THESIS

IMPROVED DISTANCE LEARNING ENVIRONMENT
FOR MARINE FORCES RESERVE

by

Roy Ian Agila

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## 11. SUPPLEMENTARY NOTES

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## 13. ABSTRACT (maximum 200 words)

MarineNet offers distance learning (DL) training and education (T&E) opportunities to all Marines. For active duty Marines, government-provided desktops and laptops (GPDLs) typically support DL T&E or learning resource centers (LRCs) located inside many military installations. In contrast, Marine Forces Reserve (MFR) personnel have a unique challenge: most MFR units are located in home training centers (HTCs) away from military installations. Consequently, reserve Marines do not have GPDLs or LRCs to access DL T&E. The current alternative is for MFR personnel to use personal devices outside of the Nonsecure Internet Protocol Router Network (NIPRNET). This alternative assumes MFR personnel will purchase or already have their own devices. In addition, devices outside of the NIPRNET tend to experience compatibility issues when accessing some MarineNet courseware. This research tested equipment, software, and virtual machine (VM) architectures to find a technologically efficient alternative to GPDLs and LRCs that can support the unique needs of MFR. The emphasis is on researching mature technologies and leveraging free Internet options currently available in the United States. An efficient alternative is proposed to provide reserve personnel with a device to access the Internet, offering free Wi-Fi at the HTCs, and deploying VMs based on the VMware architecture.

## 14. SUBJECT TERMS

distance learning, virtual machine, Marine Forces Reserve, learning resource centers,
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September 2016

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ABSTRACT

MarineNet offers distance learning (DL) training and education (T&E) opportunities to all Marines. For active duty Marines, government-provided desktops and laptops (GPDLs) typically support DL T&E or learning resource centers (LRCs) located inside many military installations. In contrast, Marine Forces Reserve (MFR) personnel have a unique challenge: most MFR units are located in home training centers (HTCs) away from military installations. Consequently, reserve Marines do not have GPDLs or LRCs to access DL T&E. The current alternative is for MFR personnel to use personal devices outside of the Nonsecure Internet Protocol Router Network (NIPRNET). This alternative assumes MFR personnel will purchase or already have their own devices. In addition, devices outside of the NIPRNET tend to experience compatibility issues when accessing some MarineNet courseware. This research tested equipment, software, and virtual machine (VM) architectures to find a technologically efficient alternative to GPDLs and LRCs that can support the unique needs of MFR. The emphasis is on researching mature technologies and leveraging free Internet options currently available in the United States. An efficient alternative is proposed to provide reserve personnel with a device to access the Internet, offering free Wi-Fi at the HTCs, and deploying VMs based on the VMware architecture.
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<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ADL</td>
<td>advanced distributed learning</td>
</tr>
<tr>
<td>CAC</td>
<td>common access card</td>
</tr>
<tr>
<td>CB</td>
<td>community broadband</td>
</tr>
<tr>
<td>CDE</td>
<td>content delivery engine</td>
</tr>
<tr>
<td>CDET</td>
<td>College of Distance Education and Training</td>
</tr>
<tr>
<td>CPU</td>
<td>central processing unit</td>
</tr>
<tr>
<td>DL</td>
<td>distance learning</td>
</tr>
<tr>
<td>DLC</td>
<td>distance learning center</td>
</tr>
<tr>
<td>DLNOC</td>
<td>distance learning network operations center</td>
</tr>
<tr>
<td>DOD</td>
<td>Department of Defense</td>
</tr>
<tr>
<td>DON</td>
<td>Department of the Navy</td>
</tr>
<tr>
<td>EDCOM</td>
<td>Education Command</td>
</tr>
<tr>
<td>FLC</td>
<td>functional learning center</td>
</tr>
<tr>
<td>FOUO</td>
<td>for official use only</td>
</tr>
<tr>
<td>GAO</td>
<td>Government Accountability Office</td>
</tr>
<tr>
<td>GCSS</td>
<td>Global Combat Support System</td>
</tr>
<tr>
<td>GPDLs</td>
<td>government-provided desktops and laptops</td>
</tr>
<tr>
<td>HD</td>
<td>hard drive</td>
</tr>
<tr>
<td>HTC</td>
<td>home training center</td>
</tr>
<tr>
<td>MIE</td>
<td>Microsoft Internet Explorer</td>
</tr>
<tr>
<td>IoTs</td>
<td>Internet of things</td>
</tr>
<tr>
<td>IT</td>
<td>information technology</td>
</tr>
<tr>
<td>JIE</td>
<td>Joint Information Environment</td>
</tr>
<tr>
<td>LMS</td>
<td>learning management system</td>
</tr>
<tr>
<td>LOC</td>
<td>lines of code</td>
</tr>
<tr>
<td>LOE</td>
<td>lines of effort</td>
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<tr>
<td>MCBul</td>
<td>Marine Corps Bulletin</td>
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<td>MCI</td>
<td>Marine Corps Institute</td>
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xiii
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>MFR</td>
<td>Marine Forces Reserve</td>
</tr>
<tr>
<td>MOs</td>
<td>major objectives</td>
</tr>
<tr>
<td>MOS</td>
<td>military occupational specialty</td>
</tr>
<tr>
<td>MWN</td>
<td>municipal wireless network</td>
</tr>
<tr>
<td>NIPRNET</td>
<td>Nonsecure Internet Protocol Router Network</td>
</tr>
<tr>
<td>NMCI</td>
<td>Navy and Marine Corps Intranet</td>
</tr>
<tr>
<td>NPS</td>
<td>Naval Postgraduate School</td>
</tr>
<tr>
<td>OS</td>
<td>operating system</td>
</tr>
<tr>
<td>PC</td>
<td>personal computer</td>
</tr>
<tr>
<td>PME</td>
<td>professional military education</td>
</tr>
<tr>
<td>RAM</td>
<td>random access memory</td>
</tr>
<tr>
<td>RDC</td>
<td>remote desktop connection</td>
</tr>
<tr>
<td>RSSI</td>
<td>received signal strength indicator</td>
</tr>
<tr>
<td>T&amp;E</td>
<td>training and education</td>
</tr>
<tr>
<td>T&amp;R</td>
<td>training and readiness</td>
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<tr>
<td>TECOM</td>
<td>Training and Education Command</td>
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<tr>
<td>USMC</td>
<td>United States Marine Corps</td>
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<tr>
<td>VM</td>
<td>virtual machine</td>
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<tr>
<td>VoIP</td>
<td>voice over Internet protocol</td>
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<tr>
<td>WWW</td>
<td>World Wide Web</td>
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</table>
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I. INTRODUCTION

A. BACKGROUND

Marine Forces Reserve (MFR) units are vital to the mission of the United States Marine Corps (USMC) because they offer the flexibility to increase the number of battle-ready troops at any point in time. Marine reservists normally hold primary occupations outside of the USMC and are part of Home Training Centers (HTCs) throughout the United States. The geographical distribution, diverse professional backgrounds, and unique capabilities of MFR personnel make them a force multiplier for the USMC and the Department of Defense (DOD). A major disadvantage for reserve Marines as compared to their active-duty counterparts is less access to support infrastructure. One primary example of this is that most major military installations house a Learning Resource Center (LRC), where users can access free training courses and other technical services. LRCs also provide access to digital pre-deployment training programs, military occupational specialty (MOS) courses, unit & annual required training as well as access to Marine-On-Line, MyPay, and other job-related websites. This research explores the reserve Marines’ lack of access to College of Distance Education & Training (CDET) courseware and develops options to overcome the lack of LRC support infrastructure at HTCs.

B. PROBLEM STATEMENT

Reserve Marines have minimal access to distance learning (DL) opportunities from CDET courseware. A substantial number of MFR personnel lack the necessary online access to successfully complete required professional military education (PME), annual required training, and to take advantage of other CDET eLearning opportunities. Reserve Marines may be unable to access CDET courseware due to web browser incompatibility with existing and new courseware as well as a lack of minimum hardware requirements by end users. LRCs or other government-provided desktops and laptops (GPDLs) are not readily available to most MFR personnel because their units are widely dispersed across the United States. As shown in Appendix C, MFR units are located
throughout the United States, primarily in company and platoon-size units, and typically
away from major military installations. CDET courseware available through a DL
platform is critical to the overall capability of MFR manpower and its mission
performance. The DL model used by LRCs for the active duty component is not
technologically efficient for the unique needs of the MFR community. A more versatile
and flexible DL alternative is needed to support the training and education (T&E)
requirements of MFR Marines.

C. PURPOSE

The purpose of this research is to provide MFR personnel with a technologically
efficient DL alternative to access CDET courseware. This research will evaluate current
education delivery systems as well as DL technologies that would allow MFR personnel
to access T&E modules provided by CDET. This research will include provisions to
maintain efficient accessibility to courseware and DOD cyber security standards. For
instance, the use of For Official Use Only (FOUO) and limited distribution course
materials require strict accountability and authentication for access and course
completion.

Finding an optimal conduit for CDET’s DL courseware will allow MFR
personnel to access a wealth of DL and eLearning opportunities from CDET. Completing
mandatory PME as well as courseware that will enhance their professional and personal
careers is essential for unit readiness. In addition, finding a more technologically efficient
DL alternative can negate the need for the inefficient option of outsourcing LRCs to MFR
locations throughout the United States.

D. RESEARCH QUESTION

The primary research question is as follows:

- What is a technologically efficient alternative for MFR personnel to access
  MarineNet DL courseware throughout the United States?
E. POTENTIAL BENEFITS

The benefit of this research will be the increased accessibility of CDET’s courseware to MFR personnel throughout the United States. As depicted in Figure 1, accessibility is one of the current issues affecting MFR DL opportunities for several reasons later discussed in this thesis. Ultimately, giving reserve personnel additional accessibility increases the effectiveness of USMC DL education goals.

In addition, efficiencies are possible from current methods of DL delivery when considering LRCs that require real estate, equipment, and personnel. Decreasing the footprint required to set up LRCs inside military installations eases the burden of competing for limited facilities. Identifying a more versatile and flexible DL alternative to support the T&E requirements of MFR Marines will therefore increase MFR’s combat readiness.

Figure 1. Connecting Distance Education Opportunities to Reservists.

F. SCOPE

The scope of this research involves exploring technologies in DL to present a possible solution for MFR DL accessibility difficulties. Several DL information technologies currently available in the market can facilitate the communications link
between MFR personnel around the world and DOD T&E opportunities. Research areas include DL methodology, online delivery approaches, courseware development, and virtual machines, as the means of linking courseware and end users.

G. THESIS OVERVIEW

Chapter II explores current issues with MFR personnel accessing Marine Corps DL opportunities. This chapter will also cover general information and key technologies about the DOD and industry approaches to DL. Chapter II also describes those key technologies that become the building blocks for an alternative system to the current MFR approach to DL.

Chapter III covers a technical analysis of the USMC approach to DL. This analysis includes an overview of the USMC DL organizational structure and information technology (IT) architecture. In addition, this chapter explains the current DL model as suitable more for the active duty component than the reserves at MFR.

Chapter IV describes the variables used to select software and hardware for testing. These variables guided the type of equipment tested. This chapter explains equipment testing and the results of those tests. Graphs and tables describe test results.

Chapter V describes the best alternative based on test results from Chapter IV. This chapter contains a summary of the tests conducted and the lessons learned from this research. This chapter also contains topics for future exploration that emanated from this research.
II. LITERATURE REVIEW

A. OVERVIEW

At major Marine Corps military installations, LRCs provide the conduit for DL education and CDET courseware to active duty Marines (MarineNet, 2016a). In contrast, due to MFR units’ geographical locations, Marine reservists do not have viable access to LRCs. MFR personnel also face other unique challenges. They must balance their investment of time and effort between their civilian responsibilities and those of a reserve Marine. It is essential for reserve Marines to have a flexible DL model that provides them T&E opportunities similar to their active duty counterparts. According to the Naval Postgraduate School (NPS) Naval Research Program website (2015):

Standard practice for courseware development in the CDET is to design courses to the Navy and Marine Corps Intranet (NMCI) baseline; currently Internet Explorer 10. The practice of designing electronic courseware to a specific browser baseline implies certain limitations and creates conditions where the courseware will become unsupportable as technology advances. An identified problem within the MarineNet Learning Management System (LMS) is the incompatibility of several courseware products with the top three most popular web browsers (Chrome, Firefox, and Safari) as well as with the current versions of Internet Explorer. A recognized goal of electronic courseware development is to design courses that are fully functional on any and all available operating systems and commercial browsers. As a way to mitigate CDET’s courseware accessibility issues, virtualization is seen as a method. (p. 1)

Virtualization is one approach this research will explore from among emerging technologies. Virtualization can include categories such as one-alone, one-to-one, one-to-many, or many-to-many, depending on the complexity of the information transmitted and the interaction of the students with the system (Palloff & Pratt, 2003). According to Veletsianos (2010), emerging technologies are “tools, concepts, innovations, and advancements utilized in diverse educational settings (including distant, face-to-face, and hybrid forms of education) to serve a varied education-related purpose” (p. 12). Other emerging technologies such as smart TVs, digital media gadgets, Android & Apple smartphones and tablets, and other high-tech devices, have increased the possibilities for
better synchronous and asynchronous mobile learning systems (Lee, Park, Jeong, & Park, 2015). Emerging technologies and their applications require a balance between synchronous or asynchronous designs according to established organizational DL goals (Moore & Anderson, 2003). Because of these emerging technologies, the development and improvement of better DL solutions must be dynamic and constantly improving to keep up with the increasing need of education demands (Duggal, Ali, & Sharma, 2015).

The search for better DL solutions has become a global phenomenon where new LMS platforms are evolving at a high pace throughout the education environment (Humanante-Ramos, Garcia-Penalvo, & Conde-Gonzalez, 2015). E-learning modules supported by a cloud platform offer some benefits and some challenges according to students’ educational needs and accessibility requirements (Duggal, Ali, & Sharma, 2015). Advantages of cloud computing as a platform for DL provides efficient, anywhere access to information, improved educational capability, and better educational collaboration throughout the world (Shakil, Sethi, & Alam, 2015). However, regardless of the DL model, a high probability exists for technical issues that can frustrate students to the point of exhaustion (Palloff & Pratt, 2003).

Centralized or decentralized distribution is another factor involving the effective employment of DL programs (Veletsianos, 2010). The best approach between centralized and decentralized distribution depends on factors such as costs and management control of the organization’s data. Both costs and control of an organization’s data have direct implications for the IT infrastructure. Even with a decentralized distribution of the IT architecture, the system as a whole will end up highly coupled and interconnected (Dodero et al., 2015).

B. ORGANIZATION GUIDANCE ON TRAINING AND EDUCATION

In the DOD, more than in other large organizations, the concept of “mission first, troops always” prioritizes personnel as the most important asset for mission success. Aside from inherent traits and skills DOD personnel bring to the organization, knowledge acquired through T&E adds another dimension of contribution that makes them a force multiplier. Regardless of how sophisticated the equipment, systems, and processes are,
men and women in the DOD are the facilitators who ensure either success or failure in the organization’s mission. Due to the size and complexity of the organization, the DOD needs individuals with the correct skills to operate, manage, and process everything from humanitarian missions to kinetic actions. Referring to cyber education, Commander Michael Bilzor (2015) pointed out that “few questions are more critical to the future of the DOD and the nation than how we can most effectively prepare these men and women for their mission” (p. 14).

The highest levels of the DOD leadership understand that T&E is essential to current and future conflicts. The DOD has mandates and guidelines that provide DOD personnel with opportunities to train and educate. These mandates and guidelines apply regardless of where the member is located around the world. In a report published in 2009, Strategic Plan for Transforming DOD Training, the Undersecretary of Defense instructed the DOD to “place a priority on training, education and experimentation capabilities that are forward looking and address integrated operations and irregular warfare” (p. 15). The United States Army, for instance, leverages joint and multinational exercises as well as home station live and virtual training opportunities to cut costs in a fiscally constrained environment (DOD, 2015a).

At the service level, the Marine Corps Reference Publication 3–0B (2015a), How to Conduct Training, encourages DL, stating that “based on command guidance and a leader’s experience, the leader selects key tasks for Marines to learn and then arranges for enrollment in the appropriate DL courses” (p. 16). The Marine Corps provides T&E guidance via official publications. One of these publications, the Marine Corps Bulletin (MCBul) 1500, lists requirements that apply to uniformed members in the USMC to include the reserve component, MFR (USMC, 2015b). Appendix A is the complete list of T&E requirements.

Most of the requirements listed in Appendix A have to be completed annually, based on calendar year or fiscal year timeframes. The USMC waives very few training requirements according to the unit’s type, organization, and location. All but one, Annual Cyber Awareness, can be delivered via standard unit training. Several DOD policies
provide additional guidance on unit training such as the Marine Corps Order 1553.3B (USMC, 2011).

The delivery of unit training varies widely in methodology and presentation throughout the USMC. Factors for the variation in methodology or non-standardization of unit training include allocating training time, training location, equipment used, attendees’ preexisting knowledge about the topic, and most importantly, the instructor’s knowledge about the topic and motivation to teach. The result of non-standardized delivery of T&E is a wide range in the percentage of effectiveness of such T&E. In the best-case scenario, experienced instructors consider factors that affect the transmission, reception, and assimilation of information. Some of these factors include the number of personnel receiving the instruction, the location where instruction occurs, the manner of information delivery, practical applications of the information delivered, and the instructor’s attitude towards the course. However, in some cases, large groups of individuals cram into an auditorium to hear a PowerPoint presentation about a topic. This scenario becomes worse when that particular period of instruction extends for a time much longer than the average attention span of regular individuals. In extreme cases, instructors cram slides with as many words as they can fit on them and read them verbatim from slide to slide.

C. BLOOM’S TAXONOMY OF LEARNING

Ensuring personnel is matched with the correct DL course complexity is essential to produce positive results. The mismatch of course complexity and personnel level of understanding of a particular course wastes time and resources for an outcome that is unpredictable at best. Benjamin Bloom’s original taxonomy model shown in Figure 2 helps explain this concept by breaking down how well a person knows a subject into six different levels of knowing (Mastascusa, Snyder, & Hoyt, 2011):
Bloom’s Taxonomy of learning captures the logical flow of a person’s assimilation of information. The Bloom’s Taxonomy pyramid describes the process from the time an individual learns a particular subject (bottom) to the time that individual can “judge the value of material” (Mastascusa, Snyder, & Hoyt, 2011).

Beginning with “knowledge” as the starting point of human cognition, the pyramid increases in complexity and understanding until a person reaches the point where he or she has “the ability to make judgment” (Mastascusa et al., 2011). Individuals have to start at knowledge, bottom of the pyramid, and move up to the evaluation level, on top of the pyramid (Mastascusa et al., 2011). Skipping levels does not allow individuals to build enough cognition to move to the next level (Mastascusa et al., 2011). The ability to evaluate and judge the value of material learned is not possible by skipping levels. It comes after knowledge is comprehended, applied, analyzed, synthesized, and evaluated (Mastascusa et al., 2011). Applying Bloom’s Taxonomy Model, in USMC DL opportunities can explain possible misalignments in matching personnel with correct training and readiness (T&R) courses (Thomas, Agila, & Cini, 2015).
Table 1 compares and matches the USMC T&R levels with the learning taxonomy levels of Figure 2 (Thomas et al., 2015). The scope of the courses, from 1000 to 9000 levels, follow a similar sequence to that in the learning taxonomy. On a typical learning path, an individual would start at the 1000 T&R level, or knowledge level, and finish at the 9000 T&R level, or the evaluation level of the pyramid (Thomas et al., 2015). Issues arise when an individual assigned to a USMC T&R level course that does not match his or her level of cognition according to the learning taxonomy (Thomas et al., 2015). The result is an ineffective use of funds and time for the organization. In DL, matching T&R course levels with an individual’s level of cognition is essential for an effective use of time and resources (Thomas et al., 2015).

<table>
<thead>
<tr>
<th>Bloom’s Taxonomy</th>
<th>Description</th>
<th>USMC T&amp;R Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Information retrieval</td>
<td>1000 Individual</td>
<td>Formal School training, core skills</td>
</tr>
<tr>
<td>Comprehension</td>
<td>Grasp of meaning and intent of material</td>
<td>2000 Individual</td>
<td>OJT, core+ skills</td>
</tr>
<tr>
<td>Application</td>
<td>Given a goal and conditions, remembering and applying appropriate concept.</td>
<td>3000 Team</td>
<td>Core crew skills</td>
</tr>
<tr>
<td>Application</td>
<td>See above.</td>
<td>4000 Section</td>
<td>Collective crews</td>
</tr>
<tr>
<td>Application</td>
<td>See above.</td>
<td>5000 Platoon</td>
<td>Collective sections</td>
</tr>
<tr>
<td>Analysis</td>
<td>Detecting and evaluating relationships and their organization in an application.</td>
<td>6000 Company</td>
<td>Collective platoons</td>
</tr>
<tr>
<td>Analysis</td>
<td>See above.</td>
<td>7000 Battalion</td>
<td>Collective companies</td>
</tr>
<tr>
<td>Synthesis</td>
<td>Generation of new knowledge structures.</td>
<td>8000 Regt/BDE/MEU</td>
<td>Collective battalions</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Making judgments about the value of knowledge.</td>
<td>9000 Joint Task Force</td>
<td>Collective task forces</td>
</tr>
</tbody>
</table>

D. KEY TECHNOLOGIES

Technology is advancing at a rapid pace and touching every area of human society. Any model that aims to find a technologically efficient alternative for MFR personnel access to DL opportunities needs to include mature technologies rather than emerging technologies. The earlier include technologies that have been on the market for
some time, which already have a market share. The latter include technologies that are in their infancy, which require more testing before they become mature technologies. Additionally, emerging technologies tend to have more risk associated with their research and implementation.

1. Digital Processing Power

Central processing units (CPUs) are an essential part of the “brains” in almost all-modern electronic equipment. From its invention and development, CPUs have increased in capacity and decreased in size. Increased CPU capacity meant increased computer power to process more complex tasks. Original CPUs required considerable amounts of hardware and were very costly to build and maintain. For instance, the first computer mainframes, with CPUs as their main component, occupied entire floors to operate. These mainframes had much slower digital processing power than many cell phones in the market today.

In addition to the high costs of putting the first computer mainframes together, the initial attempts to create hardware that could run simple programs resulted in the creation of massive IT infrastructure, which occupied substantial amounts of physical space and was complicated to maintain. The original mainframe computers could process one batch of instructions at a time. Mainframe operators needed high levels of computer programming knowledge to “instruct” mainframes to perform simple tasks, one at a time. Programmers would submit their instruction cards with programming code to the system administrator and wait their turn until the mainframe had processed other programmer’s cards. The original mainframes were slow and could only process few instructions at a time.

The aforementioned process meant that using earlier mainframes had the following limitations:

- **Cost:** Costs to build, operate, and maintain the first mainframes were high.
- **Mobility:** Computer processing happened only in the mainframe location.
- **Operation:** Only individuals with high levels of IT education could use the mainframes.
With new technologies, computer mainframes decreased in size, cost, and complexity. With technological advancements in faster, cheaper, and smaller CPUs, personal computers (PCs) became popular. Shown in Figure 3, the IBM 610 Auto-Point Computer built in 1954 was one of the original PCs. Labeled a PC because it served one person or one office. These earlier PCs retained many of the limitations of the original mainframes; in particular, they were stationary systems with limited capabilities.

![IBM 610 Auto-Point Computer](image)

**Figure 3.** IBM 610 Auto-Point Computer. Source: Cruz (2013).

Fast-forwarding to the year 2016, IT has improved substantially. PCs have become ubiquitous devices in most of the U. S. homes as well as private and public organizations. In addition, newer technologies have concentrated processing power into smaller devices with lower costs. For instance, an individual who does not have access to a PC can utilize cheaper, smaller and more powerful portable devices with similar processing capabilities.

2. **Mobile Devices**

Because of advancements in technology, devices that can access the Internet are becoming cheaper, smaller and more mobile. The decreased cost of IT has made mobile devices a ubiquitous technology. As digital processing power becomes less expensive, faster, smaller, and portable, its advantages will influence emerging technologies in all areas including DL capabilities. Figure 4 shows the time spent on digital media by adult
users in the United States from 2008 to 2015. These statistics demonstrate the increase in use of mobile devices in relation to the use of desktop PCs and laptops (Dogtiev, 2015). In 2008, adults spent an average of 0.3 hours during the day on mobile devices (Dogtiev, 2015). In 2015, the number of hours adults spent on mobile devices had increased to 2.8 hours or 51 percent of the total time in a day (Dogtiev, 2015). Using these statistics, we can assume that adults in the United States are (1) acquiring mobile devices at an increasing rate, (2) becoming familiar with their usage and capabilities, and (3) connecting more to the Internet. The three aforementioned actions become the driving force to develop new DL models that include mobile devices.

DOD DL programs can take advantage of the proliferation of mobile devices for two reasons. First, the DOD will save time and funding in the development, set up, and maintenance of new DL programs by utilizing devices that are commonplace in the general population. Second, by leveraging a technology commonly used by the public, the DOD will save time and resources on training personnel on how to use them. The Advance Distributed Learning (ADL) is a DOD initiative that conducts research on learning with technology. ADL has done extensive research in the area of mobile device learning. The two predominant factors that are most desirable in mobile device learning, according to ADL, are screen size and touchscreen features (Berking, Birtwhistle, Gallagher, Haag, 2013). Figure 5 shows survey results that corroborate these preferences. Modern tablets and smartphones have both better screen clarity and touchscreens (Berking et al., 2013).
3. Internet

Internet access is essential to any DL model. Internet is the backbone that links end users with servers that hold courseware. This is particularly important when
considering MFR personnel and their geo-location around the United States. Today, the Internet is a mature technology that continues to link more people and devices.

\textit{a. Origins}

Communication has been essential to human development since the beginning of human civilization. In modern times, digital communications have contributed exponentially to the development of new technologies that touch every aspect of human interaction. The creation of the Internet is a major contributing factor to the way individuals and organizations communicate today. The Internet begun with a limited scope: to provide military research communications. Since its creation, the number of nodes, distance between nodes, and communication capabilities of what we now consider the Internet has grown exponentially. The Internet has grown from being the communications bridge of a few nodes to being the link that connects billions of nodes. Today, the Internet is the foundation that links individuals, processes, organizations, services, and communities around the world. In the future, the Internet of Things (IoTs) promises to link billions of devices. The IoTs will link devices such as planes, cars, and blenders, as well as information systems such as industrial processes and military organizations.

\textit{b. Ubiquitous Internet}

Considering how ubiquitous the Internet currently is today, it is important to reflect on its capabilities when developing DL solutions. In particular, DL solutions need to consider the advantages that the Internet has contributed to mobile device utilization around the world need. Mobile devices have benefited from the Internet in that they provide common users the ability to stay connected at any time and at any place. Mobile devices’ portability, connectivity, and ease of use have contributed to the increased number of hours adults spend using them, as previously shown in Figure 4 (Dogtiev, 2015). In addition, as shown in Figure 6, mobile devices were used 75.1 percent of the time to access the Internet and 4 out of 5 consumers use them to shop (Stevens, 2016). These statistics demonstrate how common the Internet has become today.
c. From Government to Municipalities

The U. S. Department of Education is also pursuing ways to leverage the Internet and make it ubiquitous in the United States. With ConnectED, a strategic initiative to connect 99 percent of American students, President Obama is seeking to increase digital learning around the country (Keengwe, 2015). Obama’s plan is to bring next generation broadband as well as high-speed wireless to all students in America within the next five years (Keengwe, 2015). The U.S. Government, through ConnectED, has an ambitious goal, but it is not the only public or private organization with plans for large-scale Internet connectivity. Municipal Wireless Network (MWN) and Community Broadband (CB) are two emerging concepts that are being considered, tested, and in some cases fully implemented within the United States. These two concepts are similar to ConnectED in that they aim to provide free Internet access to a large number of individuals. In addition, both MWN and CB aim to provide Internet access to the public, not only students, in public buildings, local parks, and in some cases, entire cities.
MWN is still in its infancy, but the concept of free Internet access to the public is gaining traction around the United States for two reasons. First, offering free wireless Internet access is beneficial for the local economy. It directly helps the poor by giving them access to the World Wide Web (WWW) and all the benefits that come with it. Benefits of having access to the WWW include online banking, free voice over Internet protocol (VoIP) communications, social networking, email, online shopping, and access to vast amounts of information. Many of these benefits translate directly into cost savings for end users. For instance, VoIP would allow a family to have telephone access for around $1.66 a month (http://www.magicjack.com/) compared to $42 with regular land line access (Schwandt & Kroger, 2016a). Second, when MWN offers free wireless access, it opens up educational opportunities that would otherwise be unavailable for the individuals that do not currently have Internet access. MWN would supplement an existing infrastructure that already provides Internet access to about 85 percent of Americans older than 18 (Springer, 2013). An example of a MWN that is currently operational is the LinkNYC free wireless program. LinkNYC is available in Manhattan, New York, NY, as shown in Figure 7 (CityBridge, 2016). In addition to offering free gigabyte Wi-Fi, the kiosks offer a touchscreen tablet for Internet access, the capability to make free phone calls anywhere in the United States, and USB ports for charging electronic devices, as shown in Figure 8 (CityBridge, 2016). In the United States, more than 57 cities offer free wireless access similar to LinkNYC (Springer, 2013). Free wireless access will be the norm and not the exception as technology keeps improving. More and more local governments will recognize the benefits of free wireless access for the public. Leveraging these services as part of a DOD DL architecture is technologically efficient and adds mobility to end user access.
Figure 7. Finding LinkNYC Free Wireless Internet. Source: CityBridge (2016).

Figure 8. LinkNYC Free Wireless Internet Kiosks Features. Source: CityBridge (2016).
4. Virtualization

The concept of virtualization has been around for decades. As the world continues to be interconnected and cloud services become more prevalent, the concept of virtualization keeps expanding to fulfill more needs. In education, for instance, virtualization keeps expanding to every aspect of teaching and learning, inside and outside of the classroom. In DL, virtualization offers many ways in which classroom education can reach individuals regardless of their geo-location.

a. Desktops and Laptops

With the increase in processing power, the explosion of mobile device use, and the extensive availability of the Internet, virtualization is gaining acceptance as a means to deliver DL opportunities. Many institutions see virtualization as a way to reduce server and computer farms that are inefficient and difficult to maintain. Virtualization takes advantage of emerging information technologies such as cloud computing. Cloud Computing is an appealing model for organizations that need to manage large amounts of processes and distributed applications; with a scalable approach that can adjust to changes dynamically (Mahmood, 2016). Benefits of cloud computing for the DOD include decreased capital investments, lessening management requirements, improve scalability and availability of resources anywhere, and the ability to share resources (Mahmood, 2016).

Providing DL to hundreds of thousands of personnel around the world, as in the case of MFR, fit the cloud-computing domain. Server virtualization is the foundation required to provide the considerable scale of virtual machines (VMs) needed by large organizations. Server virtualization is an influential ecological solution to massive deployment of VMs utilizing cloud computing (Moritoh & Imai, 2015). Server virtualization can be better understood by first understanding the basic components of a typical PC. Figure 9 shows the basic components of a basic PC including the CPU, random access memory (RAM), hard drive (HD), and network card. On a normal setup, the aforementioned components, along with others, are put together on a computer motherboard and connected to input/output devices such as a monitor and keyboard, to
form a desktop computer. Laptop computers share similar components but add mobility to the user. If additional desktop computers are necessary, the process repeats for the number of assets required. In this scenario, the cost of buying the parts, assembling, shipping, setting them up, maintaining, upgrading, and recycling them is multiplied by as many times as desktop computers are needed. If we needed 100,000 computers for instance, we would multiply that number by the average price of a desktop computer, $379 (Schwandt & Kroger, 2016b). The cost would add up to about 37.9 million dollars. This does not consider other ancillary costs such as shipping, setup, maintenance, power consumption and replacement cost. The average number of years before desktop PCs need replacement is 4.45 years (Schwandt & Kroger, 2016c). Lastly, these desktop computers would need to occupy physical space to operate as intended, which substantially adds to the overall costs.

![Figure 9. Basic Components of a PC.](image)

On the other hand, virtualized environments have several advantages over desktop PCs and laptops. Server virtualization share all components listed in Figure 10 with the VMs located within the server. This model creates efficiencies in numerous areas. First, it saves funding by creating a virtual environment that costs a fraction of what a physical machine would cost. Second, IT system administrators have more control over every aspect of the virtual environment, to include the operating system (OS), amount of RAM, HD space, and software within the OS. Third, VMs scaled up or down depending on the needs of the organization. These adjustments can be done in a fraction of the time and without the cost it would take to procure, ship, and install a physical machine, making the use of VMs an efficient alternative to physical machines. As described by VMware (2006),
Virtualization is an abstraction layer that decouples the physical hardware from the operating system to deliver greater IT resource utilization and flexibility. Virtualization allows multiple virtual machines, with heterogeneous operating systems (e.g., Windows 2003 Server and Linux) and applications to run in isolation, side-by-side on the same physical machine. (p. 3)

Figure 10. Virtualized Environment Model.

b. **Simple Virtualization Model**

Figure 11 shows an example of how virtualized environments apply to DL. Taking advantage of virtualized environments that simulate typical desktop or laptop computers has several advantages. First, it expands the platforms from which users can access DL opportunities. This is essential to in the MFR environment where DL users employ a wide range of devices. These devices include iPads, Microsoft Windows computers, Mac computers, iPhones, Android tablets and Android mobile phones. The types of devices and OS platforms used will only increase as technology creates new
capabilities. Second, the VM can be set up to run a wide range of OSs depending on the server with which the system will communicate. This capability offers more opportunities and flexibility to access servers hosting DL courseware that require other OS platforms. Third, the VM server can create and replicate VMs that have the needed software and hardware requirements to run DL courseware. Furthermore, when requirements change at the LMS servers, updating and disseminating changes throughout the VMs is substantially less complex than doing the same updates on physical machines. Lastly, updates or changes to the VMs or the servers running DL courseware are transparent to the end user. System administrators can update software or modify the virtual environment from their consoles. By managing the VMs remotely, network administrators no longer require physical or network access to end user devices. The transparency of updates for the end user adds more flexibility to the types of devices that can be used to access DL courseware. Figure 11 shows that in theory, users can employ a variety of devices with different hardware and software configurations, sizes, manufacturers, and OSs to access DL courseware. In this model, the crucial component between the end user and MarineNet courseware is the VM. The VM provides the communications link and necessary software that allows all MarineNet courseware to work on most desktop, laptops, and mobile devices. The requirements for this model to work are as follows:

1. Virtual environment. The VM environment needs to have all software and hardware required by the LMS.

2. VM access. The VM needs to have a client, remote desktop connection (RDC), or web browser accessibility options for devices to connect.

3. Access device. The device accessing the VM needs to have the VM client installed, RDC capabilities, or a web browser compatible with the VM requirements.
Figure 11. Simple Virtualization Model.
c. **Accessing VMs**

In a virtualized environment, devices accessing the VM need only a compatible client software, a RDC, or a typical Internet web browser, depending on the VM infrastructure. In addition to proprietary VM client software, regular web browsers such as Internet Explorer, Mozilla, and Google Chrome can access the VM. In this case, a user only needs a device that can run a compatible web browser to access the VM. By increasing accessibility options, VMs work with several platforms to include desktops, laptops, mobile phones, and tablets.

For instance, VMware offers proprietary software to access VMware VMs from Mac, Linux, iOS, Windows, and Android platforms. Figure 12 is an example of how VMware VMs work via either their proprietary software or a typical Internet web browser. Having the flexibility to access VMs via Internet web browsers implies compatibility with almost any device, stationary or mobile, that can run an Internet web browser. When considering the vast use of the Internet illustrated in Figures 4 and 5, VMs open a window of opportunity to reach a large portion of the population who already has access to mobile devices.
5. **Common Access Card (CAC) Readers**

Members of the DOD use CACs to authenticate them when accessing many FOUO DOD sites. CACs are part of a digital system to encrypt communications and authenticate that the user of the system is who he or she claims to be. This system is based on a two-factor authentication security process that includes something-you-have (CAC) and something-you-know (the CAC pin number) to grant individuals access to FOUO sites. These two components provide added security because CACs and their pin numbers are verified and issued during face-to-face visits to the local Real-Time
Automated Personnel Identification System. CAC readers are the bridge between CACs and the device accessing the Internet. CAC readers come in many forms and from different manufacturers, and each model has different characteristics and uses. All Nonsecure Internet Protocol Router Network (NIPRNET) stationary terminals have a CAC reader as part of the system.

GPDLs either have CAC readers mounted on the device or have external USB CAC readers. For non-DOD devices, such as the ones used outside of DOD networks, external USB CAC readers are the most common. Complications in using CAC readers are more prevalent in devices that do not have standard USB ports. This is the case for many mobile devices such as iPads and Android tablets. Many companies have developed CAC readers to fit the most common mobile devices’ connectors. The most common mobile devices’ connectors include micro-USB (for Android devices) and lighting connectors (modern iPads). The use of CAC readers in mobile devices is not as straightforward as the use of CAC readers in desktops or laptops. The main reason for this disparity is that mobile devices’ hardware limits OS and software capabilities.
III. TECHNICAL ANALYSIS

A. MARINE CORPS DISTANCE LEARNING PROGRAM

In a document titled, *Training and Education Command (TECOM) Strategic Plan*, dated 1 July 2016, the USMC lays out its lines of efforts (LOE) and major objectives (MOs) for training and educating its force. LOE #2 points toward developing Marines’ ability to become better leaders and work at a global level. One of the two MOs of LOE #2 is to “provide the benefit of a distance education that is on par with the quality of resident courses” (USMC, 2016, p. 11). The intent is to offer DL T&E opportunities comparable to the learning achieved in resident courses. To that end, Critical Task 2.1.4 of the same document specifies that TECOM seeks to “make training and education accessible to all Marines” (USMC, 2016, p. D-25). The lead organization for this effort in the USMC is Education Command (EDCOM) (USMC, 2016). Figure 13 shows TCOM’s organizational chart.

![TECOM Organization Chart](image)

Figure 13. TECOM Organization. Source: USMC (2016).

Within EDCOM, the CDET oversees MarineNet, which provides DL capabilities to the USMC. MarineNet provides end users the ability to access DL at a global scale, and its goals encompass three main areas that include “(1) content development, (2) distribution infrastructure, and (3) management infrastructure” (MITRE Corporation, 2000, p. 1). To accomplish its goals, MarineNet uses a LMS with similar capabilities to typical LMSs found in industry. As shown in Figure 14, in an earlier MarineNet architecture model, the LMS was present at the three major functional areas: Distance Learning Center (DLC), Functional Learning Center (FLC), and area learning center (MITRE Corporation, 2000). The NIPRNET provides access to the Internet and links...
these three functional areas. In this architecture, users outside of NIPRNET had additional access restrictions that prevented them from fully accessing the FLC or DLC. In addition, duplication of efforts existed between the DLC and the FLC, as both built, deployed, and maintained courseware for the USMC. This architecture has changed since 2000, improving MarineNet’s efficiency and reducing duplication of efforts. Before 2015, the Marine Corps Institute (MCI) managed the DLC. The DLC was similar in scope to CDET. According to MARADMIN 209/15, “This [architecture] caused inefficiencies, redundancy, and a disjointed training and education continuum for the Marine Corps” (USMC, 2014, para. 1). MCI eventually consolidated under CDET (USMC, 2014).


Figure 15 shows a more updated MarineNet architecture. This model has fewer redundancies and provides a more direct access between end users accessing the network and courseware resident in MarineNet. The DL Network Operations Center (DLNOC) is
the current organization that manages the MarineNet courseware, LMS, and SCORM systems. The Content Delivery Engines (CDEs) provide MarineNet courseware to authenticated users and are located at the DLNOC. To improve latency, CDEs are set up in other locations inside major USMC installations around the United States (CDET, 2012).

![Diagram of MarineNet Architecture](image)

Figure 15. MarineNet Architecture. Source: CDET (2012).

MarineNet’s planned logical network and physical infrastructure are shown in Figure 16 and Figure 17, respectively. From the end users’ perspective, access to MarineNet occurs via GPDLs on the .mil domain or through non-DOD devices connected to the Internet (Naval Air Systems Command, 2013). From those access points, data filters through different firewalls before it reaches the intended destination inside the MarineNet network (Naval Air Systems Command, 2013). Both of these models incorporate emerging technologies in virtualization, firewalls, encryption, storage area
networks, domain controllers, and backup (Naval Air Systems Command, 2013). Examining the logical architecture, this network provides the correct balance between security and accessibility, filtering most of the network traffic coming from non-NIPRNET devices through the DMZ (Naval Air Systems Command, 2013).

B. MARINENET COURSEWARE

MarineNet servers are accessible through a regular Internet connection. Once a user authenticates and logs in, a page with access to all MarineNet resources is available. Resources available include CDET courseware as well as links to courseware from other organizations. Courseware accessible through the MarineNet webpage varies in scope from mandatory training courseware to optional courses that USMC personnel can register for to enhance their knowledge in areas other than their MOSs. Some examples
of MarineNet courses are Operating the MK-Series Vehicle Off-Road, Amphibious Operations, Dari Language, and Microsoft Office 2010: Beginning Word (MarineNet, 2016c).

The wide variety of course topics offered and the different periods when they deployed has increased standardization complexity. For instance, courses about repairing engines may require additional visual aids, such as how-to videos, as opposed to the theory and nature of war courses. In addition, many courses developed and deployed several years ago have compatibility issues with modern hardware and software. New features and capabilities are added to courses commensurate with the technology available at the time of their development and deployment. For example, software used in the creation of a particular course is updated, upgraded, or completely replaced as time progresses. Another problem involves the type of web browser employed by the end user to access a particular course. For instance, when an older course developed several years ago, it was compatible with existing web browsers at the time of deployment. Several years later, that same course may no longer be viewable when newer web browser versions developed to accommodate newer technologies in hardware and software. As a result, MarineNet has many courses that no longer work with current web browsers and/or hardware. This condition will continue as technology advances and newer hardware, software, and communication systems come online.

The lack of standardization has increased the software and hardware requirements expected from devices accessing MarineNet courses. To accommodate compatibility with existing courses, MarineNet has a long list of minimum software requirements it expects the device accessing MarineNet to have, as shown in Appendix B. The software requirements found in Appendix B are easier to implement in GPDLs because they are part of the USMC NIPRNET.

Because successful MarineNet courseware access is subject to having the correct hardware and software requirements, accessing CDET’s courseware is more complex for users not in close proximity to typical military installations. Appendix C, MFR unit locations, and Appendix D, LRC locations, demonstrates a disadvantage for MFR personnel compared to active duty personnel with ready access to GPDLs and LRCs.
Because of the lack of GPDLs and LRCs, MFR personnel access MarineNet courseware from a wide range of platforms that include personal desktops, laptops, tablets and cellphones. Reserve Marines are responsible for having the correct combination of hardware and software. This is problematic for many reasons. First, there is the possibility that a reserve Marine may not have an acceptable device to access the Internet. This situation does not exempt MFR personnel from completing required annual training, shown in appendix A, or making an effort to improve their MOS through additional MarineNet training. Second, if a reserve Marine has an acceptable device to access MarineNet, incompatibility issues may prevent him or her from successfully accessing some courses. Incompatibility issues can include having the incorrect web browser version a particular course can to work on. Third, the OS may play a part in preventing users from successfully accessing MarineNet courseware. The two most popular OSs currently available are the Mac and Microsoft OSs. The Mac OS has an additional disadvantage over some incompatible Windows platforms: most of the existing MarineNet courseware work in Microsoft Internet Explorer (MIE). The last MIE version supported in the Mac OS was MIE version 5.2 (Microsoft, 2015). As of December 31, 2005, Microsoft no longer supports MIE for Mac OSs (Microsoft, 2015). In many cases, the approach to fill these gaps at the small unit level is to conduct mass training sessions. Conducting training sessions with maximum output in terms of personnel trained rather than emphasizing actual learning is a waste of time and resources. At a minimum, mass training sessions have unpredictable results in terms of actual knowledge assimilated by students.

C. CURRENT MODEL

To provide DL capabilities, MarineNet assumes that the end user has (1) access to an Internet connection (2) access to a device capable of using an Internet connection, (3) the correct combination of hardware and software needed to run courseware at the end user device, (4) a requirement to enroll in MarineNet courses, and (5) permission to access its courseware. A successful enrollment and completion of courseware available in MarineNet needs all five assumptions. Issues arise when end users lack any or all of the
aforementioned assumptions. For many reserve Marines, these assumptions fall short of reality. This research focuses on gaps and solutions for assumptions 1–3. The current MarineNet DL system is more effective for the USMC active component but ineffective for the reserve component.

1. **End User**

   Because of the nature of the MFR mission, end users are located throughout the United States. The majority of MFR personnel muster for training at locations that are away from major military installations. As such, they lack the access to infrastructure similar to NIPRNET terminals and LRCs found at typical military installations. Appendix C shows the location of MFR units in the United States. On average, MFR personnel get together to drill (train) one weekend a month and two weeks a year at their HTCs. Regardless of the lack of resources available for reservists at HTCs, MFR personnel are still required to complete training requirements listed in Appendix A. As shown in Appendix A, very few waivers or exceptions to the annual training requirements exist. This dilemma puts reservists at a disadvantage compared with their active duty counterparts because MFR personnel have training requirements equal to active duty Marine but fewer GPDLs to complete them.

2. **Devices**

   As an organization, the vast majority of MFR personnel has limited access to GPDLs. The Inspector Instructor staff uses the few GPDLs available at HTCs. At the Orlando MFR HTC, for instance, there are around twelve GPDLs for permanent personnel compared to over 250 reservists that train there. This discrepancy in the number of computer terminals and personnel that needs Internet access makes it more problematic for MFR personnel to access DL opportunities. Marines with a desire or requirement to access MarineNet can currently do it in one of three ways: LRCs, GPDLs, or personal devices.
\textit{a. LRCs}

LRCs are facilities located at major military installations that have an average of thirty computers with ready access to .mil websites including www.MarineNet.usmc.mil. They normally carry other IT equipment as well such as printers and scanners. Appendix D shows LRC locations in the USMC. When comparing the location of LRCs with the location of MFR units of Appendix C, it is evident that LRCs do not offer a GPDLs alternative for MFR personnel. LRCs are not the solution with the current setup and would not be efficient to increase their numbers for several reasons. First, LRCs require physical space that many HTCs do not have. Many HTCs are collocated with other organizations or units that are already competing for physical space at their training centers. Second, LRCs are not a flexible platform that can accommodate MFR dynamics. Physical space and other resources would go unused because reserve personnel mainly train one weekend a month and two weeks a year. Lastly, LRCs are costly to retain when considering the costs associated with setting them up, maintaining them, and covering utility costs. Consequently, LRCs are technologically inefficient to provide MFR personnel access to DL opportunities.

\textit{b. GPDLs}

HTC’s normally have just enough GPDLs to support a small number of permanent personnel assigned as the Inspector Instructor staff. The number of GPDLs is a small fraction of the number of MFR personnel assigned to the HTC. Increasing the number of GPDLs is ineffective because of the lack of physical space and costs associated with buying new NIPRNET seats. In addition, it taxes the NIPRNET network infrastructure without making a substantial dent in the asset shortfall.

D. \textbf{IT INFRASTRUCTURE CHALLENGES}

A successful DL program requires a solid IT infrastructure as well as knowledgeable personnel who can troubleshoot any technical issues that are bound to occur. Hardware and software update constantly, making their upkeep and integration crucial for a good user experience. Figure 18 illustrates driving forces in a DL IT infrastructure. The emphasis of an effective DL program should be the end user. When
end users drive IT requirements, the organization can effectively invest time and resources to develop an effective DL program. A successful DL program is one that does not just expose students to information but requires students to learn the material covered.

![End User Drives Change](image)

Figure 18. End User Drives Change.

Figure 19 shows statistics on the reasons for the failure to graduate of some Army DL students. Courseware complexity, the information presented during the course, accounts for a small fraction of the reasons for failure to graduate (Straus et al., 2011). Most of the contributors for students failing DL courses included technical issues and a weak DL support (Straus et al., 2011). In an ideal DL program, technical issues and DL support should account for a small percentage of failures, while courseware and its complexity should account for a high percentage of non-graduation. Technical issues and DL support are issues that are more tangible. Courseware and its simplicity or complexity would be harder to manage because it deals with the intangible—the student’s ability to comprehend and learn the material.
DL recipients who experienced technical issues have a tendency to fail courses. In many cases, it is not the information’s complexity that pushes students to fail a course but technical issues that the student could not overcome. The Army created a report that, among other research, evaluated the reasons why DL students failed courses (Straus et al., 2011). An Army report called *New Tools and Metrics for Evaluating Army Distributed Learning* by Stratus et al., (2011) states that

But we do know that about one third of non-graduates with technical issues had trouble getting access to a reliable computer, regardless of whether they started the course or not. Moreover, 22 percent of respondents with technical issues also cited mobilization or deployment as a reason for non-completion. Among students who did not start the courses, 30 percent had problems getting access to an Internet connection. High-speed Internet access was not a problem for students who started but did not complete courses. (p. 26)

Both issues brought up in this Army report—troubles accessing a reliable computer and the user’s physical location—are comparable to issues experienced by MFR personnel. A high percentage of MFR personnel do not have access to GPDLs as discussed in the previous chapter. Deployed or mobilized personnel in the Army with limited access to DL courses are comparable to MFR personnel located away from typical military installations.
E. POSSIBLE SOLUTION

The literature review in Chapter II reveals three main building blocks that fill gaps in DL access for MFR personnel. As shown in Figure 20, the building blocks are mobile devices, Internet access, and virtualization. Each of the three has the potential to circumvent existing problems for MFR personnel to access MarineNet.

![Building Blocks for DL Access](image)

Figure 20. Building Blocks for DL Access.

1. Mobile Devices

As discussed in the literature review, mobile device usage has grown exponentially in the past decade, and it appears that trend will continue in the future. Any DL solution needs to capitalize on this fact quickly and effectively to reach the existing and growing mobile device audience. MarineNet can take advantage of existing experience of mobile device users to save time and resources.

2. Internet

The Internet has become ubiquitous as advancements in technology make it less costly. Free Wi-Fi is already a reality in many places, providing access to anybody within reach of the signal. Many places where free Wi-Fi is offered include local business such as Starbucks coffee shops and public areas such as public libraries. In addition, other social and political interests are pushing societies and their lawmakers to invest in
providing Internet access to the masses. In the United States, many local municipalities are providing free Wi-Fi. Ultimately, the USMC can take advantage of free Wi-Fi for reserve Marines’ Internet access.

3. Virtualization

Based on the literature review and analysis of the As-Is DL model for MFR, the use of VMs and their related infrastructure seems to be the best option. VMs allow end users to access a standardized virtual environment from which to access MarineNet resources. The simple virtualization model shown in Figure 11—from mobile device to VM to MarineNet servers—allows a more efficient way to manage thousands of virtual machines. This model can become particularly efficient when MarineNet or any other DL system offered to MFR personnel upgrades or substantially changes. The upgrade can be instantly disseminated to every VM in the network and still be a transparent process for all users. VMs and their inherent infrastructure fit the need of MFR to reach out to an unlimited number of users. These users can potentially be located anywhere around the world and still have the access and capabilities of personnel using GPDLS.
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IV. EXPERIMENTATION

This research was aimed at finding a technologically efficient alternative for reserve Marines to access MarineNet DL courseware regardless of their geo-location. The purpose of this experimentation phase was to test devices, Wi-Fi signals, and VMs that can efficiently provide access to all MarineNet courseware. The final recommendation considered the level of maturity in the technology being tested and its current market availability. Data presented in this chapter proved that technologically efficiency can occur with existing technology and not necessarily with the newest DL technology available today.

A. CONSIDERATIONS

Cost and availability were two of the factors considered when selecting hardware for testing. The primary determinant, due to current and projected funding constraints in the DOD, remains cost. In many cases, the lack of funding to initiate or to maintain a new system increases the possibility that the system will fail before it is fully implemented (DOD, 2015b). Also, funding resources become more scarce and difficult to obtain as capabilities are better understood and implemented (DON, n.d.). The DOD Agency Strategic Plan directs organizations within the DOD to budget programs efficiently (DOD, 2015c). In addition, it aims to minimize existing conflicting interests in funding utilization to achieve DOD goals (DOD, 2015c). The objective of this research falls within “Goal 4: Achieve Dominant Capabilities through Innovation and Technical Excellence” as shown in Figure 21 (DOD, 2015c, p. 22). Organizations in DOD, such as the ones depicted in Figure 21, compete for funding, and in many cases, other DOD strategic goals and objectives overshadow education and training needs. Finding the most cost-efficient use of funds to achieve DOD goals is essential for a budget-constrained environment.
Another important factor in deciding which hardware to test during this research is its availability in the private sector. Hardware that is readily available reduces procurement expenses for the DOD. This model makes a more efficient use of current technology advancements, investments in the private sector, and research and development. Table 2 depicts mobile devices and their availability and utilization percentages by the public. These statistics reveal the type of devices used to access the Internet. In 2010, close to 75 percent of the respondents used a desktop PC to access the Internet (Schwandt & Kroger, 2016d). This percentage has been decreasing to only 56 percent in 2015 (Schwandt & Kroger, 2016d). The use of mobile devices that allow individuals to access the Internet more freely has been steadily increasing (Schwandt & Kroger, 2016d). Compared to desktop PC, the use of mobile devices is more evident among individuals using tablets to access the Internet (Schwandt & Kroger, 2016d). In 2010, only about 3 percent of respondents used tablets to access the Internet compared to 31 percent in 2015 (Schwandt & Kroger, 2016d). Based on these statistics, in five years, the use of tablets has increased by a factor of ten (Schwandt & Kroger, 2016d).
Table 2. Devices Used to Access the Internet at Home in the U.S. Source: Schwandt & Kroger (2016d).

<table>
<thead>
<tr>
<th>Year</th>
<th>Desktop PC</th>
<th>Laptop</th>
<th>Mobile Phone/Smartphone</th>
<th>Games console</th>
<th>Portable media player</th>
<th>Tablet</th>
<th>Connected or Smart TV</th>
<th>e-Reader</th>
<th>A TV connected to the Internet either directly (Smart TV) or via another device such as a set-top box or a game console</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>74%</td>
<td>59%</td>
<td>27%</td>
<td>14%</td>
<td>7%</td>
<td>3%</td>
<td>0%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>63%</td>
<td>68%</td>
<td>32%</td>
<td>14%</td>
<td>6%</td>
<td>6%</td>
<td>4%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2012</td>
<td>59%</td>
<td>58%</td>
<td>31%</td>
<td>9%</td>
<td>4%</td>
<td>15%</td>
<td>3%</td>
<td>7%</td>
<td>-</td>
</tr>
<tr>
<td>2013</td>
<td>63%</td>
<td>60%</td>
<td>45%</td>
<td>15%</td>
<td>6%</td>
<td>24%</td>
<td>6%</td>
<td>6%</td>
<td>-</td>
</tr>
<tr>
<td>2014</td>
<td>54%</td>
<td>60%</td>
<td>50%</td>
<td>15%</td>
<td>5%</td>
<td>31%</td>
<td>7%</td>
<td>7%</td>
<td>-</td>
</tr>
<tr>
<td>2015</td>
<td>56%</td>
<td>61%</td>
<td>53%</td>
<td>-</td>
<td>7%</td>
<td>31%</td>
<td>-</td>
<td>10%</td>
<td>-</td>
</tr>
</tbody>
</table>

B. SOFTWARE

Software is the most dynamic of the DL building blocks for many reasons. First, software needs constant updates. Depending on the level at which the software operates, OS or application, compatibility issues are more or less common. Second, the lines of code (LOC) that make up modern software applications tend to be in the millions. LOC adds complexity to computer systems, in particular when software needs to run in parallel or on top of other software applications. Because of typical software’s dynamic nature and complexity, selecting the most compatible software is important for a robust DL model.

1. Operating System

An OS is the layer between hardware and all other applications. OSs provide the communications link that transforms application requests into executable tasks for the hardware platform. Several companies offer different types of OSs for different hardware and software platforms. The degree of mobility in a particular device influences the type of hardware used and consequently the type of OS installed on each device. As shown in Figure 22, the most popular OSs for stationary computing devices such as desktop PCs and laptops include the Microsoft Windows, Mac OS, and Linux families of OSs.
In mobile hardware, also shown in Figure 22, the most predominant OSs include different versions of iOS or Android OSs (Hopkins et al., 2016). Using popular OSs and platforms is more efficient because DL users are already familiar with the software and hardware. Current OS availability in the market and the type of hardware platform most commonly used are factors that need consideration for a more technologically efficient alternative to the MFR DL model.

![Desktop Operating System](Figure22a.jpg) ![Mobile/Tablet Operating System](Figure22b.jpg)

**Figure 22.** Desktop & Mobile/Tablet Operating System Market Share. Source: Hopkins et al. (2016).

2. **Web Browser**

A web browser is the software application on top of the OS that provides the window to the WWW. Software developers provide different features in their web browsers. These dissimilarities make it difficult to standardize the way the LMS servers communicate with the users’ web browsers or VM clients. It is not uncommon for individuals using different web browsers to have different experiences when accessing the same website. Compatibility issues are the main source of frustration for users accessing MarineNet from devices other than typical GPDLs. As shown in Figure 23, Google Chrome leads the market for both desktop and mobile/tablet use (Hopkins et al., 2016). This research will utilize Google Chrome as the web browser of choice for all devices because of its domination of the web browser market and compatibility with the courseware.
3. **Virtual Machine**

The NPS servers hosted the VM used for this research. This particular VM was separate and distinct from the typical VM students use while at NPS. Typical VMs assigned to NPS students have restrictions that include a limited amount of RAM, no persistent HD space available to a particular user, and the inability to install additional software or modify the OS environments. To install required software and modify the OS environment to fit one that was fully compatible with MarineNet, the VM used for this research was set up with administrator rights, 8 gigabytes of RAM, and 75 MB of persistent HD space. NPS uses the basic VMware infrastructure depicted in Figure 24. The NPS VM infrastructure proved to be very reliable with always-on access to the VM from any of the devices tested. Access to the NPS VM had no downtime or accessibility glitches, whether it was utilizing the school Wi-Fi or at a public Wi-Fi.
Figure 24. Basic VM Infrastructure. Source: VMware (2016).

4. MarineNet Software Requirements

MarineNet manages courseware built to support the latest OS and web browsers at the time of their design. With new technologies entering the market, some courseware was not compatible with the newest OS or web browser platforms. To enable compatibility with legacy and new courseware, MarineNet has a list of minimum software requirements. Appendix B is the complete list of software required to access MarineNet courseware. For this research, the NPS VM had all the required software as listed in Appendix B before testing. No errors or compatibility issues occurred while using the VM to test access to MarineNet courseware. A wide variety of devices used to access the MarineNet servers were successful in accessing the courses. During testing, all devices listed in Figure 25 had the same level of access to text, video, audio, and animation. No compatibility issues were evident while testing different courses with different levels of interaction between the user and the course. No compatibility issues occurred when the NPS VM was loaded with all courseware requirements and served as the platform interface between the user and MarineNet servers.
C. HARDWARE

As previously discussed, cost and market availability were characteristics considered for equipment tested during this research. Hardware tested consisted of a smart CAC reader and mobile devices. Mobile devices’ primary distinctions entailed those of size and portability.

1. CAC Reader

Smart CACs are part of the DOD’s two-factor authentication security process. An individual’s smart CAC, what a person has, together with an eight-digit pin number, what a person knows, prevent unauthorized access to most of the DOD’s secure websites. In case of MarineNet, smart CAC access is one of two options to access their website. The other option is a username and password that MarineNet issues after registration. Both options offer the same access to courseware and DL opportunities.

Biometric Associates offer different models of smart CAC readers. The company specializes in portable smart CAC readers with interfaces that work on most Apple and Android products. Model 301-LT, one of Biometric Associates’ smart CAC readers worked with all portable devices tested during this research. This particular model has both a Lightning connector for Apple mobile devices and a micro USB connector for Android mobile devices. The 301-LT worked seamless on the Insignia tablet, and both iPads. This smart CAC reader also worked on an iPhone 6+ that was not part of the experiment. In all cases, inserting the 301-LT in the mobile device I/O port allowed MarineNet to read and authenticate the user’s CAC and eight-digit pin number. No additional smart CAC reader’s drivers or software were needed to be installed for credentials to be authenticated by MarineNet servers. The remaining mobile devices had USB I/O ports that can integrate typical smart CAC readers currently available throughout the USMC. Devices with a USB I/O port also work with the 301-LT in a similar manner; allowing the smart CAC user to be authenticated by MarineNet servers.
2. Devices

Figure 25 lists the different characteristics for devices tested during this research. The main distinction in terms of software is the type of OS each device supports. The four types of platforms tested were the Microsoft Windows, Android, iOS, and OSX family of OSs. The Microsoft Windows OS family is the most abundant in the market today. Because of its market dominance, Microsoft Windows has better compatibility with most computer software available today. The OSX OS from Apple is the second most abundant OS in the market. Lastly, the Android OS is gaining market share, primarily in the mobile device market. Regardless of the OS platform, VMware, the software running the virtual desktop, has a proprietary VM client that worked harmonious with the host OS of all devices tested.

The definition of what is a full laptop and what is a tablet are blending with modern devices because of emerging technologies that make it possible to produce smaller devices that are faster and less expensive. This is the case with the Dell Venue 11 tested in this research. The Venue 11 is as powerful as a typical laptop in the market today but its size, weigh, and portability are characteristics that classify it as a tablet. This tablet comes with a full copy of Windows 8 and enough hardware capabilities to run and clearly display MarineNet courseware.

Lastly, the Kangaroo MiniPC is in a class of its own. This device has all the components of a typical desktop computer but at a fraction of the price, size, and weight. At 0.44 pounds, the Kangaroo is extremely portable but with the qualities of a larger device. The Kangaroo comes with Windows 10 OS which makes it compatible with most software found in the market today. The downside of this device is that it does not come with a monitor, keyboard, or mouse. This device works by connecting it to a monitor or TV via a HDMI cable and attaching a keyboard and mouse via its UBS port. In addition, it has Wi-Fi and Bluetooth to connect it to a wireless network and Bluetooth devices respectively. The HDMI port, Wi-Fi, Bluetooth, and USB interfaces make it a versatile device with an affordable price.
<table>
<thead>
<tr>
<th>Type</th>
<th>Tablet</th>
<th>Tablet</th>
<th>Tablet</th>
<th>Tablet</th>
<th>Laptop</th>
<th>Laptop</th>
<th>Mini PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendor</td>
<td>Insignia</td>
<td>Apple</td>
<td>Apple</td>
<td>Dell</td>
<td>Apple</td>
<td>Lenovo</td>
<td>Kangaroo</td>
</tr>
<tr>
<td>Name</td>
<td>Insignia Flex 10.1</td>
<td>iPad mini</td>
<td>Apple 2</td>
<td>Venue 11 Pro</td>
<td>MacBook Pro 8,2</td>
<td>Lenovo Edge</td>
<td>Kangaroo MD2B</td>
</tr>
<tr>
<td>Model#</td>
<td>NS-P10A6100</td>
<td>MD530LL/A</td>
<td>MD328LL/A</td>
<td>Venue 7139</td>
<td>MC723LL/A</td>
<td>Edge 2-1580</td>
<td>MD2D, SD1B</td>
</tr>
<tr>
<td>OS</td>
<td>Android Lollipop</td>
<td>iOS</td>
<td>iOS</td>
<td>Windows 8</td>
<td>OS X El Capitan</td>
<td>Windows 10</td>
<td>Windows 10</td>
</tr>
<tr>
<td>OS ver #</td>
<td>5.0.1</td>
<td>iOS 9.35</td>
<td>iOS 9.35</td>
<td>6.3.9600</td>
<td>Build 9600</td>
<td>10.11.6</td>
<td>10.0.14393</td>
</tr>
<tr>
<td>OS version</td>
<td>5.0.1</td>
<td>iOS 9.35</td>
<td>iOS 9.35</td>
<td>6.3.9600</td>
<td>Build 9600</td>
<td>10.11.6</td>
<td>10.0.14393</td>
</tr>
<tr>
<td>RAM</td>
<td>1 GB</td>
<td>512 MB</td>
<td>512 MB</td>
<td>8GB</td>
<td>6GB</td>
<td>8GB</td>
<td>2GB</td>
</tr>
<tr>
<td>Storage</td>
<td>32GB</td>
<td>64GB</td>
<td>16GB</td>
<td>256GB</td>
<td>750GB</td>
<td>1TB</td>
<td>32 GB</td>
</tr>
<tr>
<td>CPU name</td>
<td>MediaTek MT8127B</td>
<td>A5</td>
<td>A5</td>
<td>Intel</td>
<td>Intel</td>
<td>Intel</td>
<td>Intel</td>
</tr>
<tr>
<td>CPU speed</td>
<td>1.2GHz</td>
<td>2.4GHz</td>
<td>1GHz</td>
<td>1.60GHz i5</td>
<td>2.2GHz i7</td>
<td>2.5 GHz i7</td>
<td>1.44 GHz</td>
</tr>
<tr>
<td>CPU Cores</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Screen size</td>
<td>10.1-inch</td>
<td>7.9-inch</td>
<td>9.7-inch</td>
<td>11-inch</td>
<td>15-inch</td>
<td>15.6-inch</td>
<td>Variable</td>
</tr>
<tr>
<td>Resolution</td>
<td>1280x800</td>
<td>1024x768</td>
<td>1024x768</td>
<td>1920x1080</td>
<td>1280 by 800</td>
<td>1920 x 1080</td>
<td>1600x900</td>
</tr>
<tr>
<td>VM Client ver.</td>
<td>4.1.0</td>
<td>4.1.0</td>
<td>4.1.0</td>
<td>3.4.0 (2769709)</td>
<td>3.5.2 (3151577)</td>
<td>3.5.2 (31550477)</td>
<td>4.1.0</td>
</tr>
<tr>
<td>Chrome ver.</td>
<td>43.0.2357.93</td>
<td>52.0.2743.84</td>
<td>52.0.2743.84</td>
<td>52.0.2743.11</td>
<td>52.0.2743.11</td>
<td>52.0.2743.11</td>
<td>52.0.2743.11</td>
</tr>
<tr>
<td>Weight</td>
<td>1.1 lbs</td>
<td>0.68 lbs</td>
<td>1.33 lbs</td>
<td>1.55 lbs</td>
<td>5.6 lbs</td>
<td>5.06 lbs</td>
<td>0.44 lbs</td>
</tr>
<tr>
<td>Battery life</td>
<td>10 hours</td>
<td>10 hours</td>
<td>10 hours</td>
<td>8 hours</td>
<td>7 hours</td>
<td>5 hours</td>
<td>4 hours</td>
</tr>
<tr>
<td>Approx. Price</td>
<td>$110</td>
<td>$300</td>
<td>$400</td>
<td>$530</td>
<td>$2,000</td>
<td>$800</td>
<td>$100</td>
</tr>
<tr>
<td>Touchscreen</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes/No</td>
</tr>
</tbody>
</table>

Figure 25. Internet Access Devices Tested.

D. **INTERNET ACCESS**

The ability to access the Internet is essential for any DL program. GPDLs provide the only government-provided Internet access for reserve Marines stationed away from LRCs. As previously mentioned, the number of GPDLs is extremely limited compared with the number of reserve Marines typically assigned to an HTC. Chapter II discusses solutions to close this gap. Internet access has become a ubiquitous service, offered free in libraries and many municipalities. Also, many businesses now offer free Wi-Fi access.
to their customers. Another solution is to offer free access to Wi-Fi at the reserve Marine’s HTCs. Offering free Wi-Fi access at the HTCs ensures that every Marine will have access to the Internet. The cost for DOD is minimal when compared with other options such as setting up LRCs or increasing the number of GPDLs. In a budget-constrained environment, neither are viable options. The cost of Wi-Fi is proportional to the amount of bandwidth required. For a HTC with 200 reserve Marines, approximately 40 Mb/s are required as shown in Figure 26. In August 2016, the cost to purchase sufficient amounts of Internet service bandwidth from Verizon is $189.99/month (Verizon, n.d.). Comparable bandwidth services from Comcast costs $199.95/month (Comcast, n.d.).

Figure 26. Bandwidth Requirements for 200 Users.
Source: Brownpelicanwifi (n.d.).
E. TESTING

Equipment listed in Figure 25 was tested in the library basement of NPS. One wireless router located in the basement provides wireless access to devices within reach of the wireless router. This particular wireless router connects to the Internet via an Ethernet cable and the NPS network backbone. Because of the router’s location, it is uncommon to find students working in the area who are using the router. Testing for devices listed in Figure 25 occur when the router had only one logged in device. As a result, the wireless connection to that router and the Internet was isolated to the devices tested for this research.

1. Wi-Fi Connection Speed Analyzer

According to the Keuwlsoft application run on the Insignia Android tablet, the Wi-Fi connection in the testing area had an average link speed of 65 Mbps with a Received Signal Strength Indicator (RSSI) of -37 dBm (Keuwlsoft, 2016). These results were comparable with similar testing conducted throughout the NPS library. The difference between the router used for this research and others throughout the NPS library was the number of logged in users. The RSSI is an index used by the application to compare signal strengths at different places. The closer the RSSI approaches zero the better signal strength is available in that area (Keuwlsoft, 2016). RSSI readings higher than -50 dBm proved to be effective in accessing the NPS VM and run courseware from MarineNet successfully. Areas with RSSI readings lower than -50 dBm tended to have longer latencies and sluggish web browsing experiences when accessing MarineNet through the VM.

Figure 27 shows signal strength information in the area used to test the equipment for this research. Noteworthy is the fact that readings shown in Figure 27 correspond to the signal received by the Insignia Android tablet and not the strength of the signal radiated from the wireless router. Other devices would have different measurements at the same time and locating depending on the wireless capabilities of each device. Measurements taken by the Keuwlsoft application were used for comparing signal strengths at different locations inside the NPS library.
2. Internet Access Benchmark

Table 3 lists the Wi-Fi benchmark results for devices tested during this research. Test results in the first three columns of Table 3—ping, download, and upload speeds—originated from the Speedtest software, an Ookla product, and applications loaded on the devices. The results shown on the first three columns of Table 3 are the average scores for three Speedtest experiments. Results on the fourth and fifth column of Table 3 correspond to iPerf3 bandwidth tests. Specifically, the fourth column shows the number of megabytes transferred to test Internet access bandwidth. The last column of Table 3 shows ping tests run from either the command prompt in the laptops or an application in the mobile devices.

Faster devices, such as the MacBook Pro, had higher download, upload, transfer, and bandwidth test results while slower devices, such as the Insignia Android tablet, had lower scores. Ping results on the other hand, are lower for faster devices and higher for slower devices. Because of this difference, ping tests results shown in Table 3 were
converted to show an inverse proportion of the actual results. For instance, the Speedtest ping in the MacBook Pro was 7.3 microseconds, which was converted to 0.94 in Table 3. The iPad 2’s Speedtest ping run at 10.6 microseconds, which was converted to 0.53 in Table 3. In both cases, faster devices now show higher ping results while slower devices show lower ping results.

Table 3. Wi-Fi Benchmark Results Table. Source: Ookla (2016) & iPerf.fr (2016).

<table>
<thead>
<tr>
<th>Application</th>
<th>Speedtest Ping Test w/app</th>
<th>Speedtest Download Mbps</th>
<th>Speedtest Upload Mbps</th>
<th>iPerf MBytes</th>
<th>iPerf Mbps</th>
<th>Command Prompt Ping Test w/CMD Avg ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>MacBook Pro OSX Laptop</td>
<td>0.94</td>
<td>192.4</td>
<td>193.79</td>
<td>242.00</td>
<td>203.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Lenovo Edge Windows Laptop</td>
<td>0.77</td>
<td>173.09</td>
<td>191.98</td>
<td>203.00</td>
<td>170.00</td>
<td>0.25</td>
</tr>
<tr>
<td>Kangaroo Pi MiniPC Windows</td>
<td>0.94</td>
<td>152.14</td>
<td>78.31</td>
<td>198.00</td>
<td>166.00</td>
<td>0.13</td>
</tr>
<tr>
<td>Dell Surface Tablet Windows</td>
<td>0.89</td>
<td>171.79</td>
<td>66.46</td>
<td>110.00</td>
<td>92.30</td>
<td>1.00</td>
</tr>
<tr>
<td>iPad 2</td>
<td>0.53</td>
<td>19.62</td>
<td>60.57</td>
<td>172.50</td>
<td>143.00</td>
<td>0.04</td>
</tr>
<tr>
<td>iPad Mini</td>
<td>0.74</td>
<td>28.40</td>
<td>32.48</td>
<td>50.00</td>
<td>40.16</td>
<td>0.02</td>
</tr>
<tr>
<td>Insignia Tablet Android</td>
<td>0.81</td>
<td>20.90</td>
<td>17.85</td>
<td>35.01</td>
<td>29.37</td>
<td>0.11</td>
</tr>
</tbody>
</table>

Figures 28 and 29 show sample screenshots of Speedtest, iPerf3 and command prompt pings speed testing. To minimize typical Internet service provider speed variations, tests were conducted on the same day at approximately the same time. In addition, for every test, the Speedtest application utilized the same servers in Santa Cruz, California. Speedtest form Ookla is the most popular Internet speed tool available. It diagnoses the speeds at which a device connects to the Internet (Ookla, 2016). The results are specific to the device where the tests were conducted. The individualized tests run on each device demonstrated the ability of each device to connect to the Internet (Ookla, 2016). For instance, when the MacBook Pro laptop and the Insignia Android tablet were tested at the same time and with the same network connection, the former had higher download and upload speeds than the latter. Specifically, the MacBook Pro’s download speed was 192.4 megabytes per second while the Android tablet’s download speed had an average of 20.90 megabytes per second. This represents a substantial difference between
these two devices. This difference also corroborates the fact that Speedtest measures actual Internet speeds from the device’s web browser to Speedtest servers.

Additionally, iPerf3 was used as a secondary tool to measure the speed at which each device connects to the Internet (iPerf.fr., 2016). Screenshot samples of iPerf3 test conducted on the Lenovo Edge, MacBook Pro, and iPad 2 are shown in Figure 29. iPerf3 is similar to Speedtest in that it measures the Internet speed achieved at the device’s web browser (iPerf.fr., 2016). The difference lies in the destination server against which Internet speed tests are conducted. In the case of Speedtest, the target system was the Ookla servers. For iPerf3, which allows targeting a specific Internet protocol address, the
destination server used was the NPS VM. Even though both Speedtest and iPerf3 use different algorithms, data packages, and destination servers, test results are proportionally similar as previously shown in Table 3.

3. Results

Figure 30 shows the results of Wi-Fi benchmark testing. With a few exceptions, a relationship between the cost of a device and Wi-Fi latency results was found. The most expensive device, the MacBook Pro, scored the highest when compared with least expensive devices such as the Insignia Android tablet. There were outliers, such as the Kangaroo MiniPC that scored relatively similar to devices that cost between ten to twenty
times more. Significantly, the Insignia Android tablet performance was sufficient to access the NPS VM and MarineNet network. This tablet, along with the signal strength shown in Figure 27, allowed the researcher to login to the NPS VM and run MarineNet courseware successfully.

![Wi-Fi Benchmark Chart](chart.png)

**Figure 30.** Wi-Fi Benchmark Chart Results.

Based on testing conducted for this research, the Insignia Android tablet, or a tablet with similar characteristics, provide a technologically efficient alternative to access MarineNet courseware. When combined with the VM, this tablet was proven to access MarineNet courseware successfully and with no compatibility anomalies. Free Wi-Fi access at HTCs around the United States are a needed complement to the DOD-provided devices and VMs.
V. CONCLUSION

A technologically efficient alternative for MFR personnel to access MarineNet DL courseware requires the DOD to provide a mobile device, free Wi-Fi at the HTCs, and to set up VMware servers. The Insignia Android tablet provided the necessary hardware and software to access the VM and subsequently MarineNet servers. Free Wi-Fi access at the HTCs is essential to give every reserve Marine stationed away from typical military installations access to DOD servers. Lastly, VMware VMs provided the foundation to set up virtual environments that are adaptable to MFR needs.

A. DESIGNING THE CORRECT ARCHITECTURE

According to Guthrie, Lowe, & Coleman, three facets are essential to designing a solid IT architecture: the organizational, technical, and operational (2013). These facets need to be considered, evaluated, and implemented in the context of satisfying the end user requirements or functional requirements (Guthrie et al., 2013). Functional requirements represent the left and right lateral limits that can keep the organizational, technical, and operational facets focused on what the design should do and not what the design can do (Guthrie et al., 2013). The preceding facet makes a huge difference because, more often than not, organizations tend to acquire the newest technologies rather than focus on what they actually need. As shown in Figure 31, functional requirements are the boundaries of the design facets. The Organizational facet focuses on identifying personnel and describing their responsibilities (Guthrie et al., 2013). Some of the decisions include deciding who will manage the environment, configure the network, handle troubleshooting, and take responsibilities for security (Guthrie et al., 2013). The technical facet includes decisions about actual software and hardware environment required to support the functional requirements (Guthrie et al., 2013). The decisions made in this facet range from determining the brand of the server, CPU type, type of storage, network configuration, and any additional software (Guthrie et al., 2013). Lastly, the decisions in the operational phase include how to manage hosts, create VMs, make backups, and provision storage (Guthrie et al., 2013).
Figure 31. Designing VM Environment Model. Source: Guthrie et al. (2013).

B. **PROPOSED ARCHITECTURE**

MarineNet’s DL functional requirement is to provide courseware access to all Marines regardless of their geo-location. VMs using VMware helps fulfill this requirement by eliminating the software and hardware compatibility problems and it is flexible enough to adapt to emerging technologies in the future. A VM is technologically efficient when compared to physical devices such as the ones found in typical LRCs. As technology improves and new courseware is developed, the virtualized environment will adjust to the new courseware requirements in a manner that is transparent to the end user. MarineNet has the personnel and organizational structure to manage the proposed model. Cost savings from a more efficient architecture can augment any potential increase in the number of personnel required or additional hardware to support the updated structure. The technical aspect of this architecture uses existing technologies in terms of the virtual desktop architecture and access devices. During the operational facet of the proposed architecture, outsourcing the hosting and management of VM servers can be considered as a means to streamline the program and increase efficiencies.
The proposed architecture in Figure 32 shows virtual servers at the center of the architecture. As proven in Chapter IV, as long as a user can successfully access the virtual environment, the VM will act as the link between the user and MarineNet courseware. Issues with MarineNet compatibility and accessibility can be minimized by using a more technologically efficient architecture as sown in Figure 32. At the bottom right of Figure 32, a reserve Marine has many more options to access MarineNet. These options include using free Wi-Fi access at the HTC, some public buildings, private businesses or private access to the Internet at home. In this scenario, a reserve Marine is not limited to the few GPDLs at the HTC but has a wide range of devices he can use to access courseware.

Figure 32. Proposed Architecture for MFR Personnel Access to MarineNet.
Figure 25 lists the seven devices that successfully connected to the NPS VM. This list is not inclusive, but rather a small sample of devices currently available in the market. The devices selected for this research had different hardware and software platforms. This diversity of hardware and OSs tested provides possible applicability on a larger number of devices in the market with similar characteristics. The attribute that generated better results was Wi-Fi speed rather than the device itself. Based on this study, it is recommended to have a Wi-Fi speed no lower than -37dBm and 65 megabits per second as measured with Keuwlsoft’s Wi-Fi connection speed analyzer (shown in Figure 27). Slower Wi-Fi speeds tended to degrade the quality of the Internet connection to the VM. Considering the Wi-Fi benchmark results in Figure 30, the slowest device, the Insignia Android tablet, was sufficient to access the VM and courseware successfully. In closing, the researcher recommends all three components—a government provided tablet, free Wi-Fi access at the HTCs, and a VM infrastructure—to provide a technologically efficient alternative for reserve personnel located away from LRCs to access MarineNet courseware.

C. FUTURE RESEARCH

The results of this research include the building blocks and proposed architecture that efficiently support MFR DL needs. These results did not consider specific security or policy concerns that can apply to the DOD. In addition, the use of VMs can be applied in other DOD systems to mitigate difficulties with compatibility and availability.

1. Security

Cyber-attacks can occur at the VM portal. Additional studies based on the proposed architecture in Figure 32 need to be done in data encryption and user authentication to prevent a NIPRNET security breach through the VM or user devices. Because the VM will interact directly with edge devices, security measures—such as intrusion detection systems, vulnerability scanners, gateways, firewalls, and encryption software—need to be set up and configured correctly. Additional questions include:

- What are the network security guidelines that need to be put in place to protect the NIPRNET from cyber-attacks?
• What are the VM’s cyber-security safeguards needed to protect the NIPRNET?

2. VM DOD Policies

The DOD’s policies affecting the implementation of the proposed architecture need to be evaluated. The DOD is a large organization that spans the entire globe. Because of its size and reach, adapting to existing or new technologies has always been a challenge for the organization. The proposed model would need to be validated with existing DOD policies that can potentially restrict the capabilities VMs offer to MFR DL, making VMs inefficient in the process. Additional question includes:

• Do existing DOD policies support or limit the proposed DL model for MFR personnel?

3. Other DOD Systems

Recommendations from this research can support other DOD IT efforts such as the Joint Information Environment (JIE) and Global Combat Support Systems (GCSSs). According to the Government Accountability Office, the JIE aims “to consolidate IT infrastructure in order to achieve savings and improve network security (GAO, 2016, p. 1). Because the JIE is a joint effort, the IT infrastructure involves consolidating thousands of IT systems that, in the majority of cases, have disparate technologies. Compatibility and accessibility issues are bound to exist, which will increase the complexity of the final JIE IT infrastructure. VMs can potentially decrease compatibility and accessibility difficulties by consolidating systems and programs in a virtual environment. A consolidated virtual environment would reduce the end user computer’s requirements in terms of both hardware and software. As for GCSSs, computers around the world accessing its servers and running the program locally experience increased latency issues. A VM co-located or in close proximity to the GCSSs servers that performs all tasks requested by the customer would be substantially faster than the current setup.
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APPENDIX A. MCBUL 1500 EXCERPT

Appendix A is the complete list of requirements all U.S. Marines need to complete during the period given (USMC, 2015b). This list is made up of T&E that applies to all Marines regardless of MOS, rank, or location (USMC, 2015b).

<table>
<thead>
<tr>
<th>Annual Training Requirement</th>
<th>Mandate Authority</th>
<th>Order</th>
<th>Waiver</th>
<th>Delivery Method</th>
<th>Training per Fiscal (FY) / Calendar (CY) Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marine Corps Water Survival Training (MCNST)</td>
<td>NC</td>
<td>MCO 1500.51D, Marine Corps Water Survival Training (MCNST), dtd 10 Nov 10</td>
<td>Commanding Generals Page 9-1, paragraph 2</td>
<td>Unit Training1</td>
<td>To be determined by the first general officer in the chain of command.</td>
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<td></td>
</tr>
<tr>
<td>Hasing</td>
<td>SECHAVINST 1610.2A</td>
<td>MCO 1700.28B, Hasing, dtd 20 May 13</td>
<td>Page 2, paragraph 4.b</td>
<td>Unit Training1</td>
<td>(CY) - Refresher training1</td>
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<td>Sexual Assault Prevention and Response (SAPR)</td>
<td>DOD DODI 695.02</td>
<td>MCO 2561.5B, Sexual Assault Prevention and Response Program, dtd 01 Mar 13 (SAPR) MARADMIN 234/13</td>
<td>No waivers or exemptions</td>
<td>Unit Training1</td>
<td>(FY)</td>
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<tr>
<td>The Marine Corps Operations Security (OESEC) Program</td>
<td>DOD DODD 5205.02E</td>
<td>MCO 3070.1A MARADMIN 761/11 Annual Operations Security (OESEC) Training</td>
<td>Paragraph 3 - 5</td>
<td>No waivers or exemptions</td>
<td>Unit Training1 or MarineNet OESECUS001</td>
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<td>Chemical, Biological, Radiological and Nuclear Defense Training Requirements</td>
<td>NC</td>
<td>MCO 2400.39, Chemical, Biological, Radiological and Nuclear Defense Training Requirements dtd 07 Dec 11</td>
<td>Exempt Personnel: Page 4, paragraph 8.e</td>
<td>Unit Training1</td>
<td>Active component individual training: Every 2 fiscal years and at least 6 months prior to deployment. Reserve component: At least 6 months prior to deployment.</td>
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<tr>
<td>Marine Corps Combat Marksmanship - Rifle</td>
<td>NC</td>
<td>MCO 3574.2L, Marine Corps Combat Marksmanship Programs, dtd 04 Sep 14</td>
<td>MCO 3574.2L, Marine Corps Combat Marksmanship Programs, dtd 04 Sep 14</td>
<td>Unit Training1</td>
<td>(FY)</td>
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<td>Annual Training Requirement</td>
<td>Mandate Authority</td>
<td>Order</td>
<td>Waiver</td>
<td>Delivery Method</td>
<td>Training Hours per Fiscal (FY)/ Calendar (CY) Year</td>
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<tr>
<td>Marine Corps Combat Marksmanship - Pistol</td>
<td>NC</td>
<td>NOO 3574.2L, Marine Corps Combat Marksmanship Programs, dtd 04 Sep 14</td>
<td>NOO 3574.2L, Marine Corps Combat Marksmanship Programs, dtd 04 Sep 14</td>
<td>Unit Training¹</td>
<td>Active Component FY Reserve Component: At least 6 months prior to deployment. Marines selected to SSgt will conduct initial qualification w/in 2 years of promotion.</td>
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<td>Operational Risk Management (ORM)</td>
<td>DOD</td>
<td>DODI 6055.1</td>
<td>W/ERRATUM, Operational Risk Management (ORM), dtd 15 May 04</td>
<td>Page 3, paragraph 5</td>
<td>No waivers or exemptions</td>
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<tr>
<td>Marine Corps Equal Opportunity (EO) and Sexual Harassment</td>
<td>DOD</td>
<td>DODI 1950.2</td>
<td>NMC 5554.10</td>
<td>Page 4-5, paragraph 4061.2</td>
<td>No waivers or exemptions</td>
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<td>Marine Corps Physical Fitness Program - PFT</td>
<td>NC</td>
<td>NOC 1105.18 W/CH 1, Marine Corps Physical Fitness Program, dtd 01 Aug 08</td>
<td>KN0L (1), page 1-1, paragraph 2.a</td>
<td>DC MCRP, CG NMC, Commanders MARFORCOM, MRFORPEAC, MRFORPEES, MARSOC, and MEF Commanders Enclosure (1), page 1-13, paragraph 7.b</td>
<td>Unit Training¹ (CY)</td>
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<tr>
<td>Marine Corps Physical Fitness Program - CFT</td>
<td>NC</td>
<td>NOC 1105.18 W/CH 1, Marine Corps Physical Fitness Program, dtd 01 Aug 08</td>
<td>KN0L (1), page 3-1, paragraph 2.a</td>
<td>DC MCRP, CG NMC, Commanders MARFORCOM, MRFORPEAC, MRFORPEES, MARSOC, and MEF Commanders Enclosure (1), page 1-13, paragraph 7.b</td>
<td>Unit Training¹ (CY)</td>
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<tr>
<td>Annual Training Requirement</td>
<td>Mandate Authority</td>
<td>Order</td>
<td>Waiver</td>
<td>Delivery Method</td>
<td>Training Hours per Fiscal (FY) / Calendar (CT) Year</td>
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<td>Level 1 AT Awareness Training / Counter Intelligence Awareness and Reporting</td>
<td>DOD DODI 2000.12 DOD D540.96</td>
<td>DOD 3302.1E, Marine Corps Anti-Terrorism Training Program, dated 8 Mar 2008</td>
<td>Page 10, paragraph 7.a</td>
<td>No waivers or exemptions</td>
<td>Unit Training or MarineNet JATVL10000 (CT)</td>
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<tr>
<td>Annual Cyber Awareness / FIT Training</td>
<td>DOD DOD D670.01-M</td>
<td>MARADMIN 208/19 Updates to Annual Cyber Awareness Training</td>
<td>Paragraph 4.a</td>
<td>No waivers or exemptions</td>
<td>Marine Net in required CYBER090000 (FY)</td>
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<tr>
<td>Violence Prevention Awareness Training</td>
<td>DOD DOD D1488.96</td>
<td>NCO 5550.3, Violence Prevention Program, dated 01 Dec 2012</td>
<td>Paragraph 3.b(8) and Appendix D</td>
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<td>Unit Training or MarineNet ILEVUPA01A (CT)</td>
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<tr>
<td>Tobacco Cessation (Semper Fit)</td>
<td>DOD DOD 32 CFR 89.6</td>
<td>NCO 1700.29, Marine Corps Semper Fit Program Manual, dated 08 Jan 19</td>
<td>Page 6-7, paragraph 4.b (9)(c)</td>
<td>CMC (HR), Page 1-4, paragraph 12</td>
<td>Unit Training or Marine Net STG082C300 (CT) Note 3</td>
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<tr>
<td>Unit Marine Awareness and Prevention Integrated Training (UMAPIT)</td>
<td>DOD Multiple DOD and DODI: DOD DOD DOD D540.14 DOD DOD D540.96</td>
<td>MARADMIN 593/12, Marine Corps Substance Abuse Program: NCO 1584.11, Family Advocacy Program NCO 1720.2 Marine Corps Prevention Program</td>
<td>MARADMIN 593/12, Paragraph 5: MARADMIN 101/10, Combating Trafficking in Persons Annual Training Requirement</td>
<td>No waivers or exemptions</td>
<td>Unit Training (CT) Note 4</td>
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<td>Records Management Training</td>
<td>DOD DOD D5210.0</td>
<td>DOD DOD D5210.1</td>
<td>MARADMIN 593/12, Mandatory Annual Records Management Training NCO 5210.11F, Marine Corps Records Management Program</td>
<td>MARADMIN 593/12, Paragraph 5: MARADMIN 101/10, Combating Trafficking in Persons Annual Training Requirement</td>
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<td>Combating Trafficking in Persons (CTDP)</td>
<td>DOD DOD D5210.0</td>
<td>MARADMIN 101/10, Combating Trafficking in Persons Annual Training Requirement</td>
<td>Page 5, paragraph 8.3</td>
<td>Unit Training with DoD provided materials or MarineNet DD01AD009000 (FY)</td>
<td>Refresher course authorized if full course completed in previous 3 years</td>
</tr>
</tbody>
</table>

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APPENDIX B. MINIMUM MARINENET REQUIREMENTS

Appendix B is the complete list of software requirements to access MarineNet courseware (MarineNet, 2016b). This list of requirements ensures the device can run all courseware available in MarineNet servers, old and new (MarineNet, 2016b).

<table>
<thead>
<tr>
<th>OS</th>
<th>Software Description</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>WXP</td>
<td>XP Citrix Web Client</td>
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<td>Windows 7</td>
<td>Citrix Web Client</td>
<td>5.4.0.36</td>
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<td>Microsoft Office Suite (includes Word, Excel, PowerPoint, Access, Outlook, and InfoPath)</td>
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<td>WXP</td>
<td>Office 2007 Suite</td>
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<td>Office Suite 2007</td>
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<td>Office 2010 Suite</td>
<td>(SP1)</td>
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<td>Windows 7</td>
<td>Data Center Operations (DCO) XXMP Client</td>
<td>5.4.0.36</td>
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<tr>
<td>WXP</td>
<td>Office 2007 Compatibility Pack</td>
<td>SP2</td>
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<td>Windows 7</td>
<td>Adobe Connect</td>
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<td>WXP</td>
<td>Net-Centric Enterprise Services (NCES) Collaboration Suite:</td>
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<td>IBM Lotus SameTime</td>
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<td>DCO XXMP Client</td>
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<td></td>
<td>Adobe Connect</td>
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<td>Reflection</td>
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<td>Reflection</td>
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<td>Service Pack 3 (SP3)</td>
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<td>WXP XML Core Services 4</td>
<td>4 SP2</td>
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<td>WXP XML Core Services 6 (SP2)</td>
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<td>WXP</td>
<td>Encryption Anywhere</td>
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<td>Windows 7</td>
<td>Enterprise Management Tools</td>
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<td>Desktop Validator</td>
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<td>Windows 7</td>
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<td>Encryption Anywhere Removable Storage (DAR)</td>
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<td>Radia Client</td>
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<td>WXP</td>
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<td>McAfee HIPS</td>
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### Portable Utilities
(for unclassified portable Client Data seats only)

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<td>Juniper NetConnect Secure Sockets Layer (SSL) virtual private network (VPN)</td>
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<td>WXP NetScreen-Remote VPN Client</td>
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<td>WXP Remote Access Service (RAS) Tools (unclassified)</td>
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### System Tools

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<td>W7</td>
<td>DELL OpenManage Client Instrumentation (OMCI) System Tool</td>
<td>8.0.1.150</td>
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<td>W7</td>
<td>HP CMI System Tool</td>
<td>1.5.0A</td>
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APPENDIX C. MFR UNIT LOCATIONS

Appendix C is the entire list of MFR unit locations (MFR, 2014). Some of the locations coincide with military installations. A vast majority are not located in close proximity to any military installation. This fact prevents MFR personnel from having access to DL opportunities provided by LRCs.
ARKANSAS

- CO 1 3RD BN 23RD MAR REGT
- DET CO I 3RD BN 23RD MAR REGT

CALIFORNIA

- 2ND INTEL PRODUCTION TM CO A INTEL SPT BN
- 6TH ENGR BN
- 7TH DENTAL BN
- TRANSPORT CO CLB 23 CLB 4
- 1ST CIVIL AFFAIRS GROUP
- 1ST INTEL PRODUCTION TM CO A INTEL SPT BN
- HQ SPC CO F-4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN

ARIZONA

- BULK FUEL CO C
- 6TH ENGR SPT BN
- HQ SPC CO F-4TH LAR BN
- CO A 4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN

ALABAMA

- 1ST TASK FORCE 3RD BN 14TH MAR REGT
- 3RD FORCE RECON CO
- 6TH AIR SENSORS PLT HOSVC CO INTEL SPT BN
- CO L 3RD BN 23RD MAR REGT
- DET CO L 3RD BN 23RD MAR REGT

ALASKA

- DET HP CO D 4TH LAW ENF BN
- AIR SENSORS 37TH
- 3RD AIR & NAVAL GUARD ARM BN
- TRANSPORT CO CLB 23 CLB 6

ARIZONA

- BULK FUEL CO C
- 6TH ENGR SPT BN
- VMTF-401, MAG-41
- HQ SPC CO F-4TH LAR BN
- CO A 4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN

ALASKA

- 1ST CIVIL AFFAIRS GROUP
- 1ST INTEL PRODUCTION TM CO A INTEL SPT BN
- MARINE CORPS RESERVE TRAINING CENTER, BLDG 26, FL 1
- LOS ANGELES, 90220
- 4TH DENTAL BN

ARIZONA

- BULK FUEL CO C
- 6TH ENGR SPT BN
- VMTF-401, MAG-41
- HQ SPC CO F-4TH LAR BN
- CO A 4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN

ALASKA

- 1ST CIVIL AFFAIRS GROUP
- 1ST INTEL PRODUCTION TM CO A INTEL SPT BN
- MARINE CORPS RESERVE TRAINING CENTER, BLDG 26, FL 1
- LOS ANGELES, 90220
- 4TH DENTAL BN

ARIZONA

- BULK FUEL CO C
- 6TH ENGR SPT BN
- VMTF-401, MAG-41
- HQ SPC CO F-4TH LAR BN
- CO A 4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN

ALASKA

- 1ST CIVIL AFFAIRS GROUP
- 1ST INTEL PRODUCTION TM CO A INTEL SPT BN
- MARINE CORPS RESERVE TRAINING CENTER, BLDG 26, FL 1
- LOS ANGELES, 90220
- 4TH DENTAL BN

ARIZONA

- BULK FUEL CO C
- 6TH ENGR SPT BN
- VMTF-401, MAG-41
- HQ SPC CO F-4TH LAR BN
- CO A 4TH LAR BN
- HQ CO 2ND BN 23RD MAR REGT
- HQ 4TH DENTAL BN
COLORADO

- 1ST HUMAN INTEL SUPPORT TM
  CO B INTEL SPT BN
  7 N SNOWMASS ST, STOP 61
  AURORA, 80011
  720-845-7685

- 1ST INTEL PRODUCTION TM CO B INTEL SPT BN
- 2ND INTEL PRODUCTION TM (JRC) CO B INTEL SPT BN
  N SNOWMASS ST, STOP 61
  AURORA, 80011
  720-845-7680

- ALL-SOURCE FUSION PLT
  CO B INTEL SPT BN
- CO BI-3 INTEL SPT BN
- IMAGERY INTERPRETATION PLT
  CO B INTEL SPT BN
  7 N SNOWMASS ST, STOP 61
  AURORA, 80011
  720-845-7681

- HQ CO CLR 65 CLR 4
  7 N SNOWMASS ST, STOP 61
  AURORA, 80011
  303-543-3667

- DITY Q 5TH BN 11TH MAR REGT
  7 N SNOWMASS ST, BLDG 1201
  AURORA, 80011
  303-961-4616

DISTRICT OF COLUMBIA

- 2ND CIVIL AFFAIRS GROUP
  BLDG 351
  990 POREMBA CT SW
  WASHINGTON, 20033
  202-337-0780

- DET 2 SUPPLY CO CLR 65 CLR 65
  BLDG 351
  990 POREMBA CT SW
  WASHINGTON, 20033
  202-685-2295

- DET PRP CO CLR 45
  BLDG 351
  990 POREMBA CT SW
  WASHINGTON, 20033
  202-685-0504

- SCOB (HQ) 4TH MED BN
  990 POREMBA CT SW
  WASHINGTON, 20033
  910-433-3150

DELAWARE

- BULK FUEL CO (B-) CLR 45
  6TH ENGR SPT BN
  3902 KIRKWOOD HWY
  WILMINGTON, 19808
  302-232-3400

FLORIDA

- 1ST HUMAN INTEL SUPPORT TM
  CO C INTEL SPT BN
- 4TH CIVIL AFFAIRS GROUP
  1000 NW 52ND AVE
  HIALEAH, 33015
  305-626-5173

- CO (B-) 4TH AA BN
  8820 SOMERS RD S
  JACKSONVILLE, 32218
  904-237-9466

- HQ CO CLR 45
  BLDG 440, 1210 NAVAL FORCES CT
  MARINA, 32069
  768-655-4365

GEORGIA

- 26TH HQ 4TH DENTAL BN
  HQ CO 4TH DENTAL BN
  1210 NAVAL FORCES CT
  ATLANTA, 30306
  678-655-4365

IDAHO

- DET 2 SUPPLY CO CLR 45 CLR 4
  814 RADFORD RD, BLDG 7105
  MCCL ALBANY, 37104
  229-539-1423

- HHMA-771-3 MAG-46
- HQ, DET A, MAG-46
- MAG-46 DET A, MAG-46
  620 BEAUL DE BLDG 2071
  ROBINS AIR FORCE BASE, 31098
  770-222-5401

- ENGO SPT CO CLR 45
  BLDG 1202, 62 LEONARD-NEAL ST
  SAINT AUGUSTINE, 32084
  904-656-1118

- CO B 4TH REGT BN
  1180 ROSENWELL ST SE
  SMYRNA, 30080
  404-326-4593

- PRP CO (-) CLR 45
- HQ USAF SMYRNA CLR 45
  1180 ROSENWELL ST
  SMYRNA, 30080
  770-655-7206

- FOOD SERVICE CO CLR 45
  1180 ROSENWELL ST
  SMYRNA, 30080
  770-655-7206

HAWAII

- 2ND & 3RD PLT., CO E ANTI-TERRORISM BN
  1011 SUMNER RD
  KMB KANEHOE BAY, 96714
  808-228-4520

- WPNMS CO (-) 2ND BN
  24TH MAR REGT
  1855 BLACKHAWK DR, STE 701
  FORT SHERIDAN, 60067
  847-266-3069

- MAG-48 HQ
  ACMT MAG-48
- MARS 48 MAG-48
- MMWS 48 (-) MAG-48
- MMWS 48 DET A MAG-48
- 3RD CIVIL AFFAIRS GROUP
  BLDG 3200, STE 200
  2000 DEPOT DR
  GREAT LAKES, 60088
  847-772-9673

ILLINOIS

- 2ND HUMAN INTEL SUPPORT TM
  CO B INTEL SPT BN
  304 W WEST FOSTER AVE
  CHICAGO, 60625
  312-807-0704

- HQ CO 50TH BN 24TH MAR REGT
  304 W WEST FOSTER AVE
  CHICAGO, 60625
  773-539-6464 X 318

- WPNMS CO (-) 2ND BN
  24TH MAR REGT
  1895 BLACKHAWK DR, STE 701
  FORT SHERIDAN, 60067
  847-266-3069

- MAG-48 HQ
- ACMT MAG-48
- MARS 48 MAG-48
- MMWS 48 (-) MAG-48
- MMWS 48 DET A MAG-48
- 3RD CIVIL AFFAIRS GROUP
  BLDG 3200, STE 200
  2000 DEPOT DR
  GREAT LAKES, 60088
  847-772-9673

CONNECTICUT

- MAINT SERVICE CO CLR 25 CLR 45
  30 WOODWARD AVE
  NEW HAVEN, 06512
  203-469-5922

- CO F 2ND BN 25TH MAR REGT
  1 LINSEY DRIVE
  PLAINVILLE, 06062
  860-931-3265

- DET HQ BN 1ST BN 25TH MAR REGT
  1 LINSEY DRIVE
  PLAINVILLE, 06062
  860-931-2628

73
Louisiana

- WPNS (C) (-) 3RD BN 23RD MAR REGT
  8110 SGR-1 ROAD
  BAYARD, LA, 70810
  295-279-1088
- CO B 1ST BN 23RD MAR REGT
  1449 SWAN LAKE RD
  BOSIER CITY, LA, 71111
  318-340-3309
- VMR BELLE CHASSE
  400 RUSSELL AVE, BOX 30
  NEW ORLEANS, LA, 70113
  504-332-2987

Kansas

- CO 1ST 6TH BN 24TH MAR REGT
  NMERC BLDG 47 DICKMAN AVE
  DES MOINES, IA, 50315
  515-285-2066
- ENVIRONMENTAL SCS DIV
  FORCE HEADQUARTERS GROUP
- HQ (-) 1ST MLG
- HQ 4TH MAROY
- HQ 4TH MAW
- HQ BN, MARINE FORCES RESERVE
- HQ CO HQ BN MARFORRES
- HQ (C) (-) HQ BN
- HQ (C) (-) INTEL SPT BN
- MARINE CORPS INDIVIDUAL RESERVE
  SUPPORT ACTIVITY
  1600 OPLUSUEAS AVE
  NEW ORLEANS, LA, 70116
  504-615-9149
- HQ DET, MAG-49
  400 RUSSELL AVE, BOX 30
  NEW ORLEANS, LA, 70113
  504-678-3115
- HMNA-777 DET, A, MAG-49
- MALS 49 DET, C, MAG-49
  400 RUSSELL AVE, BOX 30
  NEW ORLEANS, LA, 70113
  504-940-4405

Maine

- CO A (-) 1ST BN 25TH MAR REGT
  101 FRANKLIN ST
  SACO, ME, 04072
  207-279-6600

Maryland

- WPNS (-) 1ST BN 25TH MAR REGT
- DET (C) (-) 1ST BN 25TH MAR REGT
- DET (D) 1ST BN 25TH MAR REGT
- 51 QUEBEK ST
  DEVENS, MA, 01824
  978-509-8775
- HQ 25TH MAR REGT
  4 LEXINGTON ST, BLDG 642
  FORT DEVENS, 01824
  978-796-3761

Michigan

- MACHINE GUN PIAT SPT
  CO ANTI-TERRORISM BN
  700 EAGLE DR BLDG 1003 AFRIC
  WESTOVER, WV, 25402
  304-973-3428
- BRIDGE CO 6TH ENGR SPT BN
  6TH ENGR SPT (-) 6TH ENGR SPT BN
  101 BASE AVE
  BATTLE CREEK, MI, 49015
  269-964-8882
- CO A 1ST BN 24TH MAR REGT
  1860 MONROE NW
  GRAND RAPIDS, MI, 49505
  616-613-5579
- CO C 1ST BN 24TH MAR REGT
  3423 N MARTIN LUTHER KING JR BLVD
  LANSING, MI, 48906
  517-897-0560
- DET B, MSS-297 MLSS-47
  1435 N PERIMETER RD
  MOUNT CLEMENS, MI, 48045
  586-605-0110
- 14 D4 41TH DENTAL BN
  25660 ELLSWORTH ST, BLDG 1009
  SELFRIEG, 48045
  586-339-6269
- HQ CO 1ST BN 24TH MAR REGT
  27800 C ST, BLDG 1000
  SELFRIEG, 48045
  313-647-1663

Minnesota

- MWSS (-) 5TH
  5905 34TH AVE S
  MINNEAPOLIS, MN, 55405
  612-865-4003
- 4TH LAW ENFORCEMENT BN
  6400 BLOOMINGTON RD
  ST. PAUL, MN, 55110
  651-726-1305
Oklahoma

- Anti-Tank Training Co
- Tow Sect 1st BN 23rd MAR REGT
- Tow Sect 1st BN 24th MAR REGT
- Tow Sect 1st BN 25th MAR REGT
- Tow Sect 2nd BN 23rd MAR REGT
- Tow Sect 2nd BN 24th MAR REGT
- Tow Sect 2nd BN 25th MAR REGT
- Tow Sect 3rd BN 23rd MAR REGT
- Tow Sect 3rd BN 24th MAR REGT
- Tow Sect 3rd BN 25th MAR REGT
- Tow Sect 4th BN 25th MAR REGT
- 1600 E New Orleans
  Broken Arrow, 74014
  918-279-3812

- Btry F, 2nd BN, 16th MAR REGT
  5365 S Douglas Blvd
  Oklahoma City, 73150
  405-370-7617

Oregon

- 622-4th Dental BN
  6736 N Basin Ave
  Portland, 97217
  503-285-4566

- HSOCo C-1st Bn 26th Eng BN
  6395 N Basin Ave
  Portland, 97217
  503-286-3962

- Engn SVC Co CBL 32 CBL 4
  3105 Pierce Pkwy Ste E
  Springfield, 97477
  541-343-7296

Pennsylvania

- Btry I, 3rd BN 11th MAR REGT
  1400 Postal Rd
  Allentown, 18109
  610-826-1455

- Hq Btry 3rd BN 14th MAR REGT
  2501 Ford Rd
  Bristol, 19007
  215-236-4732

- 1st & 2nd Plt Trk Co
  25th MAR REGT
  261 Industrial Park Rd
  Erindale, 19001
  610-433-3400

- Truck Co-( ) 25th MAR REGT
  3936 Old Frenche Rd
  Erie, 16504
  814-494-1916

- Bridge Co 8th Engn 5th BN
  601 Kedron Avenues
  Folsom, 95630
  916-932-4119

- 600 N 2nd BN 25th MAR REGT
  2981 North 2nd St
  Harrisburg, 17110
  717-637-3169

- 6th TAV 52nd BN
  200 Aviation Dr
  Johnston, 15922
  888-329-3503

- Hq CO 1st BN 25th MAR REGT
  625 E Pittsburgh/Kingressport North Versailles, 15277
  412-672-6789

- Engn SVC Co CBL 31 CBL 4
  11808 Wyoming Ave
  Wyoming, 16644
  570-226-1947

Puerto Rico

- Det 1 Lngd Spt Co CBL 145
  615 S Terminal Rd
  Ft Buchanan, 00936
  253-320-5716

- Bridge Co C, 6th ESB
  3114 Jackson Ave, Bldg 3114
  Memphis, 38112
  901-324-1107

Rhode Island

- Trans SVC Co CBL 25 CBL 45
  3114 Jackson Ave, Bldg 3114
  Providence, RI 02905
  401-784-4000

South Carolina

- CD 4th Lab BN
  Bldg 3430, 5405 Ledisburg Rd
  Eastover, 29044
  803-783-0795 X 11

- Det 3 Supply Co CBL 45 CBL 45
  MRC 2517 Vector Ave
  Charleston, 29418
  803-744-2520

- Det 3 Supply Co CBL 45 CBL 45
  200 King Graves Rd
  Charleston, 29406
  803-794-2583

- Det 3 Supply Co CBL 45 CBL 45
  660 Perimeter Rd
  Greenville, 29605
  864-289-3937

Texas

- Det 1 Maint Co CBL 453 CBL 4
  220 2nd St
  Abilene, 79607
  325-696-6878

- WPNS Co-( ) 1st BN
  23rd MAR REGT
  3512 Emma Browning Ave
  Austin, 78709
  512-402-0266

- Btry D 2nd BN 14th MAR REGT
  4800 Pollard St
  El Paso, 79930
  915-726-3845

- 6th Hq 6th Dental BN
  1803 Doolittle Ave
  Fort Worth, 76127
  817-782-1809

- CD 4th AA BN
  MRC 202 Fort Point Bldg 60
  Galveston, 77550
  409-682-4368

- Hq Btry 2nd BN 14th MAR REGT
  312 Marine Corps Dr
  Grand Prairie, 75050
  469-853-0426

- Det Co 1st BN 23rd MAR REGT
  3500 Igle Ave
  Harlingen, 78550
  956-202-3587

- Co A 1st BN 23rd MAR REGT
  10190 Aerospace Ave
  Houston, 77034
  713-649-9938
Appendix D lists the locations of all LRCs (MarineNet, 2016a). When comparing both this appendix and Appendix C it is evident that the vast majority of MFR personnel does not have access to LRCs.

### APPENDIX D. LRC LOCATIONS

<table>
<thead>
<tr>
<th>Location</th>
<th>Address</th>
<th>Hours</th>
</tr>
</thead>
</table>
| **MCAGCC 29 Palms, CA** | Bldg 1653, Griffin Rd. & 7th St.  
(760) 839-7145  
0900–1600 Mon–Fri  
Bldg 1612 North, Brown St.  
(760) 650-1176  
0800–1600 Mon–Fri |                     |
| **MCAS Beaufort, SC**   | Bldg 807, Hoffmecker Ave., Rm 41  
(843) 229-7223  
0900–1600 Mon–Fri |                     |
| **MWTC Bridgeport, CA**  | Mountain Warfare Training Center  
Bldg 202, Tyster St., 2nd Floor  
(760) 932-1936  
1100–1300 & 1630–2230 Mon–Fri |                     |
| **MCB Camp Lejeune, NC** | Base Library  
Bldg 1220, West Rd.  
(910) 451-6760  
0800–1600 Mon–Fri  
French Creek  
Bldg FC330, Gonzalez Blvd.  
(910) 461-1647  
0900–1700 Mon–Fri  
Stone Bay  
Bldg R84, Range Rd.  
(910) 440-2582  
0800–1600 Mon–Fri  
Camp Geiger  
Bldg G64, Rm 118  
(910) 449-2047  
0900–1600 Mon–Fri  
Camp Johnson  
Bldg M402, Harlem Dr.  
(910) 460-1400  
0800–1600 Mon–Fri  
Court House Bay  
Bldg 8012  
(910) 460-7459  
0800–1600 Mon–Fri |                     |
| **MCB Camp Pendleton, CA** | Sae Onofre  
Bldg 520512  
(760) 763-0120  
0800–1600 Mon–Fri  
Del Már  
Bldg 210725  
(760) 763-0118  
0800–1600 Mon–Fri  
Horno  
Bldg 53622  
(760) 763-3258  
0800–1600 Mon–Fri  
Margarita  
Bldg 33243  
(760) 763-3065  
0800–1600 Mon–Fri  
Mainside 13 Area  
Bldg 13091  
(760) 725-8126  
0800–1600 Mon–Fri  
Mainside 14 Area  
Bldg 14137  
(760) 763-4964  
0800–1600 Mon–Fri |                     |

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<th>Location</th>
<th>Address</th>
<th>Phone</th>
<th>Hours</th>
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<tbody>
<tr>
<td>8th Marine Regiment</td>
<td>Bldg 114, A St.</td>
<td>(910) 450-9486</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td></td>
<td>Bldg 220185</td>
<td>(750) 763-5035</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td>2nd Marine Div</td>
<td>Bldg 510, N St.</td>
<td>(910) 465-0733</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td></td>
<td>Bldg 4157B</td>
<td>(750) 763-4584</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td>Camp Lejeune</td>
<td>Bldg 524, McHugh Blvd.</td>
<td>(910) 460-5168</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td></td>
<td>Bldg 430406</td>
<td>(750) 763-1908</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td></td>
<td>Bldg 219, F St.</td>
<td>(910) 451-0920</td>
<td>0800–1600 Mon–Fri</td>
</tr>
<tr>
<td></td>
<td>2 Mar Reg area</td>
<td>(760) 763-5280</td>
<td>0800–1600 Mon–Fri</td>
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</table>

**MCAS Cherry Point, NC**

Education Center
Bldg 4335, C St.
(252) 468-7196
0800–1600 Mon–Fri

Bldg 1760, Cooley Ave.
(573) 596-0131 ext. 62797
0800–1900 Mon–Fri
1200–1700 Sat–Sun

**MCAS Okinawa, Japan**

Camp Foster
Base Library
Bldg 5679
645-8002
0900–1700 Mon–Fri

Camp Schwab

**MCAS New River, NC**

HQ Area
Bldg AS 213, Bancroft St.
(910) 499-6737
0800–1600 Mon–Fri

Camp Foster
Base Library
Bldg 5679
645-8002
0900–1700 Mon–Fri

**MCAS Miramar, CA**

Bldg 5305, Miramar Way
(858) 577-8743
0800–1600 Mon–Fri

**MCAS Parris Island, SC**

Bldg 923, Chosin Reservoir Rd., Rm 27B
(843) 228-3546
0800–1600 Mon–Fri

**MCAS Iwakuni, Japan**

Bldg 497
0800–1600 Mon–Fri

**MCAS Miramar, CA**

Bldg 5305, Miramar Way
(858) 577-8743
0800–1600 Mon–Fri
MCAS Yuma, AZ
Bidg 328, 2nd Deck
(928) 269-6501
0800–1600 Mon–Fri

MATS&-21 Pensacola, FL
3450 Farrar Rd., Room D400
(850) 452-9480 ext. 3107
0800–1600 Mon–Fri

MCB Quantico, VA
Bidg 2006, Hawkins Ave., Rm 332
(703) 764-4288
0800–1600 Mon–Fri
LIST OF REFERENCES


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Schwandt, F., & Kroger, T. (2016d). *Which of the following devices do you use to access the internet at home (e.g. visiting web sites, emailing, online gaming, downloading files)?* Retrieved from: http://www.statista.com/statistics/199055/devices-used-to-access-the-internet-at-home-in-the-united-states/


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   Naval Postgraduate School  
   Monterey, California