formerly known as the Information Systems Audit and Control Association) (ISACA Cloud Computing Vision Series White Paper, July 2012). Net present value (NPV), break-even (BE), benefit cost ratio (BCR), and financial return on investment (ROI) metrics were calculated for the two architecture variants, previously described in this paper, against the baseline/status quo program. Table 2 summarizes the two architecture variants across financial and non-financial dimensions. Representative numbers are being used to protect the acquisition sensitive content of the actual data, but still illustrate the intent of the financial and non-financial data attributes. When used together these metrics provide leaders relevant data for decision making.

Sensitivity analysis was performed on both architecture variants by varying the utilization rate of the individual systems and the ITE SoS. The utilization rate directly influences the required number of cores, and the amount of storage and memory required by the reduced hardware footprint obtained through resource pooling and cloud migration. Results showed that economic viability of both architecture variants is highly sensitive to utilization assumptions. As a result, more detailed analysis and forecasting of the system and ITE SoS utilization is required prior to the selection of an architecture variant.

Table 2. Summary of Business Case Analysis Results

Overall Comparison of Alternatives	Financial					Non-Financial	
	NPV	Break Even	ROI	BCR	Savings $K	Technically Feasible	Additional Benefit
Baseline/ Status Quo	N/A	N/A	N/A	N/A	N/A	Y	
Architecture Variant 1	$10M	FY2024	5%	4.36	$12M	Y	Reduced concerns with network latency, special purpose hardware, and translation of network protocols
Architecture Variant 2	$15M	FY2025	8%	2.5	$18.5M	Y	Aligned with Army policy and guidance on data center consolidation

PATH FORWARD

Roadmaps were developed for each of the architecture variant considered in the BCA. The purpose of the roadmaps is to provide a high-level Plan Of Action & Milestones (POA&M) to support the detailed planning, budgeting and execution of the architecture variants. Each roadmap identifies the activities that must be accomplished to implement a specific architecture, with recommended start and end dates for each activity.

The activities in each roadmap are logically grouped into four broad swim lanes, described below, that will be generally applicable to the cloud migration of training and simulation systems. An example roadmap is provided in Figure 3. Program identifiers have been removed from the example roadmap to protect acquisition sensitive information.

- Tools and Technology – activities that involve software development and the acquisition and implementation of tools and software packages. Examples of activities in this swim lane include standardizing on a virtualization platform across the ITE SoS, completing the virtualization of an individual system, and obtaining software that will be used to manage and provision shared computing resources.
- Integration and Test – activities that involve the integration and testing of the individual systems and the integrated SoS. Examples of activities in this swim lane include the testing of an individual system after it has been virtualized, piloting a system in a cloud computing environment, integration and testing of systems that are using shared computing resources, and testing to assess the performance of individual systems and the integrated SoS.
- Process – activities that involve complying with existing processes, and the development and implementation of new processes. Examples of activities in this swim lane include obtaining a new Authorization To Operate (ATO) for a system or SoS that has migrated to a shared computing environment, and developing the business processes for training services and applications that are provisioned to the training Point of Need from a cloud computing environment or enterprise data center.
- People – activities that involve the hiring and/or training of personnel to operate and maintain the deployed systems and SoS. For example, the deployment of the systems in shared computing resources requires processes for managing and provisioning the shared computing resources, as well as resource management and provisioning software. The personnel must be trained in the processes and the use of the software.

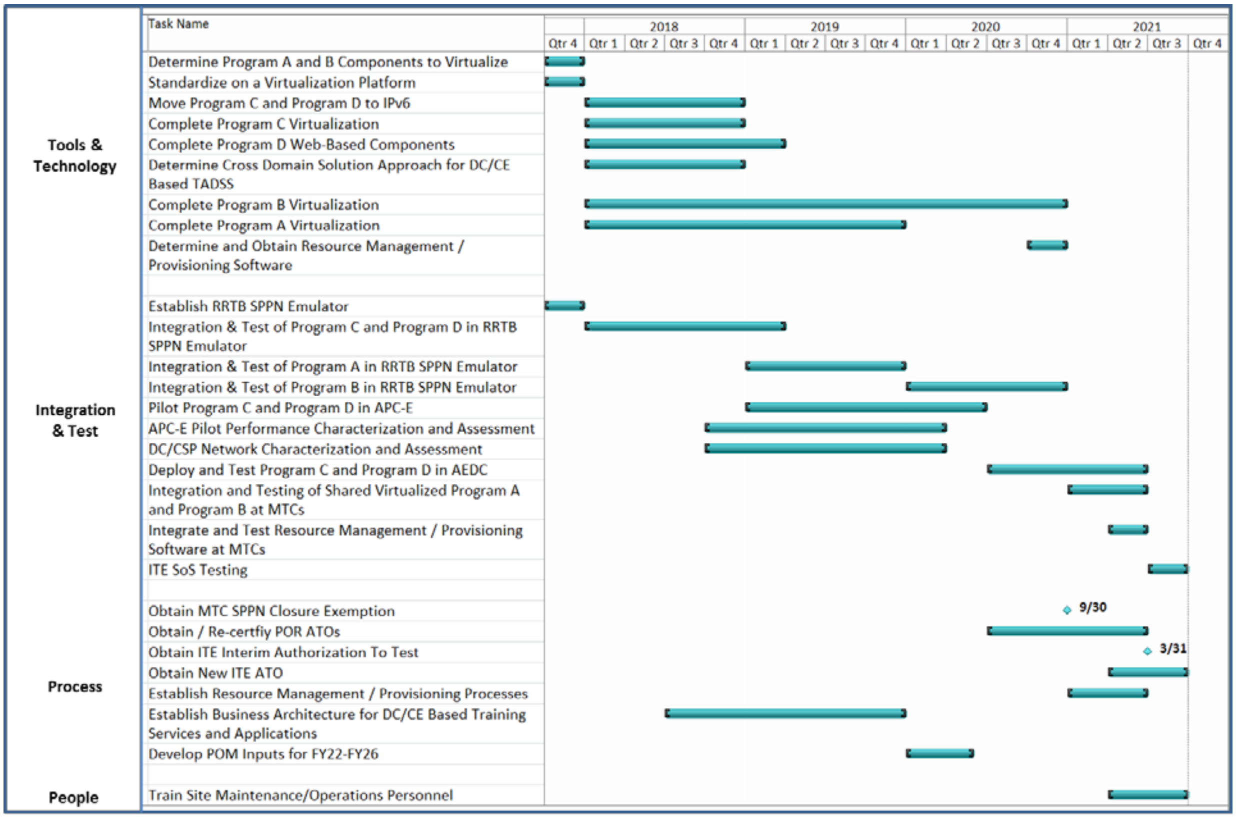

Figure 3. Example Roadmap.

SUMMARY

This paper has presented general criteria and processes that can be broadly used in assessing training and simulation systems for migration to a cloud computing environment or an enterprise data center. These include the technical assessment criteria, the business case analysis methodology, and the roadmap approach. When used together, an organization can determine the technical feasibility of system migration, the economic viability of migration, and the actions required to complete the migration.

Previous BCAs assessed the economic viability of migrating individual existing training PORs to a cloud computing environment and found no migration alternative resulted in significant economic or technical benefit from the "as is" program. This BCA assessed the migration of existing training PORs from a portfolio perspective, which allows the potential for pooling and sharing of computing resources across the PORs. Based on the projected resource utilization and excess capacity, resource pooling can provide a means to reduce the physical hardware footprint and thereby reduce cost over time, enhancing the business case for migration. Other organizations investigating cloud migration should consider migration from the portfolio perspective.

While both architecture variants assessed in the BCA demonstrated economic viability, the architectures of the legacy systems and the impacts of existing network performance (geographical distances) on the systems' real time requirements warrant further analysis and risk reduction activities. Piloting one, or more, of the PORs in the Army's APC-E at Redstone Arsenal, measuring network performance from the APC-E to the MTCs, and investigating ways to improve network performance through software defined networking are some of the activities either underway, or being planned, as part of PM ITE's Synthetic Simulation Transformation (ST2) product line. These activities, in conjunction with the recommendations and the roadmaps developed during this BCA, will allow PM ITE to work proactively with the Army CIO/G-6, the Army's Training and Doctrine Command, and the units being trained at the MTCs to ensure the effectiveness of a migrated ITE.

REFERENCES

Office of Management and Budget, (2016, August 1), Memorandum M-16-19, "Subject: Data Center Optimization Initiative (DCOI)"

Department of Defense Chief Information Officer, (2014, October 23), Memorandum, "Subject: Use of Enterprise Information Technology Standard Business Case Analysis"

Department of the Army Chief Information Officer/G-6, (2015, March 26), Army Cloud Computing Strategy, Version 1.0

Secretary of the Army, (2016, December 9), Memorandum, "Subject: Army Directive 2016-38 (Migration of Army Systems and Applications to Approved Hosting Environments and Consolidation of Data Centers)"

Department of the Army Chief Information Officer/G-6, (2015, July 23), Memorandum, "Subject: Guidance for Migration to, and Use of, Commercial Cloud Service Providers (CSPs)"

Office of the Assistant Secretary of the Army, Acquisition, Logistics & Technology, (2014a), Army Common Operating Environment Data Center/Cloud Computing Environment Architecture, v 2.0.2

Office of the Assistant Secretary of the Army, Acquisition, Logistics & Technology, (2014b), Army Common Operating Environment Data Center/Cloud Computing Environment Architecture Compliance, v 2.0.2

Johns Hopkins University Applied Physics Laboratory, (2016a), Business Case Analysis: Live, Virtual, Constructive – Integrating Architecture Cloud Migration, NSAD-R-16-030

Johns Hopkins University Applied Physics Laboratory, (2016b), Business Case Analysis: Games For Training Cloud Migration, NSAD-R-16-026

Johns Hopkins University Applied Physics Laboratory, (2016c), Business Case Analysis: Synthetic Environment Core Cloud Migration, NSAD-R-16-029

National Institute of Standards and Technology, (2013, July), NIST Cloud Computing Standards Roadmap, NIST Special Publication 500-291, Version 2

MITRE Corporation, (2015, October 6), Point of Need Study: VBS and EST "Cloud Hosted" Experiment, Preliminary Analysis – Executive Summary Version

Department of Defense Chief Information Officer, Director, Architecture & Interoperability, (2012, September 18), Core Data Center Reference Architecture, Version 1.0

Defense Acquisition University, (2017, February 26), Defense Acquisition Guidebook, https://www.dau.mil/tools/t/Defense-Acquisition-Guidebook

Department of Defense, (2015, June 9), Instruction 500.73, "Cost Analysis Guidance and Procedures"

ISACA Cloud Computing Vision Series White Paper, (July 2012), "Calculating Cloud ROI: From the Customer Perspective"