NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

COLLABORATION DURING MEDICAL EVACUATION FROM THE BATTLEFIELD AND WITH FEDERAL AGENCIES DURING EMERGENCY RESPONSE USING INFORMATION TECHNOLOGY

by

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June 2020

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REPORT DOCUMENTATION PAGE			*Form Approved OMB No. 0704-0188*
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC, 20503.			
1. AGENCY USE ONLY ***(Leave blank)***	**2. REPORT DATE** June 2020	**3. REPORT TYPE AND DATES COVERED** Master's thesis	
4. TITLE AND SUBTITLE COLLABORATION DURING MEDICAL EVACUATION FROM THE BATTLEFIELD AND WITH FEDERAL AGENCIES DURING EMERGENCY RESPONSE USING INFORMATION TECHNOLOGY			**5. FUNDING NUMBERS**
6. AUTHOR(S) Kenneth J. Bush and Christopher W. Skirvin			
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)

The medical staff of the Department of Defense (DOD) is responsible for effective, efficient, and quality care of more than 10 million beneficiaries. They provide medical support during military operations and maintain the health of the troops who are part of the United States fighting forces. Because of the size, complexity, and mission associated with each branch of service, DOD allows each branch to have a medical service head. The Army, Navy, Air Force, and Public Health each have their own surgeon general, who serves as the top-ranking officer for the medical department of those respective services. In 2013, under the National Defense Authorization Act (NDAA), the Defense Health Agency (DHA) was formed to streamline and coordinate medical services for DOD. Medical Evacuations (MEDEVAC) from the battlefield have seen significant advances over the past 50 years; however, with the advancement in technology such as telemedicine, improved collaborative tools can be implemented to enhance the "Golden Hour" and provide better quality of care for troops on the battlefield.

Additionally, the military has served as supplemental support for emergency response during disasters in the United States. Dynamics of disasters, emergencies, and warfare have turned anything but conventional over the past 20 years. This change calls for a more efficient and effective process for emergency preparedness in the DOD.

14. SUBJECT TERMS collaboration, medical, MEDEVAC, telemedicine, cross-agency, information technology, BUMED, emergency preparedness			**15. NUMBER OF PAGES** 49
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	**18. SECURITY CLASSIFICATION OF THIS PAGE** Unclassified	**19. SECURITY CLASSIFICATION OF ABSTRACT** Unclassified	**20. LIMITATION OF ABSTRACT** UU

NSN 7540-01-280-5500 Standard Form 298 (Rev. 2-89) Prescribed by ANSI Std. 239-18

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COLLABORATION DURING MEDICAL EVACUATION FROM THE BATTLEFIELD AND WITH FEDERAL AGENCIES DURING EMERGENCY RESPONSE USING INFORMATION TECHNOLOGY

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MASTER OF SCIENCE IN NETWORK OPERATIONS AND TECHNOLOGY

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ABSTRACT

The medical staff of the Department of Defense (DOD) is responsible for effective, efficient, and quality care of more than 10 million beneficiaries. They provide medical support during military operations and maintain the health of the troops who are part of the United States fighting forces. Because of the size, complexity, and mission associated with each branch of service, DOD allows each branch to have a medical service head. The Army, Navy, Air Force, and Public Health each have their own surgeon general, who serves as the top-ranking officer for the medical department of those respective services. In 2013, under the National Defense Authorization Act (NDAA), the Defense Health Agency (DHA) was formed to streamline and coordinate medical services for DOD. Medical Evacuations (MEDEVAC) from the battlefield have seen significant advances over the past 50 years; however, with the advancement in technology such as telemedicine, improved collaborative tools can be implemented to enhance the "Golden Hour" and provide better quality of care for troops on the battlefield.

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LIST OF ACRONYMS AND ABBREVIATIONS

AOR	Area of Responsibility
ATAK	Android Tactical Assault Kit
BATDOK	Battlefield Assisted Trauma Distributed Observation Kit
BUMED	Bureau of Medicine and Surgery
BUMEDINST	Bureau of Medicine and Surgery Instruction
CAC	Common Access Card
CERT	Community Emergency Response Team
COTS	Commercial Off the Shelf
COVID-19	Coronavirus 2019
DHA	Defense Health Agency
DODI	Department of Defense Instruction
DON	Department of the Navy
EHR	Electronic Health Record
FEMA	Federal Emergency Management Agency
GPS	Global Positioning System
HA/HR	Humanitarian Assistance/Disaster Relief
HAP	High Altitude Platform
HIPPA	Health Information Privacy and Portability Act
IT	Information Technology
KIA	Killed in Action
MANET	mobile ad hoc network
MEDEVAC	Medical Evacuation

MSCDOD	Department of Defense
MTF	Military Treatment Facility
NDAA	National Defense Authorization Act
PHEM	Public Health Emergency Management
SD	Systems Dynamics Theory
WMN	Wireless Mesh Network

ACKNOWLEDGMENTS

I, Kenneth, would like to thank God for having favor in me during my entire career. I am grateful for yet another opportunity to enhance myself. I thank my parents for instilling in me the love for people and the importance of education. I would like to thank my wife for loving and supporting me in everything I do. You are truly a "Good Thing" and a gift; I married up. This thesis is dedicated to my sons and daughter. The world you live in is much different than I remember at your age. Remember, whatever you do in life should always be centered around the love for God, your family, and everyone throughout this world. Each person you come into contact with gives you an opportunity to make a good, lasting impact on the world. I pray that I give you an example of a foundation to build your life upon … then make yourself better than me.

I, Christopher, would like to thank my wife for the love and support you provided during the past two years here at NPS. None of this would be possible without you, and I love and appreciate you. I would like to dedicate this thesis to my mother. Her will and drive taught me to always try to have a positive impact on our society, and I believe this research gives us an opportunity to do just that.

We would like to thank our professors here at NPS, our advisor Dr. Bordetsky, and our Program Advisor Mr. Glenn Cook. You all have made us better officers, students, and Sailors. To BUMED M4, CDR Seaman, CDR Lang, CDR Murriel, and the Patient Administration Officers who assisted us with this research, thank you!

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I. INTRODUCTION

The medical staff of the Department of Defense (DOD) is responsible effective, efficient, and quality care for over 10 million beneficiaries. They provide medical support during military operations and maintain the health of the troops who are part of the United States fighting forces. Because of the size, complexity, and mission associated with each branch of service, DOD allows each branch to have a medical service head. The Army, Navy, Air Force, and Public Health each have their own Surgeon General, who serves as the top-ranking officer for the medical department of those respective services. In 2013, under the National Defense Authorization Act (NDAA), the Defense Health Agency (DHA) was formed to streamline and coordinate medical services for DOD. Medical Evacuations from the battlefield have seen significant advances over the past 50 years; however, with the advancement in technology, such as enhanced collaborative tools, enroute care can improve and provide better quality of care for troops from the battlefield and from point-to-point care.

Additionally, the military has served as supplemental support for emergency response during disasters in the United States. Dynamics of disasters, emergencies, and warfare have turned anything, but conventional over the last 20 years. This change calls for a more efficient and effective process for emergency preparedness in DOD. Disasters are described as events that happen rarely, with the high potential for uncertainty and broad consequences. Responding to such events requires multiple entities that must communicate, collaborate, and make decisions that affect an entire population or populations. This type of collaboration includes multiple entities from different backgrounds, with different mission sets working together. The diverse backgrounds of abilities to respond contributes to the need for responding personnel to have all of the necessary resources available in real-time, to meet the goals of the emergency response system.

A. PURPOSE

This research will identify gaps and successes of organizational communication within the Department of Defense (DOD) during medical evacuations (MEDEVAC) from kinetic spaces, and with other federal agencies during emergency response under Emergency Preparedness using Information Technology (IT). An analysis of this communication will result in recommendations regarding lack of smooth collaboration and how these may be remedied. This thesis intends to utilize tools such as MAX.gov, created by Office of Management and Budget for purpose of collaboration between federal entities. Additionally, this thesis will incorporate tele-medicine tools to enhance the collaboration concept across the board. This thesis intends to recommend follow-on research that explores the environmental and organizational aspects of collaboration with the goal of implementing an improved design utilizing MAX.gov collaborative tools.

B. METHODOLOGY

The research will identify the need for a collaboration tool that can be utilized throughout DOD and other federal agencies in response to MEDEVACs, mass events, and emergency preparedness. The methodology for this research will consist of a tool developed within MAX.gov through system dynamics research model. Systems dynamic (SD) is a modeling tool that captures the reciprocal and temporal causal mechanisms that are captured in complex and dynamic systems (Fang, Lim, Qian, & Feng, 2018).

C. SCOPE AND LIMITATIONS

This thesis will identify the benefit a patient tracking collaboration tool will have on MEDEVAC and emergency preparedness throughout DOD and other federal agencies. Additionally, it will show the capability of this tool to share with civilian entities during a mass event or crisis. Due to current shelter-in-place protocols, research limitations for telemedicine will be limited including technical specifications from previous research completed in the field. All experiments were conducted via Patient Administration Officers from Military Treatment Facilities (MTF).

D. RESEARCH QUESTIONS

1. How is collaboration being executed from lower echelon to higher echelon levels?

2. How can tele-health be used to determine MEDEVAC treatment and final transport destination?

3. What communication/collaboration and policy gaps exist between DOD MEDEVAC communication, and DOD and Federal Agencies Emergency Preparedness Response Systems?

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II. BACKGROUND

A. INTRODUCTION

Disasters and attacks can be unpredictable in details, location, source, type, and severity. The branches of service in DOD all have separate missions and separate emergency response plans. Under DHA, collaboration amongst the medical departments of the services is the key element for success of all medical programs. The scope of emergency preparedness and management is no different. According to VanVactor in 2016, DOD cognizance within healthcare logistics should evolve concerning threats of national security caused by natural, technological, adversarial, and human-caused crises; with much attention given towards supply chain management's role in emergency preparedness response.

Section 214 of the E-Government Act of 2002 called for the Office of Management and Budget (OMB) to collaborate with the Federal Emergency Management Agency (FEMA) to ensure that information technology is looked upon as a possibility to enhance emergency preparedness and response (Rao, Eisenberg, & Schmitt, 2007). Information technology will be vital in connecting, informing, and saving the lives of populations that are affected. Sharing information such as the number of beds available, capabilities, supplies, and staffing is vital information that is needed during times of disasters. Each military facility should be able to look, in real-time, to see what each other facility's status is in case of an emergency. Through information technology, rescue missions can be coordinated, disaster areas can be examined, and facilities can be resupplied efficiently without any delay in treatment for patients. With real-time data sharing during disasters, emergency management and preparedness will take the extra step forward to disaster response.

B. MEDEVAC FROM THE BATTLEFIELD

In 2009, then Secretary of Defense Robert Gates, proposed and later mandated that all trauma related casualties are transported within one hour or less; the hour became known as the Golden Hour (Kotwal, Howard, & Orman, 2016). The same study showed fatality statistics rates prior to the Golden Hour were 16% killed in action (KIA) and 14% died after arriving at the closest MTF. After the implementation of the Golden Hour, those rates dropped to 10% KIA and 8% for transport to the nearest MTF. The statistics for casualties who died of wounds remained relatively unchanged at 4% (Kotwal, 2016). The study displays improvement from fatalities after the Golden Hour; however, MEDEVACs were still taking place after locating the closest MTF, usually via several phone calls or email.

A delay in evacuation, early mortality, and delayed access to definitive care increase the chances for permanent loss of limb and death on the battlefield. Modern combat has changed since the days of the Cold War, and are now common in urban arenas. The most common ways mortality data is recorded is in killed in action (KIA) and died of wounds (DOW). During the past 150 years, KIA data during battle has remained steady at 20%, from the Crimean War through the Afghanistan War with Russia (Kotwal, , 2016). Lessons learned from World War II converged into modern anesthetic, blood transfusion, antibiotics, and important policies concerning rapid evacuations to MTFs for critically wounded troops, greatly reduced the DOW rate to half of what the United States Army dealt with in early World War II (Kotwal, 2016).

The added complexity of urban warfare has increased the dangers and hardships of evacuation from the battlefield. Former Commandant of the Marine Corps, General Charles Krulac described urban conflict as a "three-block war, where we expect to be providing humanitarian assistance in one part of the city, conducting a peacekeeping operation in another and be fighting a lethal, medium intensity battle in yet a third part of the city" (Krulac, 1997). DOD has continued to improve and redesign the forward deployed medical system to adapt to this new austere environment over the past two decades. Military medicine developed the Forward Surgical Team, giving faster and closer surgical capabilities near the point-of injury; therefore, expanding the very important "Golden Hour" for injured casualties (Schauer, Naylor, Oliver, Maddry, & April, 2018). A study posted in The American Journal of Emergency Medicine shows data from the Joint Trauma System's (JTS) Department of Defense Trauma Registry (DoDTR) between January 2007 and August 2016 (Schauer, S. G.M 2018). The DoDTR is a web-based data collection tool designed to support performance improvement initiatives for combat casualty care (Registries, 2020).

The important fact for providing casualty care on the battlefield is to provide care as quickly as possible. It is a broad known fact that the main cause of death on the battlefield is hemorrhage. About one tenth of all deaths are caused by hemorrhage from an extremity that does not receive effective first aid on the battlefield (Kotwal, 2016). This research mentions studies that show constant loss of blood that does not receive immediate medical attention to the level of shock, may benefit from recovery methods that can extend the “Golden Hour” to a beyond a four window before advanced care can be provided (Kotwal, R.S., 2016). This is a good place to begin to insert telemedicine onto the battlefield in some form that will assist the Corpsman with providing high quality of care that is guided by a licensed provider not located on the battlefield or during evacuation.

C. DEPARTMENT OF DEFENSE EMERGENCY PREPAREDNESS

DOD takes the responsibility of responding to natural disasters, public health emergencies, and mass events that can occur on and off of military installations. Department of Defense Instruction (DODI) 6200.03, managed out of the Office of the Under Secretary of Defense for Personnel and Readiness, establishes the policy, responsibilities, and guidance for mission readiness during public health emergencies. Military commanders and commands must remain prepared and ready to protect the lives and property on installations at all times. Military commanders must also be ready to respond to the call for assistance outside of military installations, making timely decisions and expecting a level of uncertainty in their decision-making process. Figure 1 shows the decision-making process algorithm for circumstances surrounding a public health emergency (Department of Defense [DOD], 2019).

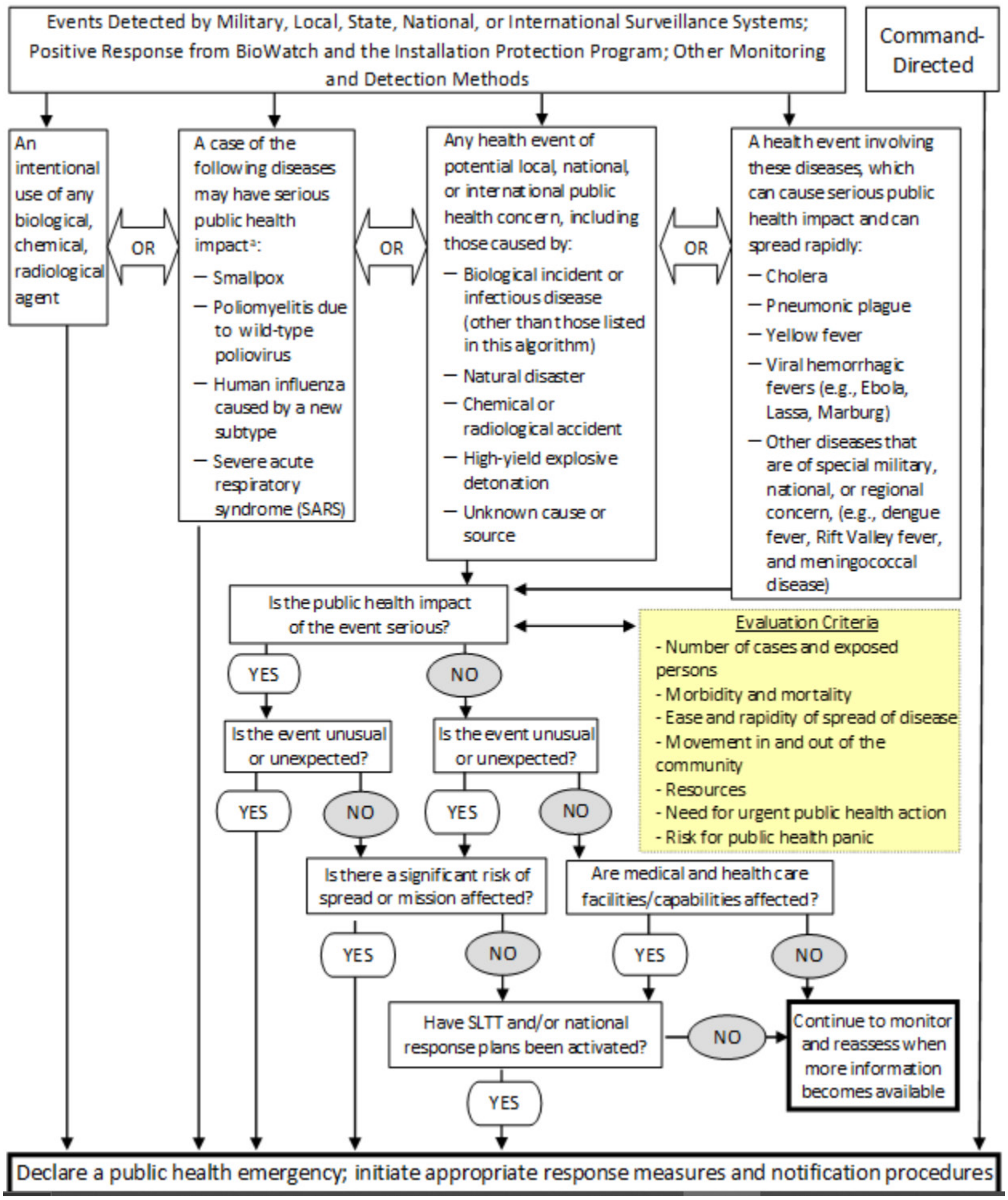

Figure 1. Public Health Emergency Decision Algorithm. Source: Office of the Under Secretary of Defense for Personnel and Readiness (DODI 6200.3) (2019).

D. FEDERAL AGENCIES EMERGENCY PREPAREDNESS

Federal policies only define the minimum requirements for emergency management. These policies are aligned with state and local laws, and include business continuity guidelines for critical infrastructure. FEMA's (Federal Emergency Management Agency) Community Emergency Response Team (CERT) program is designed to have volunteers from local areas organize themselves to provide immediate assistance to areas that may not receive federal aid quickly due to lost communications or an inability to travel (FEMA). FEMA is the federal agency responsible for coordinating the role of the federal government in emergency preparedness, response, and recover during disasters that affect the United States domestically. FEMA is part of the Department of Homeland Security, birthed after the terrorist attacks of 2001. FEMA not only has the responsibility for guidance during natural disasters, but also during man-made events such as terrorist attacks. The coordination of Department of Homeland Security and DOD is critical when the latter takes place, to share information regarding the lives and infrastructure that remains critical.

E. MAX.GOV COLLABORATION TOOL

Collaboration on the battleground and across federal agencies has been an outdated and cumbersome process. Currently, there is no single place for cross-agency collaboration between federal agencies, and medical evacuations from the battlefield happens in steps, instead of getting the patient to the type of immediate help that is sometimes required. There is not a single location which DOD and each federal agency can go or have access to for every essential member. Many commercial platforms are unavailable on federal systems due to security concerns, which causes cross-agency collaboration a very slow process.

After the Persian Gulf War, there were widespread complaints in DOD concerning the casualty evacuation system used to track and locate service members who had been evacuated to MTFs and other facilities (Erwin, S., 2003). The TRANSCOM Regulating and Command and Control Evacuation System (TRAC2ES) was developed to monitor the movement of casualties once they were outside of the combat zone, and to be compatible with the Defense Department's Global Transportation Network. TRAC2ES is a web tool that consists of a total of three systems, contracted by Booz Allen Hamilton, cost the government $109M (Pike, J., 1998). TRAC2ES is the current system used during patient transport by units tracking their MEDEVAC personnel who have left the AOR. TRAC2ES was developed to combine transportation, logistics, and clinical decision elements during patient movement into an automated information system. However, this system lacks real-time data updates and dependable clinical decision elements. Additionally, it does not give the transferring or accepting medical professionals control over the transport of the patient.

OMB created MAX to suit the expanded need for collaboration within the federal government: "MAX.gov (MAX) is a government-wide suite of advanced collaboration, information sharing, data collection, publishing, and authentication tools and services" (MAX.gov). Both FEMA and DOD have begun to utilize MAX.gov as a tool to connect entities within their own organizations. MAX is developed and maintained by the Office of Management and Budget, originally for budget formulation and execution within the federal government (MAX.gov, 2016). DOD, Department of Human and Health Services (HHS), Department of Homeland Security (DHS), Veterans Affairs (VA), and the Defense Health Agency (DHA) are currently some of the federal agencies utilizing the granular permissions of MAX that enables easy-to-manage access controls, which are highly customizable to fit their specific need and mission. FEMA currently uses MAX to maintain the National Business Emergency Operations Center (NBEOC), a virtual clearing house for information being shared by both public and private stakeholders for preparation, response, and recover from disasters (FEMA Fact Sheet). MAX offers both Common Card Access (CAC) access and login by username and password, allowing the system to be used in both DOD and public environments, as shown in Figure 2.

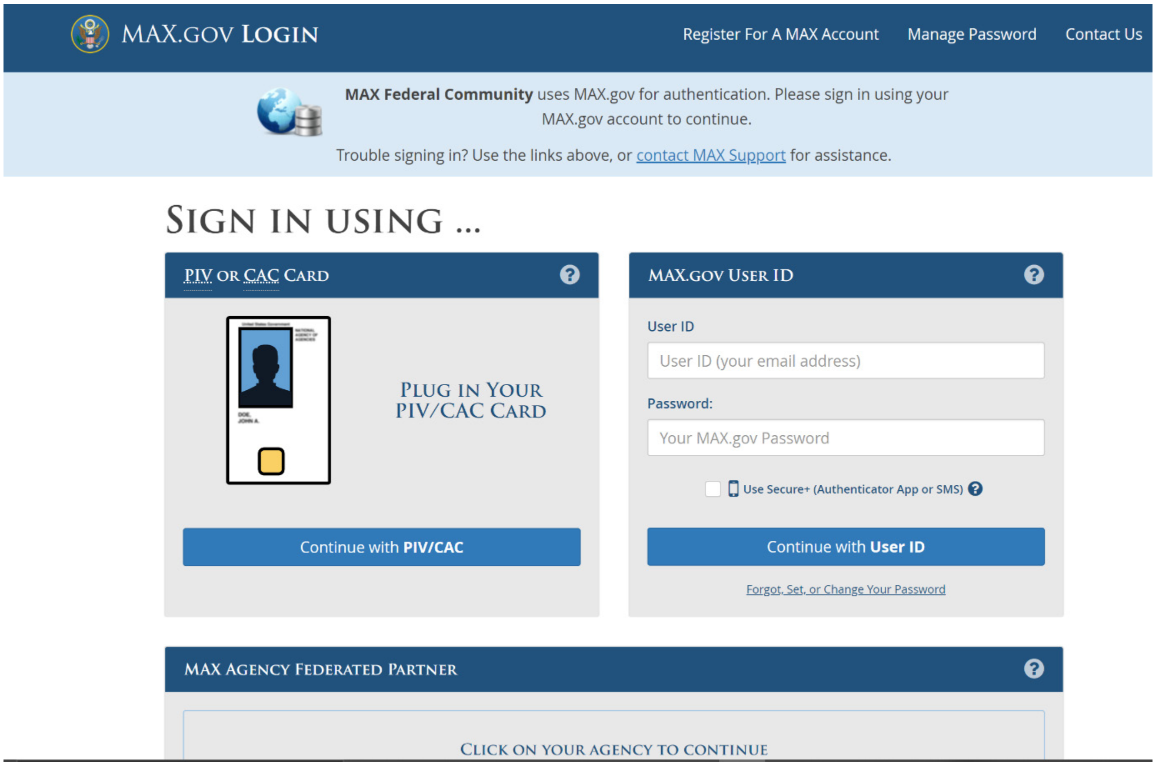

Figure 2. MAX.gov Login Homepage. Source: MAX at www.max.gov.

MAX has the unique capability to use satellite images, displaying real-time locations and AOR updates, thus being a good tool for enroute care. The interactive maps show federal treatment facilities, with the ability to show updates during disasters such as, earthquakes, fires, weather conditions, etc. Figure 3 displays the Navy Medicine Incident Command System Map, that include an option for updates from FEMA, U.S. Army, and U.S. Air Force, and airports throughout the country. This interactive map can be designed for use anywhere in the world, and to display all pertinent information necessary for patient transport and evacuation.

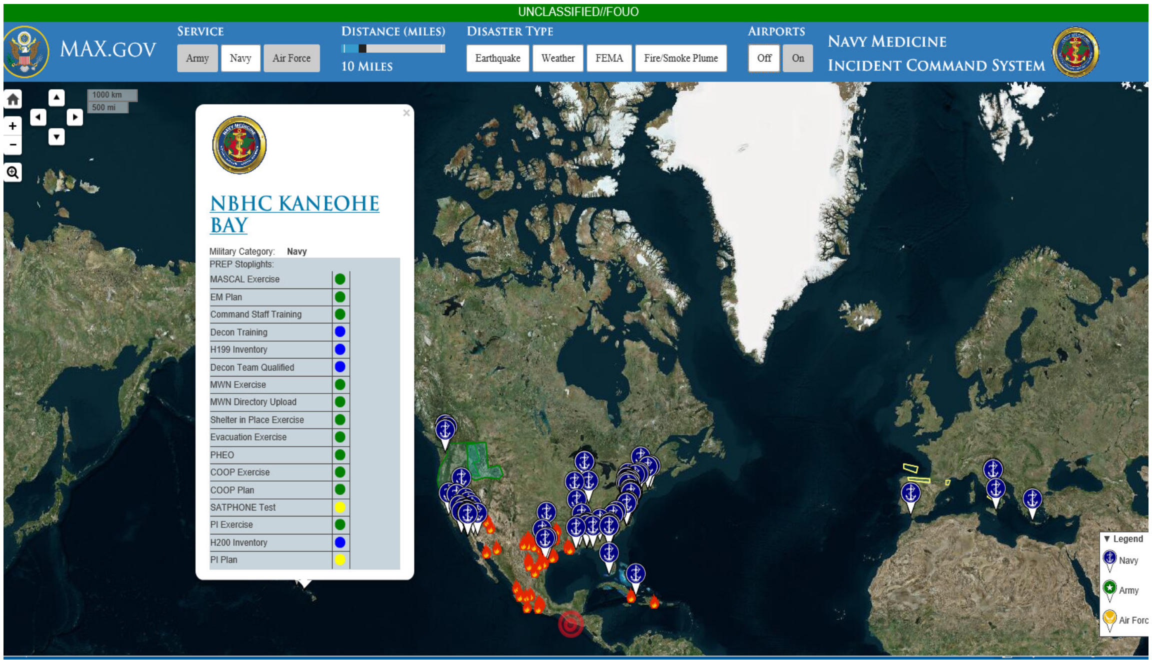

Figure 3. Navy Medicine Incident Command System Map. Source: Max.gov Website.

The Bureau of Medicine and Surgery (BUMED) Emergency Management Preparedness Division (EM) uses MAX to manage Navy Medicine's EM program. During the Coronavirus (COVID-19) pandemic, BUMED has used MAX to receive daily updates via its Portal for Readiness and Emergency Preparedness (PREP) community page to track data throughout Navy Medicine. The data is updated by each MTF and used to inform the Surgeon General on the Navy's COVID-19 readiness. The data collection status notifications in MAX allow each level of the Chain of Command to be notified at specific times when an item is "Green" (Ready), "Yellow" (Intermediate), and "Red" (Overdue). Figures 4 and 5 explains how this information is reported and read more thoroughly, providing the EM with a real-time status of readiness throughout the fleet without a spreadsheet or phone call. MAX offers real-time information that is well informed, allowing for good decision-making in critical areas, such as MEDEVAC and patient transport.

Operational Group	Capability	Functional Group	Requirements	Green	Yellow	Red	Blue	Reference
EM	Emergency Management Response	M&P	MTF EM plan is integrated with host installation mass casualty response plan (for tenant command MTFs) and contains Functional Response plans (1) MWN, (2) Shelter-in-place, and (3) Evacuation that meet the minimum requirements	MTF EM plan is integrated with host installation mass casualty response plan, if applicable, all 3 functional response plans meet minimum requirements, and has been reviewed in past 12 months	MTF EM plan is not integrated with host installation mass casualty response plan, if applicable, not all 3 functional response plans meet minimum requirements, or hasn't been reviewed in past 12 months	MTF does not have a signed EM plan	N/A	BUMEDINST 3440.10A, pg 4, Std 1

Figure 4. Interpreting the Data Dictionary. Source: Max.gov Website.

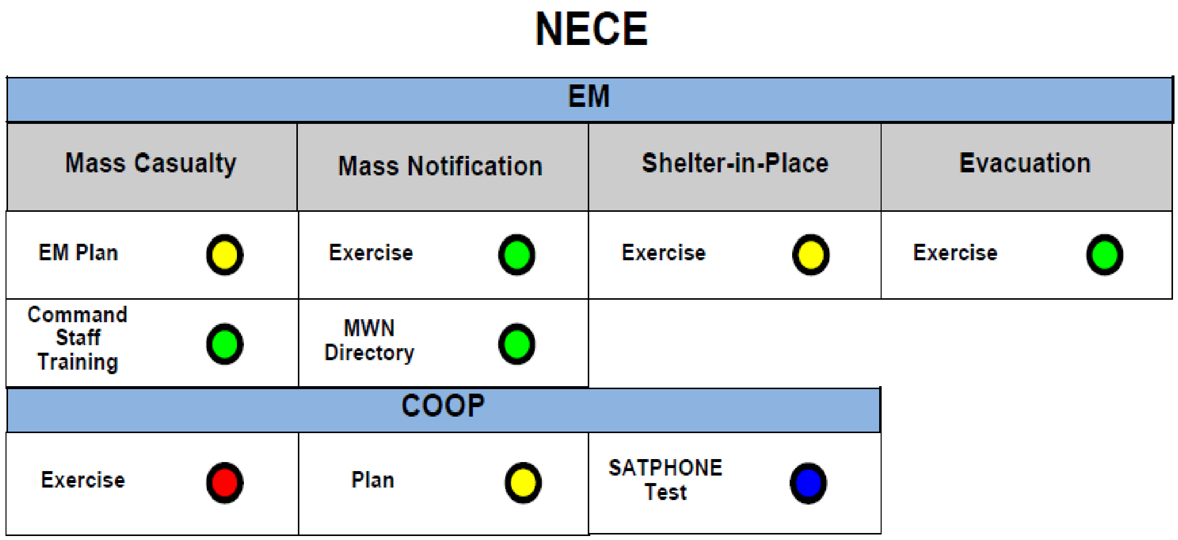

Figure 5. PREP Spotlight Readiness Report. Source: Max.gov Website.

F. TELEMEDICINE COLLABORATION

New technologies, such as telemedicine, have the ability to be incorporated into disaster response systems (Latifi, R., Doarn, C.R., Zoicas, C., Arafat, R. & Hostiuc, F., 2017). Telemedicine is an intelligent addition for responses such as pandemics and in rural areas that lack access to healthcare. Telemedicine provides communication technology with the ability to deliver economical and effective medical services from a far distance (Wang, S., Parsons, M., Stone-McLean, J., Rogers, P., Boyd, S., Hoover, K., Smith, A., 2017). This thesis will look into communication links for telemedicine during MEDEVACs, with high bandwidth reach back for instructions from voice, picture, video, and augmented reality. The United States Army began research into telemedicine during field operations, to give medical providers at MTFs a better idea of critical patient data for incoming patients (Medical Health Intelligence, 2018). This would also assist the Hospital Corpsman and Medic in the field with proper support that will extend the Golden Hour rule.

III. LITERATURE REVIEW

For the purposes of this thesis, the literature will address current and future needs for collaboration of Department of Defense medical evacuations, and with collaboration of the emergency management programs of other federal agencies. In order to bring together the different organizations to the point of collaboration, knowledge management, and information systems with regards to patient transport, we will conduct an integrative literature review of these topics. For our purposes, we will concentrate on how information technology and collaboration tools, such as Max.gov, can be applied in cross-agency and organizational communication.

We will start by looking at the improvements made regarding combat casualties. The Military Healthcare System has discovered innovative ways to attain the lowest combat death rate in U.S. history during the wars in Afghanistan and Iraq (Schauer, S. G.,2019). The battlefield environment has changed over the course of the last two decades, and the military has designed its system to fit this mold. The "Golden Hour" has been expanded with the extension of Surgical Teams closer to the battlefield and kinetic areas. But what happens if these areas are not available? What happens if the extension of that care can be pushed even farther through tele-medicine? Future disaster medicine outcomes can be improved based off lessons that have been learned from recent military and civilian studies conducted on telemedicine use during disaster response (Garshnek, V., & Burkle, Jr., F. M., 1999).

Prior to the wars in Iraq and Afghanistan, most combat related injuries were penetrating. During the course of the last 17 years, more blast injuries are being presented on the battlefield due to modern explosive devices being the desired choice of weaponry in those areas of the world. Combat trauma has unique considerations regarding such things as acute resuscitation, persistence of threat in a tactical environment, and resource constraints due to austere environments (Edwards, S., & Smith, J., 2016). Because of the capabilities and effectiveness of technologies in telemedicine, it should be implemented into disaster response (Latifi, R., 2017).

There have been an increase of mass events and medical emergencies around the world over the past 20 years. Currently, the world is adapting in response to the COVID-19 pandemic. Disasters have negatively impacted over 800 million people over the past two decades (Chan, T., Griswold, W., Killeen, J., Lenert, L., 2004). Connecting treatment MTFs around the world is more critical now than any other time in our history. There have been many new tools that have come of age during the rise of the current pandemic. While information technology has a history of assisting with tracking viruses and illnesses, having the ability to see resources available at different facilities would greatly assist medical professionals with decision-making life-saving measures.

Cross-agency collaboration has to be driven by leadership communication and understanding. Leaders must be able to actively listen and respect the qualities of each organization, to include differences in policy and culture. Public managers have to use their relationship skills and organizational structures effectively during cross-agency collaboration (Fountain, J. (2013). Cross-agency collaboration can allow for cost savings, reduction in redundancy, better efficiency with patient care, and a more effective medical outcome. Fountain states that cross-agency collaboration is not new to the federal government. Collaboration using information technology has been happening since the Clinton administration; however, with the advances made in recent years through information technology, enhancing disaster response can be happen using sites such as Max.gov.

Most cellular communication will crash in areas affected by a natural disaster. There are other options, such as the hybrid-MANET, which could be used in place of a traditional system (Verma, H., & Chauhan, N. 20,15). There are other challenges using advanced information technology close to a battle space. The two fundamental characteristics of wireless communication both present challenges in providing reliable and secure communication that are kept away from the adversary (Mukherjee, A., Fakoorian, S. A., Huang, J., & Swindlehurst, A. L., 2014). In this paper, we will look at the physical layer to ensure better security for troop movement, asset location, and safe patient care, in a possibly kinetic environment.

IV. METHODOLOGY

A. INTRODUCTION

Diesters during the past two decades have shown the grave need for patient tracking systems that are useable for multiple agencies and organizations to use. Even during this current time during the COVID-19 pandemic, the need for a stable and collaborative system has become important to families and facilities trying to keep track of patient movement when local hospitals have become overwhelmed with admissions. In a combat zone, lack of real-time patient tracking can cause operational and psychological stress for those involved and responsible for updating the Chain of Command with each patient movement.

MAX is the only true cross-agency, intergovernmental secure platform that can be used as a collaboration platform. MAX offers an entirely new way of working through analytics, report generation, and other secure services that is already owned by the government. MAX was designed in 2007 to solve the issue of needing to pass budget information back and forth securely between OMB and other federal agencies (Dronfiled, M., Nagl, L., Santoro, K., & Schoenbach, A., 2016). MAX uses a two-factor authentication, usually relying on the Common Access Card (CAC) and the Personal Identify Verification (PIV) cards that are issued to every federal employee to access computer networks on any federal system. MAX also has the ability to allow for non-federal employees to gain limited site access through sponsorships by other federal employees with access. Hence, it is a flexible and practical way to collaborate securely interagency and outside with local facilities during an emergency response.

Developers at OMB created the MAX Federal Community, the collaboration knowledge platform used inside of the site, on commercial web service called Confluence (Dronfiled, M., 2016). The main goal was the create an environment where government employees could securely collaborate cross-agency; however, the development team began to further customize the platform as user needs increased, and has expanded to include tools that allow for data to be collected, analyzed, and written into reports that can be shared throughout the federal government.

B. RESEARCH DESIGN

The DOD policy as outlined in DoDI 6000.11, states that a Patient Movement system will be established and maintained to safely transport uniformed service members who are casualties and other beneficiaries within and from a combat zone to appropriate level of care (Office of Under Secretary of Personnel and Readiness (DoDI 6000.11), 2018). The policy also states the same for DOD civilians and contract personnel who are supporting U.S forces in contingency operations. One of the key elements in transporting patients is to know and understand bed capacity at each facility. Each morning, BUMED requires MTF Commanders to report their bed capacity by 0900. This report is limited due to multiple issues, such as real-time updates since the report is sent in only once per day at 0900. The report is sent by each facility through a spreadsheet that has to be combined at each reporting level before a clearer picture is available to the Surgeon General. Due to limitations attributed to travel restrictions caused by COVID-19, this researcher developed a reporting mechanism in MAX to replace the current reporting solution.

BUMEDINST 6321.3B gives direction on reporting bed capacity to each MTF. Under the instruction, each MTF must maintain current statistics on bed capacity by room and medical service to provide accurate information to DOD (Bureau of Medicine and Surgery (BUMED), 2016). The policy calls for a comprehensive physical audit of the bed capacity that is similar to enclosure (2) of the instruction, which is included in Figure 6. The spreadsheet is set up by MTF, Navy Medicine East (NAVMED East) and Navy Medicine West (NAVMED West), and by location (CONUS and OCONUS). It provides an easy illustration of the bed capacity broken down at each facility.

NAVMED EAST						
FACILITY	STAFFED	UNSTAFFED*	EXPANDED	TOTAL	EXTERNAL	BASSINETS
CONUS						
NMC PORTSMOUTH						
NH JACKSONVILLE						
NH PENSACOLA						
NH BEAUFORT						
NH CAMP LEJEUNE						
FHCC GREAT LAKES						
SUBTOTAL						
OCONUS						
USNH GUANTANAMO BAY						
USNH NAPLES						
USNH ROTA						
USNH SIGONELLA						
SUBTOTAL						
TOTAL						

NAVMED WEST						
FACILITY	STAFFED	UNSTAFFED*	EXPANDED	TOTAL	EXTERNAL	BASSINETS
CONUS						
NMC SAN DIEGO						
NH BREMERTON						
NH CAMP PENDLETON						
NH OAK HARBOR						
NH 29 PALMS						
SUBTOTAL						
OCONUS						
USNH GUAM						
USNH OKINAWA						
USNH YOKOSUKA						
SUBTOTAL						
TOTAL						
GRAND TOTAL						

Figure 6. Example of Bed Capacity Report for BUMED. Source: BUMEDINST 6321.3B (2016)

C. DATA COLLECTION

Although this example provides a snapshot of the bed capacity for NAVMED East and West once per day, a tool showing data in real-time would improve this report, especially during a time of emergency response. A collaboration tool was setup in MAX, providing data in real-time, which could be updated after each admission with data ingest from the DOD Electronic Health Record (EHR), MHS Genesis. The page was created in MAX Community, and access given to Patient Administration Department Officers located at MTFs in the NAVMED West region. Figure 7 displays the community page, shows a detailed breakdown of each facility, structured by region, CONUS and OCONUS.

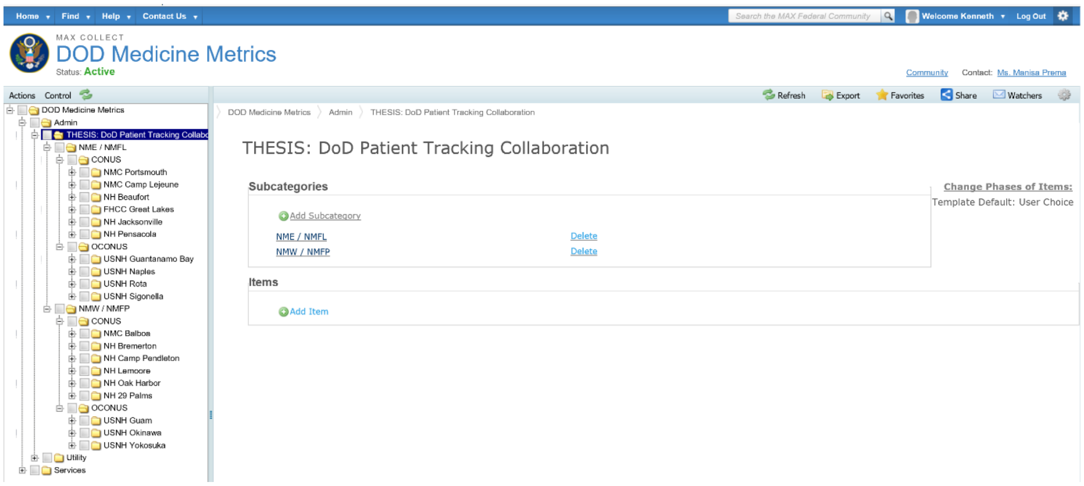

Figure 7. BUMED Patient Tracking and Bed Capacity Metrics. Source: Max.gov Website.

D. REAL-TIME ANALYSIS

Under this model, each PAD would have the ability to report bed capacity by occupied, staffed, and available, viewable not only by BUMED Headquarters, but also other MTFs throughout DOD. As a need for patient transport arises at a certain MTF, the PAD under direction of the Commander and medical provider, will request a bed within the specific medical service needed for the patient. The accepting MTF will receive a notification of the transfer request, and "Accept" or "Reject" within the collaboration tool. This research provided data input from two MTFs, with the data being updated in real-time throughout the day. This data, as seen in Figures 8 and 9, provided BUMED with accurate information for decision-making at the highest levels.

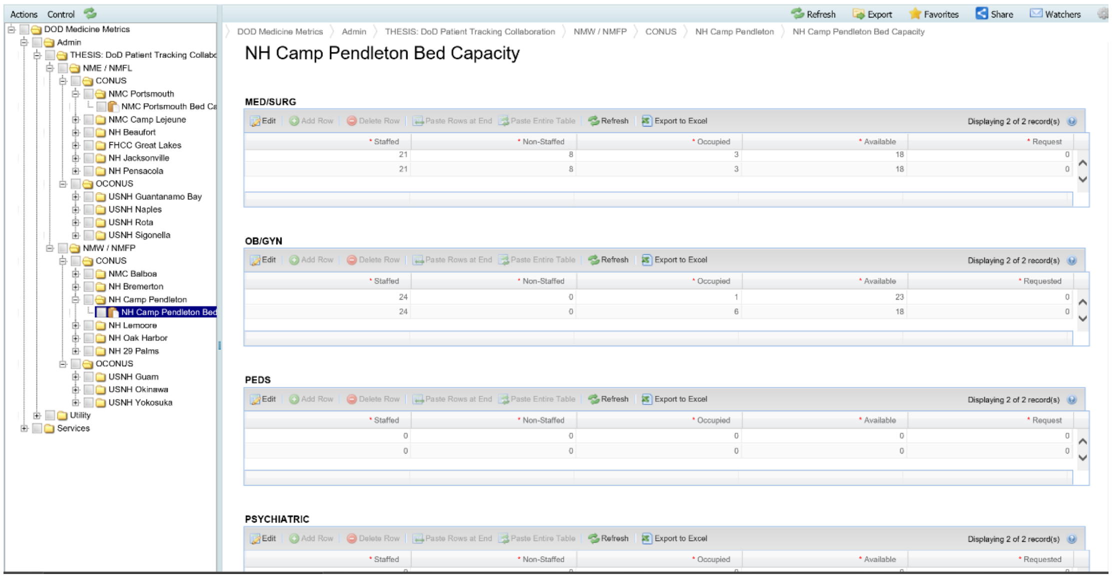

Figure 8. Naval Hospital Camp Pendleton Daily Bed Capacity Report. Source: MAX Community (https://www.max.gov).

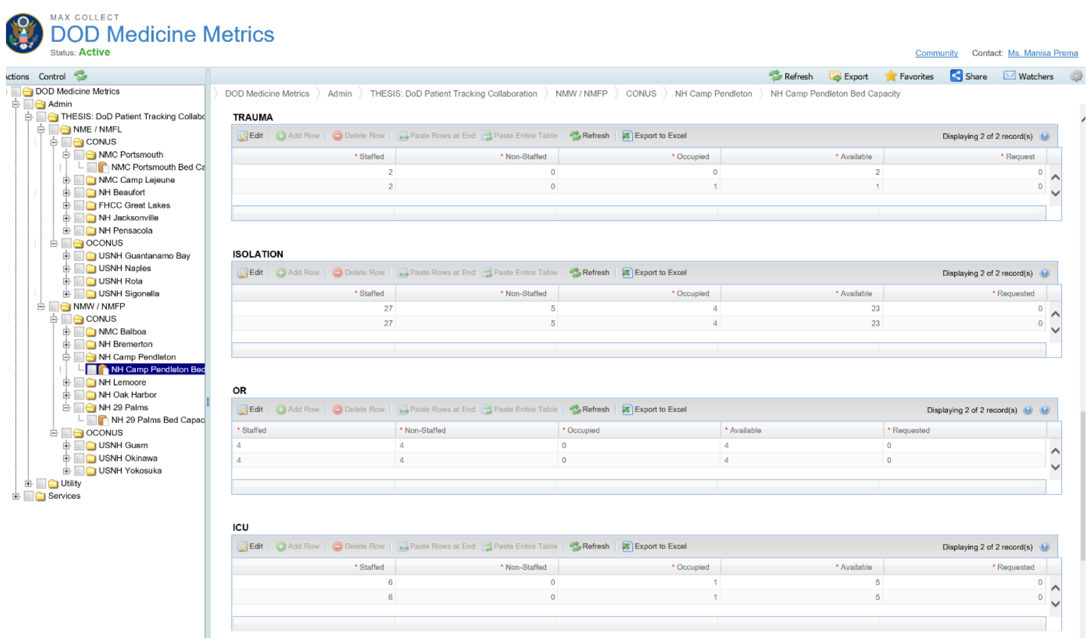

Figure 9. Naval Hospital 29 Palms Daily Bed Capacity Report. Source: MAX Community at www.max.gov.

Current patient tracking systems consists of phone calls from transferring facilities to receiving facilities to check real-time status of bed capacity, and service availability. The time between the combat injury and recovery is reversely related to the time that elapsed to control bleeding. In the same, extended MEDEVACs of critically injured troops present the same hazard (Gerhardt, R., Cap, A., Cestero, R., Dubick, M., Heiner, J., Koller, A., Army Inst Of Surgical Research Fort SAM Houston Tx., (2013). Hospital Corpsman are trained to ensure this happens on the battlefield in a combat zone, but the quick evacuation of casualties to the right MTF will vastly increase their survival rate. Likewise, during an emergency response at home, timely evacuations are vital to survival, which makes the case for efficient information. MAX collaboration provided the participating PAD Officers and BUMED with a tool that allowed them to make informed decisions, if necessary.

E. FEDERAL AGENCY COLLABORATION

While MAX offers one of the best solutions for cross-agency collaboration in the federal government, each agency has an intra-agency space and an interdepartmental space. This allows projects within that agency to only be accessible to its members, but still allow invites for those outside of the agency. This includes state and local government, non-profit organizations, and civilian partners (Dronfiled, 2016). The expansion of MAX has crossed into HHS, NASA, HUD, and 30 Indian tribes in the U.S.

F. TELEMEDICINE

Telemedicine has become a routinely used service in the U.S. healthcare system. Telemedicine has proven to be effective in rural areas, which present significant challenges "resulting from geographic, demographic, and socioeconomic factors" (Wang, 2017). From an economic standpoint, telemedicine is an effective way to deliver medical services over distance. and provides many advantages, such as improved access, improved continuity of care, and increased availability of patient information (Wang, 2017). This can be very useful during a patient transport.

Emergency responses to disasters now require use of information technology and telecommunication, and has proven to be effective. However, telemedicine has not been a frequent tool used during emergency response (Garshnek, V., 1999). DOD has done research on use of telemedicine on the battlefield, and have done testing during real and simulated civilian disaster response. The Battlefield Assisted Trauma Distributed Observation Kit (BATDOK) is designed to optimize delivery of care for causalities on the battlefield (*Journal of AHIMA*, 2017). BATDOK is a device mounted on the wrist of a military member, that runs off of an Android smartphone connected to wireless sensors that displays their health status (*Journal of AHIMA*, 2017). This tool enables the medical personnel on the battlefield to make life-saving decisions based upon immediate documentation on the patient's status in real-time.

This researcher was unable to test this device in the field with the MAX collaboration tool due to restrictions presented by COVID-19 pandemic; however, the plan for future research is to utilize a Mobile Ad Hoc Network (MANET), in combination with the first smart radio MPU5, to create secure networks for the critical data to transfer back to providers monitoring the system. The MPU5 is a smart radio, equipped with data, video, voice, and a fully integrated Android computer system (Persistent Systems, 2018). The MPU5 is able to create a powerful and secure network anywhere, and features interchangeable frequency module, to the multi-functional side connectors that are both IPv4 and IPv6 compatible. It is designed for extreme weather conditions and to work in the harshest environments, such as a battlefield, and has security with an integrated GPS (Persistent Systems, 2018). A MANET is the perfect solution for emergency response or in a combat zone hit area. In a MANET, mobile nodes are connected through Wi-Fi interface and connect directly to access points in the area (Verma, 2015). Most emergency response networks use the same features of cellular communication, which would work perfect with BATDOK's Android system. The Android device will be able to run the Android Tactical Assault Kit (ATAK) application with a medical plugin.

The combination of BATDOK and ATAK is used to provide the medical professionals update real-time data on ground personnel. In addition, using the goTenna Pro X for low-bandwidth, internal communications that is similar to how Special Operations Teams are currently using, will enhance the communication and telemedicine settings. goTenna advertises that up to 17 radios can be used on one MANET, while "every MPU5 on a Wave Relay network communicates with each other; forming a true peer-to-peer mobile network with no master node or base station" (GoTenna Mesh, 2019; Persistent Systems, 2018). It has a distance of 130 miles and is also a self-forming/healing network that can survive a failure in its transmission path. WIMAX could be used in a

Multi-Tier Architecture, that is used as an intermediate between Wi-Fi and satellite layers (Verma, H., 2015). WIMAX provides a range of about "seven miles, with high speed transmission of up to 63Mbps for downlink and 28Mbps for uplink" (Verma, 2015).

The high bandwidth reach back enables Telemedicine in the form of instructions from voice, picture, video, and up to augmented reality with a Halo Lens type aid. The MANET will feed back into the Tactical Operations Center (TOC), which is used to feed the medical information. Figure 10 shows a conceptual network diagram utilizing a High-Altitude Platform (HAP).

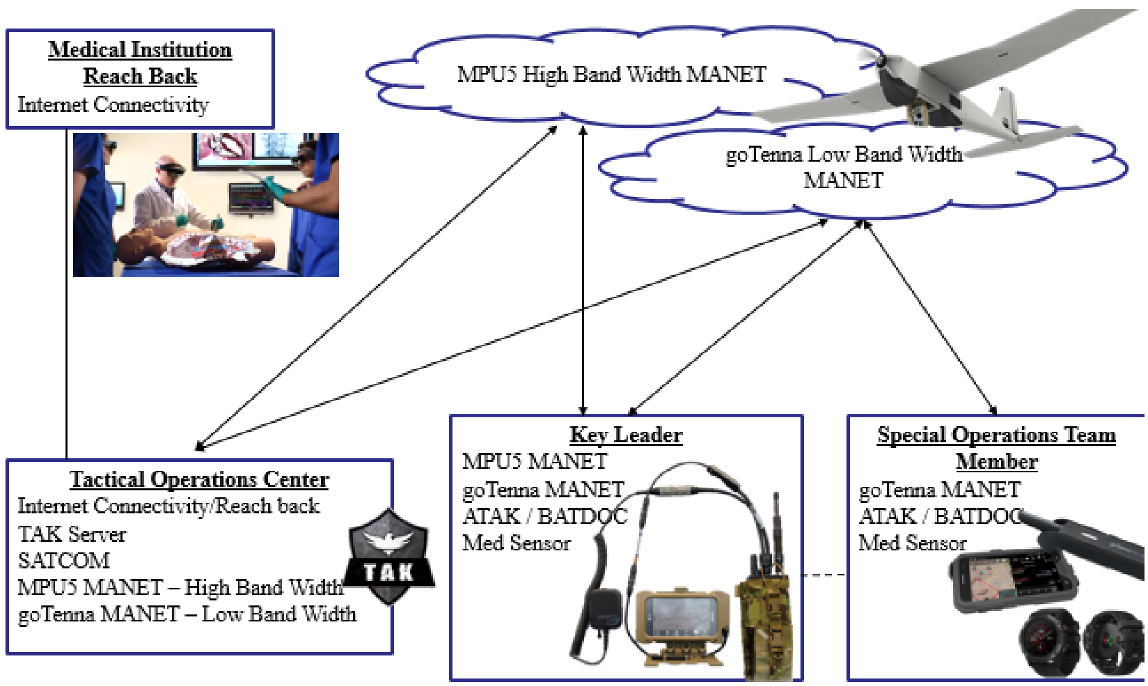

Figure 10. Optimized Battlefield Network. Adapted from GoTenna Mesh (2019); Persistent Systems (2018).

In a study done about the connectivity challenges of autonomous ships in austere environments, one of the main methods suggested for use are HAPs. HAPs can function less than 14 miles from the ground and cover smaller areas easier than satellites (Höyhtyä, Marko & Huusko, Jyrki & Kiviranta, Markku & Solberg, Kenneth & Rokka, Juha, 2017).

HAPs are also more simple and cheaper to deploy than launching a huge satellite into space, and can be accessible through 5G network (Höyhtyä, 2017).

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V. CONCLUSION AND FUTURE CONSIDERATIONS

Emergency response and MEDEVACs need tools that cross agency boundaries for effectiveness and collaboration. Patient tracking is one example of the widespread activities during an emergency response that involves multiple federal institutions. Collaboration also improves healthcare, by tying together other services such as telemedicine with the assistance of local and state efforts. Many other activities in this technological age should be able to go beyond telephones and email, while requiring better security. This is an in-house development that would save the government over $700 thousands in development costs, while costing around $46 thousands annually to maintain, as shown above in Figure 11 through calculation and design in Microsoft Project by this research team. In future research consideration, this team would like the opportunity to test the MAX collaboration tool with the added telemedicine piece during a MEDEVAC simulation.

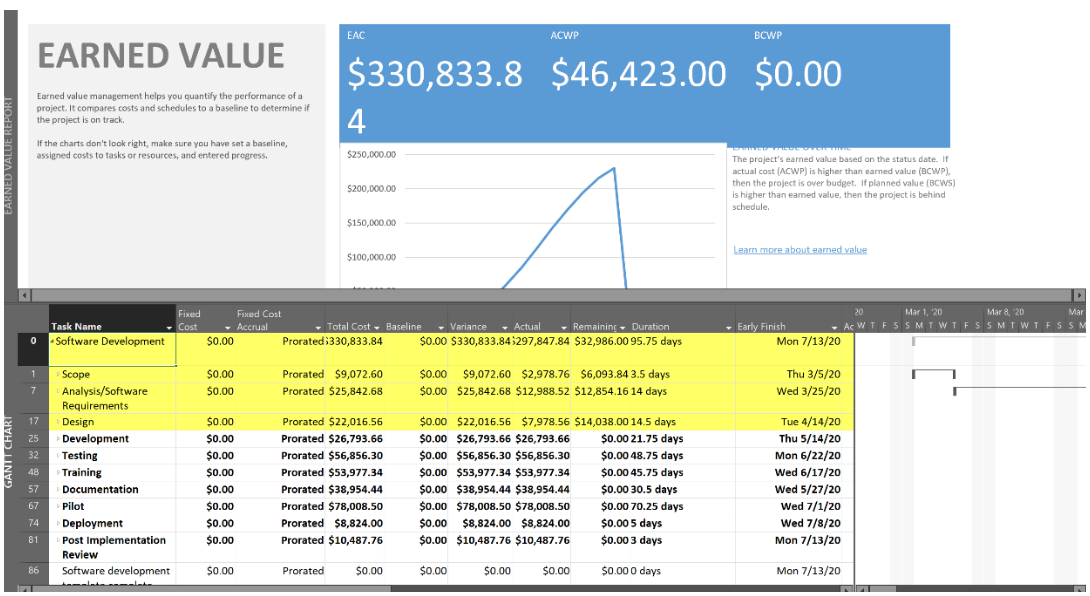

Figure 11. Collaboration Project Budget Breakdown. Adapted from OPM at www.opm.gov (2020).

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