NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

REPLACING POWERPOINT WITH EXTENDED REALITY FOR MARINE CORPS PLANNING, CONCEPTS OF OPERATIONS, AND AFTER ACTION REPORTS

by

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December 2020

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REPORT DOCUMENTATION PAGE	*Form Approved OMB No. 0704-0188*

1. AGENCY USE ONLY *(Leave blank)*	**2. REPORT DATE** December 2020	**3. REPORT TYPE AND DATES COVERED** Master's thesis

4. TITLE AND SUBTITLE
REPLACING POWERPOINT WITH EXTENDED REALITY FOR MARINE CORPS PLANNING, CONCEPTS OF OPERATIONS, AND AFTER ACTION REPORTS

5. FUNDING NUMBERS

6. AUTHOR(S) Daniel G. Jagears

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Postgraduate School
Monterey, CA 93943-5000

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
N/A

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release. Distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT (maximum 200 words)

Marines in the combat arms are severely limited in the planning phase of operations due to outdated briefing methods and limited technology. For that reason, this research investigates alternative methods for modernizing operational briefs in the Marine Corps combat arms community. The author surveyed Marines in the combat arms on the desirability of current PowerPoint and sand-table briefing methods versus briefings in a digital 3-dimensional environment with extended reality (XR). The alternatives presented in the survey were based on extensive market research conducted for this project in the different fields of the XR environment, including virtual reality (VR), augmented reality (AR), and mixed reality (MR) in order to assess the practicality and costs of introducing XR. The findings suggest that XR may increase attention, learning, and retention when compared to the lecture-based model used in PowerPoint. Moreover, the Marines surveyed are ready and willing to replace PowerPoint, so long as the solution supports joint interoperability and does not simply supplement the status quo. Lastly, it was determined a strong preference for any particular type of XR does not exist as the current generation is not fully aware of briefing technologies external to the 2-dimensional model of PowerPoint.

14. SUBJECT TERMS
after action report, AAR, augmented reality, AR, extended reality, XR, mixed reality, MR, rehearsal of concept, rough order of magnitude, Sand Table Exercise (STEx), Tactical Decision Game, TDG, virtual reality, VR

15. NUMBER OF PAGES
113

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	**18. SECURITY CLASSIFICATION OF THIS PAGE**	**19. SECURITY CLASSIFICATION OF ABSTRACT**	**20. LIMITATION OF ABSTRACT**
Unclassified	Unclassified	Unclassified	UU

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. 239-18

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MASTER OF BUSINESS ADMINISTRATION

from the

NAVAL POSTGRADUATE SCHOOL
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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	after action report
AR	augmented reality
CONOPS	concept of operations
ROC	rehearsal of concept
ROM	rough order of magnitude
STEx	sand table exercise
SOM	scheme of maneuver
TDG	tactical decision game
VR	virtual reality
XR	extended reality

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ACKNOWLEDGMENTS

I would like to extend my sincere gratitude to the following individuals, for without them I would have been forever stuck in Chapter I.

To my wife, Crystal: thank you for all of your hard work and sacrifices made for this family. You continuously operated on minimal sleep as you wrangled a rambunctious 5-year-old while simultaneously working the night shift in a community hospital, all in the middle of a global pandemic.

To Commander Kathleen Giles, USN, NPS: thank you for your diligence in correcting all of my formatting and grammatical errors. Your attentiveness has undoubtedly made this project bearable to read.

To Dr. Simona Tick, NPS: thank you for your consistently joyous attitude and well wishes. Without your encouragement, I probably would have burned out only a few pages in.

To Major Lee Boyce, USMC, MARSOC: thank you for your assistance in coordinating this effort. I would have been completely lost without your guidance.

With a deep desire to avoid disappointing any of you, I was able to complete this on time and to the best of my abilities. Thank you all for your continuous mentorship.

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I. INTRODUCTION

In today's fast-paced operating environment, Marine Corps combat arms must do everything they can to stay ahead of the enemy and exploit the enemy's weakness. As the USMC's firepower improves they must not forget that each battle begins in the briefing room. Limited by the 2-dimensional picture in PowerPoint presentations, our leaders are forced to illustrate a 3-dimensional operating environment within the confines of technology from the 1980s, and although satellite imagery has improved over the past several decades, the Marine Corps continues to place these depthless images on sheets of paper for professional briefings. This research aims to capitalize on the high-resolution imagery and advancing technologies that are currently available within the civilian sector and update the way the Marine Corps brief their commanders and troops. This project seeks to validate the need to introduce these new technologies into Marine Corps briefing rooms by way of advanced delivery methods in the form of extended reality (XR). Defined best by Bernard Marr of Forbes Enterprise Tech branch:

> XR is an emerging umbrella term for all the immersive technologies. The ones we already have today—augmented reality (AR), virtual reality (VR), and mixed reality (MR) plus those that are still to be created. All immersive technologies extend the reality we experience by either blending the virtual and "real" worlds or by creating a fully immersive experience. (Marr, 2019, para. 1)

With XR, the Marine Corps has the potential to improve the way it plans, executes, and back briefs in the fully immersive battlefield in which they intend to engage.

A. RESEARCH OBJECTIVE

This project intends to determine the most effective means of providing planning, concept of operations (CONOPS), and after action briefings to the area responsible commanders and combat engaged Marines. This project focuses on the possibility of incorporating advanced satellite imagery with state-of-the-art XR technology so that the combatant commander and troops on the ground are exposed to their area of operations (AO) well in advance. This project explores the desirability, practicality, and range of

costs for this technology. The end goal is to provide the decision maker with a viable solution to the current 2-dimensional problem and hopefully encourage the acquisition of a prototype simulator.

To achieve this goal, this project examines the effectiveness of current briefing methodologies in the Marine Corps and attempts to determine if investments in new technologies are better than the status quo. The Marine Corps is no stranger to technology, and the majority of the time has benefited from the advanced discoveries in private and corporate-funded research. But far too often has the U.S. military invested billions into programs that never came to fruition; programs such as the Marine Corps Expeditionary Fighting Vehicle (USNI News, 2019) and VH-71 Presidential Helicopter (USNI News, 2018) or the Army's Future Combat System (Feickert & Lucas, 2009) and Comanche Helicopter (Ward, 2012). To prevent the reoccurrence of past mistakes, this project seeks to ensure this modern adaptation is desirable, practical, and affordable. This project focuses on the appropriate Marine Corps Doctrinal Publications (MCDP), Joint Publications (JP), and relevant NPS projects completed by past graduates to ensure the associated briefings can be accomplished through an extended reality (XR) environment. Additionally, this project looks into the ease of set-up, execution, and tear down of associated software and hardware in the XR field, and weigh the opportunities and obstacles in regards to application. Finally, this project attempts to provide a first estimate of the costs associated with implementing XR into a Marine Regiment.

B. RESEARCH APPROACH

This project focuses on a series of questions that enable the researcher to come to a clear and concise opinion on the matter, and provide the reader with a recommended course of action (COA), enabling them to make a command decision.

The primary questions associated with this project are as follows:

1. What are some of the challenges with the current status quo of Marine Corps briefings?
2. 2)What are some feasible alternatives to the current briefing methods?

3. What are the relevant pros and cons to consider when choosing the best alternative?

The secondary questions associated with this project are as follows:

1. What are the first estimate costs for equipping a Marine Regiment with XR technology?
2. What are the core differences between combat arms, logistics, and financial briefings?

This study utilizes two separate methods of collecting and analyzing data. The first, via interview, aimed at Marines in the combat arms Military Occupational Specialties (MOS) of the Marine Corps. These Marines are the primary beneficiaries of the research and, therefore, their opinions have the greatest impact on decision points and recommendations in the analysis. The interviews focus on capturing feedback on: the ease of understanding the mission through the current methodology, the ability to remember what was briefed, how the details in the PowerPoint brief were similar or different when compared to actual execution, and personal opinions for an advanced briefing method such as XR. The second method is based on market research in the XR field and an analysis of the practicality and affordability of introducing new technology into the operating forces. This market research focuses on the current abilities of XR technology and its limitations as it relates to user interface and image integration to ensure the user can replicate and interface with the mission environment. This project assesses user-friendliness as it relates to set-up and associated hardware.

The methodology used in this project research consists of the following steps:

1. Conduct a thorough literature review of previous relevant studies.
2. Interview relevant subjects on the effectiveness of current methods.
3. Conduct market research into the practicality of introducing XR technology into the Marine Corps.
4. Synthesize results in parts 1 - 3 to develop a recommendation.

C. CHAPTER SUMMARY

This project focuses on the desirability, practicality and initial costs of replacing PowerPoint with any form of XR. By examining the current methods used to provide planning, CONOPS, and after action briefings, this project aims to identify the strengths and weaknesses in the status quo. This project provides an extensive background on the types of briefings along with the methodologies used to deliver these briefings, as well as the key aspects of each form of XR. Through detailed literature review and market research, this project aims to determine the practicality of the new technologies. Additionally, a survey provided to Marines currently engaged with the status quo provides a first-look estimate of the desirability of replacing PowerPoint with XR. Finally, the author provides several examples of practical uses for XR as it relates to the Marine Corps, determined from capabilities discovered during the market research.

II. BACKGROUND

There is no arguing that the United States Marine Corps is primarily a warfighting organization. The history, doctrine, and structure all revolve around the combat arms specialties and tend to draw from its basic framework and schema that make it function as a martial culture. One of the key components that make the Marine Corps so effective, and what gives the individual Marine so much confidence, is their ability to understand the plan as a whole and utilize the decentralized decision-making granted to them by having a thorough understanding of the commander's intent. This understanding of the commander's intent is gained through an understanding of the course of action (COA) developed, detailed schemes of maneuver, and reflective after action reports (AAR). For fiscal year (FY) 2020, the U.S. Congress authorized a total Marine Corps end strength of 186,200 active duty personnel (National Defense Authorization Act for FY20, 2019) to be spread across several hundred separate Military Occupational Specialties (MOS) (Commandant of the Marine Corps, 2013), both enlisted and officer. In every one of these MOSs, Marines conduct informational briefings to better inform a mass of people on a specific course of action (COA), a concept of operations (CONOPS), or to back brief via an AAR. The current methodologies used are outdated, often ineffective as they stifle critical thinking, and provide little information (Gobry, 2017) for the Marines that will be utilizing the information presented to conduct real world operations. Current technologies give way to a superior means of developing those knee-jerk reactions that are often necessary when the initial plan or CONOPS fail.

This background chapter provides the reader with information on the purposes for providing briefs, the current methodologies used, as well as information on the application of technologies in the fields of extended reality (XR). With this information, the reader should gain an understanding as to why current methods are being reconsidered.

A. TYPES OF BRIEFINGS

1. COA Development and COA Wargaming

The Marine Corps utilizes a rather thorough method of developing detailed plans via the Marine Corps Planning Process (MCPP). The MCPP is often utilized when the commander of a unit feels the inherent need to develop a plan based on the current situation, intelligence received, or direction from their higher headquarters. According to the doctrinal publication for the MCPP (Headquarters U.S. Marine Corps, 2015), the planning process is designed to promote understanding among the commander, his staff, and subordinate commanders regarding the nature of a given problem and the options for solving it. The plans which result may be considered hypotheses that will be tested and refined as a result of execution and assessment (Headquarters U.S. Marine Corps, 2015). COA Development and COA Wargaming are the second and third steps of the MCPP (Figure 1), and are used to provide the commander with options and refine those options as they relate to mission accomplishment. The results of COA development and wargaming often require planners to return to the problem framing step of the planning process based on the theorized actions/reactions of the enemy and other alterations to the plan. COA development is often completed via PowerPoint while wargaming is executed via tactical decision game (TDG).

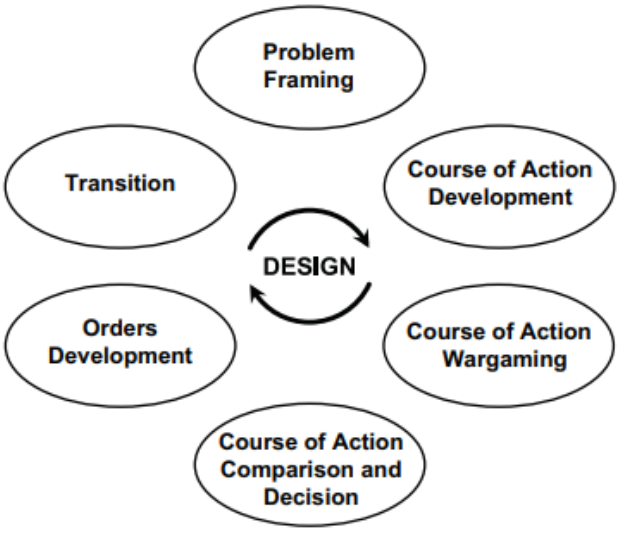

Figure 1. Overview of the MCPP. Source: Headquarters U.S. Marine Corps (2015).

2. Scheme of Maneuver (SOM)

Taught at the Marine Corps Basic Officers Course in Quantico, Va., the SOM is an integral part of the CONOPS plan that familiarizes the Marine with the proposed battlefield and ensures that they are not stepping onto completely unknown territory. Second only to the Commanders Intent, the SOM is one of the most important briefs a Marine can give or receive prior to combat operations. Often delineated as either offensive or defensive, the offensive SOM identifies the main and supporting efforts for the mission (distribution of forces), how the unit should conduct the attack (form of maneuver), a definitive direction of attack, geographic locations that exist for the unit commander to "assign responsibility, coordinate fire and maneuver, and control operations"(Marine Corps Training Command, 2015, p. 19), and a consolidation point for when the attack has concluded (Figure 2). On the other hand, the defensive SOM identifies the defensive method to be assumed (type of defense), distribution of forces, the cardinal direction of the defense (orientation of the defense), how the defense should arrange their fighting positions (occupation plan), tactical control measures, and finally what type of barriers and secondary positions should be configured prior to the enemy's arrival (security plan) (Figure 3).

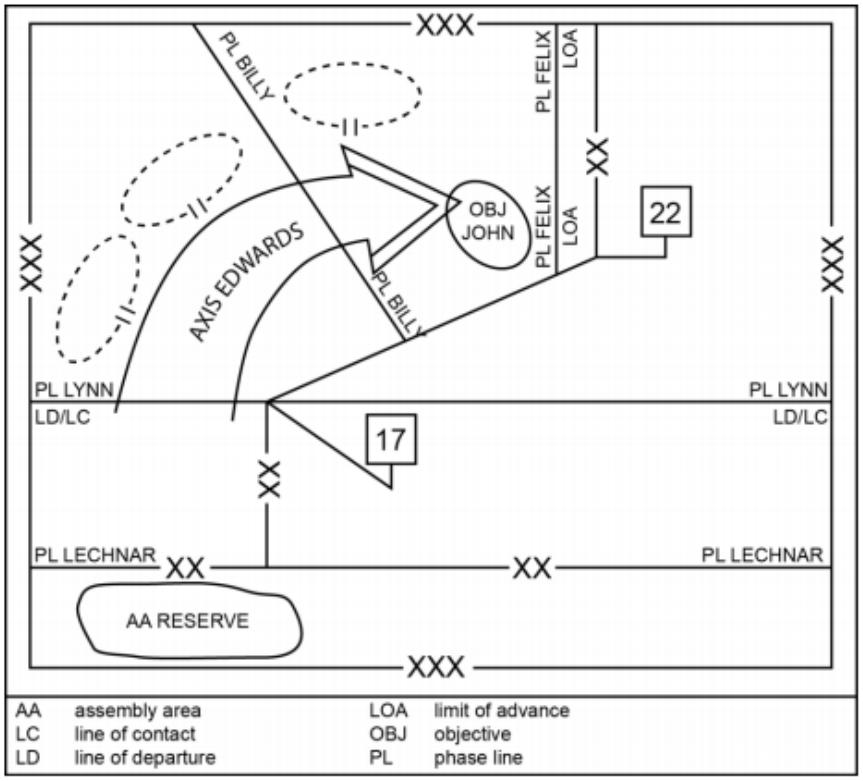

Figure 2. Tactical control measures of the offense. Source: Department of the Army (2013).

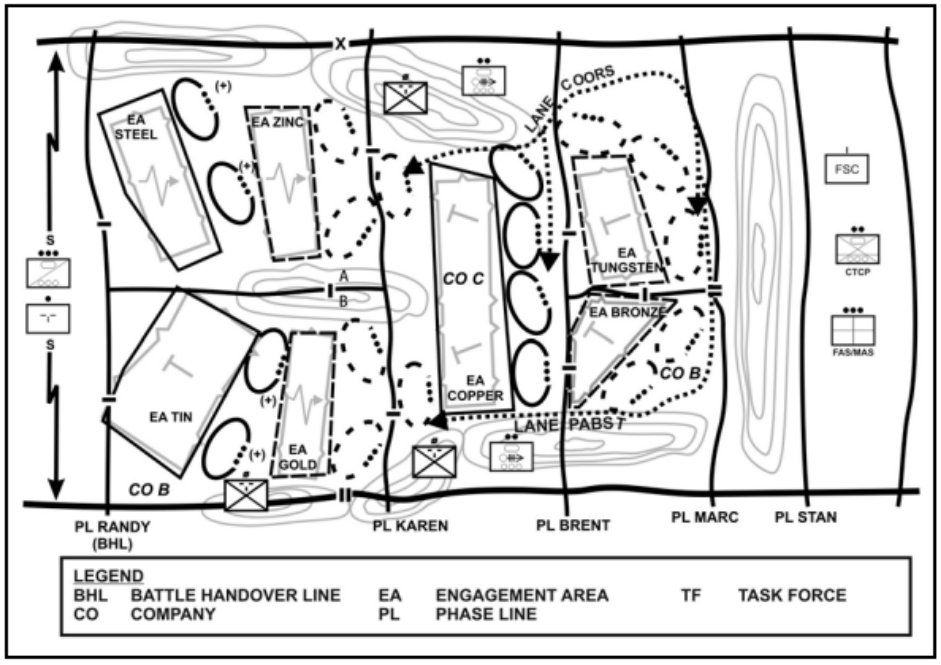

Figure 3. Defense in depth. Source: Department of the Army (2013).

3. After Action Reports (AAR)

The Marine Corps writes lessons learned covering exercises, training and other planned events, to include combat operations and observations so that it may provide recommendations for improving future operations. The Marine Corps Center for Lessons Learned (MCCLL) is a CAC-enabled website that hosts a repository of information on the AAR published by the Marine Corps. These AARs focus on the observations, insights and overall lessons learned by participants, planners, and leaders engaged in training exercises, and operations (combat and noncombat). These reports exist so that future generations of planners and warfighters may benefit from a well-documented history. The primary mission of the MCCLL is that it:

> focuses on tactics, techniques and procedures of immediate importance to the operating forces thereby identifying gaps and best practices, and recommending solutions across the doctrine, organization, training, materiel, leadership, personnel and facilities (DOTMLPF) spectrum. (Marine Corps Center for Lessons Learned, 2020, p. 1)

Many future planning efforts, and the environment in which they exist, are reconstructed based upon the information contained within the AAR.

B. CURRENT BRIEFING METHODS

The methods of briefing mentioned in section A are offered via various techniques that enable the commander and participants to gain a deeper understanding of the proposed mission and its environment. These methods (discussed in B.1-4) can be provided independently, or with the aid of one another. For example, a higher level briefing may be provided to the commander in a PowerPoint presentation that will also be shared with the Marines conducting the exercise and operation. The commander may be able to fully grasp the conduct of the exercise or operation via the PowerPoint, or s/he may require a kinesthetic aid such as a Sand Table Exercise (STEx). Additionally, the commander may be perfectly content with the PowerPoint but insist that the Marines play out the exercise or operation through a Tactical Decision Game (TDG) in order to further refine the plan. In some cases, it may deem it essential that a unit receives a PowerPoint brief on the material followed by a STEX and then a TDG before an exercise or operation

is conducted. This decision usually depends on the event and the commander's preference.

1. PowerPoint

PowerPoint (PPT) presentations have long been used by the military, corporations, and educators as visual aids to provide information, plans, a sales pitch, or an idea. PPT allows the user to present data, maps, infographics, text, and video in a way that is far more succinct than a research paper or detailed CONOPS. PPT presentations allow the presenter to provide the most relevant data to their audience in a way that is meant to keep them entertained as well as informed. The slides within the presentations are often teeming with transition animations, color, word art, clip art, images, and gifs. PPT is included in the most basic Microsoft Office package, and is easy to use. In the Marine Corps, PPT is often used to provide the audience with a step-by-step of the planned COA and any other pertinent background information that may have led the unit to produce the information briefing. For the Marine Corps, the structure of the PPT slides often mimic that of the Marine Corps 5-Paragraph Order, that is "SMEAC" (USMC Officer, 2017). The detail of the information from the 5-paragraph order that is transferred over to the PPT is often abbreviated to a series of dashes, bullets or acronyms so that the briefing can be delivered with brevity.

2. Tactical Decision Games (TDGs)

A Tactical Decision Game (TDG) is the Marine Corps method of running through a SOM or COA to further refine and attempt to identify unknowns that remained hidden during the COA Development portion of the MCPP. TDGs are used during wargaming for the planners and as a tool to enhance the Marines decision making process while also building upon communication skills. During any type of TDG, the planner or briefer is presented with a dilemma and must define a course of action appropriately based on the enemy's most likely course of action. There is often deep discussion and the simulation is rewound as plans are changed and decisions refined to counter the enemy. Often seen as a version of a role-playing game, there are many methods of conducting a TDG. One of the most popular is the conduct of a Sand Table Exercise (STEx).

3. Sand Table Exercises (STEx)

The Sand Table Exercises (STEx) is one of the primary methods of conducting a TDG. Elaborate, three-dimensional terrain models are built utilizing sand and various craft items to recreate a two-dimensional map so that the individual/s receiving the brief can gain a better understanding of the challenges or advantages that the terrain may introduce. The STEx is an effective tool when briefing the COA, SOM, or AAR as it allows those in attendance to gain a better understanding via a bird's eye view of the situation, and how the individual infantry components fit into and affect the bigger picture. With a STEx, each component of the exercise/operation is present and able to witness the overall plan, so that they can see how their element interacts with others in the battlespace. Other benefits of the STEx include a perception of the enemies' advantages and disadvantages from their terrain, as well as insight into the actions or inactions of leadership in the battlespace. The STEx is the primary means of delivering briefs in the Marine Corps leadership programs as it "fosters proximity; eye contact; free movement, and presents the learner an almost irresistible attraction to get their hands on the problem" (Anderson et al., 2004, p. 6). The sand tables utilized in the STEx often vary in size and can range anywhere from a 2ftx2ft model to the size of a football field (Figure 4).

Figure 4. Football field-sized sand table for Operation Desert Shield. Source: Haynes (1990).

4. Rehearsal of Concept (ROC) Drill

The Rehearsal of Concept (ROC) Drill is often the last brief a unit receives prior to conducting the actual exercise or operation. The purpose of the ROC Drill is to ensure that all elements understand their role in the evolution and to provide them with a final opportunity to ask questions before execution. The commander and supporting staff must be present during the ROC drill to address questions or issues. The method in which the ROC Drill is delivered can vary depending on the time available. The preferred method of conducting a ROC Drill is in a large open space with a clear and concise map and plenty of room for all involved, however, it can also be conducted in the field environment with any materials the briefer can find that can enable them to construct a scaled-down version of the battlespace. The ROC Drill is a final point of confirmation and synchronization, ensuring the tasks of the subordinate units and the subsequent actions are understood by all.

C. EXTENDED REALITY BRIEFING METHODS

The field of extended reality (XR) refers to any state in which reality is altered, either in its entirety or through minor changes to the user's environment (Irvine, 2017). These changes are generated by wearable technology and spatial computing and their differences are briefly described in Figure 5, with further discussion in paragraphs C1-C3.

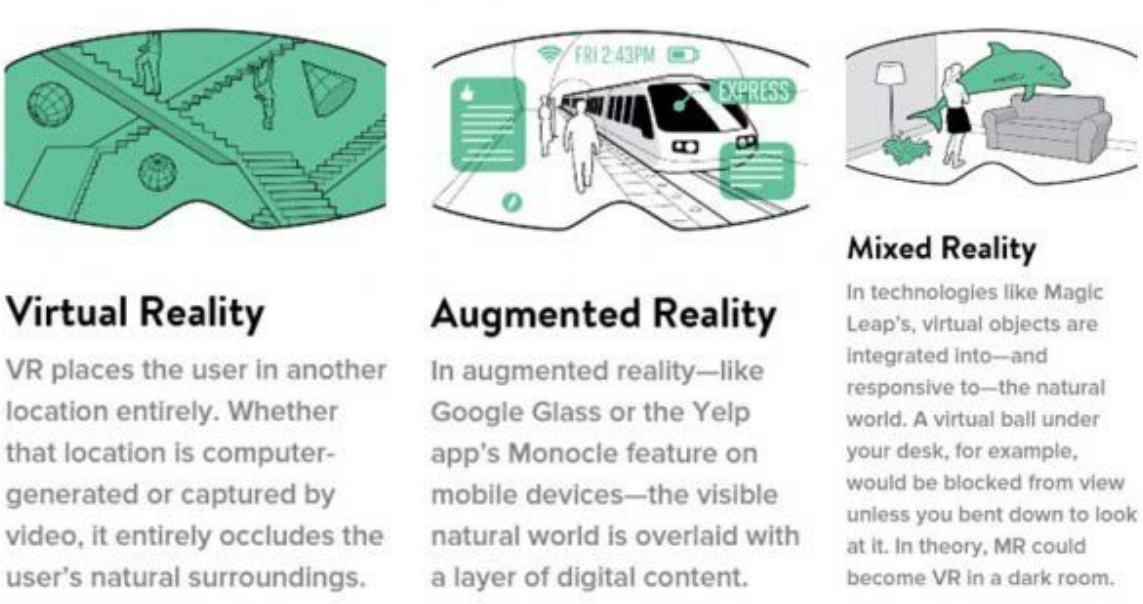

Figure 5. Distinction between VR, AR, and MR. Source: Agulhon (2018).

1. Virtual Reality

Virtual reality (VR) is the most immersive form of XR as it is used to generate a fully artificial environment. VR requires the user to wear a special headset that will completely replace the user's environment with a computer-simulated model that is either drawn from real world places, is 100% synthetic, or a combination of both. VR utilizes both PC connected and standalone headsets, sometimes requiring special controllers. Those that can be connected to a PC can draw their full computing power, allowing for a higher quality experience. Standalone headsets exist as a single unit, do not require a PC for operation, and therefore allow the user to freely travel with the technology. Of the two variations, the standalone models are significantly cheaper, however, the PC version is

able to render a more elaborate environment (Gleb, 2020). VR is currently used to immerse the user in varying aspects of sports and physical training, mental health simulations, medical training, education, exploration, and gaming (FDM Group, 2020). Depending on the needs of the user, the costs of VR can easily exceed several hundred thousand dollars when all subcomponents and software development are taken into consideration.

With both types of headsets, the user is limited in their range of movement to the physical space around them. To solve this problem, several companies have created omni-directional treadmills called “Slidemills” that allow the user to move about their VR environment while remaining stationary in the real world. Additionally, future technology (and a patent filed with the United States Patent and Trademark Office) hint at specialized shoes that removes the treadmill and allows the user to essentially skate in place (Rathi & Ratner, 2020).

2. Augmented Reality

Augmented reality (AR) is the technology of altering the real-world environment, and providing the user with a view of virtual objects or data in a simulated overlay (Irvine, 2017). One could also refer to AR as a form of supplemented reality where the environment is not immersive but rather includes objects or overlays that supplement what the user can see. In an AR environment the user does not interact with the object, but is able to envision how that object would modify their real world surroundings. Current AR technology exists through the cameras and applications on smartphones, as well as external wearable devices. Current AR technology primarily caters to the consumer and allows measurement, exploration, and object placement for retail purposes. As mentioned above, wearable AR exists (e.g., Google Glass) and can provide temperature, weather, news, speed, and inventory location at a fraction of the cost of other forms of XR. This form of reality has the ability to link with networks and provide the user with superimposed imagery data while remaining detached from a physical PC (Andrews et al., 2019).

3. Mixed Reality

Mixed reality (MR) is the combination of VR and AR and allows the user to manipulate the data and objects placed into the real world view. The key difference between the three is that MR has a view similar to AR, but like VR allows you to manipulate the computer generated data and objects around you. The objects in the MR environment can be manipulated through facial and/or hand gestures and gives the user real time data and options similar to the Heads-up-Display (HUD) used in the F-35, F-22 and C-17 (BAE Systems, 2020). Unlike AR, objects that exist in MR can be occluded by other real life objects and altered by the user wearing the special headset. The headset for MR does not fully impede the users field of view, but does restrict it more than an AR set would. MR headsets (such as the Microsoft HoloLens) are typically more expensive than AR or standalone VR headsets, and are primarily used in manufacturing, retail, health, and education (Microsoft, 2020).

D. CHAPTER SUMMARY

The Marine Corps uses several methods of delivering briefings to Marines who will either become actively engaged in combat operations, or will recieve a post-operational briefing to understand key lessons learned. Through a 2-dimensional PPT, a 3-dimensional STEx, or physical walkthrough via a ROC, a briefer has the ability to deliver a detailed COA, wargame scenario, SOM, or AAR. Through an examination into the background of VR, AR, and MR, one can begin to understand the key differences of each. Knowing that VR is the most inclusive, AR is the least, and MR lies somewhere in between allows the reader to estimate the applications of XR. By providing a basic background of all fields of XR, one can gain an initial understanding of the different technologies and make assumptions as to how each could replace the status quo. In order to gain a better understanding of learning, one must conduct a literature review into the current methodologies as well as the potential of VR, AR, and MR.

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III. LITERATURE REVIEW

The purpose of this chapter is to establish a firm relationship between current XR usage and the potential uses in the Marine Corps, as well as determine the effectiveness of PPT briefings in instructional and training settings as it might relate to COA Development, SOM and AARs. Additionally, this chapter reviews the capabilities of XR in order to determine whether or not it is a viable replacement for PPT. The literature reviewed for this project focuses on scholarly articles that discuss the format and future of operational briefings, the effectiveness of PPT when delivering a presentation or period of instruction, and how others have analyzed the potential of the VR environment. These reviews should aid in understanding whether or not the current delivery methods should be replaced, and if the proposed would be suitable for military briefings.

A. FUTURE BRIEFINGS MUST HAVE STRUCTURE

From the literature researched, the primary concern with information briefings is that they often lack standardization across the service (Sanford, 2013). While it is true that schools in each of the Marine Corps training pipelines define the format of the Operations Order (OpOrd) in much of the same way, as soon as they depart for the fleet that format has the potential to change as each commander and unit has its own individual preference on presentation format. For example, one commander may mandate that all SOM briefings be briefed in detail, utilizing PPT in a formal manner, whereas another may prefer an informal PPT where the staff delivers only the key points of the exercise. This issue is not unique to the Marine Corps, according to one study regarding the CONOP process for Army Special Forces, "strong support exists... for doctrinalization of the CONOP" (Sanford, 2013, p. 43). This same study details how the constant change in command and location wreak havoc on the approval time for a CONOP due to each commander having his or her own preference when it comes to structure and content. The Sanford study found that these constant changes to the CONOP format frequently delay detachment operations as the staff tends to hold onto or reject a CONOP until it fits their own style preference. While this study focuses on the

relationship between CONOP procedure and doctrine, it is relevant because it showcases one of the many issues with how Marines receive and deliver briefings in the Marine Corps.

B. ADOPTING EVOLVING TECHNOLOGIES

Although PPT has proven to be a very effective tool in education and military briefings for over 30 years (Buffalo 7, 2018), like all other antiquated systems the Marine Corps must seek a more modern replacement. In a study on advanced material presentation the author found through a survey of 27 students that over 60% preferred a higher level of technology in the classroom, while the remaining students mentioned that the technology should fit the needs of the presentation (Hougen, 1998). In this same study, several students mentioned that introducing interactive technology would benefit the learning environment and aid the kinesthetic learners. Additionally, none of the students in this study mentioned that increasing technologies made learning any harder, instead they all leaned towards the belief that technology enables learning. However, it must be noted that this particular study does discuss a point of student aggravation when advanced technology is used and the instructor is not proficient with the technology. In a separate study, the author discovered that a more advanced online presentation mode was more advantageous for those being briefed (Moulton et al., 2017). The primary difference between the online model was the ability to pan and zoom through animated components of the brief. Those briefed with the online tool "Prezi" not only found that this subtle advancement more engaging, but also more organized, persuasive, and effective when compared to a traditional PPT or an oral briefing (Moulton et al., 2017).

C. THE MARINE CORPS MUST DITCH THE LECTURE-BASED MODEL

Aside from advancing technology in the classroom, many learners agree that educators must get away from lecture-based presentations and move into a more hands-on model. According to a research article published in the journal of the *Proceedings of the National Academy of Science*s (PNAS), when students are presented with opportunities to be active participants in the learning experience, the failure rate decreases by a mean rate of 12% (Figure 6) and exam scores tend to increase by 6% (Freeman et al., 2014).

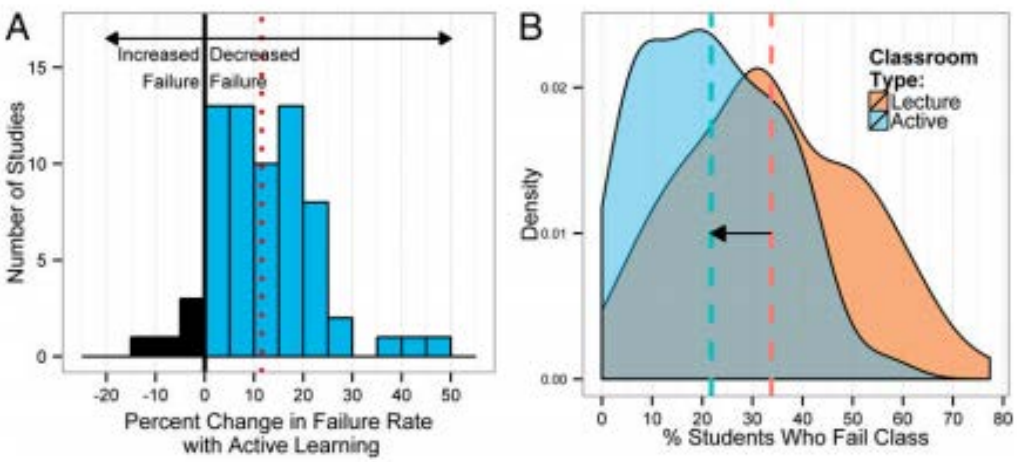

Figure 6. Changes in failure rate when students are engaged in active participation. Source: Freeman et al. (2014).

In an attempt to get rid of the lecture-based model and expand into more technologically advanced models, the U.S. Department of Education has posted a report that "suggests virtual environments and games can help increase empathy, self-awareness, emotional regulation, social awareness, cooperation, and problem solving" (Office of Educational Technology, 2017, p. 14). The suggestion for this type of immersion education is becoming more prominent as educators are becoming aware of the individual nature of learning. In a recent interview with the National Public Radio titled "Students Don't Learn from Lectures," the founder of the online Khan Academy states that the majority of people can only pay attention for the first 10-18 minutes of a lecture, and after that they experience periods of "checking in" for approximately 10 minutes followed by further bouts of inattentiveness (Khan, 2012). Another study goes as far as to suggest individualizing every single training plan so that the learner is able to detach from the "one-size-fits-all" model that became the standard in the 19th century (Robbins, 2016). The author of this study goes on to infer that the primary reason for the lecture-based model was to groom future factory workers during the industrial revolution, and that this ineffective model must evolve into "a workplace where rapid technological advance is the norm and critical thinking skills are ever more in demand" (Robbins, 2016, p. 30).

D. IS XR A SUFFICIENT SUBSTITUTE?

PPT has been a reliable tool in the Marine Corps arsenal since its inception. If a replacement were ever to come along, it would have to have a clear cut advantage in the briefing room that improves training or operational performance. Although it would be difficult to discern the benefits of the switch until well into its inception, there is one key indicator that one may be able to measure right away, and that's the individual's ability to recall what was taught. According to research presented by Dr. Barbara Oakley, the ability to recall helps to enhance understanding of the material as it creates neural hooks that are connected to previous experiences (Tedx, 2014). Furthermore, recalling information is a good indicator that the individual was able to regenerate the information from inside themselves and not repeat something that was memorized for the moment (Oakley, 2014). From the research noted in section C, one can see that the lecture-based method is not as effective as it was in the past. As XR makes its way into the 21st century, there are very clear advantages to these systems that are not available in PPT. One study shows some of the capabilities of VR and how the programmer or instructor is able to define certain roles, limit access, or test individuals while they are in a certain program. Figure 7 was retrieved from this study on the immersive benefits of VR as it applies to higher education. In this study, the researchers reviewed 38 articles on the application of fully immersive VR and its benefits to higher education. In their research, they discovered that the social competencies, in the left column of Figure 7, improved along with collaboration as well as the participants' ability to remember their hands-on experience in full detail (Radianti et al., 2020).

Categories	Explanation
Realistic surroundings	The virtual environment is of high graphic quality and has been designed to replicate a specific environment in the real world. For example, this applies to medical students who develop their surgery skills in an authentic-looking operation room.
Passive observation	Students can look around the virtual environment. This design element also applies to applications in which users can travel along a predefined path and look around while doing so. However, they are neither able to move around on their own nor to interact with virtual objects or other users.
Moving around	Students can explore the virtual environment on their own by teleporting or flying around.
Basic interaction with objects	Students can select virtual objects and interact with them in different ways. This includes retrieving additional information about an object in written or spoken form, taking and rotating it, zooming in on objects to see more details, and changing an object's color or shape.
Assembling objects	Students can select virtual objects and put them together, including the creation of new objects by assembling several individual objects.
Interaction with other users	Students can interact with other students or teachers. The interaction can take place in form of an avatar and via communication tools such as instant messaging or voice chat. This design element also includes the possibility of students visiting each other's virtual learning spaces.
Role management	The VR application offers different functionalities for different roles. A distinction is made between the role of a student and the role of a teacher. For a teacher, the VR application offers extended functionalities, such as assigning and evaluating learning tasks or viewing the learning progress of students.
Screen sharing	The VR application allows students and teachers to stream applications and files from their local desktop onto virtual screens. This allows them to share and edit content from their local desktops with other users in the virtual environment (e.g., PowerPoint, Google Drive, and Google Docs).
User-generated content	Students can create new content, such as 3D models, and upload this new content to the virtual environment. This design element also applies when the user-generated content can be shared with other users so that they can use it in their virtual environment as well. This design element does not apply when students can only access virtual objects that were created by developers and provided by a library in the virtual environment.
Instructions	Students have access to a tutorial or to instructions on how to use the VR application and how to perform the learning tasks. The instructions can be given by text, audio, or a virtual agent. This design element does not apply when students have to discover how to use the virtual environment or how to perform learning tasks on their own.
Immediate feedback	Students receive immediate textual, auditory, or haptic feedback. The feedback informs students about whether they have solved the learning tasks correctly and whether interactions with virtual objects were successful. In some cases, feedback may also be provided by simulating the results of an interaction with virtual objects, for example, when the corresponding chemical reaction is simulated after chemicals have been mixed in a virtual laboratory.
Knowledge test	Students can check their learning progress through knowledge tests, quizzes, or challenges.
Virtual rewards	Students can receive virtual rewards for successfully completing learning tasks. Students can be rewarded virtually by receiving achievements, badges, higher ranks on a leader board, and by unlocking exclusive content, such as hidden rooms or additional learning content.
Making meaningful choices	Students learn in the virtual environment through participating in a scenario (role-playing) that can end in different ways. In this scenario, they have to make decisions that affect the outcome of the scenario. This design element does not apply when the students' decisions have no influence on the outcome of the scenario.

Figure 7. Applications of the immersive environment. Source: Radianti et al. (2020).

Another study on introducing XR technology into the classroom emphasizes the importance of the VR (immersive) environment by stating, "The learner can participate in the learning environment with a sense of presence, of being part of the environment." (Pantelidis, 2009, p. 3). This coupled with the Radianti article could reap huge benefits for the Marine Corps, primarily if the Marines participating in the VR training were able to retain all of the details of their training environment. According to this same article, the students engaged in VR training were actively engaged throughout the entire regimen as they were able to interact with every part of the simulation. In this article, Pantelidis describes scenarios when VR is appropriate, and when it is not (Table 1). In all aspects,

VR would be an appropriate means of COA Development and Wargaming activities, as well as the SOM and highly detailed AARs.

Table 1. When it is appropriate to use VR in a training environment. Adapted from Pantelidis (2009).

WHEN TO USE	**WHEN NOT TO USE**
- A simulation could be used	- No substitution is possible for teaching/training with the real thing
- Teaching or training using the real thing is dangerous, impossible, inconvenient, or difficult	- Using a virtual environment could be physically or emotionally damaging
- A model of an environment will teach or train as well as the real thing	- Using a virtual environment can result in a simulation so convincing that some users could confuse model with reality
- Travel, cost, and/or logistics of gathering a class for training make an alternative attractive	- Virtual reality is too expensive to justify using, considering the expected learning outcome
- Shared experiences of a group in a shared environment are important	
- The experience of creating a simulated environment or model is important to the learning objective	
- Information visualization is needed, manipulating and rearranging information, using graphic symbols, so it can be more easily understood	
- A training situation needs to be made really real	
- Needed to make perceptible the imperceptible	
- Teaching tasks involving manual dexterity or physical movement	
- Essential to make learning more interesting and fun	
- Mistakes made by the learner or trainee using the real thing could be devastating and/or demoralizing to the learner, harmful to the environment, capable of causing unintended property damage, capable of causing damage to equipment, or costly	

E. CHAPTER SUMMARY

Understanding how learning is achieved and what leads to higher learning allows educators, instructors, and briefers to formulate their lessons in a way that maximizes learning. Having the research to support average attention spans, coupled with how people learn, and the preference of structure across common briefing subjects allows the instructor to tailor their presentation so that all involved are able to retain to his or her maximum capabilities. If the person providing the brief is able to implement some form of advanced technology, this may also increase the potential of the learning environment as most students are able to increase interest with the implementation of new and exciting technology. One may also be able to conclude that XR can enhance the education experience, so long as it is introduced under the correct conditions. In the Marine Corps, individuals experience PPT briefings for nearly every evolution they endeavor. These teaching strategies may aid in enhancing these periods of instruction and lead to increased retention in mission essential tasks. However, in order to determine the applications and implementation of XR into Marine Corps briefings, one must further define the methods of how to assess the desirability, practicality and costs.

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IV. METHODOLOGY

This study used two methods of data collection and analysis to determine the practicality of implementing XR into USMC briefings. The first method used consisted of a survey distributed to units that have first-hand knowledge on the benefits and challenges of current briefing methodologies. The second method consisted of market research in the field of XR, where the products offered by multiple industry leaders are analyzed and further research is conducted on the tangible uses of their XR products.

A. SURVEY

The focus of this project is on the effectiveness of PPT as it relates to the COA, SOM/CONOP, and AAR briefing, and whether or not an improved replacement could be found in XR. The primary recipients of the proposed replacement were the Marines receiving and delivering the aforementioned PPT briefs. Because of this, the survey questions were carefully scripted and the audience specifically chosen so that one could ascertain whether or not the Marine Corps should invest in XR technologies. The survey did not ask for any personal identifiable information, and if any were provided then the results of the survey were discarded. Distribution of this survey was coordinated through the MARSOC G5/G8 and conducted via the *Max.gov* website. A copy of the survey is located in Appendix A.

The survey consisted of 11 Likert scale questions, each with a five-point range, and three open response questions. Additionally, the three questions that were used as a basis for this project were also provided, so that those surveyed could have a greater understanding of why they were providing answers to the 14 questions presented to them. The Likert scale questions allowed space for the surveyed individual to provide clarification, if they chose to elaborate on their response. The questions for this survey are included as Appendix A and in Chapter V, Survey Results.

B. MARKET RESEARCH

Market research was conducted to gain an understanding of the current capabilities of XR. This project studied currently published scholarly articles, reviewed the reported specifications and prices from several manufacturers, and analyzed the tech reviews published across several respectable tech sites. This research was conducted in order to gain a better understanding of XRs current abilities and limitations, how users interact with the technology, its overall "user friendliness", and the practicality and affordability of introducing this new technology

1. Scholarly Articles

By reviewing research that has already been conducted in the field of XR, this project aims to bypass the bias that one may receive when looking at the manufacturers claims. By reviewing professional articles, one may be able to gain an understanding of the true capabilities of XR and review how other researchers are using this relatively new technology. Just as important as the capabilities, this project seeks to determine the limitations of XR by understanding where others have attempted application in their research, and failed.

2. Manufacture Reported Specifications

Due to concerns that manufacturer claims may be inflated, or the product's capabilities ambiguously stated at the maximum levels of performance, it is important to compare several manufacturers in the field of XR to help establish a base level of performance for the proposed technology. This comparison is essential to understand what it being reported, what is currently being developed, and at what cost. Manufacturers may often overstate their products capabilities to improve sales by providing test results at the product's maximum capacity, which is why the aforementioned tech article reviews will be conducted in Chapter VI. Any findings that disproportionally conflict with the manufacturers' claims will also be noted in Chapter VI.

3. Website and Tech Reviews

Various websites on the internet, such as *CNET*, *The FDM Group*, and *Medium*, include product reviews and technology analysis of XR gear currently on the market. This portion of the project analyzes these tech reviews in order to determine which of the XR systems are most user friendly, and which should be avoided. Furthermore, this review aims to gain a better understanding of the system requirements and installation so that one can assess the practicality of introducing XR into a Marine Corps environment with inexperienced users.

C. DESIRABLE, PRACTICAL, AFFORDABLE

The survey questions and market research conducted for this project were done so in order to determine the desirability, practicality, and affordability of XR as it relates to the Marine Corps. The primary purpose of the survey was to measure the interest of the Marines that are actively receiving the COA, SOM/CONOP, and AAR briefings and determine whether or not the Likert scale questions discovered any desire in replacing PPT with any form of XR. The primary purpose of the market research was to review the current applications of XR, offer suggestions for adaptation into the Marine Corps and provide a rough order of magnitude (ROM) estimate on the initial costs.

1. Is It Useful, Advantageous, or Pleasing?

Often linked with "fun," measuring *desirability* for a product or idea can be difficult as both are deemed "intangible aspects of the user experience" (Benedek & Miner, 2002, p. 1). However, when attempting to measure desirability, it is best done utilizing either a formal interview process, or a Likert scale survey (Benedek & Miner, 2002). Microsoft researchers determined that if one were to attempt to measure desirability, it could be done by gauging the usefulness of the product to its potential user, whether or not it would advantageous for the user to engage with the product, and if the user could find pleasure while using the product (Benedek & Miner, 2002). For that reason, the questions in this particular survey are aimed at the usefulness, advantages, and perceived joy of XR and PPT.

2. Is It Practical from All Angles?

PPT is a tool that the armed services, corporations, schools, and everyday professionals have been using for decades. While conducting market research for this project, PPT was ignored as one could ascertain that it has been practical since its adoption by the Marine Corps and educational institutions. The purpose of this research is to determine whether or not XR is practical for the Marine Corps. In that aspect, this project focused on the unique abilities of XR and how they could be compared to the capabilities of PPT for planning, SOM, and AAR briefs. Furthermore, this portion of the market research considered the physical size of the differing XR units, transportability, ease-of-use, and required hardware. Lastly, the practicality aspect explored the use of XR in a forward deployed environment.

3. What Are the Costs?

As it pertains to XR, this project focused on the rough estimates for the initial purchase of the hardware, the average costs of software development and integration, and the associated operation and maintenance costs. This portion of market research focused on actual advertised costs or costs that have been openly discussed in online forums.

When acquiring new software, consumers are often faced with the dilemma of buying or leasing the software. If bought outright, the consumer owns the product and does not have to worry about an annual renewal or certain restrictions placed on the product by the developer. However, if the software is leased then the consumer is privy to updates, tech support, often lower costs, and an option to cancel or not renew when the product no longer meets their needs. When making this decision, the consumer should be aware of several factors that may ultimately make up their mind. These factors include: suitability, scalability, flexibility, support, interoperability, time-to-implementation, implementation risks, property rights, and the cost of ownership (Rubel, 2020).

Table 2. Factors to consider during software acquisition. Adapted from Rubel (2020).

Suitability	The software must meet the mission of the company or unit. Readily available or "off the shelf" products rarely meet the needs of the consumer and a more refined or custom product is often required.
Scalability	The software should be scalable to the consumer to the consumers' needs whether they need it for one computer or 1,000 computers. Depending on the application, the software should function the same across all devices.
Flexibility	Technology is always advancing, and so is the software and hardware that define it. The software should be flexible enough for updates and changes as they apply to the needs of the consumer, their mission, and overall advances in technology.
Support	The consumer must consider the availability of support when it comes to potential software issues. Whether it be on-site technical support or a 24/7 phone line, the consumer should be aware of their needs and options. Additionally, the consumer should be aware of the level of support provided.
Interoperability	The software used should be able to "speak" to other systems used by the consumer. Whether it be during the actual system operation or an output, the interface should be automatic.
Time-to-implementation	The software should be available when the product is required, sometime sooner if testing, training, and familiarization are to occur. The consumer should avoid scope creep where new features are being added during software development, so that the developers are able to deliver the software on time
Implementation risks	Not paying attention to all of the above can introduce risk to the software that neither the consumer or developer planned for. Using professional developers and maintaining clear communication should help mitigate these risks.
Property rights	"The term "purchase", when applied to software, is misleading. In most circumstances, a company does not buy the software. They have only a license to use the software. There is no explicit or implicit ownership, and certainly no rights to the source code" (Rubel, 2020, para. 8).
Cost of ownership	Understanding the cost of "ownership" is essential when making the decision to lease or buy. The initial investment in custom software or "off the shelf" software should be considered along with the maintenance and upkeep of the software. The consumer should discuss both options with the developer and fully understand what is the best choice for their purpose.

D. CHAPTER SUMMARY

As defined in the above, this project aims to form its analysis of the potential of replacing PPT with XR through the literature review conducted, as well as the survey listed in Appendix A, and detailed market research. The survey was built using the LimeSurvey software and promulgated through *Max.gov* to the Marines of a special operations command, who are dedicated to the creation and delivery of COA, CONOPS, and AAR style briefings. The market research was conducted via a wide-range review of online sites that focused on the practicality of XR, as well its current uses in education and information. Additional information focused on the costs of XR, to include hardware, software, and maintenance, and was obtained from manufacturers and online blogs.

V. SURVEY RESULTS

The survey included below and in Appendix A, was built with the online program, LimeSurvey, and presented to an anonymous Marine Corps special operations unit via the *Max.Gov* website. A Marine Corps special operations unit was selected due to their specific combat related missions, and their frequent use of PPT for mission orientated briefings. The questions were approved by the Naval Postgraduate School institutional review board (IRB) as well as the Marine Corps IRB and Human Research Protection Official. In total, this survey solicited a response from 30 Marines, and received 14 responses via *Max.Gov*, as well as two full and two partial responses via email. Of the 14 surveyed in *Max.gov*, nine completed the survey in its entirety, to include responses to the Likert scale prompts. The survey results for the Likert scale prompts are included as Appendix B., which offers a bar chart for the 9 responses. The following is the author's interpretation of the results, arranged in order of the questions presented.

A. LIKERT SCALE PROMPTS

Q: The current methods of briefing meet the needs of the Marine Corps and should not change. (Options range from "Strongly Disagree" to "Strongly Agree").
Rationale: This is an overarching question and was included because of the understanding that some individuals are content with the status quo and any change to their routine would feel disruptive.

Survey results for this question indicate that the majority remain neutral with a strong preference leaning towards disagreeing that current briefing methods do in fact meet the needs of the Marine Corps and should not change. From the nine that provided complete responses, zero indicated that the status quo should remain as is.

Written responses to this question further expand on the desire for change with responses such as "the current methods of briefing are cumbersome and are a significant time investment by an operational unit", "(PPT) is slow, inefficient, cumbersome, unable

to exploit opportunities for branches and sequels, it produces lazy thinking", and "PowerPoint is inefficient and does not always convey the required information to the audience." Despite the negative comments about the status quo, some participants expressed concern that one cannot quickly disregard PPT that they "would have to have an idea of the alternative before supporting a change." Responses that leaned towards neutral also favored PPT in its current usage stating that it is "ubiquitous and incorporate(s) a lot of capability not only to present, but also to collaborate and contribute" but didn't disregard change stating that new technology "is great if everyone has access to the equipment required to drive it."

Q: More often than not, the information received in PowerPoint briefings is: (Options range from "Lacking" to "Too Much").
Rationale: Based on the understanding that the optimal way of learning differs from person to person, this question attempts to focus on what is gained by the PPT from the perspective of the visual, auditory, and kinesthetic leaners.

Survey results for this question appeared evenly distributed with a slight preference leaning towards information is "lacking" in PPT presentations.

Written responses in the comments section mirrored that of the Likert scale questions as users submitted responses such as "Totally lacking. It only supports the status quo in fully developed theaters of action" and "Unless you were present for the briefing and were able to take extensive notes, PowerPoint is usually not a good media format to ensure important information is received by the audience." Additional responses indicated that the information conveyed in the PPT is based entirely off the individual presenting the material, with that factor changing from brief to brief. Several others in the survey mentioned the need for "scalable requirements for PPT" as content being "entirely based upon the skill and knowledge of the creator of the briefing" and "the time and effort taken by the presenter to prepare slides that are interesting and visually significant, and to prepare his or her part of the presentation" were purely indicative of how the information was received.

Q: The length of current PowerPoint Presentations are: (Options range from "Excessively Long" to "Way too Short").
Rationale: This question depends entirely on the mission and briefer, but studies show that the average person's attention span is limited by motivation, relevance, and context (Bradbury, 2016). A concurrence in the "Excessively Long" option may signal failure in any of these categories.

The large majority of survey results for this question indicated that PPT briefings were excessively long, with only a small portion of surveyors selecting the "Just Right" or "A Little Long" option. Not a single person surveyed felt that PPT briefs were lacking in the time category.

The comments for this questions indicate that the primary reason PPT presentations extend longer than anyone could anticipate is because "too much data" is being placed into the briefs that is "based upon the knowledge, skill, and experience of the briefer." This comment is echoed by another stating the presenters "have an excessive amount of slides and information that is irrelevant to the speakers desired endstate", hinting that the individual providing the information is giving up absolutely everything they know, instead of focusing on relevant information. For one individual surveyed, they offered a comfortable timeframe for receiving PPT presentations, stating "most folks can't focus for much more than 45 minutes at a stretch without a break" which far exceeds the 10-18 minute duration discussed in Chapter III, Section C. The same individual also offered that perhaps "a different more immersive medium might stretch that ability to stay engaged."

Q: The PowerPoint presentation coupled with a Sand Table Exercise (STEx) helps me to understand the mission. (Options range from “Strongly Disagree” to “Strongly Agree”).
Rationale: This question seeks to understand the relationship between the PPT and the STEx and whether or not there is a connection to their answers in question 2 and 3.

This survey question received a fairly equal response across all selections, further reinforcing that some individuals are hands on or kinesthetic learners while some have no problem learning without the technological assist, as discussed in Chapter III, Section B.

The responses for this question indicated that although individuals did not require a STEx to understand the briefing, they agree it was an essential part of the mission briefing. Those surveyed stated “the mission brief and PPT should be two different products”, that “PPT alone is totally insufficient for mission planning, rehearsals, etc.”, and that “PowerPoint doesn't always translate into enough detailed information to understand a scheme of maneuver.” From these responses, it is clear that even when a PPT brief is provided, there is an essentiality that the briefer physically walk their audience through the battlefield via a physical model.

Q: Receiving a PowerPoint presentation and then recreating a STEx based on the information received is: (Options range from “Very Difficult” to “Very Easy”).
Rationale: Again, this question is meant to measure whether or not there is a relationship between the answers received in questions 2 and 3.

Survey responses for this question ranged from neutral to very difficult with over half of the recipients stating they were “neutral” in their responses. The majority of the comments for this question indicated that PPT could not be the only driver behind creating a detailed STEx. Those surveyed mentioned that it “depends on the quality of the information you received, not the medium it was received” and that it is often necessary

to obtain “speaker notes” or backup slides. Either way, the general response was that one could not rely on PPT alone to build a STEx, unless the “presentation was of good quality.” The responses for this question hinted that the more detailed information the audience receives, the more likely they will be able to build a quality STEx.

Q: I find building and conducting STEx contribute to the effectiveness of understanding the operation. (Options range from “Strongly Disagree” to “Strongly Agree”).
Rationale: This question is meant to determine how many of those involved in the briefings are more likely to be kinesthetic learners, which can lead to an assumption that they would benefit from a more immersive environment.

Over half of those surveyed indicate that they agreed on the effectiveness of visual aids when understanding the overall operation. Only one person surveyed disagreed on the effectiveness of the STEx as a visual aid.

The written responses reinforced the survey responses as the majority were in strong favor of a visual aid, stating the “STEx is a valuable tool at all three levels of war: tactical, operational, and strategic” and the “STEx forces planners and executers to become intimately aware of the implications of terrain on operations.” One individual argued that a STEx created 30 years ago would be more advantageous and superior to a modern day PPT briefing as it “provides depth” and that “any kind of live walk through/talk through is going to enhance and reinforce material presented in a brief.”

Q: There is no need for the Marine Corps to invest in a program that would replace PowerPoint. (Options range from “Strongly Disagree” to “Strongly Agree”).
Rationale: This question is meant to measure whether or not the individuals involved are searching for an alternate to PPT. As stated in Chapter II, students expect technology to “evolve”. An abundance of answers in the “Strongly Disagree” option may indicate if that time is near.

Survey responses for this question show that the majority disagree and that the Marine Corps should look to invest in a more modern approach to how we deliver briefings. Some individuals offered a neutral response to this question, with further clarification provided in their comments.

The comments for this question all hinted towards caution as users expressed deep concern on “collaborative planning” tools that ensured “joint applicability”. Individuals surveyed were adamant that “there is no point in investing development funding, training hours, or sustainment efforts into a program that is exclusively used by the Marine Corps” stating that it “would create redundant efforts when having to build briefs for cross DoD, interagency, or bilateral work”. The fear is again reverberated with individuals being “leery of pursing anything that doesn't have joint applicability and support” due to the Marine Corps being a “joint force, and if we create something that is only digestible by Marines, we are immediately creating a friction point”. Further concern expressed is that the new investment should be “equally as portable and prolific as PowerPoint”. Even though the majority of the individuals expressed their concern in new technology, none opposed its introduction, stating that they first “need an idea of the alternative”.

Q: I am already familiar with virtual, augmented, or mixed reality (VR/AR/MR) (see question 14 for examples). (Options range from “Strongly Disagree” to “Strongly Agree”).
Rationale: Responses to this question are meant to estimate the Marine Corps readiness to receive a newer and advanced technology.

Of those surveyed, nearly half of the individuals expressed familiarity in XR. All others surveyed indicated they had little to no knowledge of the technology.

Only one response was received in the comments section of this question, indicating that they are “aware of this system, but have never seen it in person or even a description of its capabilities”. As XR is still relatively new to society and not entirely mainstream, this was not a surprise.

Q: I have used some version of VR/AR/MR before. (Options range from "Strongly Disagree" to "Strongly Agree").
Rationale: This question was originally grouped with question 8 but was separated to determine of those familiar have also experienced XR first hand. This question is meant to carry more weight in the individual's response to question 10.

Roughly the same amount of the respondents in the previous question answered that they have used the technology "once or twice" but did not indicate which platform or medium it was used on, no comments were provided.

Q: I have a basic idea how VR/AR/MR could replace PowerPoint. (Options range from "Strongly Disagree" to "Strongly Agree").
Rationale: The basis for this question is to attempt to understand how open minded XR recipients might be. For those that answered "Strongly Agree" in question 9, this question seeks to understand if the technology introduced is capable of evolving further once implemented.

Based on the answers provided above, it is unsurprising that the majority of individuals surveyed answered that they did not have an idea of how XR could replace PPT. For this survey question, only two individuals answered that they did have an idea for XR.

The responses in the comment section were somewhat polar opposites. One individual stated that he or she has discussed the possibilities of XR with people that have experienced it, but could not say if they "would replace PPT with VR/AR/MR without seeing it and actually experimenting with it". Another individual provided an answer similar to how the U.S. Army is using VR and MR to gain "an exact view of terrain, structures, objectives, potential enemy and friendly placements, etc." as mentioned in the following chapter, Section A.4.a and A.7.a.

B. OPEN PROMPTS

Q: What is your biggest complaint when receiving a PowerPoint Presentation?
Rationale: This question is meant to assess the individual's complaint, and is expected to aid in determining if the bias for or against PPT is self-driven.

The majority of the complaints in PPT were related to the time it takes to build, deliver, or receive, and the level of content within the brief. Those surveyed mention that people tend to "keep adding requirements to briefs to show how good they are instead of following the format. One uppers keep increasing the time we spend on making products pretty. If there were standardized formats it would make life simple", possibly alluding to why briefs exceed their intended time frame and include so much content. Additional complaints included a "lack of background and insufficient information to understand what has been provided" as well as "presenters tend(ing) to use words and not pictures to create a lasting impression on the receiver of the information", again suggesting that PPT briefs lose the interest of the kinesthetic learner. One individual also mentions that complaints within any given brief will ultimately boil down to one factor, and that's the individual's personal inability to provide a quality brief.

Q: In your opinion, what are PowerPoint's limits?
Rationale: This question is meant to identify the challenges of the current status quo and assess whether or not PPT is able to evolve beyond these challenges.

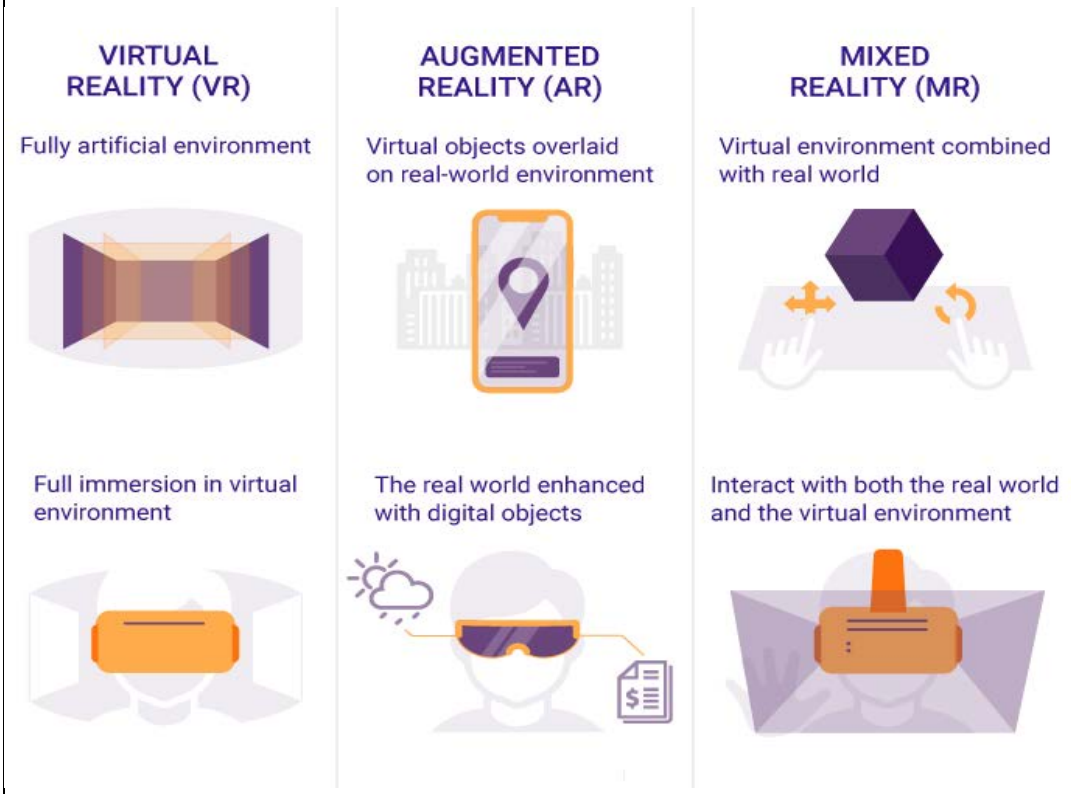
According to the open response questions in the survey, the primary limits of PPT are the lack of details that can be placed on any given slide. This coupled with "the experience and skill level of the producer" can lead to unimpressive briefings that lose the interest of their audience. One user stated that the "(U.S.) armed forces have reached the full potential of PPT in 2008" and that the DoD "should have progressed beyond this antiquated technology years ago". Additional complaints lodged at the limits of PPT are that "it has limits in terms of interactivity - it's fairly one dimensional and depends heavily on the preparation and capability of the briefer" and "the amount of time that it takes to create, present, receive, and disseminate information far exceed its value".

Q: In your opinion, what are PowerPoint's strengths?
Rationale: This question is meant to assess the strengths of PPT and see if XR can replicate or enhance these strengths.

The common consensus of PPT's strength is that it's extremely easy to use, its accessible, and familiar across the entire DoD and beyond. PPT provides the user with an "availability to recall previous meetings, topics, CONOPS, etc." and that it is "very easy to use at the basic level". PPT contains "a common language" and "that everyone understand(s) how to manipulate the software" not to mention that "it is backwards compatible with previous generations of PPT". Additionally, PPT briefs are fully customizable to the individual organization, allowing them to be built at any size while "using concepts represented by graphics and not merely words."

Q: Based on the information and image below, which medium would be the better replacement for PowerPoint?

Table 3. Difference between VR, AR, and MR. Adapted from *Forbes* (2018).

VR – **Fully immersive** environment in which the user can alter and interact with every element of his/her surroundings.	AR – Eyewear that allows the user to **view** digitally placed objects and data in the real world environment.	MR – Headset that allows the user to **view and interact** with digitally placed objects in the real world environment.
		
Rationale: This question polls those surveyed and hopes to receive answers that open the imagination of the individual.		

For this particular survey question, each of the possible answers were chosen with a fairly even spread across all categories, with the exception of "No answer" not being selected at all. With those surveyed being unfamiliar with the different variants of XR technologies, and considering the table in question 14 only provides wave top information, this does not come as a surprise.

The comment section for this question varied from full support of XR to one user even holding on to the status quo. The individual vying for the status quo stated, "I don't believe that AR/VR/MR at this point is a suitable replacement for PPT. As much as I dislike sitting through a PPT, AR/VR/MR requires extra hardware, software, equipment, and training just to be able to use let alone present a brief through. Not only does this add extra complexity to getting or giving a simple brief it requires much more sustainment and IT support on the back end". Meanwhile other respondents stated "A certain level of optional interactivity would be very complimentary to a PowerPoint backbone" suggesting that XR actually supplement PPT. On the contrary, another individual thought that using "VR or MR while still providing the information required to fully replace PPT and not having to do both" would be the most preferred way ahead. Additional concern was based on the location of where XR will be utilized with one individual stating "AR and MR are only of value if you can use the ground the mission will actually occur on. Usually that is not the case… so we are left with VR".

C. EMAIL RESPONSES

During the conduct of this survey the author received emails from individuals who were not comfortable completing the survey, or felt that their contributions would negatively affect the outcome. For that reason, these individuals provided the following responses in the form of an email that must be included in order to fully grasp the current understanding of XR in the Marine Corps. These responses are provided in their entirety with only personally identifiable information removed:

> The problem I have with this survey is that it depends on the reader (me) having a base of knowledge that I just don't have with regards to the alternatives. It's not that I wouldn't like to see a change in favor of a new system or technique, but rather I cannot judge any of the six alternatives

> that you proposed on the last question as I have never seen any of them demonstrated. I'm not advocating the status quo, but I can't recommend a change either.
>
> I support your effort and would like to point out that I am not opposed to new technology, but I cannot support a COA that I have not personally examined.
>
> I don't have any practical experience with some of the alternatives mentioned in the survey. Like any tool in the box, PowerPoint has its strengths and weaknesses. PowerPoint may not be the best option for mission planning briefs, CONOPS, etc. but it may be the best option for generic briefs such as Command Briefs for VIPs.

D. CHAPTER SUMMARY

Strong opinions on the status quo exist in those surveyed, with the majority of individuals preferring a replacement of PPT as it applies to COA development, wargaming, CONOPS, and AAR briefings. However, despite the desire for a replacement, those surveyed did not have an opinion, nor could they envision a medium for replacing PPT. Those surveyed did share a common concern, each believed that it would be hazardous for the Marine Corps to rush into replacing PPT without first familiarizing or standardizing the replacement technology. Of the 14 surveyed, nearly half expressed familiarity with any sort of XR technology and only a few provided personal opinions on the subcategory of XR that could replace PPT. Of those that provided an opinion, and based on the figure presented in question 14, 30% selected AR as the replacement, 22% selected VR, 22% had no opinion, 11% selected MR, and the final 11% chose to remain with the status quo. Each of the individuals surveyed believed that they could have responded with more accuracy if they had more information on the capabilities of XR. This could be an indicator that the individual Marine is not aware of the potential technologies available to the professional educator.

VI. MARKET RESEARCH

As with any new technology, there are going to be differing opinions based on whether the individual providing feedback is a vested stakeholder or not. Clearly those that have interest in the company, the hardware or software, the share price, or etcetera are going to inflate their review and therefore their opinion must be taken with caution. On the other hand, the reviews of the consumer can go either way depending on personal preferences, influence from competitors, initial expectations, or overall return on their investment. In order to capture an unbiased opinion of the product or end item, one must analyze the reviews submitted by all parties. For that reason, this chapter focuses on the manufacturer reported specifications and tech reviews by credible sites such as *CNET*, *The FDM Group*, and *Medium*, tech reviews from bloggers, and both positive and negative feedback from consumers. With this information, this chapter discusses the advantages and disadvantages of XR, some first estimate costs for varying systems, and whether or not XR is practical for the Marine Corps.

A. DIFFERING FIELDS OF XR

As discussed in Chapter II, Section C., there are currently three categories within the realm of XR. Starting with the least immersive in augmented reality, then mixed reality and finally full-on virtual reality. There are benefits to each and a wide array of applications in which these technologies can be used. Clearly each has its own limitations and uses when it comes to utilization in the Marine Corps, and based on the needs identified in Chapter V, Section A. The purpose of this section of this chapter is to attempt to identify the particular field that will be most beneficial to the Marine Corps application.

1. Capabilities and Applications of Augmented Reality

The applications of AR extend from the medical field to the elementary school classroom and everything in between. According to an article written by James Paine of West Realty Advisors for the website Inc.com, “AR is emerging as one of the key drivers of the tech economy… AR apps, headsets, and smart glasses hold the promise to add

value to virtually every industry – from retail to industrial manufacturing" (Paine, 2018, para. 1-2). From this same article, the author describes the possible applications of AR as it relates to medical, retail, repair and maintenance, design and modeling, business logistics, tourism industry, classroom education, field service, entertainment properties, and public safety. Although every topic mentioned in the previous sentence can, in one way or another, benefit the Marine Corps, the purpose of this project is to determine benefits as they relate to planning, CONOP/SOM, and AARs. Because of this, one must look at the current uses of AR and see how they could be applied to the Marine Corps.

a. AR in the Commercial Industry

AR is used in a wide variety of ways that assist the user in visualizing how a particular object would look if it were placed in their real world. The Swedish furniture maker and distributor IKEA uses AR in its mobile application (app) that allows potential customers to place a 3-dimensional object in their home by utilizing the camera on their smartphone or tablet (Vakhnenko, 2019). In July 2016 software company and mobile game developer Niantic released the popular AR app "Pokémon Go" allowing users to interact with and "catch" Pokémon with the swipe of a finger (Hanke, 2016). Since then, Niantic has been focusing on "building a state of the art planet-scale augmented reality platform… (that) includes a massively scalable engine for shared state and user interactions already proven to support hundreds of millions of users and a client platform that sets the standard for mapping, security, and AR capabilities" (Niantic, 2020, para. 1). The developers at Niantic have made great strides in the AR market as they work to enhance the capabilities of their games, even introducing an added feature to Pokémon Go that they call "Reality Blending" (Baker, 2020). This particular feature allows certain objects in the AR app to be occluded by real life barriers such as walls, trees, people, and etcetera (Statt, 2020) (see Figure 8). This particular feature could benefit the Marine Corps by placing simulated objects such as improvised explosive devices (IEDs), enemy troops, or other obstacles behind real life features, forcing the user to evaluate their entire environment.

Figure 8. Occlusion in AR. Source: Ahir (2020).

b. AR in the Medical Field

According to a study conducted by researchers at the University of Applied Sciences and Arts in Dortmund, Germany, AR "offers a new approach for treatments and education in medicine. AR aids in surgery planning and patient treatment and helps explain complex medical situations to patients and their relatives" (Eckert et al., 2019, p. 1). AR is currently being used in a variety of ways as it relates to the medical field and expediting patient care. In one example, an app was created by Lucien Engelen of the Radboud University Nijmegen Medical Center that allows the user to locate automatic external defibrillators (AEDs) by providing a grid overlay on their phone, along with distance, directions, and a list of emergency phone numbers (Mesko, 2019) as seen in Figure 9. This particular feature could aid the user with locating team members or aid stations in their battle space.

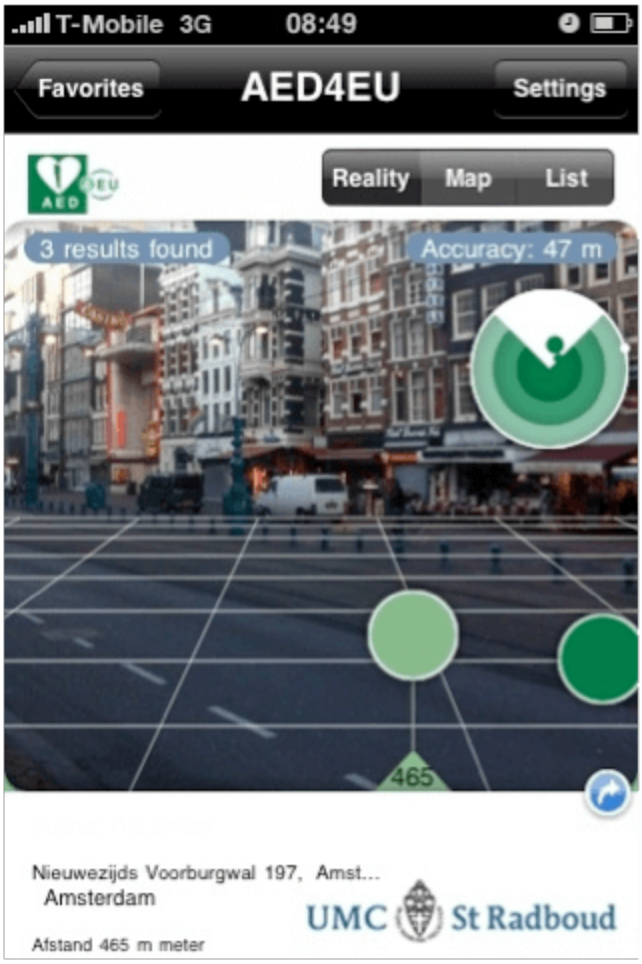


Figure 9. AED Overlay in AR. Source: Mesko (2019).

Other applications include AR overlays for vein locations so that medical professionals are able to identify a proper insertion point for intravenous injections (IVs) (Mesko, 2019). With this, the creator of the device claims the individual is 3.5 times more likely to find the vein on their first stick with their projection-based AR (AccuVein, 2019). To take it a step further, surgeons at the Imperial College in London are using the Microsoft HoloLensÔ in conjunction with a computed tomography angiography to accurately locate the blood vessels, bone, and soft tissue in a patient. As seen in Figure 10 this technology places an AR projection over the surface of the skin before a surgical incision is made. This application has been deemed more reliable and less time consuming than the current standard (Wimalasena, 2019). This particular technology has

far reaching capabilities for Corpsman embedded with Marine units as well as providing building overlays for Marines prior to their entering.

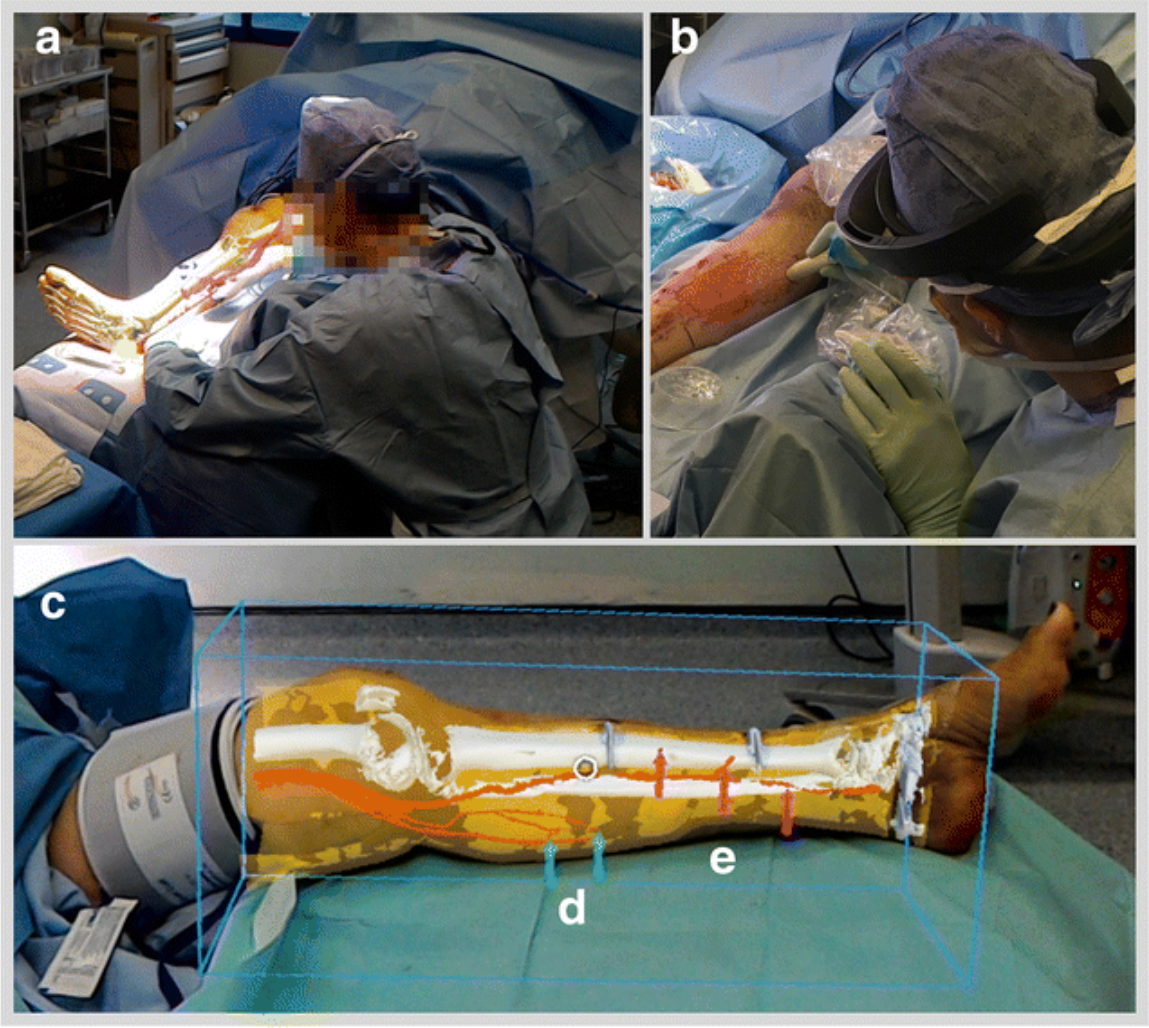


Figure 10. AR in reconstructive surgery. Source: Pratt et al. (2018).

c. AR in the Classroom

Due to the rising number of smartphones in the classroom and with most of them capable of running AR software (Moyers, 2020) and (ARCore, 2020), the possibility of running AR in the classroom is at almost every student's fingertips. With Google's ARCore software and applicable chipsets being available in Android phones as far back as late 2017 (Amadeo, 2017), and Apples ARKit being available in all phones and tablets

running on an A9 chipset since late 2015 (Apple, 2020), students today are able to utilize one of the many AR apps available to them in the Google Play or Apple App Store. A prime example of an educational app that is available in both stores is Google Expeditions. Google Expeditions allows the user to explore detailed objects such as the International Space Station, historical landmarks, architectural structures, natural landscapes, and even the human anatomy (Google, 2020). AR is also helping individuals learn languages through the Google Translate app. With Google Translate students can translate printed text directly from objects in real life (Renard, 2018). Certain AR applications, such as Apple's JigSpace, also teach the user about the inner workings of complex mechanical objects through a 3-dimensional exploded diagram (Langevin, 2018) as seen in Figure 11. In this particular application the user is able to move around and view every aspect of the object just as a maintenance technician or engineer would be able to. Apps such as these can give Marines an advantage in any foreign battlefield where the language is unfamiliar, or with unfamiliar technology during a mechanical failure.

Figure 11. Exploded view of mechanical device in AR. Source: AR Critic (2017).

According to one online article, teachers are using AR to replace PPT in the classroom by incorporating Google Street View. In this particular example, students are drawing on images in Google Street View and have "created images that could be viewed at any angle. This helped them create views of the world that could be manipulated in 360 degrees. Such approaches helped to increase student engagement and get them doing hands on work in augmented reality" (Loveless, 2020, para. 25). Lastly some teachers are even using AR as a means to introduce themselves or a historical person of interest via animation, a narrative, or biography simply by scanning a photo on a wall (Loveless, 2020), enabling the student to become acquainted with the faculty or subject without having to open an email or a textbook. In this instance, AR could be used to brief mission targets and provide full profiles on suspected combatants simply by looking at a photo or any other preprogrammed item.

2. Initial Cost Estimates of AR

In order to obtain an AR experience that is applicable to the needs of the individual and the Marine Corps, one must look at the costs as they relate to hardware, software, planning, and maintenance.

a. AR Hardware

As mentioned in the paragraph on "AR in the Classroom", the large majority of smartphones purchased after 2017 are already AR capable and in the hands of consumers everywhere. Advances in smartphone technology allow the phone to "handle augmented reality apps with finesse" while performing "complex AI tasks without lag time" (Moyers, 2020, para. 4) thanks to its ability to handle 600 billion operations per second (Hollister, 2019). According to Statista.com, when purchased new by an enterprise, the average price for a smartphone in 2020 is $613.13 (O'Dea, 2020), and each of the smartphones referenced on this page are all AR capable with the latest Qualcomm, Apple, or Samsung chipset.

Aside from smartphones, there are also AR wearables manufactured by companies such as Microsoft, Epson, and Nvidia. These wearable devices are solely for

AR or MR applications and have a full range in price and size from $1,000 for the Vuzix AR smart glasses (Statt, 2019) to $3,500 for the Microsoft HoloLens 2 (Microsoft, 2020).

b. AR Software, Maintenance, and Technical Expertise

As mentioned in Chapter IV, Section C.3 the costs of software depend on the suitability, scalability, flexibility, support, interoperability, time-to-implementation, implementation risks, property rights, and cost of ownership. With AR the user is not fully immersed in the environment and is instead viewing their own environment with AR overlays. Because of this, the level of detail in the overlays is what truly affects the costs as they relate to any type of XR. According to an article written on the Invisible Toys website, there are three factors affecting the creation of an AR app: the scope of the work, the timeline, and the development team (Golosovskaya, 2020). Each of these factors consumes valuable man-hours that the company could be using to develop products for others, and therefore must charge accordingly. According to this article, the cost of AR software development in North America begins at approximately $150 per hour and can take anywhere from 160-1000+ hours to develop, depending on the complexity (Golosovskaya, 2020, para. 7). In terms of dollars, that can equate to anywhere from $24,000 to $150,000 for a single application. If a full time technician is required for maintenance, the user can expect to spend anywhere from $34k to $51k per year in salary expenses (Glassdoor, 2020).

3. Pros and Cons of AR

One of the primary advantages of AR is that the hardware required to operate rests in the pocket of nearly every individual in the developed world. With the average American owning a smartphone no greater than three years old (Kerr, 2019) one could expect nearly every individual to be carrying an AR capable device. Couple that to the already available and often free apps on the Google Play or Apple App store and you have the ability to familiarize Marines with the AR environment prior to making any monetary investments. However, the applications of AR are limited as the user is not able to interact with the objects projected on their device. If the Marine Corps were to invest in AR equipment, the initial investment would probably include head-mounted

equipment so that users may view their environment without tying up their hands. Additionally, custom software would be required that could simulate instances or obstacles that would otherwise be briefed via a 2-dimensional PPT slide. As it stands, the Marine Corps may benefit from utilizing AR in an environment that is known and readily available to move about, so that these simulated overlays can be viewed in real time. Such environments may include a logistics staging area, a training mock up, or a location where a static defense is being constructed.

4. Capabilities and Applications of VR

The idea of using virtual reality to escape the real world has existed since 1962 when cinematographer Morton L. Heilig patented the first VR machine, known as the Sensorama (Heilig, 1962). Originally envisioned as an advanced method of viewing cinema, the Sensorama added "smell, stereo sound, vibrations of the seat, and wind in the hair" (USC School of Cinematic Arts, 2020, para. 1) to the film so that the viewer was able to completely immerse themselves in a foreign environment. Although the industry has not spent much in advancing the olfactory or gustatory senses, the recent years have seen an explosion in technology focused on the military, and medical field (FDM Group, 2020).

a. VR in the Military

VR is already being used in all three services of the U.S. military in order to enhance the effectiveness of its machines and personnel (Naveen, 2019). At the time of this project, the Air Force is known to be investing in its own Agency for Modeling Simulation, in which they are testing platforms to the fullest extent without displaying capabilities in "free space" (Lange, 2020, para. 6). Working out of the University of Central Florida, the Air Force Agency for Modeling Simulation has formed a "collaborative alliance that includes all military branches, industry and academic organizations" (Lange, 2020, para. 7) working towards enhancing the capabilities of modern aircraft in a safe and hazard free environment.

For the U.S. Army, their own Combat Capabilities Development Command is using VR technology along with 2-dimensional imagery to create and interact with data rendered in a 3-dimensional environment (U.S. Army CCDC Army Research Laboratory

Public Affairs, 2020). For the U.S. Army CCDC, a specialized team prepares the environment ahead of time in order to mitigate software setup and equipment issues so that the end user is able to "explore the benefits of VR and AR at their leisure" (U.S. Army CCDC Army Research Laboratory Public Affairs, 2020, para. 10). These scientists at the U.S. Army CCDC have also used VR to conduct research on computational fluid dynamics, network modeling, and human sciences with a focusing on enhancing the technology so that it becomes as commonplace and easy to use as a personal computer (U.S. Army CCDC Army Research Laboratory Public Affairs, 2020, para. 20).

The U.S. Navy is currently utilizing VR to practice real-time flight operation procedures on a simulated flight deck while the actual ship remains pier side (Towner, 2020). While inside the carrier-advanced reconfigurable training system (C-ARTS), sailors with zero experience in flight deck operations are observing scenarios and going through all the motions that would otherwise encompass a real mission, all while saving time and money by avoiding the expenses of being underway (Towner, 2020). As seen in Figure 12 and 13, the VR system for the C-ARTS includes a large semi-tractor trailer which holds all the necessary computers for the programs, the applicable head mounted display and controllers, as well as internal space to move about and explore the VR environment.

Figure 12. C-ARTS trailer. Source: Cape Henry Associates (2020)

Figure 13. C-ARTS in use. Source: Commander, Naval Air Force Atlantic Public Affairs (2020)

Each of the military services look at VR as an innovative technology that is already familiar to the upcoming generations. As these generations have become acquainted with similar technologies through video games, computers, and smartphones, the military is looking to exploit this opportunity by implementing VR into its training regimen in order to "keep innovating and advancing" (Lange, 2020, para. 10) at the same pace as the recruits of the future. With a heavy initial investment, VR is currently being looked at as a platform that can save money over time as it doesn't require aircraft to fly, ships to deploy, or service members to physically be in the area in which they intend to operate (Naveen, 2019).

b. VR in Medical

VR in the medical field goes all the way back to 1965 when Dr. Robert Mann introduced a simulator loaded with 3-dimensional images in order to determine the most practical procedure for an orthopedic disease, as well as to train resident practitioners (Graur, 2014). The medical field has since experienced many advancements in both the ways it determines treatments and the how it trains, yet those familiar with VR continue to seek new methods of implementing the technology into the field of medicine.

Professionals in the medical field are utilizing VR to simulate the ways proteins are packaged into 3-dimensional molecules so that they can understand "the molecular biology of diseases such as: Alzheimer's disease, mad cow disease, Huntington's disease, Parkinson's disease, cystic fibrosis and cancers" (Graur, 2014, sec. 3). Figure 14 shows one of the ways in which VR is used to fold and package these proteins via an online game known as "foldit". Through this game, and others like it, scientists are able to engage gamers and the computing power of their personal computer in order to determine the many different ways in which a protein can be folded in hopes of finding cures to complex diseases (Dsilva et al., 2019). This particular version of VR and its ability to "borrow" computing power alludes to the possibility of developing complex scenarios without overwhelming one single computer.

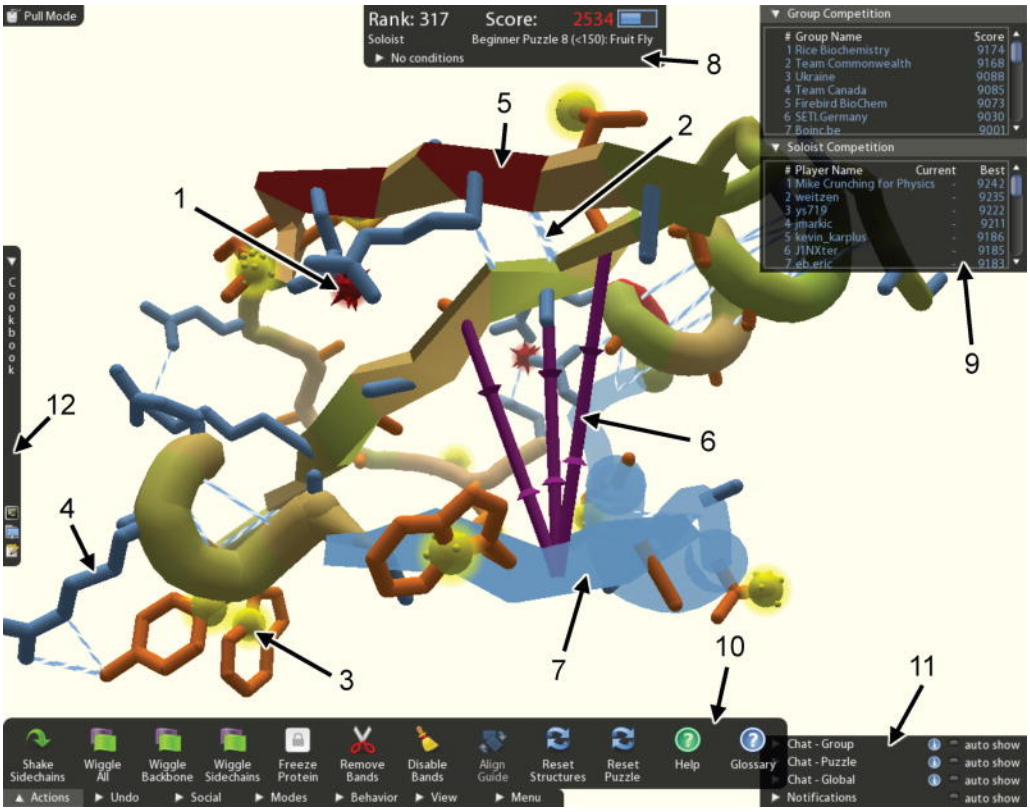


Figure 14. Protein folding in VR. Source: Cooper et al. (2010).

Another focal point in the medical field is the use of VR to simulate complex surgeries that would otherwise be performed on expensive and hard to obtain cadavers. In order for medical students to practice certain surgeries on the dead, they must first ensure their school has the proper labs set up to receive cadavers, as well as the additional funding to ensure the bodies are properly kept and buried when no longer needed, all of which can cost millions of dollars (Gholipour, 2019). In order to bypass these barriers, certain entities are going “cadaverless” and focusing on VR as a means to teach and learn the anatomy of the human body (Gholipour, 2019). For example, Figure 15 shows a total knee arthroplasty being performed in the Fundamental Surgery labs as they obtain accreditation from the American Academy of Orthopedic Surgeons in order to allow future orthopedic surgeons to obtain continuing medical education credits via VR (Cision, 2019).

Figure 15. Knee surgery in VR. Source: Cision (2019)

Companies such as Immersive Touch, Medical Realities, and Fundamental Surgery are providing intuitive VR technologies that are aiding surgeons in perfecting their trade and provide a means of measuring surgical performance, gains in proficiency, and further providing a comparative link amongst other surgeons in the field (Reisenwitz, 2019). In order to fully render these 3-dimensional surgical tables, surgeons and engineers are working together to deliver the most accurate setting possible, within the confines of modern technology (Graur, 2014). Teams from the Kaiser Permanente School of Medicine, the University of Iowa Carver College of Medicine, and the University of Oxford (Pottle, 2019) are utilizing VR in their classrooms to teach heart surgery, laparoscopic surgery, and fully interact with a virtual patient and environment (Gholipour, 2019). Furthermore, students are able to:

> (interact) with the virtual environment and patient as they would in real life. They can take a history, examine, investigate, diagnose and treat the patient. Family members and an interdisciplinary team can be added, with everything from patient observations to blood gases to realistic conversation adapting dynamically, as in real life. Patients can become confused, agitated and look physically unwell, while the bustle of a virtual hospital and emotional engagement with emergency scenarios and lifelike characters in real time builds a sense of stress. (Pottle, 2019, para. 15)

Examples like those above hint at the endless possibilities of VR and the programmers' ability to create fully dynamic worlds for the end user. For the Marine Corps this could mean recreating the Second Battle of Fallujah as an AAR or teaching moment for future generations.

VR in the medical field is not only focused on treating the body, but also the mind. VR is currently being used in psychiatry as a means to safely replicate certain scenarios that might trigger psychotic episodes. In these instances, the psychiatrist is able to analyze the patient as they are reacting with the hope of providing a more accurate diagnosis and treatment plan (Srivastava et al., 2014). This same study also focused on the use of VR in the treatment of posttraumatic stress disorder (PTSD). With VR, the psychiatrist is able to re-introduce the patient to a battlefield environment, "exposing the patient to the source of their condition combined with relaxation training will enable them to adapt to the stress. Further as they are exposed to this gradually, the level of threat is removed, which then decreases their feelings of anxiety" (Srivastava et al., 2014, para. 8). Using VR in this instance does not directly correlate to operations briefings, but as it goes for treating PTSD it could aid in getting Marines back in the fight or help to instruct others on "what went wrong" in order to avoid future cognitive trauma on the battlefield.

5. Initial Cost Estimates of VR

Similar to the requirements of AR, VR also requires a software, hardware, and support package to be able to operate efficiently. As it currently stands, this package will also have to be tailored to the specific mission of the Marine Corps.

a. VR Hardware

One of the key requirements of VR is to maintain a fully immersive environment, and in order to do that the user must be able to view the VR environment through some sort of head mounted display (HMD). Previously companies like Google and Oculus made a HMD that allowed the user to slide their smartphone into a slot, but unlike AR, the VR environment is no longer available through a user's smartphone. As of October 2019, both of the primary manufacturers for the phone-based VR devices have discontinued their VR mobile headsets (Robertson, 2019). For that reason, those that wish to interact with VR must do so through a VR specific device. These devices are commercially available from companies like Facebook, Google, Sony, and Valve. Table 4 provides the MSRP, basic specifications, and required hardware for each of the top VR headsets of 2020, as reported by a recent CNET review (Stein, 2020). The values highlighted in Table 4 indicate the optimal choice for each category. Aside from the basic headset, additional hardware may be purchased that will allow the user to physically walk as they move about the VR environment. As mentioned in Chapter II, Section C.1. some companies are investing in omni-directional slidemills that will act as a mobile platform for the user to move about. The cost of these slidemills range in price from $500 up to $100,000 and are still mostly in the developmental phases (Lodola, 2018). In the meantime, other companies are offering alternatives to slidemills in the form of shoes with built in roller skates at a cost of $269 (Cybershoes, 2020), a puck that the user is able to stand and pivot on for $99 (3dRudder, 2020), and an air cushion that the user would sit on and lean into for £119 (~$145) (VRGO, 2020).

Table 4. VR headsets cost with required hardware. Adapted from VRCompare (2020)

	Oculus Quest 2	Sony PlayStation VR	Valve Index	HTC Vive Cosmos
MSRP	**$299**	**$299**	$999	$699
Hand Controllers Included	**Yes**	No	**Yes**	**Yes**
Standalone	**Yes**	No	No	No
Field of View	92	96˚	**114˚**	103˚
Weight	**503g**	600g	809g	702g
Display Type	LCD	OLED	2 x LCD	2 x LCD
Resolution	**1832x1920**	960x1080	1440x1600	1440x1700
External Hardware Required	**None**	Sony PlayStation 4 (or newer) + Controllers	PC with at least: GPU: GTX 1070 CPU: Intel i5 4590 RAM: 8GB	PC with at least: GPU: GTX 970 CPU: Intel i5 4590 RAM: 8GB

b. VR Software, Maintenance, and Technical Expertise

As with the AR option, there is currently nothing available in the commercial market that would immediately satisfy the needs of the Marine Corps. In order to develop an app in the VR industry that would suit the needs of the Marine Corps, some estimate that the costs could range anywhere from $40,000 to $200,000 per application, which accounts for approximately 500 to 2000 hours spent on developing the app and can vary based on the level of clarity that the end user requests (Morozova, 2020). If the end user requires follow on technical expertise after the application is launched, they can expect to spend anywhere from $34k to $51k per year in order to hire the VR technician as a full time employee (Glassdoor, 2020).

6. Pros and Cons of VR

From the beginning, one of the clearest advantages of VR is that the user is able to recreate a nearly unlimited environment with data occupying the physical space of a hard drive. The environment in which the user intends to operate is far safer than the standard and will allow the user to take risks without losing personnel, assets, or money (Roundtable Learning, 2020). Another advantage to VR is based on who the Marine Corps is currently recruiting. The Marine Corps is investing in individuals that have grown up with video games and tend to find VR environments exciting and engaging (Statista Research Department, 2015). Lastly, VR is adaptable to almost any individual or environment and setting. Users can place themselves anywhere in the world in the midst of any situation and run reactionary drills many times over. When compared to the costs that would otherwise be spent on munitions, travel, and the physical environment the high price tag of VR development and equipment can seem miniscule (Jenkins, 2019). Although it is adaptable, VR is not for everyone. One of the downsides to VR is the physical side effects exhibited by some users. Some users experience:

> VR-induced sickness which can present with dizziness, nausea, headache, eye strain, reduced limb control, reduced postural control, decreased sense of presence, and the development of responses inappropriate to the real world. Subjects who develop seizures when watching television or playing video games, should not be exposed to VR. (Srivastava et al., 2014, para. 10)

7. Capabilities and Applications of MR

MR is often confused or merged with AR as some columnists forget the subtle difference between the two. With MR, the user has the ability to interact with the virtual objects placed in the environment (Franklin Institute, 2017). With MR one can take advantage of certain aspects of the simulated environment while still interacting with the real world and observing the people in it.

a. MR in the Military

The U.S. Army and Navy seem to be already capitalizing on the advantages of MR in the armed forces. With the Army investing in equipping combat personnel and the Navy focusing on the maintainers.

The U.S. Army CCDC is using a combination of the technology mentioned in Chapter VI, Section A.4.a. to create a MR environment that the user can interact with all while maintaining face to face communication with their audience (U.S. Army CCDC Army Research Laboratory Public Affairs, 2020). With this technology, the user is able to view the material they are presenting while simultaneously interacting with their environment, viewing the audience, as well as projecting their environment on a screen for all to see. Furthermore, the U.S. Army plans to purchase 40,000 pairs of MR goggles, based on the Microsoft HoloLens, that they are calling an integrated visual augmentation system (IVAS). If properly implemented, the IVAS will give soldiers on the frontline a superior tactical advantage as they will be able to quickly identify friend or foe, while maintaining situational awareness of the battlefield (Mizokami, 2020). Plans for the IVAS include integration with "Next Generation Squad Weapon systems… to 'see' through the sights of their IVAS goggles to aim and fire their weapons. A soldier would be able to hold her rifle out around the corner of a building, never physically laying eyes on the target but able to see the target through IVAS and open fire" (Mizokami, 2020, para. 6). The U.S. Army also plans on integrating several other technologies into their IVAS system that will provide the user with an almost "Iron Man" type point of view. This point of view will give the user a see-through display similar to that of a fighter pilot, allow them to access information from higher, supporting, and adjacent units, provide visibility in low-light situations, as well as map overlays, and "rapid target acquisition and aided target identification" (Siter, 2019).

The U.S. Air Force is testing the X2 MR Glasses made by a company called ThirdEye Gen, coupled with software from 3D Media to replace technical publications and tablets used by maintenance crews on the aviation flight line (Kanowitz, 2020). With MR, the Air Force is using detailed overlays and step-by-step instructions to facilitate maintenance in hopes of improving efficiency and safety. Maintenance personnel using

the X2 MR Glasses are able to open documents via voice command, interact with the pages and overlays by taking screen shots and zooming in on particular areas, as well as call for help and share their view with technical experts across the globe (Kanowitz, 2020). In order to do this, 3D Media has created their own proprietary version of a simultaneous localization and mapping (SLAM) software that is capable of understanding the environment around the user, allowing them to remove and replace the glasses without losing their point of reference in the real world (ThirdEye Gen, Inc., 2020). These glasses also come equipped with thermal imaging capabilities, can be used indoors or outdoors, and are compatible with a multitude of open source applications (ThirdEye, 2020).

b. MR in Education

Similar to the section on "AR in the Classroom", Chapter VI, Section A.1.c., MR in education has the ability of benefitting the user through hands-on interaction. The primary difference is that the MR user can interact with his or her environment as they reorganize objects and explore the consequences of their actions. In the MR environment, students have the opportunity to move past "learn by listening" and begin to "learn by doing" (MyViewBoard, 2019). In its current application, MR is being used at every level from middle school to the doctoral level of education. In some examples, educators are using MR to replace frogs in their science labs as they focus on eliminating animal abuse, cutting waste and the requirement to maintain dissection equipment (Zimmerman, 2018). In other cases, faculty and students at the Case Western Reserve University are using MR to observe and interact with everything from the intricacies of a beating heart, or the human skeletal structure as seen in Figure 16, to the architectural design of historical buildings (Microsoft HoloLens, 2015).

Figure 16. Interactive skeletal structure in MR. Source: Microsoft HoloLens (2015).

8. Initial Cost Estimates of MR

MR is still a relatively new concept and therefore not many technology experts are reporting on the costs of MR. With only two competitors releasing MR devices in the last year, the following data is limited to the manufacture provided information.

a. MR Hardware

Most MR hardware is capable of viewing the world through an AR lens, however the same cannot be said for AR to MR or even VR to MR. For that reason, the number of companies offering MR glasses and HMDs is limited to two major vendors at this time. For these vendors, it would appear as though the tech is relatively the same, with the major differences being between the weight and cost. The two companies currently offering MR glasses are the well-known Microsoft and the up-and-coming ThirdEye. Microsoft offers the HoloLens 2 at a weight of 20 ounces and a price of $3,500 (Microsoft, 2020), while ThirdEye offers the X2 MR at a weight of six ounces and a price

of $2,000 (Nichols, 2019). Neither of these MR capable devices require any external hardware and are able to operate as a fully functional headset as seen in Figure 17.

ThirdEye X2 MR Glasses

Microsoft HoloLens 2

Figure 17. MR head mounted displays. Source: ThirdEye (2020) and Microsoft (2020)

b. MR Software, Maintenance, and Technical Expertise

At the time of this project, no articles or postings could be found on the price point for developing MR applications or the time it would take to do so. Considering that MR is an enhanced version of AR yet not as immersive as VR, one could assume that the price to develop an MR appropriate application would lie somewhere between the price point of these two technologies. With AR averaging a range of $24,000 to $150,000 and VR averaging a range of $40,000 to $200,000, one could assume that MR application develop would be around the $30,000 - $175,000 range. Similar to the employee salary of the VR and AR technician, one could expect pay $34k to $51k per year for a full time MR technician (Glassdoor, 2020).

9. Pros and Cons of MR

Mixed reality has potential in the U.S. military as it allows the users to continue to train in areas already owned and operated by the U.S. government. Providing the trainer and the trainee with interactive overlays allow organizations to create complex situations in familiar environments without having to spend money on munitions, red team operatives actors playing as the opposition, live animals, or people in "cut suits" necessary to practice combat lifesaving skills (August & Payton, 2017). For the individuals at the Case Western Reserve University, they look at MR as being extremely advantageous as it "enables this exploration to occur on a social level. Students are not closed off from the world or the people around them" (Workman, 2018, para. 14) which has the ability to foster emotional learning. In a study conducted by Microsoft's education department, there was a 35% increase in student engagement and information retention when material was taught via immersive and 3-dimensional technologies, and 22% improvement in test scores when students used immersive technology (Bonasio, 2019). According to a website devoted to technology professionals, one of the key disadvantages of MR technology is the price of the hardware itself (Ball, 2020). With only two producers of MR wearables, it's clear that this will continue to be a disadvantage until others enter the market. Additionally, the Microsoft website lists the range of the HoloLens focal plane at anywhere from 1.25-5m (~ 4-16ft) which doesn't

fare well for extended range applications (Paul, 2020), product specifications are not readily available to the public for the X2 MR glasses.

B. PRACTICALITY IN THE MARINE CORPS

While the Air Force, Army, and Navy currently experiment with the different XR technologies, it's difficult to say exactly how the Marine Corps could or would implement these devices into their training and briefing regimen. Considering the focal point of this project is on equipping a unit for COA development, Wargaming, SOM briefings and AARs, one could predict that the Marine Corps would adapt a methodology similar to that of the Army. Each of the technologies mentioned above have their own advantages and disadvantages as well as overall practicality for each service branch. Below are the potential uses of each technology as assumed by the author of this project.

1. AR in the Marine Corps

Considering that AR is a technology offered via smartphone or wearable HMD, and the user is not able to interact with their environment, its most practical application would probably be conducting site surveys and exploration of terrain occupied by friendly forces. Assuming a commander is occupying a FOB and wants to view a defense plan while simulating proposed sites for obstacles, phase lines, or engagement areas, AR could come in handy. The commander or team briefing the commander could have visual overlays placed on the real terrain and play back the videos to all Marines stationed aboard the FOB so that a particular defense plan was fully understood.

2. VR in the Marine Corps

Being a fully immersive environment, the possibilities of VR are virtually endless. However, there are some instances in the Marine Corps in which VR could become extremely advantageous to Marines at any level of the command. Having the ability to conduct mission related reconnaissance at any location in the world would reap huge rewards for any combat unit. As mentioned in Chapter VI, Section A.4.a, the Army is currently working with scientists to convert 2-dimensional images into 3-dimensional terrain models. With the number of advanced drones, manned aircraft, and satellites in

space constantly taking high definition photos of the earth, there are a vast number of pictures available from anywhere in the world that the Marine Corps could potentially operate in. With a combination of these high resolution images and advances in photogrammetry, detailed 3-dimensional environments could be recreated in VR for Marine Corps units to operate within. Once inside these VR environments, the Marines would be able to conduct any number of battlefield scenarios as well as provide an in-depth walk-about, wargame, or realistic AAR.

3. MR in the Marine Corps

Similar to how the U.S. Army utilizes MR, the Marine Corps could use it to run SOM scenarios with all hands MR equipped. As mentioned in Chapter III, Section D., the ability to participate in an event leads to retention in the majority of the individuals. Further emplacing obstructions or obstacles in the individual's path would allow the individual to work through a potential problem ahead of time, with the hope that they are mentally and emotionally equipped to handle a similar scenario, when confronted with a life altering decision. Additionally, the advantages of MR extend beyond the training and briefing grounds, and wearing this technology in training can ensure the user is accustomed to wearing it when advances are made in next generation weapons technology and MR is deployed into the operating environment.

C. ROUGH ORDER OF MAGNITUDE ESTIMATE

A standard Marine Corps rifle platoon consists of 43 Marines and is often the most utilized combat unit in the Marine Corps (Headquarters US Marine Corps, 1998, p. 4-7). Because the platoon typically operates as an integral unit, these 43 individuals are typically subjected to the same training regimen. For this reason, Table 5 shows the ROM estimate to equip a Marine Corps rifle platoon. Prices for the individual piece of XR technology were taken as the average price across that particular medium of XR. As mentioned in Table 4, certain VR devices require external hardware to operate the HMD. At the time of this project, the Asus ROG Strix Hero II was considered the best overall laptop capable of operating the different VR devices, and is priced at $1599 per laptop (Valentinuzzi, 2020).

Table 5. XR rough order of magnitude estimate.

	Individual unit (x43)	Additional Hardware (x43)	App. Development	1 year of support	Total
AR	$26,365		$87,000	$42,500	$155,865
VR	$24,682	$68,757	$120,000	$42,500	$255,939
MR	$118,250		$102,500	$42,500	$263,250

Adapted from O'Dea (2020); Glassdoor (2020); Golosovskaya (2020), Microsoft, (2020); Morozova (2020), Nichols (2019); Valentinuzzi (2020); and VRCompare (2020).

D. CHAPTER SUMMARY

Each field of XR has its own advantages and disadvantages as it relates to the practicality and costs of implementation into the Marine Corps. Each highly capable of becoming combat integrated as well as maintaining the ability to extend into the medical and logistics fields. While VR offers a fully immersive environment, the individual user may be limited to a defined space and environment as prescribed by the software engineer and VR environmental architect. With AR, the user can experience enhanced overlays while maintaining situational awareness with the real environment, but is limited to viewing and not interacting. A combination of VR and AR is seen in MR, where the user is able to interact with the enhanced overlays without limiting his or her field of view, however these overlays may only exist within a limited range. In regards to cost, AR is the clear winner with a ROM of $155,865 necessary to equip a Marine Corps rifle platoon. This estimate is followed by VR at $255,939 and finally MR at $263,250.

VII. CONCLUSIONS AND RECOMMENDATIONS

This project examined the desirability, practicality, and ROM costs of replacing PPT with XR in the Marine Corps. The author utilized the survey in Appendix A to gauge desirability, and market research to measure practicality and predict costs. Furthermore, the author discussed the different types of briefings that are essential to the battle rhythm of Marine Corps operations, and how PPT is involved in each of these evolutions. From course of action development and wargaming, to detailed schemes of maneuver and after action reports, the Marine Corps relies on PPT to provide detailed operation information to troops and commanders alike. As discovered during the survey, these PPT briefs also act as the catalyst for follow on action such as sand table exercises and other forms of visual aids for the briefer and their audience.

Several research questions were addressed in this project.

1) What are some of the challenges with the current status quo of Marine Corps briefings?

As detailed in chapters III and V, one of the key factors into how information is received via the lecture based delivery method and how technology could play a huge part in increasing student learning through interaction and inclusion is standardization across teaching platforms and an increase in visual aids and participation. Research showed that the individual learner was able to retain more of the information provided, for longer periods of time with standardization, whereas in a lecture based model the student was only able to remain engaged for approximately 10-18 minutes, an interactive and inclusive briefing could lead to 100% engagement throughout.

2) & 3). What are some feasible alternatives to the current briefing methods, and what are the relevant pros and cons to consider when choosing the best alternative?

Market research into the differing extended reality platforms showed that not only is the technology available for implementation today, but that it is valid tool for teaching, learning, and retention. With virtual reality offering a fully immersive and personally

tailorable environment, users are able to simulate anything they can imagine, or anything that may be useful to advancing a lesson plan. While augmented reality is limited to providing overlays in the real world environment, it has huge potential in planning and visualizing prior to the actual emplacement of troops, obstacles, phase lines, or engagement areas. Furthermore, mixed reality can be used as a combination of the two, giving the individuals a clear field of view while providing interactive overlays in a real time environment. Each of these technologies has the potential to increase learning as it gets the individual away from the lecture and into the activity, creating first hand experiences of the proposed event or evolution of events.

- Recommendations

The Marine Corps should consider the desirability of replacing PPT before investing in any sort of advanced technology. For those surveyed, there is a deep desire to advance beyond PPT and into a platform that is more engaging, more relatable, and more concise, while also being less time consuming. In its current form, the individuals surveyed feel that the status quo has become more of a procedure that drags on through every painful step, instead of the information tool that it was originally designed to be. The primary obstacle for advancing beyond PPT is that those surveyed are unaware of the potential technologies outside of the 2-dimensional model currently being used. To close this gap, the Marine Corps could recommend the individual Marines test different AR applications on his or her personal electronic devices prior to the investment of more advanced XR. Information on the differing fields of extended reality are not as common-place or understood as PPT is. Many of those surveyed had never heard of virtual reality, mixed reality, or augmented reality and because of that seemed comfortable with defaulting back to the status quo until something prominent or revolutionary presented itself. The survey results indicated that the desire to remain with PPT is likely related to its ease of use, widespread understanding of the application, and simply because it's the current go-to product for all joint operations.

In researching the practicality of replacing PPT with some sort of extended reality, the information provided by the U.S. Army's Combat Capabilities Development

Command proved that these technologies are ready to supplement troops on the battlefield today. Further research by the U.S. Army, Air Force and Navy have provided insight into how the Marine Corps might adopt this research and implement it into current practices to replace PPT without losing any features. Having the ability to create 3-dimensional worlds from 2-dimensional images could literally place the Marine in the proposed battle field. This virtual walkthrough would then be able to replicate an actual leader's recon in a safe and controlled environment without the need for complex sand tables, graphics, hard copy maps, and etc. Furthermore, these virtual walkthroughs have the ability to be recorded and replayed again and again, offering valuable insight to terrain and building layouts that could not be obtained from 2-dimensional overhead imagery.

As with any program in the Marine Corps, cost will also be a deciding factor in whether or not the service will be able to invest. As noted in the Table 5, the ROM necessary to equip standard rifle platoon for any of these technologies can range from $155,000 to $264,000. Having an understanding of the individual costs of the unit allows program officers and budgeteers to determine if an investment is affordable to the Marine Corps. Understanding that technology costs do not stop at the acquisition of the hardware, and that these costs extend to the lines of code in the software and the continued technical support of the program will help the Marine Corps be better fiscal stewards of the tax payers dollar. With augmented reality hardware available at the price of a smartphone, and virtual and mixed reality hardware coming in at approximately three times the cost of that, the Marine Corps must decide if and where it would cut costs in order to obtain this new equipment. Furthermore, the Marine Corps should understand that software development and maintenance costs exist relative to the size of the environment in which they intend to create. Regardless of how the Marine Corps looks at investing in the next technology, they must also understand that one cannot simply compare what has already been spent on PPT to the proposed investment in the new technology. What has been invested in PPT to date is considered a "sunk cost", or funding that will never be returned regardless of future decisions.

Finally, when making the decision to replace PPT with any form of extended reality, one must also consider the disadvantages to both. The limitations of PPT were clearly expressed in the survey results of Chapter V, with most surveyed stating a lack of depth, no clear standardized briefs, and PPT being a huge time constraint as the primary downsides of what they felt to be an archaic briefing tool. But despite its downfalls, PPT is a known technology used across all inter and intra service agencies, whereas the very idea of extended reality is barely known across those surveyed. Furthermore, with the inability to interact with the environment thru the cheapest platform of extended reality available, augmented reality may only be as rewarding as the lecture based model and the current status quo. And although virtual reality offers the maximum immersion level, some of the side effects of the technology can make its users nauseous and therefore may negate the overall learning experience. If one were to ignore the aforementioned technologies based on their drawbacks to learning, then they would be left with the under researched and limited options of the mixed reality mediums.

Future research into this topic should focus on several different questions that may assist the Marine Corps in advancing beyond PPT. These questions are focused on the application of XR, but could extend into other technologies as they present themselves.

1. How can the Marine Corps close the knowledge gap that exists between the military and modern technology?
2. What would be the actual cost estimate to build an XR related application specific to the needs of the Marine Corps?
3. 3. Aside from the Marine Corps combat arms, what other units within the Ground Combat Element (GCE), Logistics Combat Element (LCE), or Aviation Combat Element (ACE) could benefit from XR or other advanced technologies.

APPENDIX A. SURVEY

The following survey was created in order to gain an understanding of the effectiveness of current briefing methodologies used in the Marine Corps and to further determine if the advancements in today's technology would be more beneficial to the future of battlefield intelligence.

If you feel that you would like to elaborate on your answer, or offer a follow-on comment, please do so in the space provided.

The following survey questions relate only to briefing for Course of Action Development, the Scheme of Maneuver, and After Action Reports.

1) The current methods of briefing meet the needs of the Marine Corps and should not change.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

_____
_____
_____
_____

2) More often than not, the information received in PowerPoint briefings is:

Lacking	Somewhat lacking	Just Right	Somewhat too much	Too much
☐	☐	☐	☐	☐

_____
_____
_____
_____

3) The length of current PowerPoint Presentations are:

Excessively Long	A Little Long	Just Right	A Little Short	Way Too Short
☐	☐	☐	☐	☐

4) The PowerPoint presentation coupled with a Sand Table Exercise (STEx) helps me to understand the mission.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

5) Receiving a PowerPoint presentation and then recreating a STEx based on the information received is:

Very Difficult	Difficult	Neutral	Easy	Very Easy
☐	☐	☐	☐	☐

6) I find building and conducting STEx contribute to the effectiveness of understanding the operation.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

7) There is no need for the Marine Corps to invest in a program that would replace PowerPoint

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

_____
_____
_____
_____

8) I am already familiar with Virtual, Augmented, or Mixed Reality (VR/AR/MR) (see question 14 for examples).

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

_____
_____
_____
_____

9) I have used some version of VR/AR/MR before.

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

_____
_____
_____
_____

10) I have a basic idea how VR/AR/MR could replace PowerPoint

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

_____
_____
_____

11) What is your biggest complaint when receiving a PowerPoint Presentation?

_____
_____
_____
_____

12) In your opinion, what are PowerPoints limits?

_____
_____
_____
_____

13) In your opinion, what are PowerPoints' strengths?

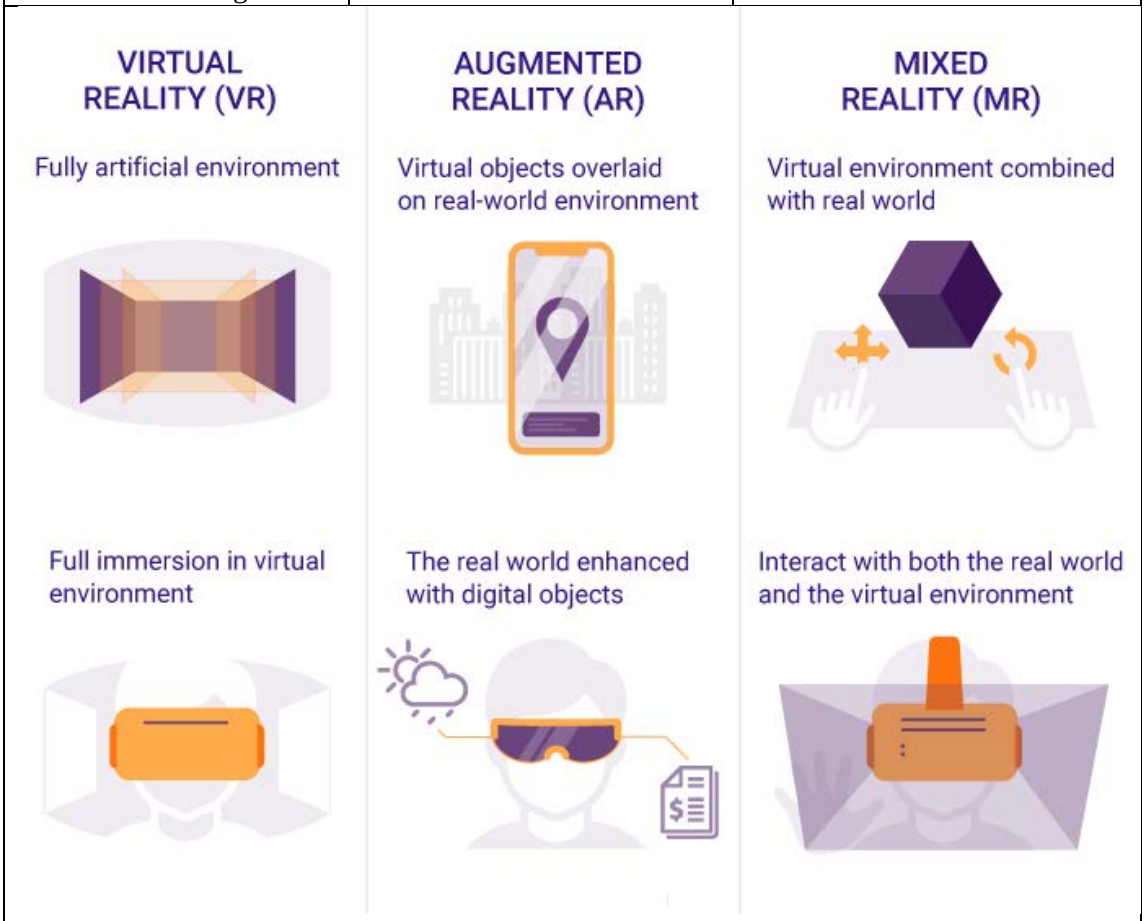
_____
_____
_____
_____

14) Based on the information and image below, which medium would be the better replacement for PowerPoint?

15)

Virtual Reality (VR)	Augmented Reality (AR)	Mixed Reality (MR)
☐	☐	☐

VR – **Fully immersive** environment in which the user can alter and interact with every element of his/her surroundings.	AR – Eyewear that allows the user to **view** digitally placed objects and data in the real world environment.	MR – Headset that allows the user to **view and interact** with digitally placed objects in the real world environment.

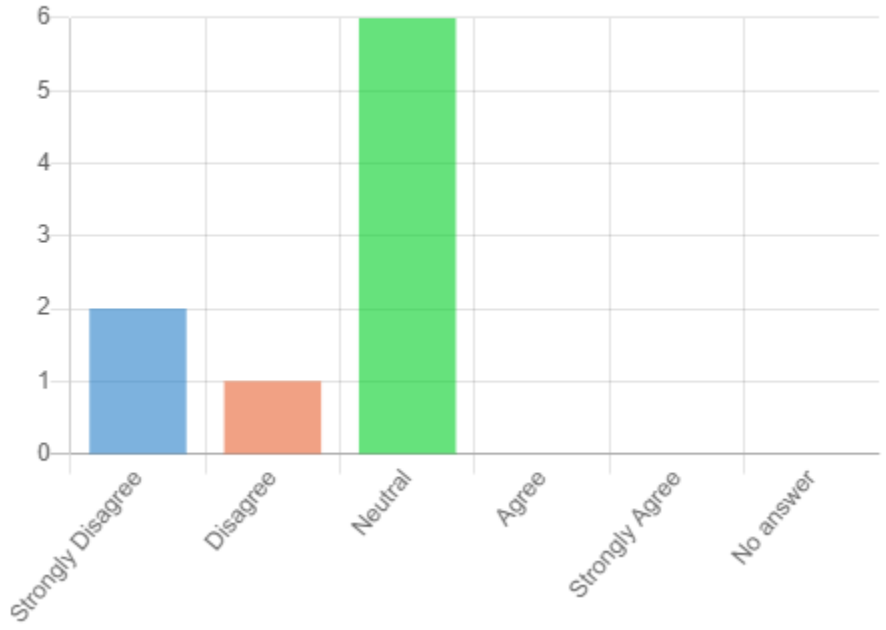


The following questions, along with current Marine Corps Publications and scholarly articles, were the basis of the questions in this survey. If you feel like expanding on anything presented in this survey, please utilize the space provided to do so.

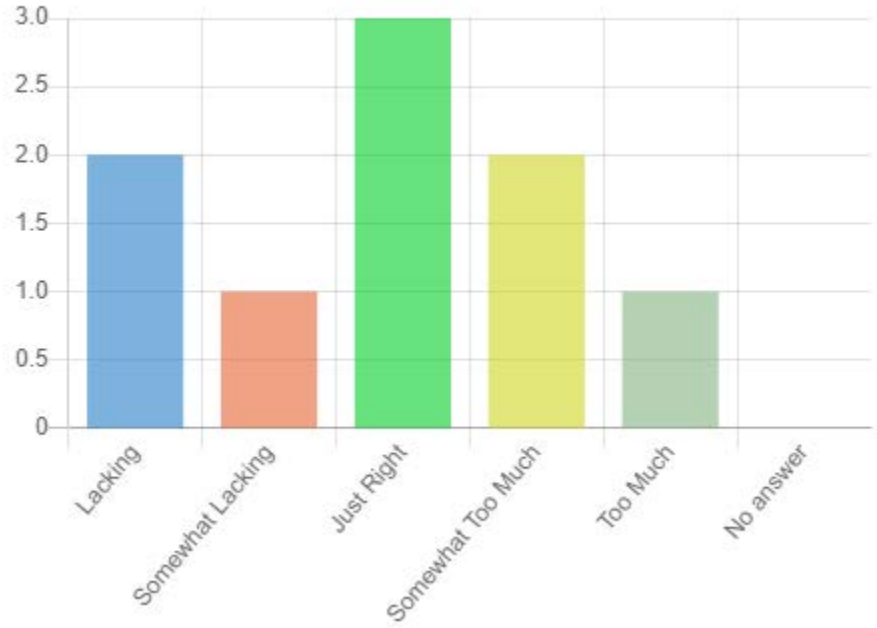
1. What are some of the challenges with the current status quo of Marine Corps briefings?
2. What are some feasible alternatives to the current briefing methods?
3. What are the relevant pros and cons to consider when choosing the best alternative?

APPENDIX B. SURVEY RESULTS

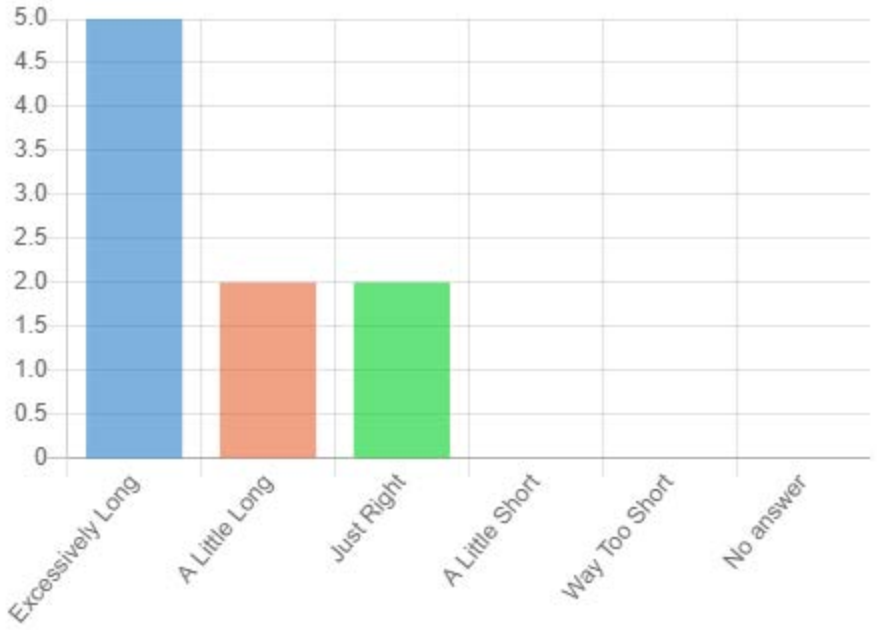
1) The current methods of briefing meet the needs of the Marine Corps and should not change.



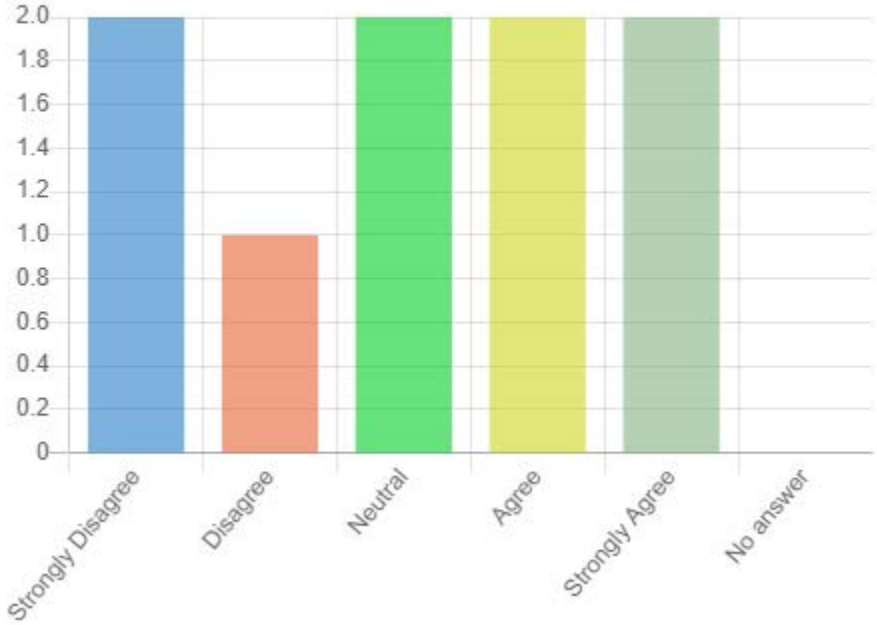
2) More often than not, the information received in PowerPoint briefings is:



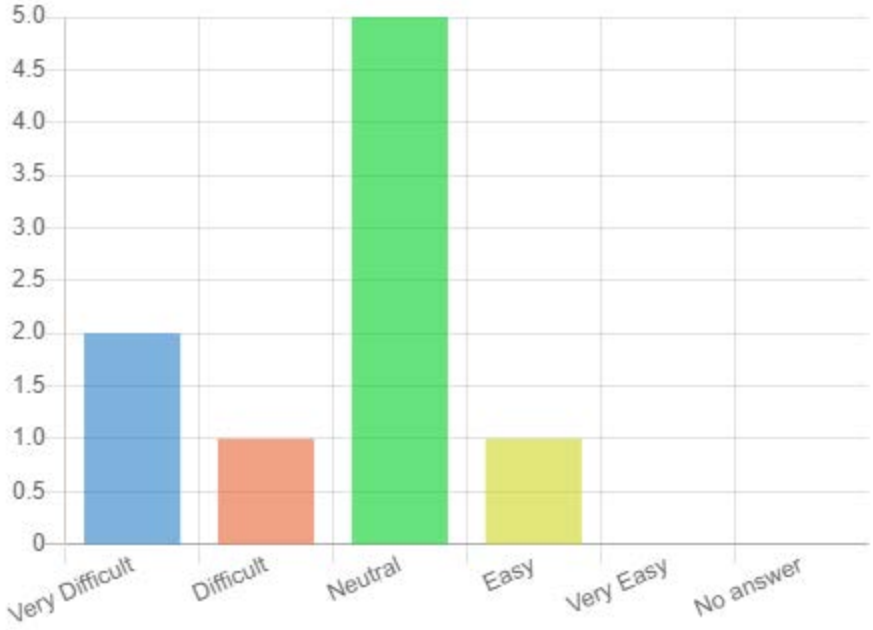
3) The length of PowerPoint Presentations are:



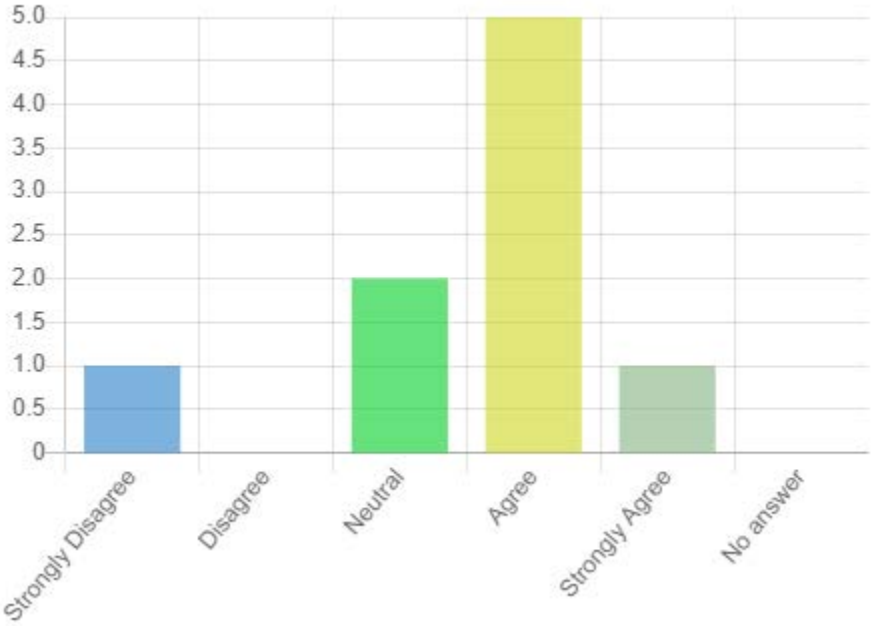
4) The PowerPoint presentation coupled with a Sand Table Exercise (STEx) helps me to understand the mission.



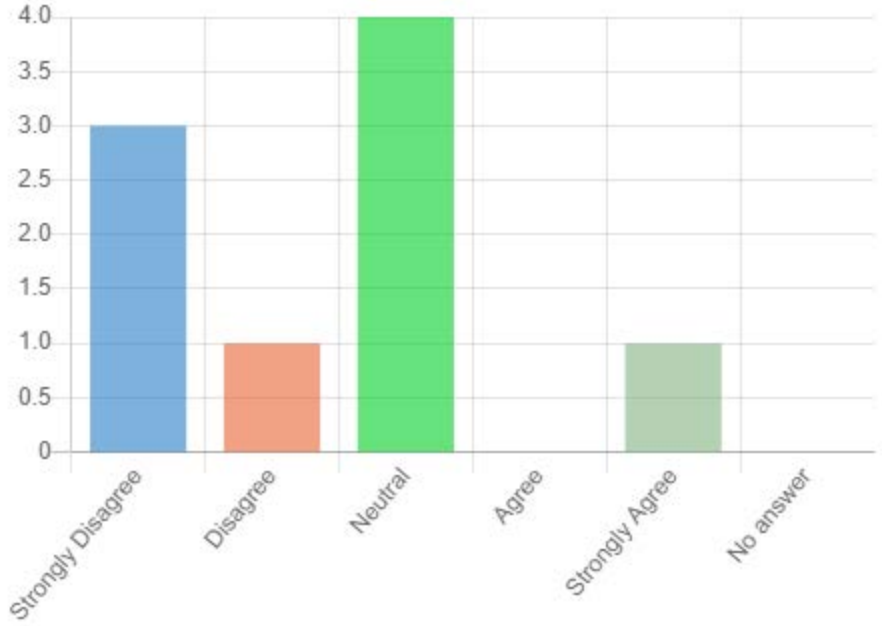
5) Receiving a PowerPoint presentation and then recreating a STEx based off the information received is:



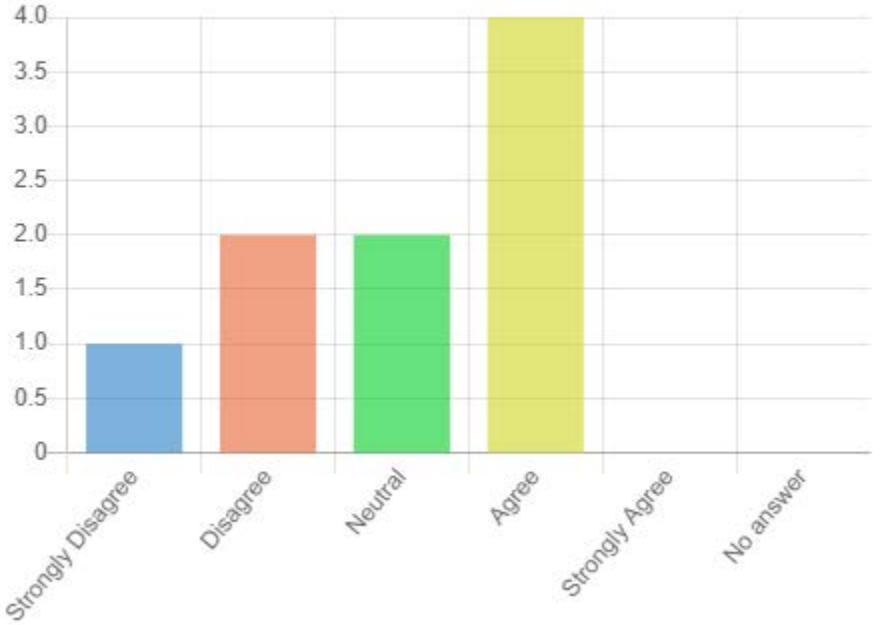
6) I find building and conducting a STEx contributes to the effectiveness of understanding the operation.



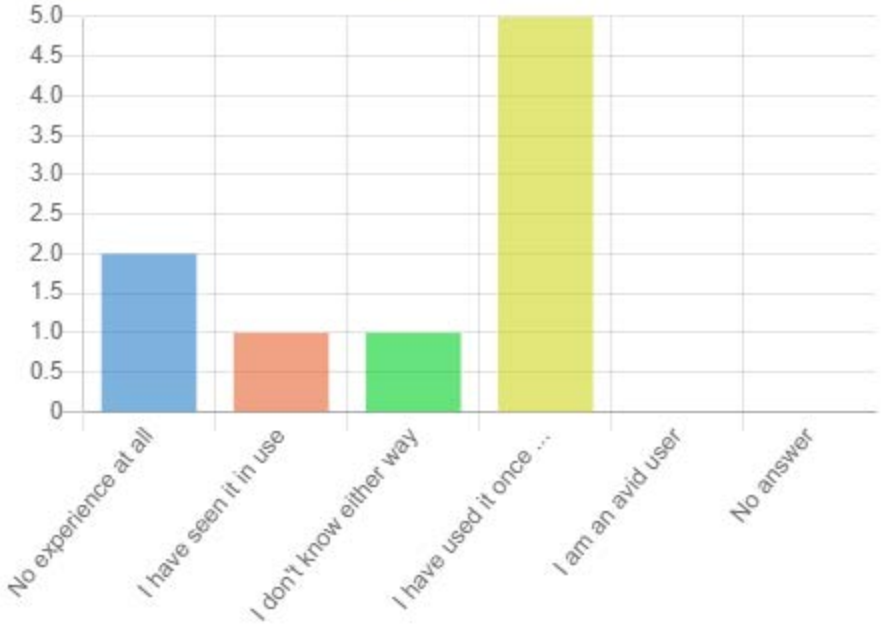
7) There is no need for the Marine Corps to invest in a program that would replace PowerPoint.



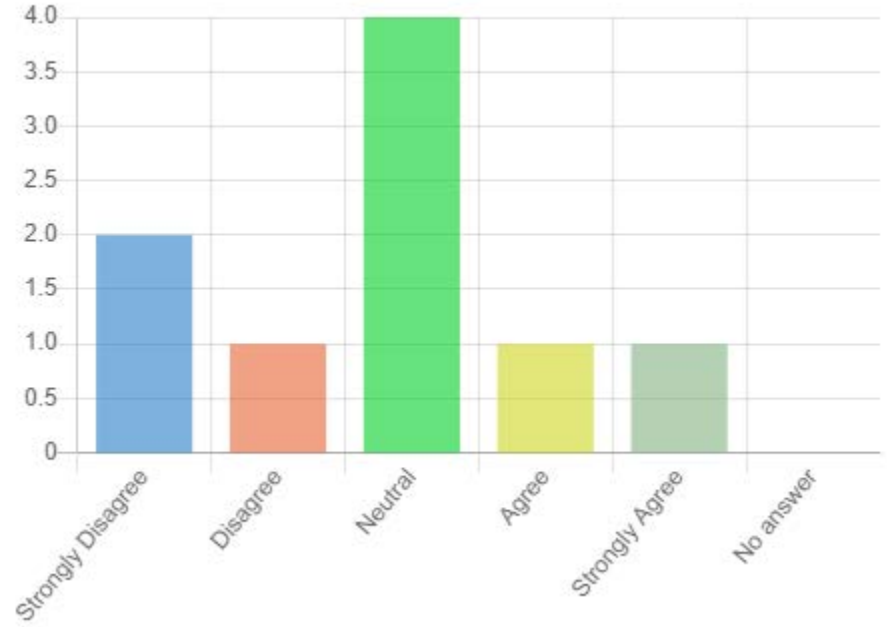
8) I am already familiar with Virtual, Augmented, or Mixed Reality (VR/AR/MR).



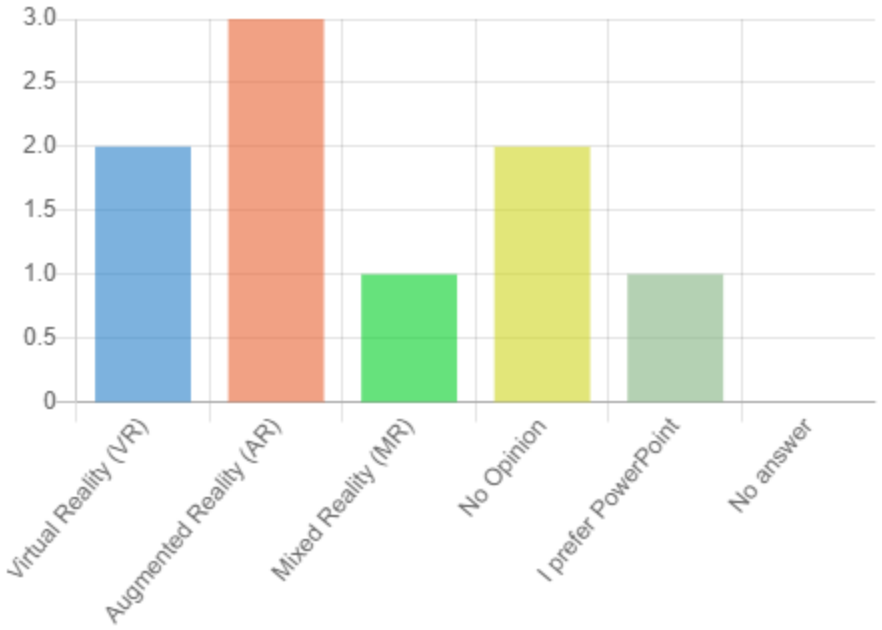
9) I have used some version of VR/AR/MR before.



10) I have a basic idea how VR/AR/MR could replace PowerPoint



14) Based off the information in the image below, which medium would be the better replacement for PowerPoint?



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