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The Future of Small Navy Ship Sickbays and Army Aeromedical Evacuation Aircraft

10 December 2014

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THE FUTURE OF SMALL NAVY SHIP SICKBAYS AND ARMY AEROMEDICAL EVACUATION AIRCRAFT

ABSTRACT

The Office of the Chief of Naval Operations commissioned a study to investigate the future configuration of Navy ship sickbays. Due to space constraints, sickbay capabilities are limited. Similarly, Army aeromedical evacuation helicopters have limited space to treat patients. This joint study explores how to best utilize advanced medical technologies in the sickbay of the future for the Navy's cruiser, littoral combat ship, and mine countermeasure ship and Army aeromedical evacuation platforms.

This study assesses the current portable medical technologies in the selected Navy ship authorized medical allowance lists to support the force health protection functions. The study also evaluates portable medical devices in Army aeromedical evacuation medical equipment sets. Collectively, capability gaps are identified and serve as the baseline for recommending future medical technologies.

This study recommends medical devices with the potential to advance patient care and proposes significant investments in bandwidth, network, and infrastructure. Smart technologies will be important in space-constrained medical environments; however, organizational restructuring and policy change is required to address the root cause of outdated medical systems. This study also recommends more inter-service collaboration, the establishment of an aeromedical evacuation program of record, and the utilization of open systems architecture for procuring future medical devices.

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Air Ambulance
AMAL	Authorized Medical Allowance List
ACP	Army Campaign Plan
AE	Aeromedical Evacuation
AE2C2VS	Army AE En route Critical Care Validation Study
AHLTA-Mobile	Armed Forces Health Longitudinal Technology Application–Mobile
AIREVAC	Air Evacuation
AMEDD	Army Medical Department
AMEDDC&S	Army Medical Department Center and School
AMOGS	Advanced Medical Oxygen Generating System
ASIOE	Associated Support Items of Equipment
ASPG	Army Strategic Planning Guidance
ASI	Additional Skill Identifier
AVN	Aviation
BBP	Better Buying Power
CALAB	Council of Aeromedical Logistics, Acquisition, and Budget
CC-NRP	Critical Care National Registry of Paramedics
CCATT	Critical Care Air Transport Team
CBA	Capabilities-Based Assessment
CDD	Capability Development Document
CPD	Capability Production Document
CPR	Cardiopulmonary resuscitation
CCEMT–P	Critical Care Emergency Medical Technician–Paramedic
CONUS	Continental United States
COTS	Commercial Off-the-Shelf
CG	Cruiser
CRH	Combat Rescue Helicopter
CSL	Centralized Selection List

DA	Department of the Army
DAMO	Director of Army Aviation
DASC	Department of the Army Systems Coordinator
DCDD	Directorate of Combat and Doctrine Development
DFSS	Design for Six Sigma
DHA	Defense Health Agency
DMMPO	Defense Medical Materiel Program Office
DOD	Department of Defense
DOORS	Data Object Oriented Repository System
DOTmLPF-P	Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities, and Policy
DS	Direct Support
ECCN	En route Critical Care Nurse
FVL	Future Vertical Lift
GS	General Support
EMI	Electromagnetic Interference
EMT-B	Emergency Medical Treatment–Basic
ERCS	En Route Care System
FHP	Force Health Protection
HEMS	Helicopter Emergency Medical Services
HH	Hospital Helicopter
HSM	Helicopter Maritime Strike
ICD	Initial Capabilities Document
ICDT	Integrated Capabilities Development Team
IMMSS	Interim MEDEVAC Mission Support System
IMPACCT	Improved MEDEVAC Paramedic and Critical Care Transport
IPAT	Integrated Process Action Team
ISR	Intelligence, Surveillance, and Reconnaissance
JCIDS	Joint Capabilities Integration and Development System
JECC	Joint En Route Care Course
JPOC	Joint Product of Choice

JTS	Joint Trauma System
JTR	Joint Trauma Registry
JUMC	Joint Unmanned Casualty Evacuation Capability
KPP	Key Performance Parameters
IPT	Integrated Product Team
LCS	Littoral Combat Ship
LIW	Logistics Information Warehouse
MCM	Mine countermeasures Ship
M-MEP	Medical Mission Equipment Package
MEDEVAC	Medical Evacuation
MEDSILS	Medical Services Information Logistics System
MEPD	Medical Evacuation Proponency Directorate
MEP	Mission Equipment Package
MES	Medical Equipment Set
MMB	Medical Materiel Branch
MMESO	Medical Materiel Enterprise Standardization Offices
MN (P)	Material Need–Production
MNS	Mission Need Statement
MRMC	Medical Research and Material Command
MTF	Medical Treatment Facility
MTOE	Modified Table of Organization and Equipment
NEHSS	Naval Expeditionary Health Service Support
NHRC	Naval Health Research Command
NMLC	Naval Medical Logistics Command
PEO	Program Executive Officer
PHS	Patient Handling System
PM	Program Manager
PM-MSS	Product Manager–Medical Support Systems Project Management Office
PM ISS	Patient Movement Integrated Support Systems
PPBE	Planning, Programming, Budgeting & Execution

OCONUS	Outside the Contiguous United States
OIF	Operation Iraqi Freedom
OEF	Operation Enduring Freedom
ORD	Operational Requirements Document
OTSG	Office of the Surgeon General
OUSD AT&L	Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics
P3I	Preplanned Product Improvement
PEO	Program Executive Office
POI	Point of Injury
POM	Program Objective Memorandum
PD MEDEVAC	Product Directorate Medical Evacuation
PjM MEDEVAC (MEP)	Project Manager MEDEVAC (Mission Equipment Package)
PMO	Project Management Office
PR	Pararescue
QFD	Quality Function Deployment
ROC	Required Operational Capabilities
RDT&E	Research, Development, Test, and Evaluation
SAME	Standard Advanced MEDEVAC Equipment
SECDEF	Secretary of Defense
SKO	Sets Kits Outfits
SMEED	Special Medical Emergency Evacuation Device
TATRC	Telemedicine and Advanced Technology Research Center
TCM-L	TRADOC Capability Manager for Lift
TOE	Table of Organization and Equipment
TRADOC	Training and Doctrine Command
TRANSCOM	Transportation Command
TRL	Technology Readiness Level
TSG	The Surgeon General
UA	Unit Assemblage
UAL	Unit Assemblage List

USAARL	U.S. Army Aeromedical Research Laboratory
USAMMA	U.S. Army Medical Materiel Agency
USAMMDA	U.S. Army Medical Material Development Activity
USAMRMC	U.S. Army Medical Research and Material Command
USASAM	U.S. Army School of Aviation Medicine
USFFC	United States Fleet Forces Command
UH	Utility Helicopter
VCSA	Vice Chief of Staff of the Army
WBB	Whitney, Bradley, and Brown Incorporated

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I. INTRODUCTION

In fall 2013, the Chief of Naval Operations (CNO) commissioned a study to investigate the "sickbay of the future" onboard small naval vessels. Due to space constraints on small navy ships, sickbay capabilities are limited. Similarly, U.S. Army aeromedical evacuation (AE) helicopters have limited space to treat patients. In an effort to reach the Army surgeon general's goal to increase the patient survivability rate from 91 percent to 95 percent by the year 2020, several key stakeholders in the Army Medical Department (AMEDD) are researching new evacuation platforms, medical equipment, and a mission equipment package (MEP) that leverages advanced portable and modular medical technologies (Medical Evacuation Proponency Directorate [MEPD], 2014a, p. 7). This study examines advanced medical technologies and recommends medical devices for use in small Navy ship sickbays and AE aircraft in the next 15 to 20 years.

This study is significant because the Army and Navy are trying to solve a similar problem, deciding what future medical technologies will provide the best medical capability in confined spaces for future operations. The current fiscal environment necessitates joint and interoperable medical equipment solutions for the future of military medicine. Standardization will minimize redundancies, maximize the efficient use of resources, reduce costs, solidify "jointness," and enhance the overall quality of care provided to patients.

The benefit of this dual service study is that it leverages research and resources available from both the Army and Navy. This joint air and sea study has many synergies that make it more beneficial than a single service study. At the core of Army and Navy medicine, there is a shared purpose in providing world-class medical care to enable warfighters to accomplish their missions. Working together to identify and develop medical equipment solutions for the future will allow both services to more effectively address user needs, reduce equipment redundancies and costs, and ensure inter-service compatibility of medical technologies. This analysis seeks to find joint portable medical solutions with a common interface, so that in the future, there is a seamless transfer of medical information throughout the continuum of care.

A. PURPOSE

The purpose of this study is to examine how medical technologies are utilized on small Navy ships and Army medical evacuation aircraft for delivering optimum health care. A current capability-based review was conducted that qualitatively assessed medical technologies and equipment on these platforms. This study gathers information from a comprehensive analysis conducted on the authorized medical allowance lists (AMAL) for afloat platforms, empirical data, and an analysis of the Army's medical equipment set (MES) to determine how new technologies can advance the medical capabilities of both the surface and air platforms in the specified time frame.

The ultimate objective of this study is to provide the Office of the Chief of Naval Operations (OPNAV) and the Army Medical Department (AMEDD) recommendations for implementing advanced medical technologies in small Navy ships and AE aircraft of the future.

B. BACKGROUND

Readiness, value, and jointness are the defined strategies of Navy medicine that enable the delivery of world-class care anytime and anywhere, operating across the Navy's platform spectrum of operations. The strategy supports the Navy's mission: "to maintain, train and equip combat-ready naval forces capable of winning wars, deterring aggression and maintaining freedom of the seas," and to provide world-class healthcare across the spectrum of operations (Bureau of Medicine and Surgery, 2014, p.4).

Navy Medicine's strategy enables the tenets of the CNO through the provision of the highest quality of care to our sailors and ensures a healthy and fit force ready to accomplish the Navy's mission. Force Health Protection (FHP) is the core of Navy Medicine that defines the capabilities to sustain a healthy and fit force. The required operational capabilities (ROC) for Navy ships imbeds FHP functions as a secondary warfare mission area to meet the overall objectives of the Navy and Navy medicine.

The Army Medicine 2020 Campaign Plan (AM 2020 CP) states the AMEDD uses three strategic imperatives or lines of effort to accomplish its mission: create capacity, enhance diplomacy, and improve stamina (MEPD, 2014a, p. 3). The campaign plan states

the mission of Army Medicine is to "[provide] responsive and reliable health services and Health to improve readiness, save lives and advance wellness in support of the Force, Military Families and all those entrusted to our care" (MEPD, 2014a, p. 6). The AM 2020 CP operationalizes the vision and strategic imperatives of the AMEDD to "transform from a healthcare system to a System for Health…[and]…lead the nation in health" (MEPD, 2014a, p. 7). Within the AM 2020 CP, three lines of effort are used to achieve the Army surgeon general's end-state: "A System for Health that enables Ready and Resilient Soldiers, Families and Communities in order to prevent, shape and win" (AMEDD, 2013, p. 7). The AM 2020 CP supports the mission of the Army and is synchronized with the Army's Ready and Resilient Campaign Plan. Just as the AM 2020 CP supports the Army Campaign Plan (ACP), the Aeromedical Evacuation 2020 Campaign Plan (AE 2020 CP) aligns with the DOD Defense Planning Guide, the Army Strategic Planning Guidance (ASPG), the ACP, the AM 2020 CP, and the Army Aviation Campaign Plan (AMEDD, 2013, p. 3). The end-state of the Army AE 2020 CP is that "Army AE maintains America's trust as an adaptable, capable, expeditionary, and ready force multiplier that enables the combatant commander the ability to respond, prevent, shape, and win while maintaining a 95% patient survival rate" (AMEDD, 2013, p. 6). This project seeks medical technologies that will contribute in achieving the Surgeon General's survivability goal and revolutionizing the equipment in the sickbay of the future to meet the needs of the 21st century warfighter.

C. SMALL NAVY SHIP SELECTION

The cruiser (CG), littoral combat ship (LCS), and mine countermeasure ship (MCM) are the selected small Navy ships for our study to assess the respective sickbay capabilities. The mission and projected operating environment (POE) of these vessels are different as they operate in independent environments, and as integral elements of an expeditionary strike group (ESG), carrier strike group (CSG) or surface action group (SAG) respectively. Figures 1 and 2 show the selected ships.

Figure 1. Ticonderoga Class Guided Missile Cruiser (CG-47) Ship (from IHS Jane's, 2014a)

Figure 2. Freedom Class Littoral Combat (LCS) Ship (from IHS Jane's, 2014b)

Figure 3. Avenger Class Mine Countermeasures Ship (from IHS Jane's, 2014c)

D. ARMY AEROMEDICAL EVACUATION HELICOPTERS

The DOD uses the intra- and inter-theater AE systems to evacuate patients to the appropriate level of care. According to DOD Directive 5100.01 and Joint Publication (JP) 3–17, intra-theater AE is a secretary of defense (SECDEF) directed Army mission conducted "within a theater of operation with assets assigned to a geographic combatant commander or attached to a subordinate joint force commander" (DOD, 2010, p. 30, GL-10). Inter-theater AE is a U.S. Transportation Command (USTRANSCOM) mission accomplished by the Air Force (AMEDD, 2013, p. 3). JP 3–17 defines inter-theater AE as "the common-user airlift linking theaters to the continental United States and to other theaters as well as the airlift within the continental United States" (p. GL-10). Our study focuses on the medical equipment configuration of the Army's combat and contingency environment AE platform of choice, the H-60 Black Hawk, and its permissive environment AE helicopter, the UH-72A Lakota (see Figure 6). Currently, the Army uses four Black Hawk configurations (UH-60A, UH-60L, HH-60L, and HH-60M) to conduct the MEDEVAC mission (see Figures 4 and 5).

Figure 4. UH-60 A/L Black Hawk (from Anderson, 2013)

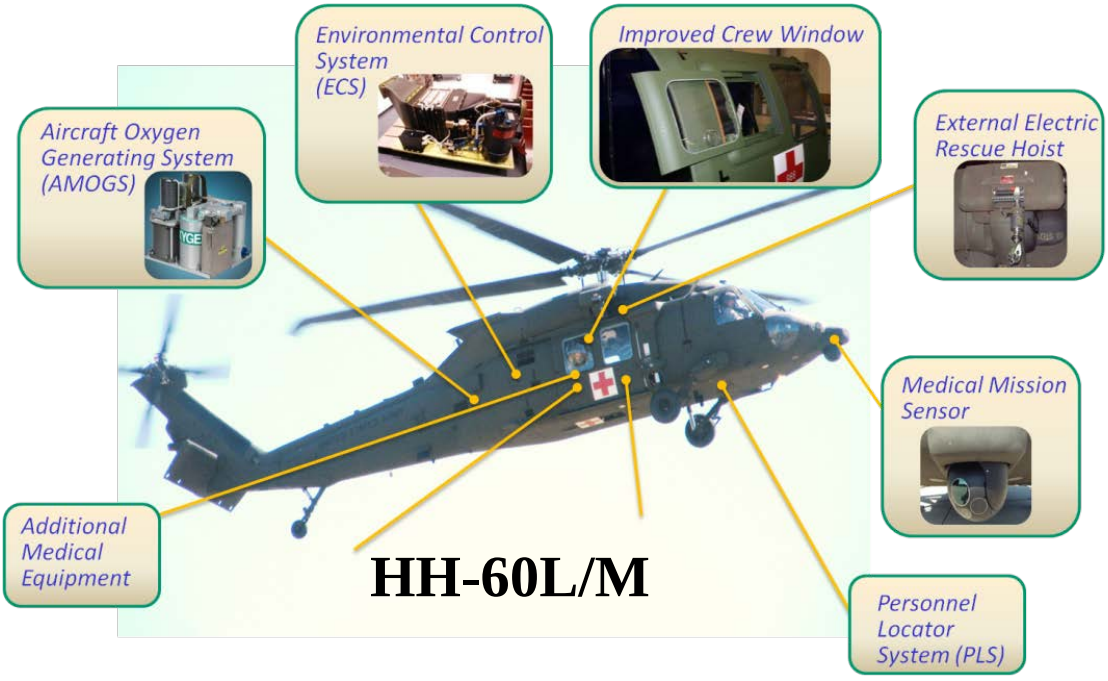

Figure 5. HH-60 L/M Black Hawk (from Anderson, 2013)

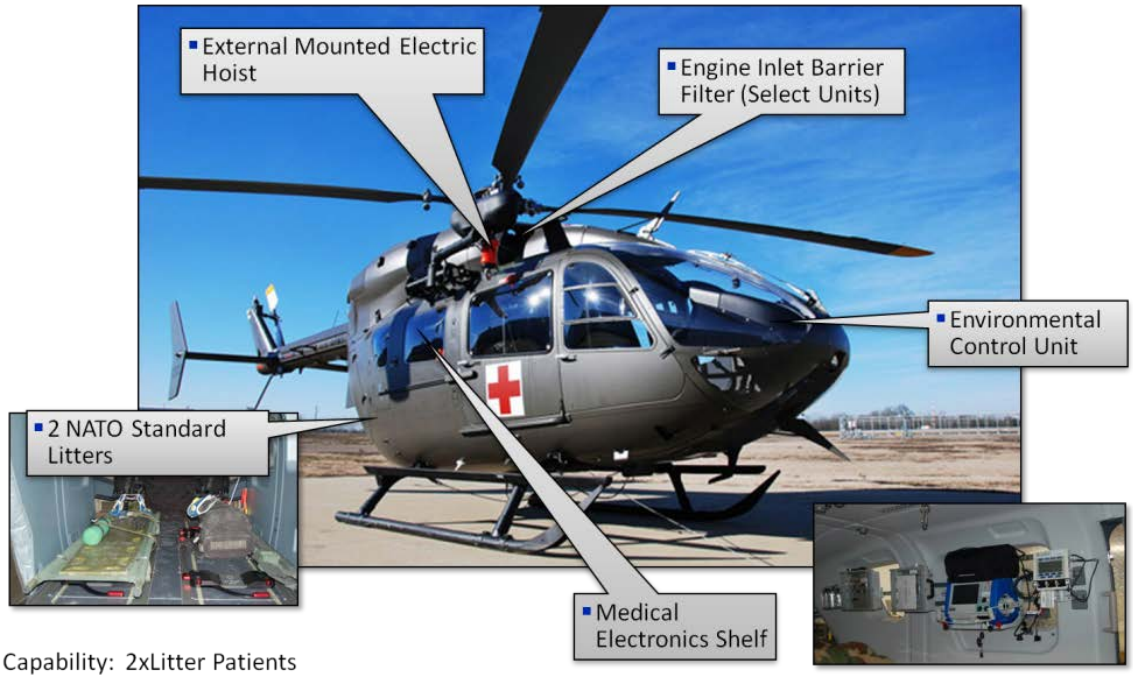

Figure 6. UH-72A Lakota (from Anderson, 2013)

E. ORGANIZATION OF STUDY

In this study, we assess the future of small Navy ship sickbays and Army AE helicopters. Chapter II presents a comprehensive literature review that discusses medical equipment in an aviation environment, FHP requirements for the selected ships, the authorized medical allowance list and Army AE portable medical technology. In Chapter III, we explain the methods employed to conduct the study; in Chapter IV, we assess portable medical technologies of the Army AE aircraft and the selected small Navy ships. Chapter V provides an assessment of future medical equipment technologies. Lastly, Chapter VI provides conclusions, recommendations, and areas for future research.

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II. LITERATURE REVIEW

A. MEDICAL EQUIPMENT IN AN AVIATION ENVIRONMENT

This section discusses the history and evolution of medical equipment in the helicopter aviation environment from the first aeromedical evacuation until the present day. It lays the foundation for a comprehensive review of literature about the use of medical devices on helicopters and small Navy ships. It shows how this study fits into the larger body of knowledge, and provides a framework for demonstrating the importance of this project (Creswell, 2008, p. 25). In order to make relevant and credible recommendations for future medical devices, this study includes a thorough analysis from a historical perspective to benefit from lessons learned.

1. The Beginning of Aeromedical Evacuation

Evacuating the wounded by air began shortly before the invention of fixed-wing flight. The first AEs took place during the Franco–Prussian War of 1870–1871 in the German siege of Paris when observation balloons were flown out of the city with 160 casualties (Dorland & Nanney, 1982, p. 6). In 1910, seven years after the Wright brothers flew the first airplane, two U.S. Army medical officers named Captain George Gosman and Lieutenant A. L. Rhodes used their personal money to design, build, and fly the world's first air ambulance at Fort Barrancas, FL (Hurd, Jernigan, & Carlton, 2002, p. 6). Despite the success of this initial test flight, air medical evacuation was not adopted as a means of moving patients until World War I.

2. World War I

In 1918, the French modified a Dorland II fixed-wing aircraft and specifically equipped it for patient movement (Hurd et al., 2002, p. 6). However, the U.S. military found its aircraft fuselages were too small for moving stretchers. As a result, the U.S. Army Medical Corps primarily used aircraft for moving surgeons to the battlefield to assist in evacuating patients by ground transportation (Hurd et al., 2002, p. 6). After World War I, the U.S. Army realized that there was a need for evacuating patients, so a

Curtiss JN-4 biplane was converted into an ambulance by modifying the rear cockpit seat to hold an Army litter (see Figure 7). For the first time, the Army was able to move patients by air.

Note. The Curtiss JN-4 *Jenny* was transformed into an air ambulance by removing the rear seat

Figure 7. The Curtiss JN-4 *Jenny* (from Hurd et al., 2002, p. 7)

3. World War II

During World War II, airplanes had a more critical role in transporting patients. At one point, the Army Air Force was evacuating almost 100,000 patients per month and in 1945, set an AE record of 4,704 patients in a day (Hurd et al., 2002, p. 9). As technology progressed and airplanes became more reliable, military leaders gained confidence in aeromedical evacuation as a safe, viable, and effective manner to move service members away from forward-deployed hospitals. In 1945, General Dwight D. Eisenhower stated, “We evacuated almost everyone from our forward hospitals by air, and it has unquestionably saved hundreds of lives—thousands of lives” (Hurd et al., 2002, p. 9).

In World War II, aviation revolutionized the way the sick and wounded were moved from the battlefield, and it significantly increased service members' chances of surviving. During this era, the first medical air ambulance squadrons were established, which ushered in the age of dedicated AE assets. According to Hurd et al. (2002), "By the end of the War, [the risk of death during AE] was only 1.5 of every 100,000 patients. AE was listed along with antibiotics and blood products as among the most important medical advances in decreasing the mortality rate associated with warfare" (p. 9). As the face of patient evacuation changed during the war, a new service emerged that would have a critical role in transforming the system. In 1947, the U.S. Air Force was established, and two years later, it was given the role of providing inter-theater AE for the entire U.S. military (Hurd et al., 2002, p. 9; USTRANSCOM, 2013, p. GL-10). Toward the end of World War II, the U.S. Army began using helicopters for medical evacuation. In 1944, Lt. Carter Harmon performed the U.S. Army's first helicopter medical evacuation (MEDEVAC) mission in Burma with the first litter-bearing Sikorsky R-4, as shown in Figure 8 (Dorland & Nanney, p. 9).

Figure 8. World War II R-4 Helicopter (from Whitcomb, 2011, p. 7)

4. The Korean War

During the Korean War, the AE system saw many advances in technology that further increased the chances of survival for the wounded. One of the more influential advances came with the Bell H-13 Sioux helicopter, which evacuated most of the 17,700 casualties moved by helicopter during the war (Dorland & Nanney, 1982, p. 11). Although the medical technologies and mechanisms available for providing care were very basic at the time, the pilots and medical personnel were remarkable at improvising and using all available resources. For example, Colonel James M. Brown, commander of the 8036d Mobile Surgical Hospital, came up with a way for the single H-13 pilots to deliver transfusions of plasma or whole blood while in flight (Dorland & Nanney, 1982, p. 16). The lessons learned from Korea were largely responsible for many of the policies and standard operating procedures that still exist today. The Korean War reinforced the need for dedicated air evacuation assets with the personnel, equipment, and training to conduct en route patient care. The Korean War gave senior military leaders a better understanding of the importance and lifesaving potential of AE.

5. Vietnam

Perhaps the most influential conflict for AE was Vietnam. Men like Major Charles L. Kelley, Patrick Brady, Mike Novosel, and many other pilots of the UH-1 Iroquois, or “Huey” (see Figure 9), have gone down in history as symbols of the legacy and tradition that was built through service members who were willing to sacrifice their lives in service to their country (Whitcomb, 2011, p. 56). These men “proved through their actions that no, aeromedical evacuation was really a medical operation which entails the use of aircraft” (Ginn, 1997, p. 322; Whitcomb, 2011, p. 56).

Figure 9. The UH-1 Huey (from Hurd et al., 2002, p. 29)

The lessons learned during this conflict greatly shaped the AE mission and the way en route patient care is provided today. For the first time, MEDEVAC helicopters were used to conduct hoist missions, and medical personnel provided care to the wounded from the point of injury until they reached the next level of care. The surge of medical technology innovation that followed the Vietnam War laid the path for a mission that has increased a patient's chances of survival from 68 percent in World War II to just under 92 percent today (MEPD, 2013, p. 4).

6. Operation Iraqi Freedom and Operation Enduring Freedom

The wars in Iraq and Afghanistan have greatly expedited the medical technology landscape. Giant leaps forward in the world of innovative medical technologies have been realized through lessons learned from more than 13 years of persistent conflict. Lenhart, Savitsky, and Eastridge (2012) noted,

> In Vietnam, transporting an injured casualty back to the United States typically took well over a month. With the advancements in aeromedical transport in OEF and OIF, most casualties reach Germany or the United States within 36 hours of injury. (p. 21)

Today the Army continues to build on these advancements as the Medical Evacuation Proponency Directorate (MEPD) and Training and Doctrine Command (TRADOC) Capability Manager–Lift (TCM–Lift) translate the lessons learned from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) into requirements documents. Obtaining these requirements documents will be crucial to Product Directorate MEDEVAC (PD MEDEVAC), Project Manager MEDEVAC Mission Equipment Package (PjM MEDEVAC MEP), U.S. Army Medical Material Agency (USAMMA), and U.S. Army Medical Material Development Activity (USAMMDA) developing future material solutions for Army Medicine and the MEDEVAC mission.

B. FORCE HEALTH PROTECTION REQUIREMENTS FOR THE SELECTED SMALL NAVY SHIPS

The CNO designates Force Health Protection (FHP) as a secondary warfare area in support of the warfighting mission of a Navy ship. The FHP requirement for the cruiser (CG), littoral combat ship (LCS), and mine countermeasures ship (MCM) define the medical capabilities of these platforms and medical services delivered. Appendices A, B, and C outline the FHP requirements for theses naval vessels in accordance with the Chief of Naval Operations Instruction (OPNAVINST) 3501 series on the required operational capabilities (ROC) for these classes of ships.

C. AUTHORIZED MEDICAL ALLOWANCE LIST

The authorized medical allowance list (AMAL) determines the minimum maintenance quantity of medical equipment and consumables for the Navy fleet and Fleet Marine Force (FMF). The authorized quantities for the line items must support 60 days of supply to perform the ROC of a ship, submarine, squadron or FMF unit. The supply source for the AMAL is the federal supply system (DON, 1993). The Naval Medical Logistics Command (NMLC), designated by United States Fleet Forces Command (USFFC), executes the management of the AMAL in support of Naval Operating Forces worldwide and the procurement support for the Shipboard Equipment Replacement Program (SERP) among its vital mission functions (DON, 2012).

The changes of AMAL items that impact ship services (water, electrical, or sewage), weight, and storage requirements require approval from the Naval Sea Systems Command (NAVSEASYSCOM) due to the physical space constraints and power capacity—among other constraints—on a Navy vessel, in particular the smaller ships. The change request must also include the size requirements (weight and cube), quantity, and justification. The approval of AMAL/ADAL revisions is executed by the chief Bureau of Medicine and Surgery (BUMED) prior to the fleet distribution (DON, 1993). The Navy Assemblage Information Logistics System (NAILS) is the web application used to access the AMAL assemblage and provides current and historical AMAL information for the Navy operational platforms. The portable medical equipment technologies for Navy ships are contained within the AMAL equipment and consumables assemblage. Appendix D displays the AMAL equipment category containing the portable medical technologies for the CG, LCS, and MCM.

D. AIR AMBULANCE MEDICAL EQUIPMENT SET

The air ambulance (AA) medical equipment set (MES) is the standard set of medical equipment issued to AA units. The AA MES line item number (LIN) is M29213 and its unit assemblage Code (UAC) is UA257B. The basis of issue is one MES per aircraft. The list is managed by the U.S. Army Medical Materiel Agency (USAMMA) at Ft. Detrick, MD and is available on the USAMMA Medical Services Information Logistics System (MEDSILS) webpage (USAMMA, 2014). The full MES 2010 UA list with pictures and a component hand-receipt are also available on the Logistics Information Warehouse (LIW) medical sets, kits, and outfits (SKO) webpage. A list of the MES 2010 durable and non-expendable items is provided in Appendix E.

The MES includes all durable medical equipment such as the ventilator, intravenous infusion pump, defibrillator, and vital signs monitor. It also includes expendable items such as gauze, bandages, and tape to provide limited resupply to the combat medic. The assemblage functional description states the “set contains medical supplies and equipment to treat, sustain and prepare casualties/patients for aeromedical evacuation…[and] contains medical materiel for the intended initial 72 hours of sustained

combat operation" (USAMMA, 2014b). Since this study focuses on providing recommendations for future medical devices for sickbays and helicopters, emphasis will be placed on evaluating the current status of MES AA portable medical electronic devices in Chapter IV. In order to provide relevant recommendations for future medical devices, it is important to first address current capability gaps and redundancies in both the MES and AMAL.

Since aeromedical assets sometimes have medical systems like oxygen generation and suction integrated into the airframe, it is important to review literature regarding requirements, capabilities, and limitations of the aircraft and medical devices. The following section provides an overview of Army AE requirements development and discusses and the current status of Army AE in the acquisition system. It also summarizes several studies aimed at improving en route care and addresses some of the inherent challenges of treating patients in a helicopter environment.

E. REQUIREMENTS FOR MEDEVAC HELICOPTERS AND MEDICAL EQUIPMENT

Army MEDEVAC helicopters and onboard medical equipment are procured through the Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System, which "[transforms] validated capability requirements into material capability solutions" (DAU, 2014). The Acquisition System is one of three major DOD processes and decision support systems the AMEDD, in coordination with Program Executive Office (PEO) Aviation, leverages to ensure the right capabilities are delivered to the warfighter. As shown in figure 10, the Defense Acquisition University (2014) states,

> JCIDS (capability requirements and non-materiel solutions), Defense Acquisition System (materiel solutions), and PPBE (resources) are three key processes in DOD which must work in concert to ensure consistent decision making while delivering timely and cost effective capability solutions to the warfighters.

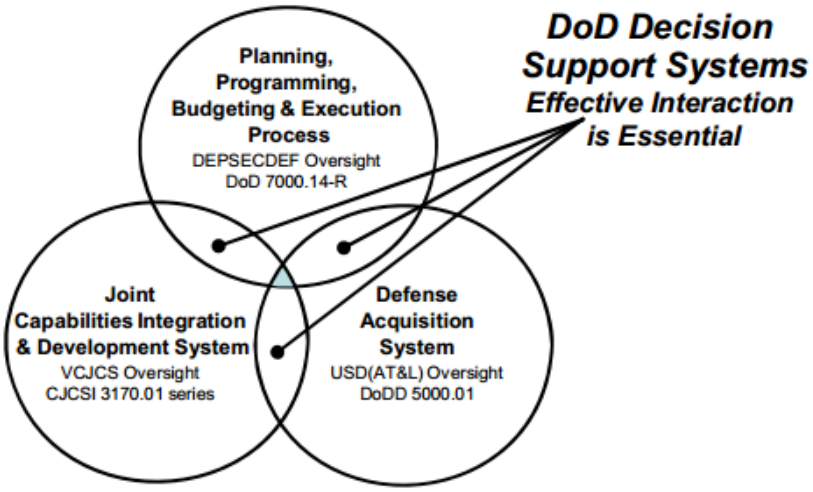

Figure 10. Three Major Decision Support Systems (from Defense Acquisition University [DAU], 2010)

Since the first requirements for AE helicopters were written, capability developers and acquisition professionals have had the challenge of integrating medical capabilities into aviation assets to perform a medical mission. These challenges were exacerbated by the fact that until recently, the AMEDD did not have Acquisition trained officers to influence requirements for AE systems from within PEO AVN. The absence of acquisition trained officers with backgrounds in aviation and medicine placed AE at a disadvantage when competing for resources (MEPD, 2014a, p. 21). Without the proper training, officers would be unprepared to effectively interact with TCM-L, the Utility Program manager, and manage requirements in the Data Object Oriented Repository System (DOORS).

Since AE represents one third of the utility fleet, the Army began to train and educate officers in acquisition to ensure "AMEDD requirements are adequately documented, funded, and resourced" (MEPD, 2014a, p. 21). As the AMEDD and PEO Aviation move forward in developing a shared capabilities development and integration plan, growing acquisition experts within the AE community who can articulate MEDEVAC capability needs will be vital. The *Aeromedical Evacuation Campaign Plan 2020* outlines the current status of AE in the JCIDS process (MEPD, 2014c):

> No formal JCIDS requirements documents exist which define the aircraft or MEP requirements for AE platforms. All of the current requirements were generated prior to formalizing the JCIDS process and have not been converted or officially 'grandfathered'. This creates funding challenges within the POM process and difficulties in changing or updating specific requirements. Given the ambiguity of the VCSA Charter with respect to specific capabilities development responsibilities, and the absence of a shared (Aviation/Medical) formal capabilities development and integration plan, AE requirements have not been captured within any formal JCIDS documents (e.g., Capability Development Document (CDD), Capability Production Document (CPD)) and a clearly defined process for shared capability development does not exist. As a result, AE capability development and improvement remains complicated and problematic. Preplanned Product Improvement (P3I) responsibilities and the conduct of RDT&E remain ad hoc and apportioned without an approved process and JCIDS reference documents. An IPAT has been directed within the AE ICDT to conduct a Capability Based Assessment (CBA) that will be developed before December 2014. This CBA will drive the development of the Initial Capabilities Document (ICD), which in turn will drive a CDD. Upon approval, this will establish a program of record with entry at Milestone B. (p. 14)

Establishing a MEDEVAC product office was a critical step toward ensuring AE crewmembers and the warfighter continue to have the best equipment possible for evacuating the wounded. APM MEDEVAC was established in 2007, a few years after the UH-60 A&L Product Office was stood up in October 2004 (Bledsoe, 2013). Then in 2012, Product Directorate MEDEVAC was created, bringing MEDEVAC a step closer to attaining autonomous funding capabilities (D.W. Creech, personal communication, June 19, 2014). As the Acquisition, JCIDS, and PPBE processes have evolved through the years, many questions have been raised about funding and budget responsibilities between the AMEDD and Army Aviation. The AMEDD has been trying to modernize its AE Black Hawks, which are some of the oldest in the Army fleet according to Whitcomb (2011, p. 232). However, the AMEDD has struggled with upgrading its MEDEVAC helicopters because they have had to compete for resources within the aviation community, which does not share the mission and vision of the AMEDD. Many of these funding and budget questions were addressed in a recent update of the *Army Medical Material Acquisition Policy* (AR 40–60), which the *AE Campaign Plan 2020* summarizes:

> Revisions to AR 40–60 clarify funding and budgetary responsibilities between the AMEDD and Army Aviation. In short, Medical Research and Materiel Command (MRMC) are responsible for medical materiel development while Program Executive Office (PEO) Aviation is responsible for integration (as per VCSA Charter). Procurement responsibilities vary but essentially, procurement within a production MEDEVAC aircraft is the responsibility of the AMEDD through PEO Aviation while procurement of Mission Equipment Package (MEP) items for use in non-production MEDEVAC aircraft is the responsibility of MEDCOM through the MRMC. (HQDA, 2014a)

The clarification of funding and budgetary responsibilities published in AR 40–60 have been crucial to the current effort in updating requirements for MEDEVAC aircraft and its medical equipment and systems. The Army Aviation procurement strategy for utility helicopters has been another challenge for Army AE. Similar in some respects to the DOD's F-35 program, the Army has used one program and one platform to fulfill multiple mission requirements. The Army has experienced great success using utility helicopters for medical purposes; however, recent lessons learned from the F-35 program suggest another procurement strategy might be more effective. Although using a common medium lift platform may seem to make more sense from a logistics perspective (e.g., personnel costs, training costs, spare parts and supply chain management costs), a panel of acquisition experts advising the Army future vertical lift (FVL) initiative submitted that "split[ting] [a] program into manageable pieces … [and] "developing a different aircraft for each set of mission requirement[s]" may be a better solution than trying to meet everyone's needs with a "single mega-program" (Freedberg, 2014a). Establishing a MEDEVAC program of record would split the PM-Utility office into more manageable pieces and enable the AMEDD, in cooperation with PEO Aviation to more effectively develop systems that meet user's needs.

A review of current acquisition trends and initiatives confirms that a MEDEVAC program of record would be in line with the strategic goals of the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD [AT&L]). A MEDEVAC program of record would match strategic acquisition goals because this "split-approach" would enable a program manager to more effectively address the diverse requirements of the mission (Freedberg, 2014a). Medical helicopters have different

requirements than standard utility helicopters used for moving soldiers and equipment. A MEDEVAC program manager that is familiar with the medical mission and how medical systems and devices integrate is critical to managing a program to meet cost, schedule, and performance objectives.

A MEDEVAC program of record with an acquisition trained aeromedical evacuation PM would also align with OUSD (AT&L) strategic objectives because she could effectively "employ a modular open systems approach to design for affordable change, enable evolutionary acquisition, and rapidly field affordable systems that are interoperable" (OUSD[AT&L], 2013, p. 79). An acquisition officer with a medical and aviation background would be best suited for this position because she has a thorough understanding of how the aircraft interfaces with medical systems. An AE acquisition officer is also knowledgeable about what systems need to be interoperable and how to integrate medical systems in an aviation environment. Implementing common standards in software and product interfaces requires an intimate knowledge of both medical and aviation systems.

As shown in Figure 11, open architecture has many benefits and has been very successful in the personal computer industry and in some DOD systems such as the Virginia class submarine program (GAO, 2013, p. 10). Additionally, the GAO (2014) reported the Air Force's Military Global Positioning System User Equipment and KC-46 Tanker Modernization program's use of open systems architecture (OSA) and effective management of technical data rights resulted in increased competition and reduced costs over the program's life cycle (p.25). Open systems architecture is also a key tenet of the Better Buying Power 3.0 initiative to "Incentivize Innovation in Industry and Government" (DOD, 2014, p.6). This initiative emphasizes the importance of ensuring our systems are "modular" and that the "government is in a position to control all the relevant interfaces so that competitors have the opportunity [to] win their way into our programs" (DOD, 2014, p. 6). In considering all the benefits of the open systems approach, it is highly advisable this method is used even if it is not possible to establish a MEDEVAC program of record. Unfortunately, this approach might not be possible as a

product office within the Utility Helicopter Project Office unless PEO Aviation adopts open system architecture as an organization.

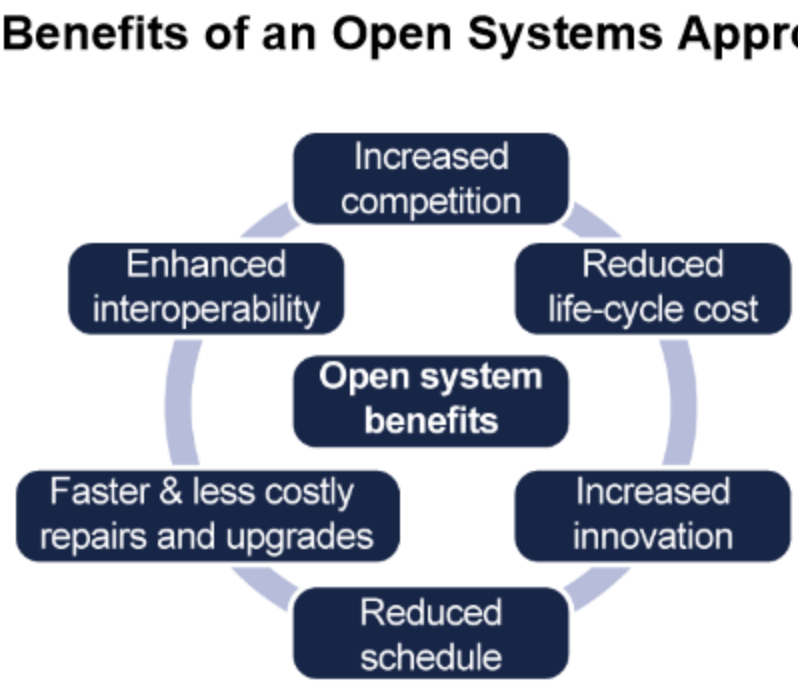

Figure 11. Benefits of an Open Systems Approach (from Government Accountability Office [GAO], 2013, p. 2)

Another unfortunate reality of acquisition reform and adopting new acquisition strategies is that the military has a history of what some, in the organizational behavior field of study, might call a "strong culture" that has become a "barrier to change" (Robbins & Judge, 2012, p. 222). Such was the frustration of former Secretary of Defense Robert Gates (2014) when he wrote,

> The difficulty in getting the Pentagon to focus on the wars we were in and to support the commanders and the troops in the fight left a very bad taste in my mouth. People at lower levels had good ideas, but they had an impossible task in breaking through the bureaucracy, being heard, and being taken seriously. The military too often stifled younger officers, and sometimes more senior ones, who challenged current practices. In a speech I gave to Air Force personnel a few days after I established the ISR task force, I made it clear that I encouraged cultural change in the services, unorthodox thinking, and respectful dissent. I spoke of earlier Air Force reformers and the institutional hostility and bureaucratic resistance they

> had faced. I asked the midlevel officers in the audience to rethink how their service was organized, manned, and equipped. I repeated my concern that "our services are still not moving aggressively in wartime to provide resources needed now on the battlefield." In a line about ISR that I penciled in on my way to the speech, I said, "Because people were stuck in old ways of doing business, it's been like pulling teeth."… In order to succeed in the asymmetric battlefields of the twenty-first century—the dominant combat environment in the decades to come, in my view—our Army will require leaders of uncommon agility, resourcefulness, and imagination; leaders willing and able to think and act creatively and decisively in a different kind of world, in a different kind of conflict than we have prepared for for the last six decades. … One thing will remain the same. We will still need men and women in uniform to call things as they see them and tell their subordinates and superiors alike what they need to hear, not what they want to hear. … If as an officer—listen to me very carefully—if as an officer you don't tell blunt truths or create an environment where candor is encouraged, then you've done yourself and the institution a disservice. (p. 133)

Overcoming cultural barriers to change in the DOD acquisition system will require strong leadership with the technical expertise and experience required to manage complex systems and develop lean processes for fielding equipment when it is needed on the battlefield. To succeed, the acquisition community must become an "incubator of leadership" (Kotter, 2012, p. 174). In other words, the organization needs to place its leaders in positions of responsibility and encourage them to lead so they can learn and reach their full potential.

In addition to leadership development, leading experts in organizational change Kotter and Schlesinger (2008) proposed that successful organizational change efforts always involve a skillful application of a number of strategies that are tailored to the types of resistance (p. 132). Therefore, skilled acquisition leaders with various approaches to manage resistance to change can break through the strong cultural barriers present in the DOD. Kotter (2007) also noted that successful change processes go through a series of phases that usually require a significant amount of time and any mistake along the way can have a devastating impact on the change effort (p. 97). If acquisition leaders are familiar with Kotter's change process stages and understand the importance of not skipping steps, they will be more effective at leading programs in a rapidly changing world. Unfortunately, even the most capable Army and Navy leaders armed with the right

knowledge and experience can only be so effective with multiple layers of bureaucracy above them.

Currently, the product office for the 592 Black Hawk MEDEVAC fleet competes for resources within the Utility Helicopter Project Office. The AMEDD and Army Aviation have a shared responsibility to provide helicopters to accomplish the AE medical mission. According to Whitcomb, modernization of the Active Army MEDEVAC fleet has also been difficult because newly procured aircraft have sometimes been diverted to Army National Guard (ARNG) units due to the legislative earmarks of senators (2011, p. 232). While procurement of MEDEVAC helicopters for ARNG units has been a vital asset to the war on terror, it has also impeded modernization of the active duty fleet.

Adding to the complexity of aviation medical materiel procurement, MEDEVAC units are provided Medical Equipment Sets through PM Medical Support Systems (USAMMDA) and PM Medical Devices (USAMMA) at Fort Detrick, MD (see Appendices E and F). The medical evacuation package, a group of subsystems and equipment for AE helicopters, is managed by the PjM MEDEVAC MEP (USAMMA). According to the USAMMA webpage, PjM MEDEDEVAC MEP was established in 2010 after "the Office of the Surgeon General (OTSG) of the Army directed the Medical Research and Materiel Command (MRMC) to become the funding source for a Project Management Office dedicated to management of the mission equipment package for MEDEVAC" (USAMMA, 2014b).

With so many stakeholders involved in AE Acquisition, identifying actual user needs and translating them into requirements for AE systems has proven to be difficult. The procurement of the HH-60M adopted many of the medical systems from the UH-60Q model Black Hawk (see Figure 12). The MEDEVAC Project Office's Lesson's Learned summary states the requirements for the HH design were nested with doctrine when the helicopter was first fielded 20 years ago; however, "today, we are out of sync" (P. B. Anderson, personal communication, June 19, 2014).

Figure 12. UH-60Q Black Hawk **(**from Anderson, 2013**)**

Since the original UH-60A Black Hawk Mission Need for Production MN (P) document was published in 1979, several capability gaps and potential improvements have been identified through MEDEVAC requirements working groups (see Appendices G and H). However, upgrades and improvements have been fragmented and not performed uniformly across the MEDEVAC fleet. The Army has had to prioritize upgrades due to fleet size and budget constraint, which has been one of the main contributing factors to the current fleet composed of four Black Hawk configurations. Appendices I, J, and K contain the MEDEVAC mission requirements matrices for the UH-60A/L, HH-60L, and HH-60M dated June 19, 2014.

In 2009, the MEDEVAC Project Office began a study to solicit feedback from MEDEVAC aircrews to find out what the users thought of fielded systems. During the study, representatives from PD MEDEVAC conducted site visits, pre-deployment screenings and post-deployment After Action Reviews (AARs). The project office representatives visited 55 different locations, 40 of which were compiled in a lessons learned database. Then in 2013, PD MEDEVAC launched a new data collection effort for this study by conducting an online survey via Army Knowledge Online (AKO). The

product office collected 81 online surveys to include in their lessons-learned database. PD MEDEVAC analyzed the four years of data and made the following observations:

1. The current HH configuration of the Black Hawk "is not suitable for the 90% mission," which is a point-of-injury (POI) pickup of two patients or less.

2. The current requirement for the HH Black Hawk "focuses on a less than 5% solution (six litters), so 95% of the time the requirement doesn't nest with the need" (see Figure 13).

3. The Interim MEDEVAC Mission Support System (IMMSS) "inherits many of the same flaws" of the HH configuration because it was designed to be "like" the HH electromechanical litter lift system (see Appendix L).

In response to the MEDEVAC Project Office Study, the U.S. Army Aviation Research Laboratory (USAAARL) conducted the AE En route Critical Care Validation Study (AE2C2VS) to "evaluate the adequacy of space available for care providers to perform advanced medical treatment scenarios on simulated critical care patients (manikins) in existing medical evacuation (MEDEVAC) aircraft" (D.W. Creech, personal communication, September 29, 2014). The results of these studies will provide the qualitative and quantitative data necessary for MEPD as the AE Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, Facilities and Policy (DOTmLPF-P) manager to collaborate with Army Aviation in developing modern requirements documents for existing AE helicopters.

Figure 13. HH-60M Litter Lift System (from Creech, 2011)

1. Medical Capabilities and Limitations

In conducting a review of literature about medical devices in an AE environment, it is important to address some of the MEDEVAC mission equipment package (MEP) items such as the medical interior, advanced medical oxygen generating system (AMOGS), and integrated suction. As noted in the April 3, 2014 MEPD Integrated Process Action Team (IPAT) meeting, some items in the MEP and medical equipment set (MES) are interrelated and should be developed together (p. 1). Co-developing the MEP and MES is important for preventing interoperability issues such as taking care not to exceed the electric power capabilities of the aircraft with carry-on medical devices. The following section reviews some of the key literature and recent studies about medical capabilities and limitations in a helicopter AE environment.

a. UH-60 Black Hawk

The Black Hawk litter lift system is one of many capabilities that have been identified as needing further development for future AE platforms. Because patient care in-flight is greatly influenced by the aviation environment and the medical resources available, it is important that the capabilities of future platforms are developed to better

suit the needs of users in their operational environment. In developing future configurations, interoperability and compact medical equipment capabilities will be among the most important key performance parameters (KPPs). Because one of the key limiting factors in the AE environment is space, transport medical equipment must often sacrifice important features to be more compact and portable. Hurd et al. (2002) accurately described this tradeoff:

> Restriction in cabin space and the standard safety practice of restraining personnel and equipment makes moving around the aircraft interior awkward, especially during emergency situations. Because aeromedical equipment must be light, durable, and field-hardened, it often sacrifices precision for ease of application and ruggedness. Although usually easy to use, the equipment itself is on occasion inaccurate and prone to malfunction. (p. 177)

Finding the balance between optimal medical performance and space constraints to provide the highest level of en route care possible is an equation that continues to challenge researchers today.

Today, the Army's PD MEDEVAC office is responsible for upgrading all Black Hawk MEDEVAC helicopters so the fleet has the same digitized capability as the HH-60M model helicopter. As the product manager, PD MEDEVAC is currently heading the Standard Advanced MEDEVAC Equipment (SAME) initiative involving multiple stakeholders, such as Directorate of Combat and Doctrine Development (DCDD), TCM-L, MEPD, Medical Research and Material Command (MRMC), and the Office of the Surgeon General (OTSG). The SAME initiative is a current effort to "provide consolidated aeromedical capabilities to better meet the MEDEVAC mission" (MEPD, 2014b, p. 8). Part of this effort is the introduction of the patient handling system (PHS) called the Improved MEDEVAC Paramedic and Critical Care Transport (IMPACCT). Although IMPACCT is still in the "early stages of development," it is a solution "focusing on the needs of the Critical Care Emergency Medical Technician–Paramedic (CCEMT–P) and En route Critical Care Nurse (ECCN) for Point of Injury (POI) and Trauma Transport, with the capability to expand to 4–6 patients for the low percentage of missions requiring mass casualty support" (MEPD, 2014c, p. 8).

IMPACCT is one initiative that is being used to consolidate aeromedical capabilities from four configurations to one and reduce life-cycle costs. The end-state of the SAME initiative is for the Army to have a "fleet of MEDEVAC aircraft that are as much the SAME as possible" (MEPD, 2014c, p. 10). Appendix M is a summary of the Standard Advanced MEDEVAC Equipment (SAME) initiative, and Appendix N is the MEDEVAC roadmap.

The U.S. Army Aeromedical Evacuation En route Critical Care Validation Study (AE2C2VS) is another recent collaborative effort involving many stakeholders in the AE Enterprise. Currently, USAAARL, MEPD, and the United States Army School of Aviation Medicine (USASAM) are combining efforts to study the capabilities and limitations of the UH-60 Black Hawk and collect data for developing the interior of treatment platforms. The purpose of this "space" or "motion" study is to "identify treatment capability gaps due to suspected equipment and material deficiencies as well as those created by the addition of the flight paramedic and the critical care nurse to the crew of the current air ambulance fleet" (MEPD, 2014c, p. 24).

The AE2C2VS study is being conducted at Fort Rucker, AL, using GoPro cameras and "XSENS" sensor suits with 16 embedded sensors to measure various sizes of male and female medics while performing 43 different medical tasks in various scenarios and configurations of the Black Hawk (MEPD, 2014c, p. 24). The data collected will help identify capability gaps and form requirements for current and future AE platforms and patient handling systems. The study will also help determine how to maximize the amount of care provided and show the limitations of patient care in a space constrained environment. The preliminary results of this study suggest a 28 inch minimum vertical clearance between litter stations (14.5 inches above the patient) facilitates performance of all medical tasks except for cardiopulmonary resuscitation (CPR) and Special Medical Emergency Evacuation Device (SMEED) tasks (D.W. Creech, personal communication, September 30, 2014). It should be noted these preliminary results are from the latest study update. Additional female medics must be evaluated to complete the final report.

Multiple stakeholders in the AE community have a vested interest in the outcomes of USAARL's studies. As an MRMC subordinate command located at Fort Rucker, AL,

> USAARL's research programs solve medical and health-related problems that compromise the safety or deter the mission performance of the aviator and Soldier. The laboratory conducts research on neurosensory injury, return-to-duty standards for wounded warriors, and equipment for the medical evacuation environment. (USAMRMC, 2014b)

The following are some are some of the core stakeholders in the AE enterprise that use USAARL studies to ensure MEDEVAC user requirements are met:

1. Medical Evacuation Proponency Directorate (MEPD)—"represents the AMEDD and TSG and facilitates DOTMLPF actions on matters pertaining to the strategic DoD directed aeromedical evacuation 'function' (MEPD, 2014a, p. 12). MEPD coordinates and disseminates information among all MEDEVAC core stakeholders and works with Army aviation to ensure the medical mission is effectively accomplished with aviation assets.

1. PD MEDEVAC—program management of the HH-60L/M medical evacuation helicopter, medical equipment package (MEP), and product sustainment of legacy UH-60A/L MEP.
2. PjM MEDEVAC MEP manages the medical mission equipment package (M-MEP).
3. USAMMA Medical Devices manages the medical components of the Medical Equipment Set (MES).
4. U.S. Army Medical Material Development Activity (USAMMDA) manages the MES.
5. Directorate of Combat and Doctrine Development (DCDD) is responsible for capability development, integration and requirements determination.

These organizations represent some of the main stakeholders that have a significant role in fielding systems that meet the needs and requirements of the warfighter. There are also very influential MEDEVAC enterprise stakeholders in companies such as Whitney, Bradley and Brown, Inc. (WBB), Navigator Development Group, Inc. and within academia. The MEPD integrated process action team (IPAT)

contracted WBB to facilitate a capabilities-based assessment that will drive the development of an initial capabilities document (ICD) with the goal of establishing a MEDEVAC program of record. The Navigator Development Group, Inc., in concert with leading academic researchers, has published numerous highly influential reports such as the 2013 study by Bastian, Fulton, Mitchell, Pollard, and Wilson that conducted a capabilities-based analysis of the requirements and capabilities of Army AE units. Another Navigator Development Group, Inc. study that will be published next spring in *Quality Progress* (Fulton, Bastian, and Wilson, in press) provides a case study for "practicing quality professionals" on how Design for Six Sigma (DFSS) is being used in the design process of the future vertical lift (FVL) MEDEVAC aircraft. Using the DFSS design process, the study will show how a Quality Function Deployment (QFD) "House of Quality" can be used for the interior design of MEDEVAC aircraft and demonstrate how this can be a very effective way to translate user requirements into capabilities. Figure 14 depicts an example House of Quality similar to what will likely be used in this study.

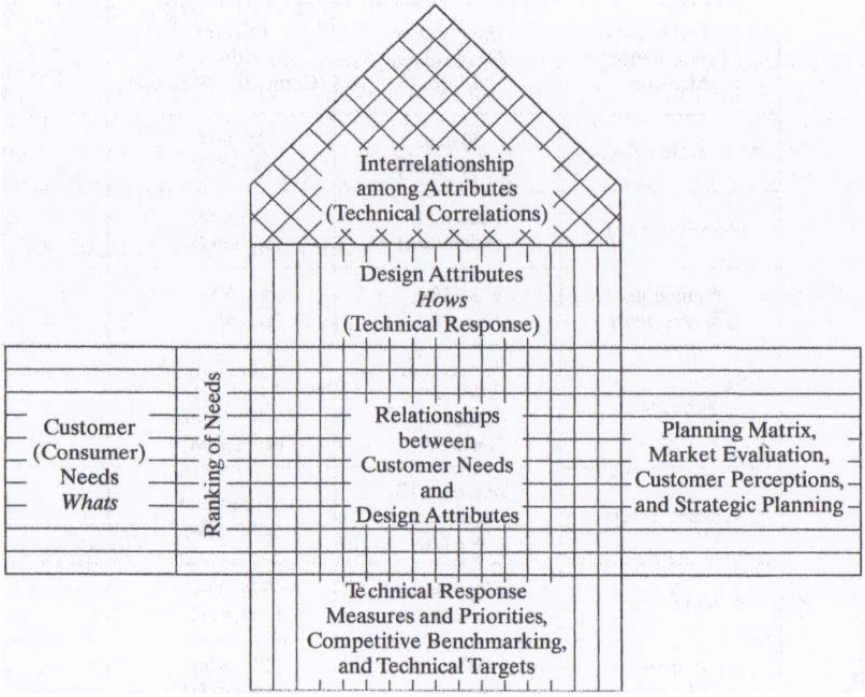

Figure 14. Modified House of Quality (from Blanchard & Fabrycky, 2011, p. 84)

Other studies from AE providers around the world have emphasized the importance of the capabilities and limitations of medical equipment on board medical aircraft. For example, a 2006 study found that the current transport ventilators

> often lack features present on larger ground-based systems such as expanded options for ventilatory modes, options for patterns of inspiratory flow, ability to provide higher levels of [Positive End Expiratory Pressure] (PEEP), and ability to reliably ventilate patients with poor lung compliance requiring high inspiratory pressures. (Turka, Sener, Tugcu, & Pauldine, 2006, p. 587)

Studies such as this underscore the importance of interoperability in future medical equipment and designing systems that can stay with patients from the initial point of care to a dedicated trauma center. Ultimately, interoperable systems will reduce the workload placed on physicians and en route care providers because they will no longer have to anticipate differences in performance characteristics of hospital and transport medical systems.

b. UH-72 Lakota

The Lakota LUH-72A is the military variant of the Eurocopter EC-145. Recent literature published on the Lakota found that not only does a piece of medical equipment have to be compact to be effective in AE, but also important is the overall layout, and the position of the patient and the medical equipment (Csáky, 2014, p. 30). Csáky (2014) investigated four Helicopter Emergency Medical Services (HEMS) providers' methods for developing configurations for their missions and found that they used some distinct approaches (p. 30). Ornge of Canada, who flies the Agusta Westland AW139 helicopter, decided to look at the best practices of other HEMS providers to determine how to best configure their helicopter (see Figures 15 and 16). DRF Luftrettung and ADAC Luftrettung of Germany used a different approach to determine the configuration for their EC145s (see Figure 17). The German HEMS providers chose to look at their existing interiors and then come up with a completely new configuration.

Figure 15. Ornge AW139 Forward-Facing View (from Csáky, 2014, p. 30)

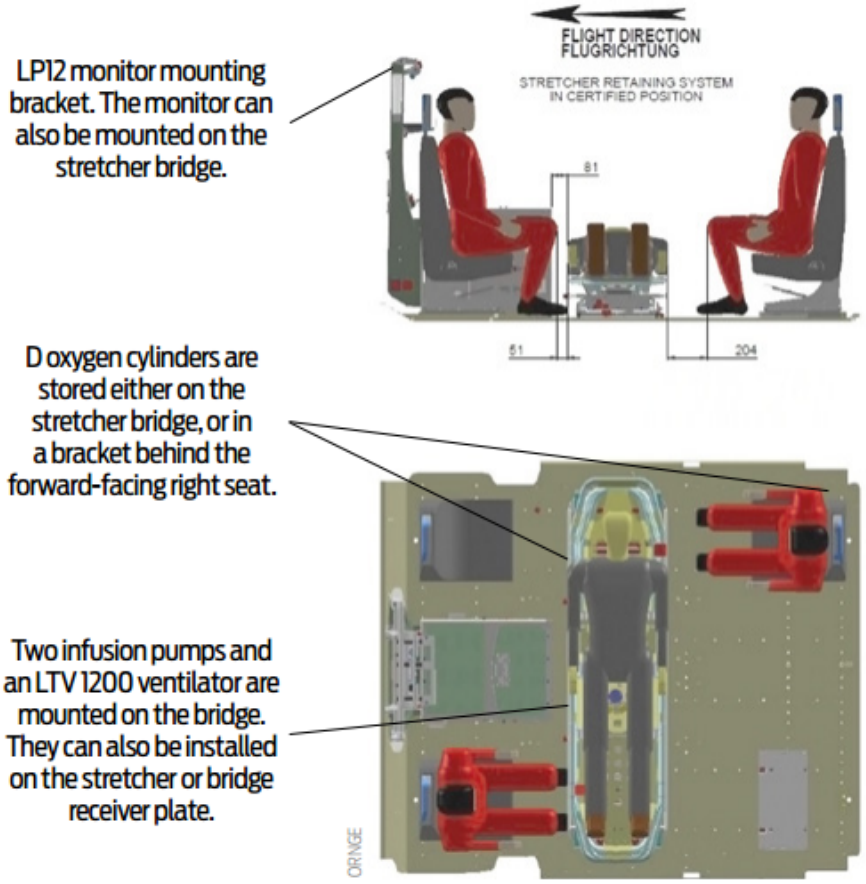

Figure 16. Ornge's AW139 Interior Layout (from Csáky, 2014, p. 30)

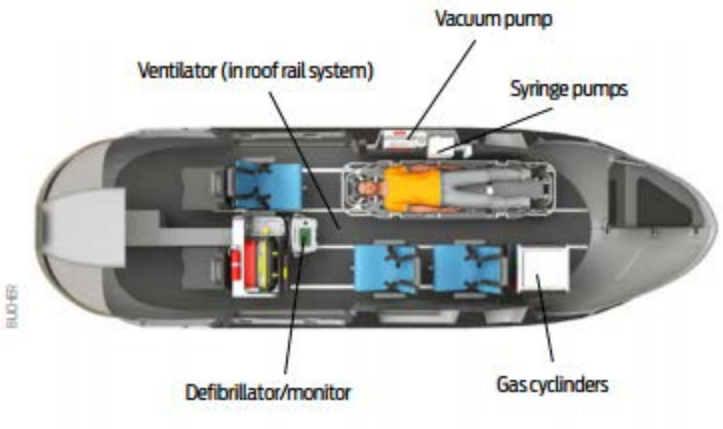

Figure 17. EC145 German (DRF Luftrettung) HEMS Configuration (from Csáky, 2014, p. 32)

The German HEMS began with a space study conducted by Weig, Niedermeier, Gehr, and Prueckner (2012) in which medical teams were video recorded performing medical tasks in the EC145 (Csáky, 2014, p. 32; Weig et al., 2012). The study analyzed the video to look for "awkward ergonomics" and used the results in a "practical design project" to develop a "new generation" medical interior with a local HEMS manufacturer (Csáky, 2014, p. 32; Weig et al., 2012). Similar to Ornge, the Polish HEMS providers, Lotnicze Pogotowie Ratunkowe (LPR), needed a configuration solution that would meet the needs of both HEMS and transportation missions. So LPR conducted a "six-month design phase, using full-size mockups" and the "cabin design was developed by a joint team of LPR and Aerolite specialist, fulfill[ing] all project prerequisites" (Csáky, 2014, p. 34). Overall, LPR was successful in developing configurations that would suit the needs of its missions in its 23 new EC135s.

Although EC135s are more compact than the EC145, and significantly smaller than the interior of a Black Hawk, the DOD will likely save a great amount of time and money by utilizing the lessons learned from these studies and leveraging commercial expertise. Much of the work has already been done developing fixed elements such as IV hooks, window, and wall rails for medical devices, as well as the devices themselves, so future defense AE platforms could realize significant cost savings and improve safety of

both patients and aircrew by implementing lessons learned from the civilian sector. Fastening straps and other antiquated securing methods for medical devices are inefficient and present a safety concern. Undeniably, one of the main limiting factors to upgrading the Army's AE helicopters to match the capabilities of our civilian counterparts is cost. Upgrading the Army's MEDEVAC Black Hawk fleet of 592 helicopters and 78 Lakotas is a much more costly endeavor than any civilian agency, most of whom have 25 or fewer aircraft (P. B. Anderson, personal communication, June 19, 2014). Also challenging is the DOD's unpredictable fiscal environment, which has led decision-makers to move most of the Army's Lakota fleet to Fort Rucker, AL, for flight training. Constantly changing requirements such as these that are placed on the Army further complicate the decision-making process for developers working to upgrade current capabilities and meet the needs of the future.

2. Army Aeromedical Evacuation Portable Medical Technology

The aviation environment presents many unique challenges for medical equipment. Medical equipment must be able to operate in a constantly vibrating environment, in a large range of temperatures, and meet shock resistance specification. According to Eshelman and Cicek (2012), medical carry-on items are generally expected be able to operate in temperatures from 0°C (32°F) to 49°C (120°F; pp. 17, 19). To ensure medical equipment can operate in these demanding environments, the equipment must conform to MIL-STD-810G (DOD, 2008). The devices also must conform to Human Engineering specifications (MIL-STD-1472G), airworthiness certification criteria (MIL-HDBK-516B), and must be assessed for airworthiness impact in accordance with AR 70–62 HQDA, 2007a). Lastly, the equipment must be interoperable with all aircraft systems and meet MIL-STD-461F electromagnetic interference requirements (DOD, 2007). For example, when a pilot keys the microphone to make a radio call, the radio cannot interfere with the electrical equipment attached to a patient. Conversely, medical equipment attached to a patient cannot interfere with aircraft operations.

Prior to any piece of medical equipment being approved for use in a helicopter, it must undergo testing by the appropriate personnel at the U.S. Army Aviation Research

Lab (USAARL). The 1989 USAARL research report titled A Survey of U.S. Army Aeromedical Equipment (Mitchell & Adams, 1989) is an example of literature published to discuss compatibility issues of medical equipment in a helicopter environment. Mitchell and Adams' main claim in the 1989 report was that some units were using medical equipment that "may not be suitable for use onboard helicopters" (p. 807). The authors explained that most medical equipment has been tested by the U.S. Air Force in a fixed-wing environment; however, helicopters have unique requirements, so the U.S. Army began a program to evaluate medical equipment for use in helicopters. This study reported the results of the 1986 and 1987 surveys that detailed the use of medical evacuation equipment in U.S. Army helicopters and compared these items to the test results of the Air Force.

In 1994, another USAARL study demonstrated the importance of testing medical devices according to the appropriate military standards prior to operating in a helicopter environment (Bruckart, Licina, & Quattlebaum, 1994). The USAARL report tested 34 medical devices, including defibrillators, infusion pumps, ventilators, vital-signs monitors, and infant transport incubators. The researchers found that 32% of the devices tested failed at least one environmental test, and 91% failed to meet electromagnetic interference standards (Bruckart et al., 1994, p. 1). The results of this USAARL study show that testing medical devices in the harsh helicopter environment is critical because the failure of a device or interference with the aircraft could be fatal for the patient or aircrew.

F. PREVIOUS STUDIES

The previous studies discussed are the afloat medical material estimates of the authorized medical allowance list and the ongoing Naval Expeditionary Health Service Support (NEHSS) working group analysis.

1. AFLOAT MEDICAL MATERIAL ESTIMATES STUDY

The Naval Health Research Center (NHRC) conducted a comprehensive analysis of the AMAL for six classes of ships titled Afloat Medical Material Estimates: Guided Missile Cruisers, Guided Missile Destroyers, Guided Missile Frigates, Littoral Combat

Ships, Mine Countermeasure Ships, and Patrol Crafts (Hopkins et al., 2014). The study conducted by Hopkins et al. reviewed the capabilities of the AMAL's assigned to these platforms. The goal was to "enhance standardization across the fleet to joint standards and analyze afloat AMAL deficiencies" (Hopkins et al., 2014, p. 1).

The study utilized the NHRC's modeling and simulation expertise to evaluate the AMALs of these ships, identify capability gaps, and enable the standardization of medical items per the mandate of the Assistant Secretary of Defense, Health Affairs that "directs services to employ efficiencies where feasible in the medical supply chain for clinically appropriate sets, kits and outfits" (Hopkins et al., 2014, p. 1). The Patient Condition Occurrence Frequency (PCOF) tool was among the casualty estimation programs that developed the injury and illness frequency distribution based on at-risk patient populations and casualty rates. The PCOF provided a patient stream that depicts a range of International Classification of Diseases, 9th Revision (ICD-9) diagnostic codes for a myriad of non-battle injuries (NBI), diseases, and combat injuries (Hopkins et al., 2014, p. 3).

The study employed the uniform distribution sampling method and assessed the AMAL requirements for disease and injury, mass casualty, women's health, and norovirus-like (NoV) outbreak scenario. Table 1 shows the selected AMALs reviewed that met the criteria of the study. The study reviewed the AMAL categories across the identified platforms and utilized the tenants of modernization, redundancy, clinical requirement, and standardization.

Table 1. AMAL Category Reviewed (after Hopkins et al., 2014)

AMAL CATEGORY	CG	LCS	MCM
General Medicine	X	X	X
Equipment	X	X	
Minor Surgery	X	X	
Laboratory	X	X	X
Pharmacy	X	X	
First Aid Box	X	X	X
Mass Casualty Box	X	X	X
Battle Dressing Station	X		X
Jr. HM Response Bag	X		
IDC Response Bag	X	X	X
MSD Common		X	

The results of the study included minimal changes to the medical equipment AMAL category of the CG, LCS, and MCM, and emphasized continued standardization efforts of equipment and consumables in accordance with the Office of the Assistant Secretary of Defense (Health Affairs) Medical Logistics Division approved items to sustain efficiencies. The central management of the smaller AMAL categories, such as battle dressing stations, mass casualty boxes, and the adaptation to one emergency AMAL for these platforms, were recommended to reduce inventory maintenance and also augment standardization (Hopkins et al., 2014, p. 25).

2. NAVAL EXPEDITIONARY HEALTH SERVICE SUPPORT WORKING GROUP ANALYSIS

Another ongoing effort is the Navy Expeditionary Health Service Support (NEHSS) working group analysis in support of the Joint Capability Integration and Development System (JCIDS) process for Navy Medicine. The overall objective of NEHSS is to "improve patient care and casualty management across the continuum of care in and from the Sea base" (WBB Inc., 2014). A current CBA was conducted to assess and identify gaps and prioritize methods to accomplish the NEHSS functions of human performance, health surveillance, preventive medicine, casualty management,

patient movement, medical logistics command and control, and health engagement operations (WBB Inc., 2014). Figure 18 is a graphical representation of the CBA process as taught at Navy Medicine Executive Medical Department Enlisted Course.

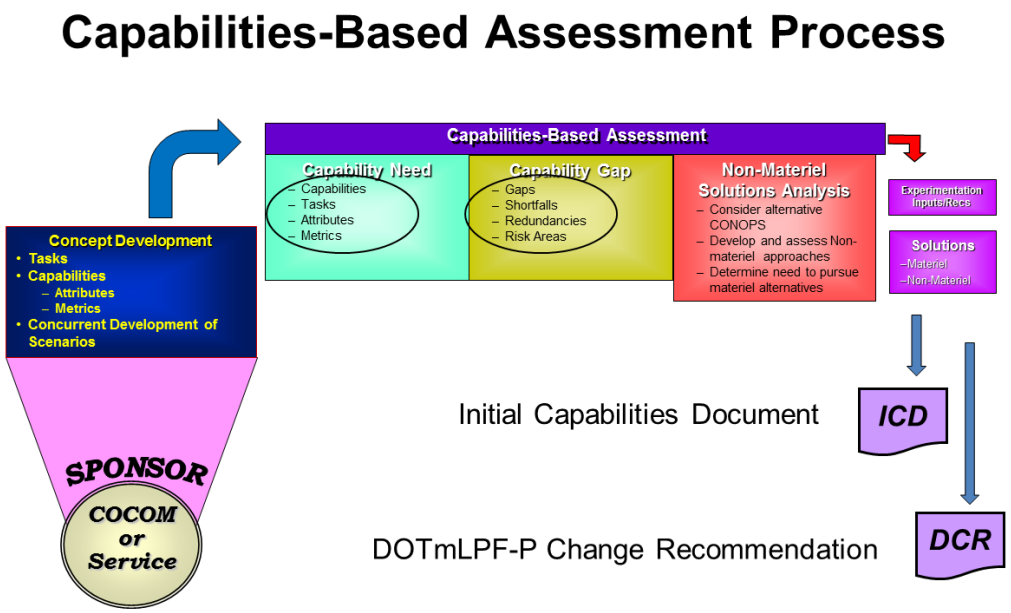

Figure 18. CBA Process (from WBB Inc., 2014)

The CBA identified 72 gaps with the three functional areas of casualty management and patient movement, with command and control having the highest levels of risk and importance to improve (WBB Inc., 2014). Furthermore, the identified gaps were approved and validated as Navy requirements by the Navy Capabilities Board (NCB). Ongoing comprehensive efforts are underway for the completion of doctrine, organization, training, material, leadership and education, personnel, facilities, and policy (DOTmLPF-P) Change Recommendation (DCR). The inputs for the DCR are collected from USFFC, NMLC, BUMED, OPNAV, and Headquarters, U.S. Marine Corps (HQMC), among others that will provide NEHSS solutions integrated throughout Navy Medicine in support of the JCIDS process (WBB Inc., 2014).

G. SUMMARY

This literature review was structured by grouping concepts that were found to be important in literature published about medical equipment. We first summarized the history of medical equipment in aviation, highlighting important themes and lessons learned since the inception of using portable medical technologies in practicing modern medicine. Next, we discussed the FHP requirements for the CG, LCS, and MCM and how they drive the medical capabilities of these platforms dictated by the ROC. We included a discussion of the AMAL and the important role it has in determining what medical technologies are required on Navy ships. Then we summarized literature published about portable medical equipment capabilities in Army AE aircraft. Lastly, we summarized some recent literature about civilian AE. This review serves as the foundation for an assessment of current portable medical technologies and provides a starting point for recommending future medical technologies for both the Army and Navy.

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III. METHODOLOGY

We assessed existing portable medical equipment capabilities in the selected small Navy ships and Army AE aircraft to provide recommendations for portable medical technologies in the next 15 to 20 years. The qualitative methodology used in this study focused on similarities and interoperability of future medical technology requirements for these two distinct operational platforms. Although there are clear differences in mission requirements for ships and AE aircraft -more clinical cases on ships and more urgent patients on aircraft. The methodology employed in this study sought to highlight opportunities for joint capability development in a space-constrained medical environment.

This study was initiated with a CNO inquiry on the configuration of the sick bay of the future and was sponsored by the Acquisition Research Program (ARP) at the Naval Postgraduate School (NPS) in Monterey, CA.

The study began by conducting a literature review of peer-reviewed professional journals, books, articles, websites, and other electronic media and other library resources. We then conducted a detailed review of the Navy Force Health Protection (FHP) requirements for the cruiser, destroyer, and littoral combat ship, and Army AE requirements for the Black Hawk, Lakota, medical equipment set, and mission equipment package.

NHRC provided us the patient condition occurrence frequency (PCOF) data used for the comprehensive afloat AMAL study. We analyzed the data to determine the most common DNBI. Additionally, we submitted a joint trauma registry (JTR) request to the Department of Defense Joint Trauma Registry to determine the most common type of injury evacuated to a role III hospital during OIF, OEF, and OND.

We conducted a series of site visits beginning with U.S. Fleet Forces Command (USFFC) at Norfolk, VA. We discussed sickbay modernization efforts and the current medical equipment technologies on small naval vessels. Next we visited the Project Manager MEDEVAC Medical Evacuation Package (MEP) U.S. Army Medical Material

Agency (USAMMA) at Fort Detrick, MD. We were provided an orientation brief and data about the USAMMA medical product portfolio. We also discussed the current medical technologies on Army aeromedical helicopters and future efforts with PM medical devices and USAMMDA.

The next site visit was to the U.S. Army Product Directorate MEDEVAC (PD MEDEVAC) office at Redstone Arsenal, AL. We received an aircraft orientation brief at Redstone Army Airfield, which included a thorough discussion of the mission equipment package. Following the brief, we met with the MEDEVAC product director and assistant project manager to discuss platform modernization efforts.

The Naval Health Research Center (NHRC) in San Diego, CA was the next location visited where we met with the subject matter experts on the Afloat Medical Material Estimates study for Navy ship AMALs. We discussed the future medical technologies considered for use on small Navy ship sickbays, among other ongoing innovative research efforts.

At the conclusion of the site visits, we returned to the Naval Postgraduate School to conduct an assessment of the data collected. We assessed literature about current technologies and evaluated the data collected during the site visits.

After reviewing current medical technologies on small Navy ships and Army AE helicopters, we began a comprehensive market search of future medical devices. This search included trade journals and magazines, investor reports, and advertisements. We also reviewed information from the Medical Informatics World Conference, American Medical Informatics Association, and Health Informatics & Technology Conference.

Next we presented our findings at the Annual San Francisco INFORMS conference. Constructive input was received from leading researchers in the fields of management sciences and we included them in this study.

IV. ASSESSMENT OF CURRENT MEDICAL DEVICES AND TECHNOLOGIES

This chapter assesses current medical technologies on the cruiser, littoral combat, and mine countermeasure ships and on MEDEVAC helicopters. The functions of Navy ship sickbays are more clinically oriented whereas the AE mission is focused on movement of patients and en route care. Therefore, many of the capabilities needed in an aeromedical environment are unnecessary onboard small Navy ships. Despite these differences in mission requirements, the medical devices and equipment carried on both platforms have many similarities. This assessment identifies capability gaps, redundancies, and issues for both services and points out practical joint solutions. It also distinguishes the most important areas for improvement and considers reasonable applications of a common interface and wireless capabilities on medical devices.

A. NAVY

The AMAL equipment category for small Navy ships of this study, the cruiser, littoral combat ship and mine countermeasure ship, includes the portable medical technology capabilities of the sickbay. The disease and injury patient stream data utilized for the afloat medical material estimates study reviewed the equipment AMAL category for identified current portable medical devices that facilitate healthcare delivery. These technologies include the automated external defibrillator, vital signs machine, electronic thermometer, and laboratory equipment.

The Zoll®Automated External Defibrillator—Lead Electrocardiography (AED; NSN 6515-01-568-3799) is a compact technology that delivers emergency heart rhythm checks and electric shocks as needed. It is a designated joint product of choice (JPOC) by the Defense Health Agency, making it a standardized item for use by all services. Its portable size and minimal weight is easily contained in a small space. It provides immediate feedback on a patient's cardiac condition through the screen display. There exists no wireless ability to transfer data to the electronic health record in the operational environment.

The Propaq LT® patient vital signs monitor with charging cradle and USB port (NSN 6515-01-546-9366) is also a JPOC item and is used to assess the patient's blood pressure, heart rate, breathing, on the monitor. The wireless connectivity and USB port augments patient information transfer but currently does not interface with the sickbay's information technology framework.

The Welch Allyn® clinical thermometer (NSN 6515-01-525-7595) is a JPOC item and is used to determine the body temperature orally through a protective sensor probe with a digital display screen. The device requires a probe cover, a consumable item and does not have the wireless capability for transmission of data to a patient's electronic health record.

Current laboratory equipment is composed of the centrifuge (NSN 6640-01-623-2349), incubator (NSN 6640-01-576-8119), and dry hematology analyzer (NSN 6640-01-510-2492), portable machines used for diagnosis of disease and injuries. The centrifuge analyzes a patient's quantitative hematocrit, the incubator provides precise temperature control for microbial specimens, and the dry hematology analyzer conducts a complete blood count assessment. The laboratory equipment provides the required clinical capabilities in the sickbay however the sizes occupy the limited spaces of the sickbay on small Navy ships.

B. ARMY

As discussed in Chapter II Section D, the unit assemblage list (UAL) 257B medical equipment set (MES) air ambulance (AA) contains the standard list of portable medical devices issued to Army aeromedical evacuation units. According to Lewis, et al. (2010), every three years the AMEDD Directorate of Combat and Doctrine Development (DCDD) coordinates with the Medical Materiel Branch (MMB) to conduct a review of medical materiel and medical equipment sets with subject matter experts (p. 45). During the latest review of the MES AA conducted on September 17–18, 2013, subject matter experts made recommendations for updating the MES to take advantage of the Army's new flight paramedic training. The panel members also recommended a new assemblage list for the UH-72 Lakota MEDEVAC helicopter. During the component review, panel

members simultaneously drafted an updated MES AA list (UA257C) and created a new component list for the MES Air Ambulance Light (UA247A) (MES Review Panel, 2013, p. 3). Upon approval of these lists, they will be posted in the Medical Services Information Logistics System (MEDSILS).

The following analysis briefly summarizes the purpose of each electronic medical device in the MES AA and assesses capability gaps that could be addressed in future medical devices used in AE aircraft. This analysis takes into account the 2013 MES AA review recommendations for the four associated support items of equipment (ASIOE) items and other electronic medical devices in the MES AA unit assemblage list. The ASIOE items in the MES AA are those that are separately documented on the organization's table of organization and equipment (TOE) or modified table of organization and equipment (MTOE).

The ZOLL M Series® CCT defibrillator (NSN 6515-01-515-4197, LIN D86072) is a portable "biphasic" defibrillator and vital signs monitor with printing capability (ZOLL, 2014a). The defibrillator monitor/recorder is one of the ASIOE that the review panel recommended the quantity be increased from one to two in both the MES AA and the proposed MES LUH. The panel's recommendations were "based on the anticipated need to transport two critical casualties in the same Aeromedical Evacuation (AE) mission. Current equipment density (one each) only supports the ability to sustain one critical casualty during AE" (MES Review Panel, 2013, p. 3). Panel members also recommended the device be upgraded to include the Vital Signs Monitoring (VSM) function so the current VSM, LIN M66626 could be removed from the table of organization and equipment (TOE). While the panel's recommendations will likely be sufficient in the near term, future defibrillators and vital signs monitors should include wireless capabilities and common interfaces to integrate seamlessly across multiple platforms, regardless of service. These devices should also be interoperable with future telemedicine, telehealth, telementoring, and wireless healthcare technologies.

The Welch Allyn Propaq® 206 EL vital signs monitor with pulse oximetry (NSN 6515-01-432-2707, LIN M66626) is a "rugged, lightweight, portable vital signs monitor for field use" (USAMMA, 2014a). The 2013 MES AA review panel recommended this

device be removed from the UAL when the defibrillator/monitor recorder is modernized as previously described. A Basis of Issue Plan (BOIP) amendment was initiated to remove the patient vital signs monitor from the MES. Integrating more functionality into fewer and smaller devices will likely have a critical role in future medical devices utilized in space constrained environments.

The Cardinal Health Alaris® intravenous infusion pump (NSN 6515-01-550-5669, LIN P16161) is a "multi-channel infusion system [that] brings clinical versatility to drug infusion technology. The instrument combines three independent infusion channels with features like dose rate calculation and portability in a small, compact size" (USAMMA, 2014c). The 2013 MES AA panel recommended the quantity to be increased from one to two per MES for both the MES AA and MES LUH (MES Review Panel, 2013, p. 4). The panel also recommended establishing a requirement for a "3-channel IV capability for each casualty" (MES Review Panel, 2013, p. 4). The recommendations of the panel will temporarily address near-term capability gaps; however, this assessment emphasizes the need for further investigation for longer term solutions. Similar to other devices assessed in this chapter, open systems architecture should be used to develop and procure future infusion pumps. Using open systems architecture would facilitate procurement of smaller and more modular solutions with common interfaces. Using common software standards and interfaces would also allow for joint interoperability, reduced costs, and ease of future upgrades.

The IMPACT® Transport Ventilator model 754M (NSN 6530-01-464-0267, LIN V99788) is a self-contained, battery powered device that provides multiple ventilator modes for patients. At a little more than 12 pounds, the device has a bright LCD for monitoring the device and alarm settings. The unit has internal positive end expiratory pressure (PEEP) and has electromagnetic interference (EMI)/radio-frequency interference (RFI) and air medical certifications. The 2013 MES review panel recommended that both the MES AA and MES LUH basis of issue plan (BOIP) be amended to include two ventilators per MES instead of just one. Presently, no capability gaps have been identified for this device. However, similar to the IMPACT® surgical suction in the next session, modernization efforts should be pursued in order to upgrade capabilities. Efforts to

develop and procure new ventilator systems should focus on an open systems architecture, human systems integration (HSI), interoperability, standardization, and integration of wireless technologies that interface with patient status monitoring devices.

The IMPACT® surgical suction apparatus (NSN 6515-01-435-0050) is a "multifunctional, continuous and programmable intermittent suction unit" that may be used for "oropharyngeal, tracheal, wound drainage, and abdominal or thoracic decompression procedures—short or long-term use" (USAMMA, 2014a). It is a joint product of choice and also used in Navy ship sickbays. The current suction apparatus is a large antiquated device with an analog gauge and small, closely positioned knobs that are difficult to manipulate in a helicopter AE environment. According to the 2013 MES AA review minutes, there are ongoing efforts to modernize this suction device and develop a suction apparatus that is specifically designed for a level II organization. Modernization, development, and procurement efforts should focus heavily on human systems integration (HSI), joint interoperability and a common interface. While it is important to look at the standard helicopter AE considerations (e.g., environmental, airworthiness, and electromagnetic interference), standardization across the DOD and human factors should be among the most critical key performance parameters of suction systems.

The enFlow® Fluid Warming System (NSN 6515-01-553-0107) is a commercially available portable device used to warm blood or intravenous (IV) fluids to body temperature before administering them to patients. The warming system delivers IV fluid or blood continuously at 104° F (40° C) from the minimal rate required to keep the vein open up to 200 ml/minute. The last 2013 MES AA review panel recommended this fluid warmer be replaced with the Thermal Angel® Kit because it has a new "Ultra Battery" and provides the same capability at about half the cost of the enFlow system (MES Review Panel, 2013, p. 4). The MES 2013 review panel's recommendations will suffice for near term improvement in cost and performance of this system; however, long-term solutions pursued over the next 15 to 20 years should look at wireless interoperability with patient status monitoring devices. In patient transfer situations, where medical devices such as the blood fluid warmer are already attached to the patient, an en route care provider could monitor and adjust multiple devices from a single handheld unit.

Instead of reading and adjusting multiple medical devices, each device would feed patient information to one electronic device that would give the paramedic the capability to simultaneously monitor multiple patients.

The Welch Allyn® Digital Thermometer Kit (NSN 6515-01-523-9935) is composed of the probe case, disposable plastic probe covers, digital thermometer, oral probe, rectal probe and well kit, and alkaline batteries. The thermometer takes both oral and rectal temperature and can be mounted on a wall. The 2013 MES AA review panel recommended replacing this thermometer with a smaller and lighter device such as a temporal thermometer that uses remote sensing technologies. A remote sensing device would eliminate the need for probe covers and reduce the probability of cross contamination. The capability gaps of this device are similar to those of the thermometer on board Navy ships. Adding to the recommendations of the MES review panel, future temperature sensing technologies should implement the capability of transmitting patient data wirelessly to an electronic health record.

The Onyx II® Military Model Finger Pulse Oximeter (NSN 6515-01-557-1136) is a fingertip pulse oximeter that provides fast SpO2 and pulse ratings. When placed over the finger it automatically turns on and provides real-time heart rate and blood-oxygen saturation levels. When taken off a patient's finger, it automatically turns off after seven seconds to save battery life. This device is the only fingertip oximeter with U.S. Military Airworthiness Certifications authorizing it for use on U.S. Air Force aircraft and U.S. Army helicopters (Nonin, 2014). It is also on the Defense Health Agency (DHA) Medical Materiel Enterprise Standardization Office (MMESO) authoritative joint product of choice (JPOC) list (DMMPO, 2014). This pulse oximeter has no wireless capability and no interface to send or record patient information in an electronic health record.

The blood glucose analyzer (NSN 6630-01-527-0969) is a commercially available item used to perform whole blood glucose testing by taking a blood sample from a finger stick. This device is compact in size, has a brightly lit display for easy viewing, and uses Precision Xtra Glucose Test Strips© to display test results in five seconds. This device is currently on the joint product of choice (JPOC) list and is also used in Navy ship

sickbays. It does not have wireless capability and cannot transmit information electronically to a patient's health record.

C. SUMMARY

This chapter assessed the medical devices and equipment contained in the authorized medical allowance lists for the cruiser, littoral combat ship, and mine countermeasures ship, and the medical equipment set for Army AE helicopters. The capabilities of the devices were evaluated and potential long term capability gaps were identified. These capability gaps will be the baseline from which this study will recommend advanced future medical technologies.

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V. ASSESSMENT OF FUTURE MEDICAL DEVICES AND TECHNOLOGIES

This chapter examines future portable medical equipment technologies and innovative concepts that will advance the delivery of healthcare on Navy ship sickbays and on AE aircraft. This assessment identifies technologies that will significantly augment the care provided on these platforms in the future. This chapter discusses the potential uses and applicability of the identified technologies and their impact on healthcare delivery. This assessment considers the operating environment and how the advances in technology that will influence the delivery of care in the next 15 years.

A. FUTURE TECHNOLOGIES

Augmenting healthcare delivery through the use of portable medical devices is a rapidly evolving field of technology that will continue to advance future medical capabilities.

The Scanadu Scout is a portable wireless device in the form of the emerging tricorder technology that uses sensors to measure heart rate, blood pressure, temperature, and respirations which are then transmitted to an application on a smartphone or portable tablets. An additional advanced capability upon enhancement of the device includes urine and saliva testing abilities for pregnancy and identification of health problems (Healy, 2014).

The potential capability of this device in the small ship sickbay and of the future is significant. The use of Scanadu scout as part of the IT framework of the sickbay will enable the seamless transition of medical information and ease of documentation into the electronic heath record. More importantly, Scanadu scout is compact (Figure 19), and can potentially replace multiple pieces of medical equipment such as the vital signs machine and clinical thermometer in the sickbay while delivering the same capabilities. It will also maximize use of space in a space constrained environment as well as improve the quality of care provided to patients.

Figure 19. Scanadu Scout (from Scanadu, 2014)

Using portable ultrasound devices in small Navy ship sickbays affords healthcare providers the technological advantage to immediately identify airway, breathing, and circulation conditions. A compact ultrasound device, such as the one shown in Figure 20, is ideal for a space-constrained environment. Currently there is no equipment in the AMAL with the abilities of this device. A healthcare provider could use this device without restrictions and it would add a necessary capability to the sickbay and enable more timely decision making for medical care.

Figure 20. Portable Ultrasound Device. (from GE Healthcare, 2014)

The Armed Forces Health Longitudinal Technology Application–Mobile (AHLTA-M) also known as the Battlefield Medical Information System Tactical–Joint (BMIST-J) is a wireless technology that serves as a diagnostic tool for medical information and telemedicine support throughout all levels of care. It provides a user interface that enables healthcare providers to quickly and accurately capture electronic health records as shown in Figure 21 (USAMRMC, 2014a). This device will provide medical personnel the capability of accessing critical patient information, such as medical histories and examinations, through a displayed treatment matrix and protocols provided by the interface. Additionally, the wireless capabilities of AHLTA-M will enable a more rapid and accurate transfer of medical information within the IT framework, facilitating a virtual medical environment that will seamlessly integrate with electronic health records. It will also enhance a healthcare provider's mobility in small Navy ship sickbays, enabling the provider to conduct patient care without being restricted to a computer station. Furthermore, the diagnostic information on the device provides updated medical electronic references and reduces the space usage of medical library publications.

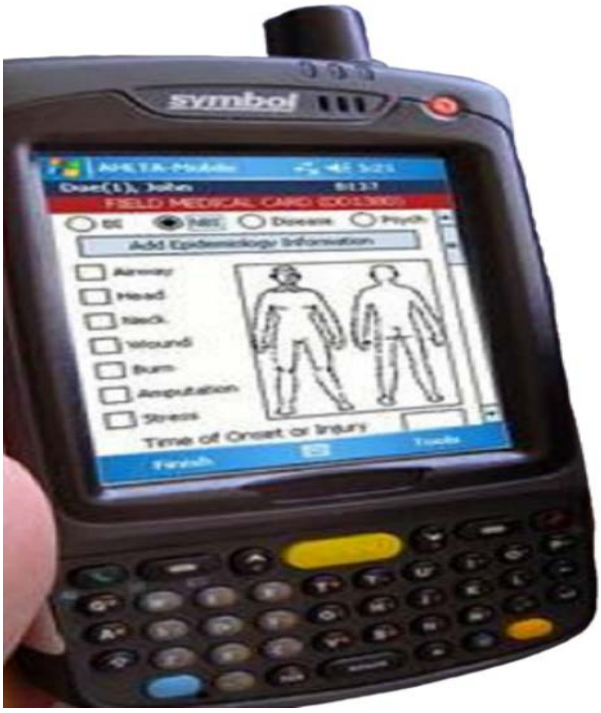


Figure 21. AHLTA-Mobile (from USAMRMC, 2014a)

The Portable TeleClinic is a telemedicine system that provides the function of a desktop telemedicine solution and includes an integrated tablet PC, built-in high definition web cameras, and industrial grade power USB ports. It can be customized with medical software and devices to conduct clinical exams. The compact technology provides the capability of sharing medical device data and images between multiple healthcare providers while conducting a video teleconference, as shown in Figure 22. The use of TeleClinic in small Navy sickbays provides an on-demand capability whereby the healthcare provider can readily seek consultation with medical experts in the diagnosis and treatment of medical cases, particularly for medical emergencies. The portable system amplifies the healthcare provider's ability to access critical information while treating patients.

Figure 22. Portable TeleClinicTM (from AMD Global Medicine 2014)

The reusable handheld electrolyte and lab technology for humans (rHEALTH) X1 prototype is a compact hand held biomedical analysis device used to analyze bodily fluids using varied diagnostics that include high-sensitivity fluorescence optics, innovative microfluidics, and nanostrip reagents to perform lab analysis functions of chemistry and hematology. According to DNA Medical Institute, the device enables point

of care blood analysis and diagnostics, providing critical information on the individual's condition using an interface that enables the user gather the medical information. The compact and advanced technology of the rHealth sensor and its point of care diagnostic capability will significantly enhance the clinical competency of small Navy ship sickbays. The device augments immediate feedback on the analysis of blood samples, enabling timely treatment by healthcare providers in the sickbay. The device is enclosed in a hardware prototype that contains the user tablet and consumables for the tests conducted as shown in Figure 23. Furthermore, the rHEALTH X1 has the technological potential to deliver multiple laboratory capabilities and can possibly replace laboratory equipment items such as the centrifuge and dry hematology analyzer.

Figure 23. The Reusable Handheld Electrolyte and Lab Technology for Humans (rHEALTH) X1 (from QUALCOMM Tricoder XPrize, 2014)

The Propaq® MD is ZOLL's newest lightweight defibrillator and patient vital signs monitor that was specifically designed to meet the needs of military and air medical operations (as shown in figure 24). The device is almost two pounds lighter than the current defibrillator/vital signs monitor, weighing in at only 11.7 pounds with study and battery. A significant improvement over the 13.5 pound legacy device in the medical equipment set (MES) 2010. According to ZOLL, the device is "60% smaller and 40% lighter than similar monitor/defibrillators" and has communications options such as integrated WiFi, Bluetooth® with USB cellular modem, and Ethernet capabilities (ZOLL,

2014b). Advertised as the “smallest, lightest, most advanced monitor/defibrillator available,” ZOLL markets their product as the “only airworthy monitor/defibrillator to offer three invasive pressure channels, necessary to monitor critical patients during long transits” (ZOLL, 2014b). The device can be powered with a rechargeable lithium-ion battery with a six-hour operating time or with an AC power adapter. According to ZOLL, the device is the “first critical care monitor/defibrillator to receive the IP55 ingress protection rating… [and]… offer multiple display modes to operate in bright sunlight or during night missions (NVG-friendly display)” (ZOLL, 2014b). The Propaq® MD’s Bluetooth® and integrated WiFi capabilities mean this device could meet future wireless integration needs. However, this is still a proprietary device and it is unclear to what degree this system was developed using open systems architecture. Before procuring such a device, consideration should be given to whether it would be feasible and cost-effective to design an alternative device using open systems architecture.

Figure 24. ZOLL Propaq® MD (from ZOLL, 2014b)

B. SUMMARY

This chapter identified portable medical devices for use in the future sickbay of small Navy ships and Army AE aircraft. After identifying the technology concepts and capabilities, the potential impacts in the two platforms were discussed. These advanced technologies will enable a virtual medical environment for small Navy ship sickbays and AE platforms and provide the capability to integrate medical information and seamlessly transfer it to the electronic health record. Advancements in technology will also make patient information more accurate, timely, comprehensive and available across the healthcare system. This will significantly improve the quality of care provided to patients.

While this list of medical devices represents a very small cross-section of future medical devices available, the greatest takeaway from this analysis is that military services should jointly pursue future systems with an open architecture approach. The open system approach emphasizes modular, lightweight, portable equipment that meet mission requirements but do not exceed the needs of the mission. For example, many of the capabilities of medical devices used in the AE environment may not be needed in the medical environment at sea. The rigorous testing medical devices undergo to attain their airworthiness certifications makes them much more expensive. Therefore, while it is important to refrain from always pursuing service specific proprietary medical device solutions, it is also not logical to procure devices that far exceed the needs of the mission.

The cutting-edge systems discussed in Chapter V can be used as a baseline for procurement professionals to negotiate, compete, design, and procure medical devices with an open systems approach. In addition to pursuing smaller, more portable, modular medical devices there are many nonmedical systems available that would meet the needs service specific mission requirements. For example, adding the Jaws of Life® to the AE medical equipment set would allow paramedics to extract patients that are trapped in vehicles. This is a critical capability that medics asked for while operating in Afghanistan. According to Fulton (2014), after action reviews and surveys from Operation Enduring Freedom (OEF) have shown a need for extraction equipment such as "saws, Jaws of Life®, [and] lifting bags" (p. 5). Unfortunately, a comparable system has not been fielded through the defense procurement system and service specific

requirements and funding have made it difficult to maximizing potential benefits from achieving commonality in medical devices.

Service-specific, stove-piped proprietary systems have been a major contributing factor to DOD program cost increases, schedule delays and performance shortfalls. The medical device procurement community can use lessons learned from other programs to avoid costly mistakes. For example, Unmanned Aircraft Systems (UAS) programs present a case where pursuing service-unique requirements has led to missed opportunities for achieving efficiencies through collaboration and commonality. According to a Government Accountability Office analysis of ten UAS programs, "service-centric requirements and funding, and ineffective collaboration were key factors that resulted in the limited achievement of commonality" (GAO, 2010, p. 3). Commonality and collaboration are important in defense acquisition because it reduces redundant capabilities and maximizes the effective use of acquisition resources. The key take away here for medical device procurement is that sometimes it does make sense to procure service unique systems because of unique mission requirements. However, program offices should always look at the costs and benefits of collaboration and commonality among other programs.

VI. CONCLUSIONS AND RECOMMENDATIONS

This study assessed the employment of medical technologies in small Navy ship sickbays and Army aeromedical evacuation aircraft. The qualitative approach enabled a joint assessment of the current medical technologies in both operational platforms. Despite the differences in mission and operating environments, small ship sickbays and helicopters are both space-constrained environments and have some similar medical equipment. This study reviewed current efforts in Navy medicine to standardize AMALs for the sickbays of afloat platforms and utilized the results as a baseline for assessing future portable technologies and providing recommendations. The portable technologies assessed could provide the sickbay of the future advanced capabilities that facilitate timely diagnosis and treatment of diseases and injuries. More importantly, these medical technologies will likely enhance the Army's and Navy's effectiveness in accomplishing each of their respective medical missions in the future.

A. RECOMMENDATIONS

The recommendations of this study seek a more joint and interoperable medical materiel environment. They serve as a foundation for future policy initiatives that promote procurement of innovative medical devices. They include increased bandwidth, smart technologies, open systems architecture, inter-service collaboration, organizational restructuring, and policy change.

1. Bandwidth

The connectivity of present and future portable medical devices will revolutionize healthcare; however, this relies significantly on the availability of bandwidth. Additional bandwidth in small Navy ship sickbays and adding such a capability to future Army AE aircraft should be carefully assessed for enduring solutions. Allocating more bandwidth to sickbays will increase care quality and aid electronic transmission of medical information using portable devices in the future medical environment.

Since the trend in healthcare is shifting toward more bandwidth intensive activities such as telemedicine, “high-bandwidth,” “low-latency,” Ethernet-based capabilities will be a force multiplier for the military health system (SBN Staff, 2012). In recognition of this trend, the Navy awarded Boeing a $16.7 million contract for the production of the Gigabit Ethernet Data Multiplex System (GEDMS) for the DDG modernization plan, increasing data transfer rates from 100 megabits per second to 1,000 megabits per second (Boeing, 2011). Although this was a step in the right direction, one of the next challenges for Navy medicine will be to ensure network administrators set policies to ensure the right amount of bandwidth is allocated to sickbays when needed.

In an ideal world all ships and aircraft would have high-bandwidth Ethernet connectivity, however, in a world of scarce resources the DOD must allocate taxpayer dollars efficiently. Since the Ethernet market has high fixed costs and low competition, this study recommends incentivizing innovation and promoting competition through research and development investments in “cooperative research” and “co-development” (DOD, 2014). Increased innovation and competition in the Ethernet market will drive down costs and create more opportunities to expand Ethernet-based capabilities.

2. Smart Technology

Using smart technologies in the future will advance healthcare delivery and provide many new opportunities. In the small Navy ship sickbay and AE environment, smart technologies such as tablet computers and mobile communicating devices enable healthcare providers to deliver effective point of care solutions, sustain treatment regimens, access digital medical references, and enhance overall patient care.

This study recommends the use of smart technologies on both platforms that provides the interface to collect and transmit medical information and data from patient vital signs monitors, patient health assessments and seamlessly transfer it to an electronic health record. The rapid technological advances of these mobile devices will further integrate wireless technology and aggregate data, which is required for advanced healthcare initiatives such as telehealth services.

3. Open Systems Architecture

This study recommends the Army and Navy use open systems architecture for procuring medical devices. Procuring medical devices with an open systems approach would facilitate modularity, interoperability, maintainability, and compatibility. These attributes would create significant life-cycle cost savings for follow-on logistics and product support while avoiding more costly proprietary technologies.

The MEDEVAC product office would also realize significant life-cycle cost savings by applying open systems architecture to current modernization efforts and future MEDEVAC platforms. Open systems architecture would facilitate future incremental system upgradability, reduced life-cycle sustainability costs, interoperability and upgradability of the mission equipment set (MES) with the mission equipment package (MEP).

4. Inter-service Collaboration

Medical device procurement in the DOD has made significant progress in recent years. This study found many commonalities in medical devices that can in part be attributed to the joint product of choice list (JPOC) and the medical materiel enterprise standardization office (MMESO). Perhaps even more influential is the push for more jointness coming from senior military leaders as a result of the initiatives of senior DOD officials and Congress. Despite the progress made to date, there are still many partnering and inter-service collaboration opportunities available.

This study highlights the importance of acquisition leaders taking every opportunity available to physically visit and collaborate with other services to find commonalities, learn from best practices, and enhance interoperability. An example of a recent collaboration effort was when PD MEDEVAC reached out to Helicopter Maritime Strike Four Six (HSM-46), a Navy search and rescue helicopter (MH-60R Seahawk) squadron, to see a demonstration of cabin capabilities, configuration, mission equipment, and hoist procedures. This opportunity afforded both services the chance to gain better visibility of how other services are performing their missions. Since the search and rescue

(SAR) mission is common in many ways to the MEDEVAC mission, efficiencies can be gained by see how another service is conducting mission tasks such as hoist operations.

Similar opportunities for collaboration could be pursued with the Navy's Helicopter Sea Combat (HSC) squadrons (MH-60H/S), Air Force Pararescue Pave Hawk squadrons (MH/HH-60G or the new CRH-60M/HH-60W) and Coast Guard Jayhawk helicopter (MH-60T) units. The MH-60H/S has more similarities to the Black Hawk than the MH-60R because it has an open cabin. Therefore, there are potentially more equipment similarities and opportunities for common solutions. The Army and Navy are already working together to conduct training for the Naval En Route Care (ERC) Program (DON, 2014d). The ERC Program trains nurses and hospital corpsman in the Joint En route Care Course (JECC) and the Army Flight Medic Course. These courses prepare the nurses and corpsmen in all aspects of the Naval En route Care System (ERCS) so they can effectively treat patients will transporting them to a higher level of care via military aircraft. In order to maximize the effectiveness of these training opportunities, the Army and Navy need to collaborate in the medical material solution space to meet mission requirements and find shared solutions where possible.

Many partnering opportunities also exist with the Air Force Pararescue (PR) community. In recent years, Air Force Pararescue squadrons have augmented Army MEDEVAC units by assisting with medical evacuation in Afghanistan (Meridith, 2007). Therefore, Army and Air Force program managers would likely benefit from working together. This is especially relevant as the combat rescue helicopter (CRH) helicopter program office is currently working hard to field a helicopter capability that will meet the future demands of the PR mission.

The Coast Guard Jayhawks also perform SAR and MEDEVAC and use a video system on the bottom of their helicopter to help with hoist operations. Partnering and collaboration opportunities with the Coast Guard would not only foster opportunities to integrate a video system into Army Black Helicopters for hoist operations but would also expose more possibilities for commonality in medical equipment and cabin configurations. As en route care becomes more of a joint mission, the opportunities for collaboration will grow.

Partnering with the Air Force for medical device procurement is potentially the greatest opportunity for the Army and Navy to maximize benefits achieved through commonality and collaboration. By doctrine, the Air Force is one of two critical components responsible for theater aeromedical evacuation. As such, they have a critical role in medical device testing and evaluation and procurement. Collaboration with the Air Force is vital to DOD wide medical device interoperability. Therefore, program managers in the medical field should continue to actively engage with the Air Force to pool resources and draw from the best practices of Air Force critical care air transport team (CCATTs) conducting air evacuation (AIREVAC).

5. Organizational Restructuring, Education, Leadership, and Policy

a. MEDEVAC Program of Record

If the DOD wants a more agile and responsive medical acquisition system it will require changes in organizational structure and policy. Too many stakeholders, layers of approval, and bureaucracy involved in the acquisition system make it nearly impossible to be agile and responsive to the warfighters needs. Efforts need to be taken to flatten organizations and reorganize so capabilities can be fielded to the right people when needed. The main organizational structure change this study recommends is to establish a MEDEVAC program of record. PM Utility helicopters is currently responsible for fielding systems for multiple mission sets. Issues with the current Black Hawk helicopter and lessons learned from the F-35 program suggest that trying to meet everyone's needs with a single mega-program that has variants of one design might not be the most effective solution. A PM MEDEVAC office would have a separate line of funding, making it easier to defend, manage and ultimately give the program a better chance of success. A MEDEVAC PM would also be able to more effectively interact with key stakeholders in the MEDEVAC Enterprise to ensure aeromedical evacuation mission requirements are met.

b. Acquisition and Engineering Education Opportunities

Building on the Better Buying Power (BBP) 3.0 Initiative "Improve the Professionalism of the Total Acquisition Workforce," the medical acquisition community

needs to focus on placing the right person, with the right skills, in the right job, at the right location (DOD, 2014). In order to achieve this goal, the DOD should increase acquisition and engineering education opportunities. For example, most of the officers in the Systems Acquisition Management MBA program at NPS are Army acquisition officers. If other services increased their participation in this program, it would not only improve the human capital externalities and "soft" benefits student receive from "intense interaction, team working, and networking" while attending NPS, but it would also improve the professionalism of the workforce (N. Dew, personal communication, April 29, 2014). Today, higher professional qualifications and technical expertise are required of program managers so they have a better understanding of the technologies they are fielding.

Medical materiel program managers need to have the technical and professional qualifications and experience. Today significant funding amounts are spent on purchasing medical equipment that is outdated by the time it is fielded. Medical personnel using the products say they have too much equipment that is never used. To mitigate this trend, objective data should be collected and analytical tools such as the quality function deployment (QFD) should be used to establish requirements and translate them into technical solutions. Then metrics should be developed and monitored to show progress, performance, and how successful the program is in meeting user needs. The money saved from downsizing medical equipment sets to the actual user requirement can be used for research, development, test and evaluation (RDT&E) for procuring modern equipment such as the devices presented in Chapter V.

The physical location of technically qualified leaders is often important. Therefore, this study recommends AMEDD acquisition representation in the Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASAALT) in the form of an O-4 MEDEVAC Department of the Army System Coordinator (DASC). The MEDEVAC DASC should sit in the Pentagon and work for the ASAALT. The DASC is a key and developmental position with the responsibility to coordinate with key stakeholders such as G3/DAMO-AV, OTSG, Army G8, AMEDD G8, MRMC, and UH/CH DASCs.

Additionally, this study recommends AMEDD acquisition representation at MRMC in the form of a MEDEVAC O-5 or O-6. This officer would function as the subject matter expert and liaison from within MRMC to coordinate with key stakeholders at Fort Detrick such as PM Telemedicine, PM Medical Devices, PM Medical Support Systems, and PjM MEDEVAC. Duty positions for this officer might include deputy for medical systems ASAALT, AMEDD senior logistician, and DA select program management positions within MRMC.

c. Leadership and Policy Change

Achieving a more joint, interoperable and responsive medical materiel procurement system will require growing the next generation of technically qualified leaders. This will maximize the potential of leadership talent and improve the acquisition workforce. Medical acquisitions need to overcome service culture barriers to change, organizational hierarchies have to become flatter and leaner, and leaders at all levels have to be encouraged to lead without unnecessary oversight.

Furthermore, a change in procurement policy is required to shift culture away from service-specific, stove-piped proprietary systems to more common solutions. Service unique requirements have been a major contributing factor to DOD program cost increases, schedule delays, and performance shortfalls. Consequently, it is important to determine which mission requirements necessitate service specific capabilities. Similarly, the costs and benefits of collaboration with other programs must be assessed.

B. LIMITATIONS OF STUDY

One of the limitations of this study is that it contains minimal information about Air Force AE. As mentioned in previous chapters, the Air Force is the Army's main strategic partner in AE. This study recognizes the Army is partnering with the Air Force in many areas. One example is the ongoing effort with the Air Force Medical Evaluation Support Activity (AFMESA) to identify oxygen sources, such as liquid oxygen (LOX), for use on high altitude MEDEVAC missions.

The focus of this study on small Navy ship sickbays was also a limitation because it excluded medical equipment and sickbay capabilities of larger vessels.

C. RECOMMENDATIONS FOR FUTURE STUDY

This study provides a solid foundation for potential areas of research. One of these areas is establishing an interoperable framework for portable medical devices that utilizes a common interface. Within this framework, the integration of medical information from the portable medical devices to the electronic health record is of paramount importance to the future virtual medical system. The capability provided in this area will enable the collection of medical information at the point of care and the seamless transfer throughout the medical treatment continuum.

Using current best practices for data analytics, design tools, optimization and modeling, and statistics analysis are other areas for future research that would likely interest product development teams. For example, one could determine the optimal configuration of medical equipment in a space constrained environment with a mathematical linear programming model where size, weight, importance, and cost are the constraints. Binary decision variables could be used to determine if a medical device should be chosen or not. Then the objective function could be set to maximize value, minimize cost or size.

Using Design for Six Sigma (DFSS), Analytical Hierarchy Process (AHP) and Quality Function Deployment (QFD) for the design and procurement of medical devices is another recommended area for future study. For a period of years, industry has used these methods for product design with great success. However, many DOD programs have not fully exploited the potential of these techniques to integrate the voice of the customer into product design. One example where customer requirements were not captured in product design was the sealed bubble window on MEDEVAC helicopters (Administrator, 2012). This design assisted in maintaining a sterile and temperature controlled environment; however, it restricted the crewmembers' ability to clear the tail of the aircraft during landing. It also made it very difficult for them to fit their heads in the bubble at night with night vision devices attached to their helmets.

The medical equipment set (MES) is another example where the Army has been slow to address the voice of the customer. According to Fulton (2014), after-action reviews and surveys from Operation Enduring Freedom (OEF) have shown there is too much equipment in the MES that is never used and extraction equipment such as "saws, Jaws of Life®, lifting bags" should be added so paramedics can extract patients from vehicles (p. 5). Many issues such as these were identified early in the Iraq war; however, the slow defense procurement process has not been able to respond quickly enough to meet the needs of the warfighter. Future studies should use resources such as the Center for Army Lessons Learned, Interagency Lessons Learned, and AMEDD lessons learned webpages to identify the voice of the customer and then use the quantitative methods previously discussed to design and procured devices that more accurately address user needs.

Some programs and initiatives are doing better than others at using widely accepted quantitative and algorithmic methods for product design and procurement. The FVL initiative is one example where acquisition and engineering professionals are using these methods. According to (Fulton et al., in press), DFSS methods that are being used in FVL MEDEVAC platform design process include "deterministic analysis, simulation-based experimental design, semi-structured surveys, workflow recording, and interactive three-dimensional computer modeling" (p. 2). Similar to the aircraft design and procurement process, a significant amount of money can be saved by using these tools to inform decision makers before they allocate funds to design and acquire medical devices.

Studies also should focus on developing the medical equipment set (MES) and mission equipment package (MEP) together because they are interrelated. The MES and MEP need to be standardized. Common interfaces and interoperability are some of the critical design and procurement issues that need to be addressed. MES and MEP design studies should also focus on lighter systems that are carry-on where possible. This will make it easier and more cost effective to upgrade, modify, repair, and maintain. For example, lessons learned from Iraq and Afghanistan have shown that the current Advanced Medical Oxygen Generating System (AMOGS) and suction that are built into some of the medical evacuation airframes are never used. The AMOGS system is not

used and is often removed because of its weight, and it draws 4% of power away from the engines when turned on. Since many of the landing zones in Afghanistan area at an altitude higher than 10,000 feet, many units have decided to remove the system to ensure they have power to land their medical evacuation Black Hawks that are already too close to their max gross weight. The suction systems that are built into the airframe are never used because they are very difficult to clean and maintain. Future studies should look at portable oxygen and suction systems used in civilian helicopter emergency medical services and recommend devices that are developed with a modular open system approach.

Long-term objectives should not only focus on common interfaces and interoperability within the DOD, but also on working with our civilian and international partners. Currently, many of our partner nations use medical systems that are not interoperable with many of our systems. This has caused issues when conducting joint patient transfers because each of the medical attendants have been restricted to using their own devices. Future studies could make recommendations about the best way to promote international standardization. This might include updating and improving current international standards or instituting new policies. Either way, current trends emphasize open system architecture, common software standards, model-driven development, and formal methods. In the DOD's fiscally constrained environment, joint procurement with an open systems approach advances technological innovation and provides dominant medical capabilities to support the warfighter.

APPENDIX A. FORCE HEALTH PROTECTION REQUIREMENTS FOR TICONDEROGA CLASS CRUISER

The following is the Force Health Protection (FHP) for CG 47 Ticonderoga Guided Missile Cruiser as outlined in the Chief of Naval Operation Instructions (DON, 2013).

CG 47 CLASS	**I**	**III**	**IV**	**V**
FORCE HEALTH PROTECTION				
FHP 23 PROVIDE MEDICAL CARE TO ASSIGNED AND EMBARKED PERSONNEL.				
FHP 23.1 Conduct sick call.	**F**	**F**	**F**	
FHP 23.3 Conduct lab diagnostic services requiring the following personnel:	**L**	**L**	**L**	**L**
(a) Hospital corpsman.				
I, III, IV(L) – Minor services within independent duty corpsman skill level and authorized medical allowance list (AMAL) limits.				
V(L) – Transfer samples to and/or use a shore laboratory.				
FHP 23.4 Conduct basic ward care.	**L**	**L**	**L**	**L**
I, III, IV(L) – For use in emergency cases where medical evacuation (MEDEVAC) is not possible or where return to duty can be expected in a short time.				
FHP 23.5 Conduct sanitation and safety inspections.	**F**	**F**	**F**	
FHP 23.6 Conduct occupational health/safety and preventive medical programs and training using the following personnel:	**F**	**F**	**F**	
(a) Hospital corpsman.				
FHP 23.8 Conduct pharmacy services requiring the following personnel:	**F**	**F**	**F**	
(a) Hospital corpsman.				
FHP 23.9 Conduct associated administrative maintenance service.	**F**	**F**	**F**	
(a) Maintain adequate medical supplies for appropriate level health care.				
(c) Provide patient/casualty administrative services.				

(d) Perform routine medical administrative services.				
FHP 23.11 Conduct ocular diagnostic and therapeutic services requiring the following personnel (choose as applicable):	**L**	**L**	**L**	
(a) Hospital corpsman.				
I, III, IV(L) – Minor services within independent duty corpsman skill level and AMAL limits.				
FHP 23.15 Conduct disease and vector control planning and operations.		**L**	**L**	**L**
III, IV(L) – Minor services within independent duty corpsman skill level and AMAL limits.				
V(L) – Assistance provided by shore facilities.				
FHP 23.17 Identify, equip, and maintain suitable spaces to provide medical care.	**F**	**F**	**F**	**F**
FHP 23.18 Identify, equip, and maintain adequate storage spaces for medical equipment and medical supplies.	**F**	**F**	**F**	**F**
FHP 23.19 Provide medical care, triage, and resuscitation commensurate with health care provider credentials using the following personnel:	**F**	**F**	**F**	**F**
(a) Independent duty corpsman.				
FHP 23.20 Provide obstetrics and gynecological medical care commensurate with health care provider credentials using the following personnel:		**F**	**F**	**F**
(a) Independent duty hospital corpsman responsibilities.				
FHP 24 PROVIDE FIRST AID ASSISTANCE.				
FHP 24.1 Identify, equip, and maintain appropriate first aid spaces.	**F**	**F**	**F**	**F**
FHP 24.2 Train assigned and embarked personnel in first aid, self and buddy aid procedures.		**F**	**F**	**F**
FHP 24.3 Train stretcher-bearers.	**F**	**F**	**F**	**F**
FHP 25 PROVIDE TRIAGE OF CASUALTIES/PATIENTS.				
FHP 25.1 Identify, equip, and maintain suitable triage spaces.	**F**	**F**	**F**	**F**
FHP 25.2 Train assigned and embarked personnel in triage care.		**F**	**F**	**F**
FHP 25.4 Train designated non-medical personnel to assist in triage management care for chemical biological and radiation (CBR) contamination casualties.		**F**	**F**	**F**
FHP 25.5 Train designated non-medical personnel in CBR casualty decontamination procedures.	**F**	**F**	**F**	**F**
FHP 25.7 Provide medical treatment for chemical biological radiological casualties.	**L**	**L**	**L**	**L**
I, III, IV(L) – Emergency cases where MEDEVAC is not possible or where return to duty can be expected in a short time.				
V(L) – Plan and train.				
FHP 26 PROVIDE MEDICAL AND SURGICAL TREATMENT FOR				

CASUALTIES/PATIENTS.				
FHP 26.1 Identify, equip and maintain suitable resuscitation spaces.		**F**	**F**	**F**
FHP 26.2 Train assigned and embarked personnel in resuscitation.	**F**	**F**	**F**	**F**
FHP 26.5 Identify, equip, and maintain suitable spaces for emergency minor surgery.	**F**	**F**	**F**	**F**
FHP 27 PROVIDE MEDICAL, SURGICAL, POST-OPERATIVE AND NURSING CARE FOR CASUALTIES/PATIENTS.	**F**	**F**	**F**	**F**
FHP 27.1 Provide hospital beds (choose as applicable):	**L**	**L**	**L**	
(b) Ward.				
I, III, IV(L) – For use in emergency cases where MEDEVAC is not possible or where return to duty can be expected short time.				
FHP 27.4 Provide suitable care for the dead.		**L**	**L**	
III, IV(L) – Temporary storage.				
FHP 29 PROVIDE ROUTINE AND EMERGENCY DENTAL CARE.				
FHP 29.1 Conduct dental sick call.		**L**	**L**	**L**
III, IV(L) – Provide examinations and treatment for minor dental problems as a part of routine sick call.				
V(L) – Conduct initial examination and refer patients to a dentist/dental clinic.				
FHP 30 PROVIDE DEFINITIVE DENTAL CARE FOR CASUALTIES AND PATIENTS.				
FHP 30.1 Provide restoration treatments and minor oral surgery including tooth extraction.	**L**	**L**	**L**	**L**
I(L) – Emergency stabilization.				
III, IV(L) – Minor treatment and emergency tooth extraction.				
V(L) – Conduct initial examination and refer patients to dentist/dental clinic.				

APPENDIX B. FORCE HEALTH PROTECTION REQUIREMENTS FOR THE LITTORAL COMBAT SHIP

The following is the FHP for the Littoral Combat Ship (LCS) as outlined in the Chief of Naval Operation Instructions (DON, 2014c).

LCSRON	I	II I	IV	V
FORCE HEALTH PROTECTION (FHP)				
FHP 23 PROVIDE MEDICAL CARE TO ASSIGNED AND EMBARKED PERSONNEL.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.1 Conduct sick call.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.5 Conduct sanitation and safety inspections.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.6 Conduct occupational health/safety and preventive medicine programs and training using the following personnel:			**F/ E**	**F/ E**
(a) Hospital corpsmen.				
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.9 Conduct associated administrative/ maintenance services:			**F/ E**	**F/ E**
(a) Maintain adequate medical supplies for appropriate level of health care.				
(b) Perform routine medical administrative services.				
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.10 Conduct on-site emergency medical treatment during hazardous evolutions including flight quarters, UNREP/refueling, and amphibious assault boat operations.			**F/ E**	**F/ E**
Note: During general quarters, casualties are normally taken to the corpsmen in the battle dressing station.				
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs				

and underway.				
FHP 23.17 Identify, equip, and maintain adequate storage spaces to provide medical care.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.18 Identify, equip, and maintain adequate storage spaces for medical equipment and medical supplies.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 23.19 Provide medical care, triage and resuscitation commensurate with health care provider credentials using the following personnel:			**F/ E**	**F/ E**
(a) Independent duty corpsman (IDC).				
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 24 PROVIDE FIRST AID ASSISTANCE.				
FHP 24.1 Identify, equip, and maintain appropriate first aid spaces.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 24.2 Train assigned and embarked personnel in first aid, self and buddy air procedures.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 24.3 Train stretcher-bearers.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 25 PROVIDE TRIAGE OF CASUALTIES/PATIENTS.				
FHP 25.1 Identify, equip, and maintain suitable triage spaces.			**F/ E**	**F/ E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 25.2 Train assigned and embarked personnel in triage care.			**F/ E**	**F/ E**
Note: Medical personnel only.				

IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 25.4 Train designated non-medical personnel to assist in triage management care for chemical, biological, and radiological (CBR) contamination casualties.			**F/E**	**F/E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 25.5 Train designated non-medical personnel to assist in CBR casualty decontamination procedures.			**F/E**	**F/E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 25.7 Provide medical treatment for CBR casualties.			**F/E**	**F/E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				
FHP 26 PROVIDE MEDICAL/SURGICAL TREATMENT FOR CASUALTIES/PATIENTS.				
FHP 26.2 Train assigned and embarked personnel in resuscitation.			**F/E**	**F/E**
IV, V(F/E) – LCSRON/LTF provides all training teams at LTFs and underway.				

APPENDIX C. FORCE HEALTH PROTECTION REQUIREMENTS FOR THE AVENGER CLASS MINE COUNTERMEASURES

The following is the FHP for the Avenger Class Mine Countermeasures (MCM) as outlined in the Chief of Naval Operation Instructions (DON, 2014c).

MCM 1 Class	**I/IM**	**IIM**	**III**	**IV**	**V**
FHP 23 PROVIDE MEDICAL CARE TO ASSIGNED AND EMBARKED PERSONNEL.					
FHP 23.1 Conduct sick call.			**F**	**F**	**F**
FHP 23.5 Conduct sanitation and safety inspections.			**F**	**F**	**F**
FHP 23.6 Conduct occupational health/safety and preventive medicine programs and training using the following personnel:			**F**	**F**	**F**
(a) Hospital corpsman.					
FHP 23.9 Conduct associated administrative/maintenance services:			**F**	**F**	**F**
(a) Maintain adequate medical supplies for appropriate level of health care.					
(d) Perform routine medical administrative services.					
FHP 23.10 Conduct on-site emergency medical treatment during hazardous evolutions including flight quarters, underway replenishment/ refueling and amphibious assault boat operations.		**F**	**F**	**F**	**F**
NOTE: During general quarters, casualties are normally taken to the corpsman in the battle dressing station.					
FHP 23.17 Identify, equip, and maintain suitable spaces to provide medical care.	**F**	**F**	**F**	**F**	**F**
FHP 23.18 Identify, equip, and maintain adequate storage spaces for medical equipment and medical supplies.	**F**	**F**	**F**	**F**	**F**
FHP 23.19 Provide medical care, triage and resuscitation commensurate with health care provider credentials using the following personnel:	**F**	**F**	**F**	**F**	**F**

(a) Independent duty corpsman.					
FHP 24 PROVIDE FIRST AID ASSISTANCE.					
FHP 24.1 Identify, equip, and maintain appropriate first aid spaces.	**F**	**F**	**F**	**F**	**F**
FHP 24.2 Train assigned and embarked personnel in first aid, self and buddy aid procedures.			**F**	**F**	**F**
FHP 24.3 Train stretcher-bearers.			**F**	**F**	**F**
FHP 25 PROVIDE TRIAGE OF CASUALTIES/PATIENTS.					
FHP 25.1 Identify, equip, and maintain suitable triage spaces.	**F**	**F**	**F**	**F**	**F**
FHP 25.2 Train assigned and embarked personnel in triage care.			**F**	**F**	**F**
NOTE: Medical personnel only.					
FHP 25.4 Train designated non-medical personnel to assist in triage management care for chemical, biological, and radiation (CBR) contamination casualties.	**F**		**F**	**F**	**F**
FHP 25.5 Train designated non-medical personnel in CBR casualty decontaminated procedures.	**F**		**F**	**F**	**F**
FHP 25.7 Provide medical treatment for CBR casualties.	**L**		**L**	**L**	**L**
I, III, IV(L) – Limited by qualifications of independent duty hospital corpsman.					
V(L) – Plan and train.					
FHP 26 PROVIDE MEDICAL/SURGICAL TREATMENT FOR CASUALTIES/PATIENTS.					
FHP 26.1 Identify, equip, and maintain suitable resuscitation spaces.	**F**		**F**	**F**	**F**
FHP 26.2 Train assigned and embarked personnel in resuscitation.			**F**	**F**	**F**
NOTE: Medical personnel only.					
FHP 26.4 Identify, equip, and maintain adequate medical supply storage spaces for appropriate level of resuscitation.	**F**	**F**	**F**	**F**	**F**
FHP 26.5 Identify, equip, and maintain suitable spaces for emergency minor surgery.	**F**	**F**	**F**	**F**	**F**

APPENDIX D. AUTHORIZED MEDICAL ALLOWANCE LIST EQUIPMENT FOR THE CRUISER, LITTORAL COMBAT SHIP, AND MINE COUNTERMEASURE SHIPS

Cruiser (CG) AMAL Equipment Listing (NAILS, 2014)

COG	ID	NSN	Item Description	QTY	UI
9B	715	6530015640746	LIGHT SURGICAL CEILING SINGLE HEAD	1	EA
9B	715	6530015894229	LIGHT FLOOR GENERAL EXAM GREEN SERIES	1	EA
9B	715	6515015683799	DEFIBRILLATOR AUTOMATED EXTERNAL -LEAD	1	EA
9B	715	6135015308136	BATTERY POWER SOURCE NON-RECHARGABLE	2	EA
9B	715	6515015469366	MONITOR PATIENT VITAL SIGNS W/CHARGING	1	EA
9B	715	6515015308140	SIMULATOR CARDIAC PATIENT END ITEM	1	EA
9B	715	6530004808286	LIGHT DIAGNOSTIC EXAMINATION BURTON TYPE 120 V 50–60	1	EA
9B	715	6640016232349	CENTRIFUGE BENCHTOP/CELL CULTURE 4X85ML MAX 0–99MIN	1	EA
9B	715	6680012346789	REGULATOR OXYGEN PRESSURE LIGHTWEIGHT W/INTEGRAL FL	2	EA
9B	715	6515015257595	THERMOMETER CLINICAL HUMAN ELECTRONIC DIGITALW/WALL	1	EA
9B	715	6640015102492	ANALYZER HEMATOLOGY FULLY AUTOMATED DRY HEMATOLO	1	EA
9B	715	6680011746276	REGULATOR PRESSURE MEDICAL GAS ADMINISTRATION APPAR	2	EA
9B	715	6685015816875	CALIBRATION KEY ELECTRONIC THERMOMETER SURE TEMP	1	EA
9B	715	3540015075630	SEALING MACHINE PORTABLE 115V 60 HZ HEAT SEALING W/PO	1	EA
9B	715	6685015840785	MONITOR,HEAT STRESS	2	EA
9B	715	6670010976167	SCALE,WEIGHING	1	EA
9B	715	6530016200664	STERILIZER M11 ULTRACLAVE 115V AUTOMATIC DOOR	1	EA
9B	715	6640015768119	INCUBATOR BACTERIOLOGICAL BENCHTOP .8 CUBIC FT.	1	EA

Littoral Combat Ship (LCS) AMAL Equipment Listing (NAILS, 2014)

COG	ID	NSN	Item Description	QTY.	UI
9B	515	6530004808286	LIGHT DIAGNOSTIC EXAMINATION BURTON TYPE	1	EA
9B	515	6680012346789	REGULATOR OXYGEN PRESSURE	2	EA

			LIGHTWEIGHT W/INTEGRAL FLOW		
9B	515	6530015894229	LIGHT FLOOR GENERAL EXAM GREEN SERIES 100/240V AC 50/60HZ	1	EA
9B	515	6640015102492	ANALYZER HEMATOLOGY FULLY AUTOMATED DRY HEMATOLOGY	1	EA
9B	515	6640015768119	INCUBATOR BACTERIOLOGICAL BENCHTOP .8 CUBIC FT.	1	EA
9B	515	6680011746276	REGULATOR PRESSURE MEDICAL GAS ADMINISTRATION APPAR	2	EA
9B	515	3540015075630	SEALING MACHINE PORTABLE 115V 60 HZ HEAT SEALING W/POLY	1	EA
9B	515	6515015308140	SIMULATOR CARDIAC PATIENT END ITEM 6515–01–568–3799	1	EA
9B	515	6685015816875	CALIBRATION KEY ELECTRONIC THERMOMETER SURE TEMP PLUS	1	EA
9B	515	6685015840785	MONITOR,HEAT STRESS	2	EA
9B	515	6135015308136	BATTERY POWER SOURCE NON-RECHARGABLE LITHIUM	2	EA
9B	515	6515015469366	MONITOR PATIENT VITAL SIGNS W/CHARGING CRADLE AND USB	1	EA
9B	515	6530014778525	RESCUE SLEEVES II ORANGE	2	EA
9B	515	6530015437127	TABLE EXAMINING AND TREATMENT MANUAL 59.5 X 28.5’’ 115 V	1	EA
9B	515	6530015640746	LIGHT SURGICAL CEILING SINGLE HEAD QUARTZ HALOGEN SHIP	1	EA
9B	515	6515015316051	SUCTION APPARATUS SURGICAL PROGRAMMABLE BAT 11–30V/AC	1	EA
9B	515	6515015683799	DEFIBRILLATOR AUTOMATED EXTERNAL -LEAD ECG CABLE	1	EA
9B	515	6530014902487	SPINEBOARD PTBL 72X16X2.250IN TAPERED 8STRAP 1000LB CAPA	2	EA
9B	515	6640016232349	CENTRIFUGE BENCHTOP/CELL CULTURE 4X85ML MAX 0–99MIN	1	EA

Mine Countermeasures Ship (MCM) AMAL Equipment Listing (NAILS, 2014)

COG	ID	NSN	Item Description	QTY.	UI
9B	315	6135015308136	BATTERY POWER SOURCE NON-RECHARGABLE LITHIUM	2	EA
9B	315	3540015075630	SEALING MACHINE PORTABLE 115V 60 HZ HEAT SEALING W/PO	1	EA
9B	315	6515015308140	SIMULATOR CARDIAC PATIENT END ITEM 6515–01–568–3799	1	EA
9B	315	6670010976167	SCALE,WEIGHING	1	EA
9B	315	6685015840785	MONITOR,HEAT STRESS	2	EA
9B	315	6530016200664	STERILIZER M11 ULTRACLAVE 115V AUTOMATIC DOOR	1	EA
9B	315	6685015816875	CALIBRATION KEY ELECTRONIC	1	EA

			THERMOMETER SURE TEMP PL		
9B	315	6515015683799	DEFIBRILLATOR AUTOMATED EXTERNAL -LEAD ECG CABLE	1	EA
9B	315	6515015257595	THERMOMETER CLINICAL HUMAN ELECTRONIC IGITALW/WALL	1	EA
9B	315	6530004808286	LIGHT DIAGNOSTIC EXAMINATION BURTON TYPE 120 V 50–60	1	EA
9B	315	6530015437127	TABLE EXAMINING AND TREATMENT MANUAL 59.5 X 28.5’’ 115	1	EA
9B	315	6680012346789	REGULATOR OXYGEN PRESSURE LIGHTWEIGHT W/INTEGRAL	1	EA

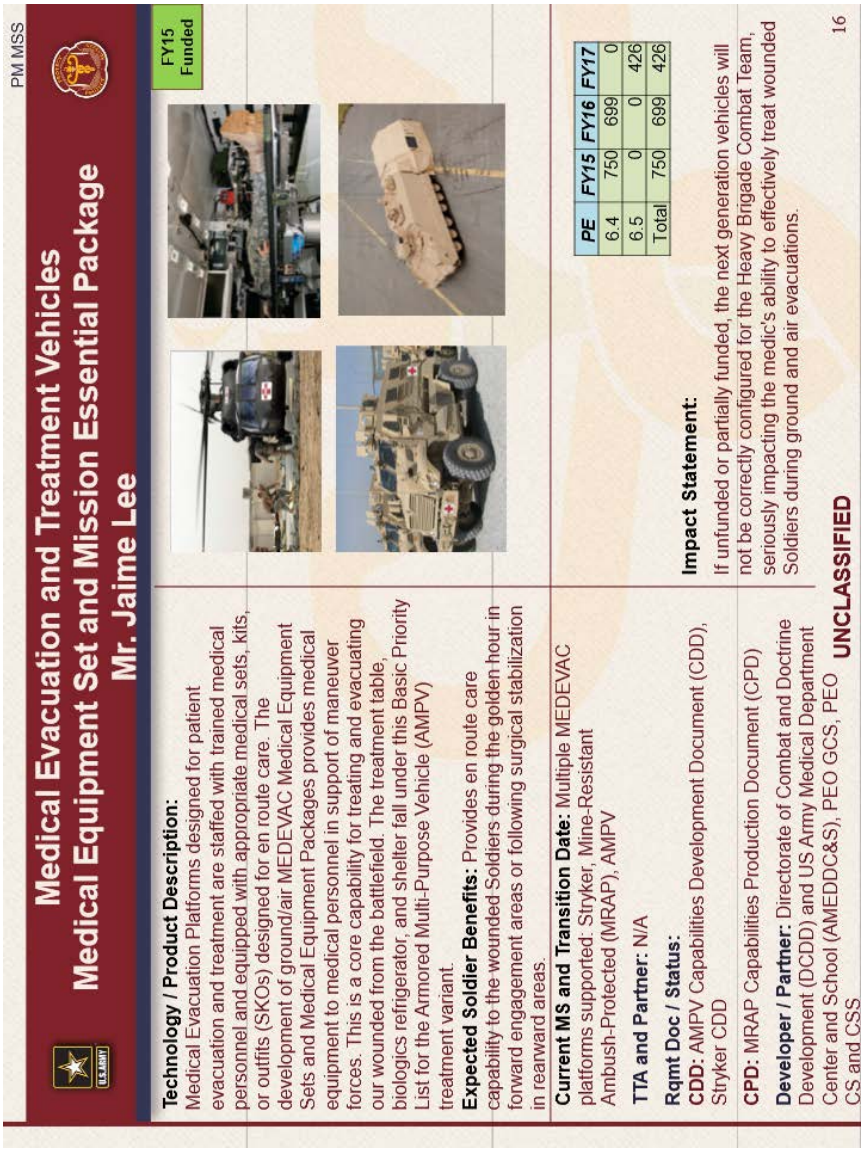
APPENDIX E. MEDICAL EQUIPMENT SET (MES) 2010

The following are the durable and non-expendable items in the Medical Equipment Set Air Ambulance 2010 UA 257B as of October 13, 2014, (HQDA, 2014c).

UAC	NSN	NOMENCLATURE	UI	Army ARC	Qty
257B	6545015850537	MES AIR AMB-2010	SE	N	1
257B	6630015270969	ANALYZER BLOOD GLUCOS	PG	D	1
257B	6545015188536	BACKPACK MEDICAL TA	EA	D	1
257B	6545015388494	BAG HELICOPTER MEDI	EA	D	2
257B	6545015389464	BAG HELICOPTER MEDI	EA	D	1
257B	7210007157985	BLANKET BED WOOL O-G	EA	D	6
257B	6530012653583	EXTRACTION DEVICE	EA	D	1
257B	6530012601227	FLOATATIN ASSY RESCUE	EA	D	1
257B	6515015278068	HEADLAMP MEDICAL	EA	D	6
257B	6530013807309	LITTER,FOLDING,RIGID	EA	D	6
257B	6515015571136	OXIMETER PULSE PORT	EA	D	6
257B	6530015157651	PANEL MODULAR MED TRA	EA	D	1
257B	6680012346789	REGULATOR OXYGEN PRES	EA	D	2
257B	6530014883977	RESTRAINT LOCKING	EA	D	1
257B	6515015139276	RESUSCITATION KIT,MOU	EA	D	1
257B	6515003634100	SAW FINGER RING 6”LG	EA	D	1
257B	6515015104342	SPHYGMONAMETER ADULT	EA	D	2
257B	6530014902487	SPINEBOARD	EA	D	1
257B	6515012508936	SPLINT TRACTION-EXTRI	EA	D	1
257B	6515013146694	STETHOSCOPE COMB 28”	EA	D	1
257B	6515015530107	BLOOD-FLUID WARMERSYS	KT	N	2
257B	6545015338202	CASE,MEDICAL INSTRU	EA	N	3
257B	6515015154197	DEFIB/MON RECORD SYS	EA	N	1
257B	6515015342369	LARYNGOSCOPE SET	SE	N	1
257B	6515015505669	PUMP IV INFUSIO	EA	N	1
257B	6515014350050	SUCTION APPARATUS,SUR	EA	N	1
257B	6515015239935	THERMOMETER KIT,CLINI	EA	N	1
257B	6530014640267	VENTILATOR VOLUME PTB	EA	N	1
257B	6515014322707	VITAL SIGNS MONITOR	EA	N	1

APPENDIX F. MEDICAL EQUIPMENT SET DEVELOPMENT USAMMDA/USAMMA

The following is the Advanced Development Board of Directors Command Budget Estimate Spend Plan for MES and MEP development for FY15–20, as of May 6, 2014 (C. R. Paschal, personal communication, June 18, 2014).



Medical Equipment Set Development
USAMMDA / USAMMA

FY15 Funded

Technology / Product Description:

Medical Equipment Sets (MES) and kits help evacuate wounded soldiers and treat battlefield injuries. Examples of capabilities include fresh/waste water distribution/collection, cold chain management, medical bags and kits, preventive medicine devices, refrigerators, freezers, and sinks.

Expected Soldier Benefits:

• Mitigate/treat trauma, hemorrhage, shock, airway management/resuscitation with minimal distress from point of injury to Role Level 2 hospitals.

Trauma Bag

Current MS and Transition Date: MES currently being upgraded, fielded, and sustained.

TTA and Partner:
As required

Rqmt Doc / Status:
CDD: CTC3 ICD Capabilities Development Document (CDD) Armored Multi-Purpose Vehicle (AMPV) from PM Heavy Brigade Combat Team (HBCT)
CPD: (Current sustainment/modernization of sets) – Core Soldier CPD

Developer / Partner: Directorate of Combat and Doctrine Development (DMMPO), and commercial partners and agencies.

PE	FY15	FY16	FY17
6.4	0	0	0
6.5	1,668	2,535	2,197
Total	1,668	2,535	2,197

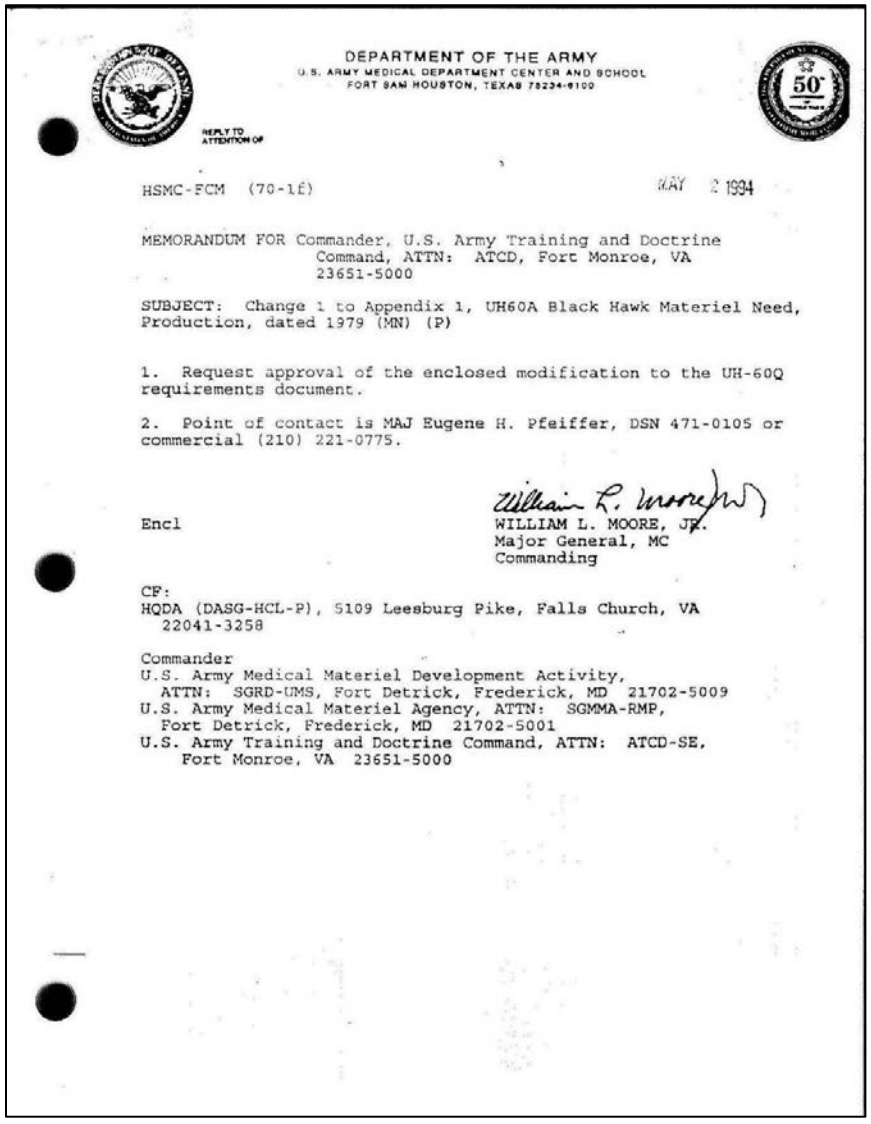
Impact Statement:
If partially funded or unfunded,

- During ground and air evacuations and field hospitalization, Soldiers will receive substandard care due to the 214 MESs, kits and outfits not being fully modernized and integrated.
- Field medical personnel will not have the best tools required for the standard of care to preserve life/limb of Soldiers on the ground due to an inability to perform verification of set compatibility with air/ground platforms through test and evaluation with designated project managers to allow for seamless and efficient integration of MES' into all platforms.

APPENDIX G. MEDEVAC REQUIREMENTS DOCUMENT CHANGE

A. MEMORANDUM FROM AMEDD TO TRADOC

The following is the May 2, 1994 memorandum from AMEDD to TRADOC requesting approval of the enclosed modification to the UH-60Q requirements document (P. B. Anderson, personal communication, June 19, 2014).



DEPARTMENT OF THE ARMY
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
FORT SAM HOUSTON, TEXAS 78234-6100

REPLY TO ATTENTION OF

HSMC-FCM (70-1f) MAY 2 1994

MEMORANDUM FOR Commander, U.S. Army Training and Doctrine Command, ATTN: ATCD, Fort Monroe, VA 23651-5000

SUBJECT: Change 1 to Appendix 1, UH60A Black Hawk Materiel Need, Production, dated 1979 (MN) (P)

1. Request approval of the enclosed modification to the UH-60Q requirements document.

2. Point of contact is MAJ Eugene H. Pfeiffer, DSN 471-0105 or commercial (210) 221-0775.

William L. Moore, Jr.

Encl

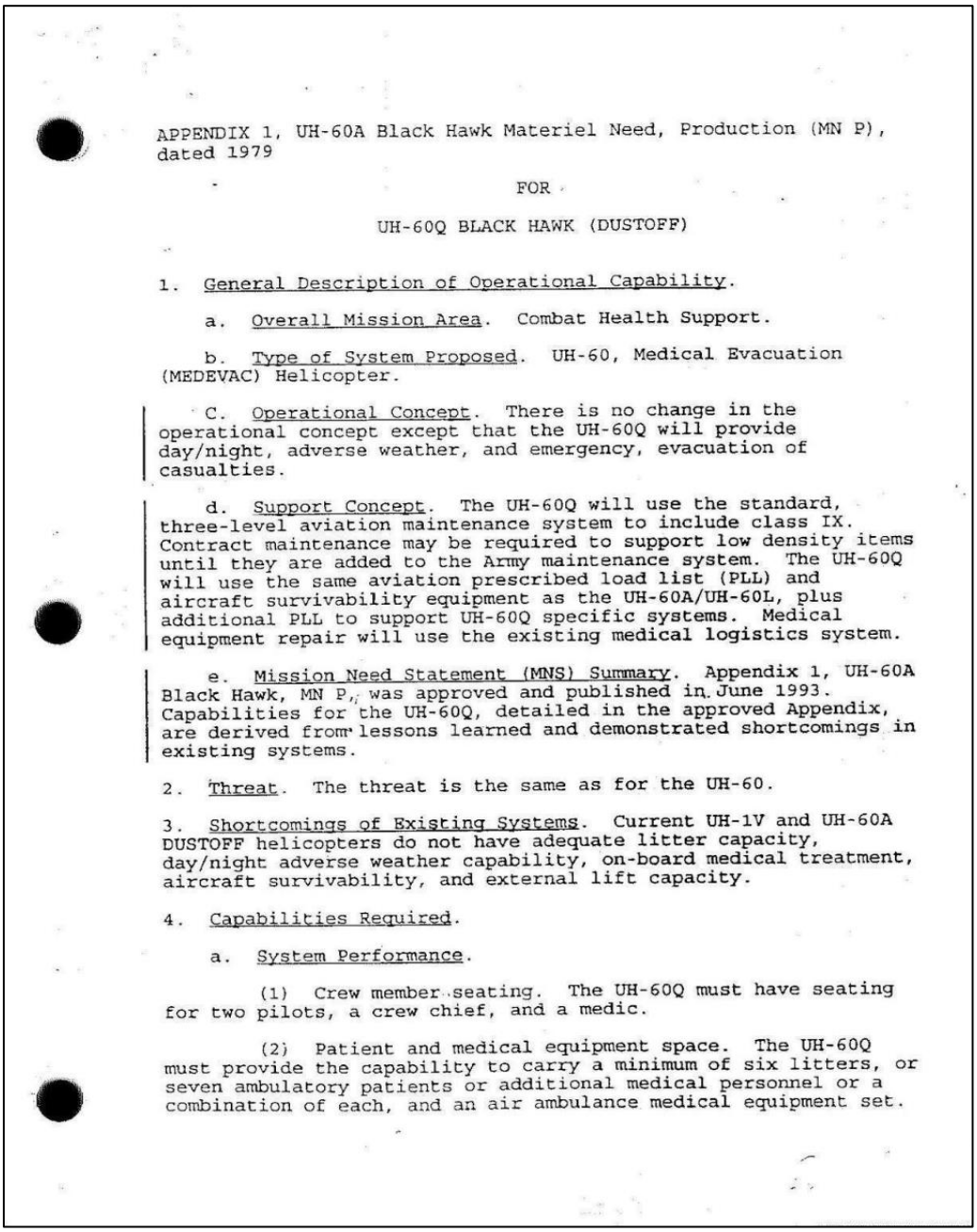
WILLIAM L. MOORE, JR.
Major General, MC
Commanding

CF:
HQDA (DASG-HCL-P), 5109 Leesburg Pike, Falls Church, VA 22041-3258

Commander
U.S. Army Medical Materiel Development Activity, ATTN: SGRD-UMS, Fort Detrick, Frederick, MD 21702-5009
U.S. Army Medical Materiel Agency, ATTN: SGMMA-RMP, Fort Detrick, Frederick, MD 21702-5001
U.S. Army Training and Doctrine Command, ATTN: ATCD-SE, Fort Monroe, VA 23651-5000

B. UH-60Q REQUIREMENTS DOCUMENT

The following is the first page of the original UH-60Q requirements document that was attached to the May 2, 1994 memorandum.



APPENDIX 1, UH-60A Black Hawk Materiel Need, Production (MN P), dated 1979

FOR

UH-60Q BLACK HAWK (DUSTOFF)

1. General Description of Operational Capability.

a. Overall Mission Area. Combat Health Support.

b. Type of System Proposed. UH-60, Medical Evacuation (MEDEVAC) Helicopter.

C. Operational Concept. There is no change in the operational concept except that the UH-60Q will provide day/night, adverse weather, and emergency, evacuation of casualties.

d. Support Concept. The UH-60Q will use the standard, three-level aviation maintenance system to include class IX. Contract maintenance may be required to support low density items until they are added to the Army maintenance system. The UH-60Q will use the same aviation prescribed load list (PLL) and aircraft survivability equipment as the UH-60A/UH-60L, plus additional PLL to support UH-60Q specific systems. Medical equipment repair will use the existing medical logistics system.

e. Mission Need Statement (MNS) Summary. Appendix 1, UH-60A Black Hawk, MN P, was approved and published in June 1993. Capabilities for the UH-60Q, detailed in the approved Appendix, are derived from lessons learned and demonstrated shortcomings in existing systems.

2. Threat. The threat is the same as for the UH-60.

3. Shortcomings of Existing Systems. Current UH-1V and UH-60A DUSTOFF helicopters do not have adequate litter capacity, day/night adverse weather capability, on-board medical treatment, aircraft survivability, and external lift capacity.

4. Capabilities Required.

a. System Performance.

(1) Crew member seating. The UH-60Q must have seating for two pilots, a crew chief, and a medic.

(2) Patient and medical equipment space. The UH-60Q must provide the capability to carry a minimum of six litters, or seven ambulatory patients or additional medical personnel or a combination of each, and an air ambulance medical equipment set.

C. RECOMMENDED CHANGES TO THE UH-60Q REQUIREMENTS DOCUMENT

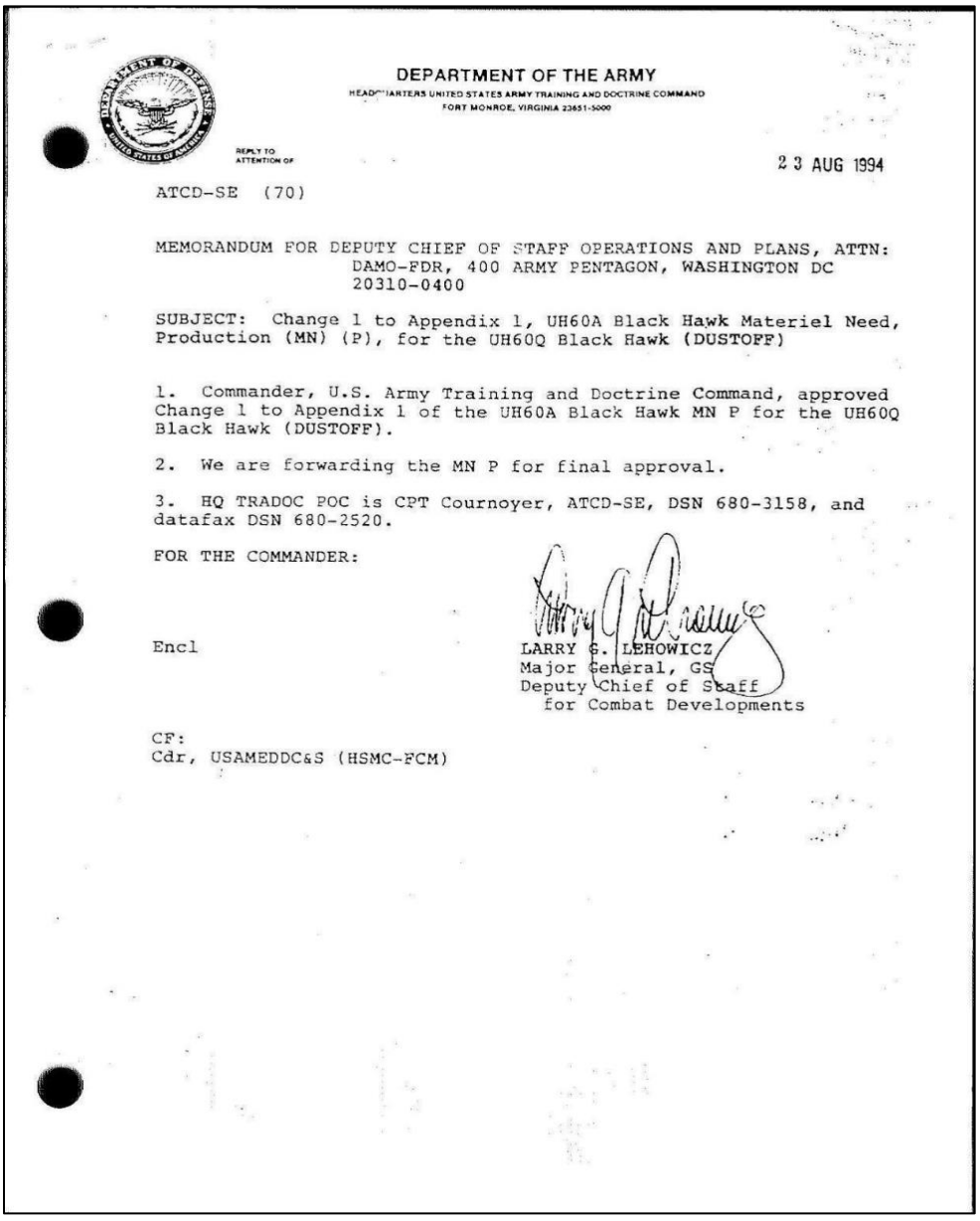
ITEM	PAGE	PARA	LIN	FIG	TAB	RECOMMENDED CHANGES AND REASON
20		4a (21)				DELETE: External Cargo Container. RATIONALE: Not considered practical within cost constraints.
21		4a (21)				RENUMBERED:
22		4a (22)				ADD: Medical Suction. The UH-60Q must provide an on-board capability for airway and gastric suction. The system must be usable at all litter stations and it must support four patients simultaneously. It must have a suction range of 0-250 centimeters (cm) of water (H2O) at six selectable levels of 20, 30, 50, 100, 150, and 250 cm H2O. It must have an accuracy of +/- 5 cm H2O from the selected setting. It must have a flow rate of not less than two liters per minute (lpm) and an accuracy of +/- 0.1 lpm of flow rate. It must be capable of continuous operation at all suction levels and intermittent operation for gastric suction (15 seconds on and 8 seconds off per cycle) at 20 cm H2O only. RATIONALE: Portable suction units used on current evacuation systems have several shortcomings that can be overcome by a system built into the aircraft. Among these are: durability, storage space, accessibility, ability to secure systems in use, and the fact one portable kit is needed for each patient. The concept of a built-in suction system was demonstrated on the proof of principle UH-60Q.
23		5b				CHANGE TO READ: Support Equipment. There may be minimal change to current aviation tools and test equipment. RATIONALE: The UH-60Q will have equipment not found on the current evacuation systems.
24		5c (2)				CHANGE TO READ: A training device representing the medical interior will be required for flight medic and flight surgeon training at the School of Aviation Medicine. RATIONALE: This needed for initial training in qualification courses.

TYPED NAME, GRADE:	TELEPHONE/AUTOVON:	SIGNATURE:
Eugene H. Pfeiffer	DSN 471-0105	Eugene H. Pfeiffer

page 8 of 9

D. MEMORANDUM FROM TRADOC TO PENTAGON

The following is the August 23, 1994 memorandum from TRADOC to the Pentagon requesting final approval for the UH-60Q requirements document modification (P. B. Anderson, personal communication, June 19, 2014).



DEPARTMENT OF THE ARMY
HEADQUARTERS UNITED STATES ARMY TRAINING AND DOCTRINE COMMAND
FORT MONROE, VIRGINIA 23651-5000

REPLY TO ATTENTION OF

23 AUG 1994

ATCD-SE (70)

MEMORANDUM FOR DEPUTY CHIEF OF STAFF OPERATIONS AND PLANS, ATTN: DAMO-FDR, 400 ARMY PENTAGON, WASHINGTON DC 20310-0400

SUBJECT: Change 1 to Appendix 1, UH60A Black Hawk Materiel Need, Production (MN) (P), for the UH60Q Black Hawk (DUSTOFF)

1. Commander, U.S. Army Training and Doctrine Command, approved Change 1 to Appendix 1 of the UH60A Black Hawk MN P for the UH60Q Black Hawk (DUSTOFF).

2. We are forwarding the MN P for final approval.

3. HQ TRADOC POC is CPT Cournoyer, ATCD-SE, DSN 680-3158, and datafax DSN 680-2520.

FOR THE COMMANDER:

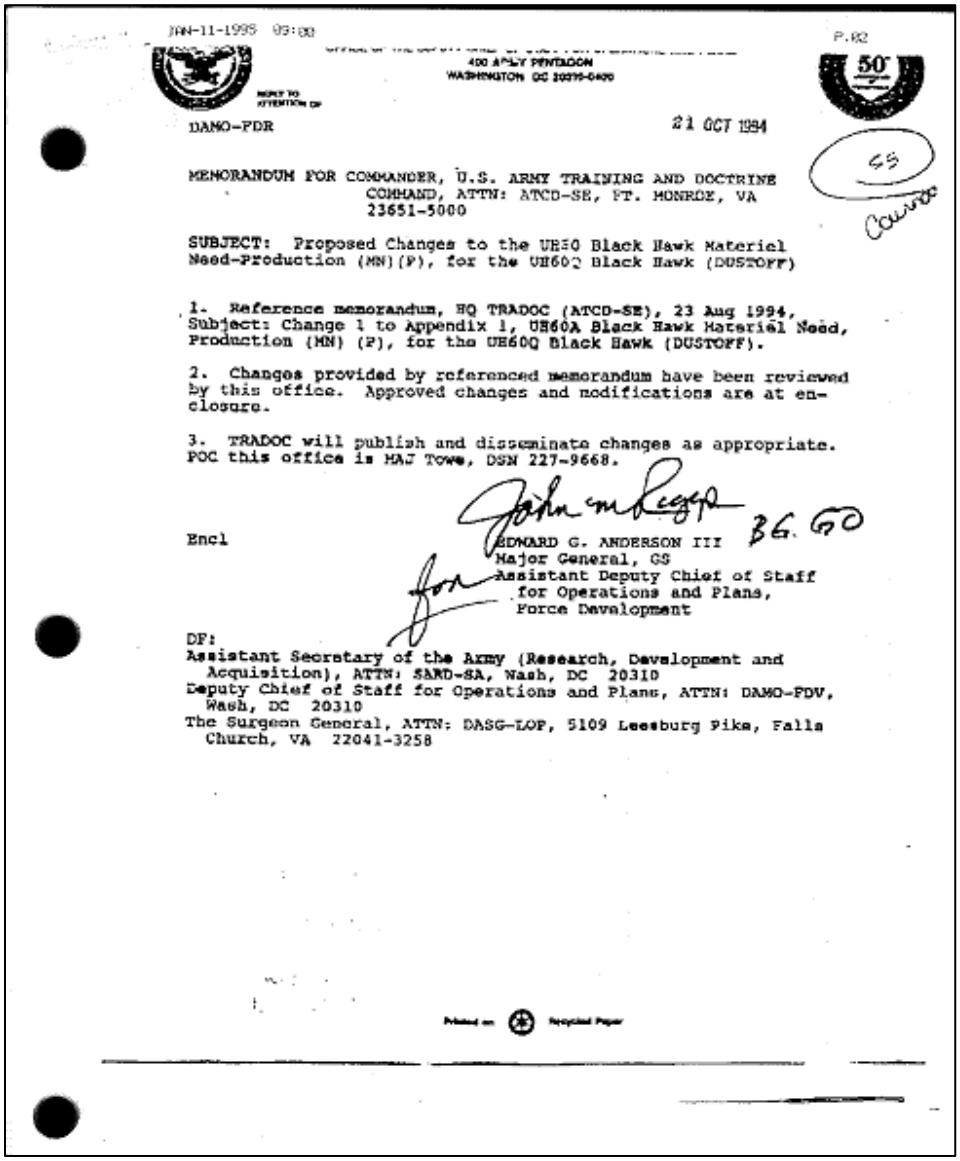
Encl

LARRY G. LEHOWICZ
Major General, GS
Deputy Chief of Staff
for Combat Developments

CF:
Cdr, USAMEDDC&S (HSMC-FCM)

E. MEMORANDUM FROM PENTAGON TO TRADOC

The following is the memorandum of approval from the Pentagon with approved changes and modifications enclosed (P. B. Anderson, personal communication, June 19, 2014).



JAN-11-1995 09:00 P.02

400 ARMY PENTAGON
WASHINGTON DC 20310-0400

REPLY TO ATTENTION OF

DAMO-FDR

21 OCT 1994

MEMORANDUM FOR COMMANDER, U.S. ARMY TRAINING AND DOCTRINE COMMAND, ATTN: ATCD-SE, FT. MONROE, VA 23651-5000

SUBJECT: Proposed Changes to the UH60 Black Hawk Materiel Need-Production (MN)(P), for the UH60Q Black Hawk (DUSTOFF)

1. Reference memorandum, HQ TRADOC (ATCD-SE), 23 Aug 1994, Subject: Change 1 to Appendix 1, UH60A Black Hawk Materiel Need, Production (MN) (P), for the UH60Q Black Hawk (DUSTOFF).

2. Changes provided by referenced memorandum have been reviewed by this office. Approved changes and modifications are at enclosure.

3. TRADOC will publish and disseminate changes as appropriate. POC this office is MAJ Towe, DSN 227-9668.

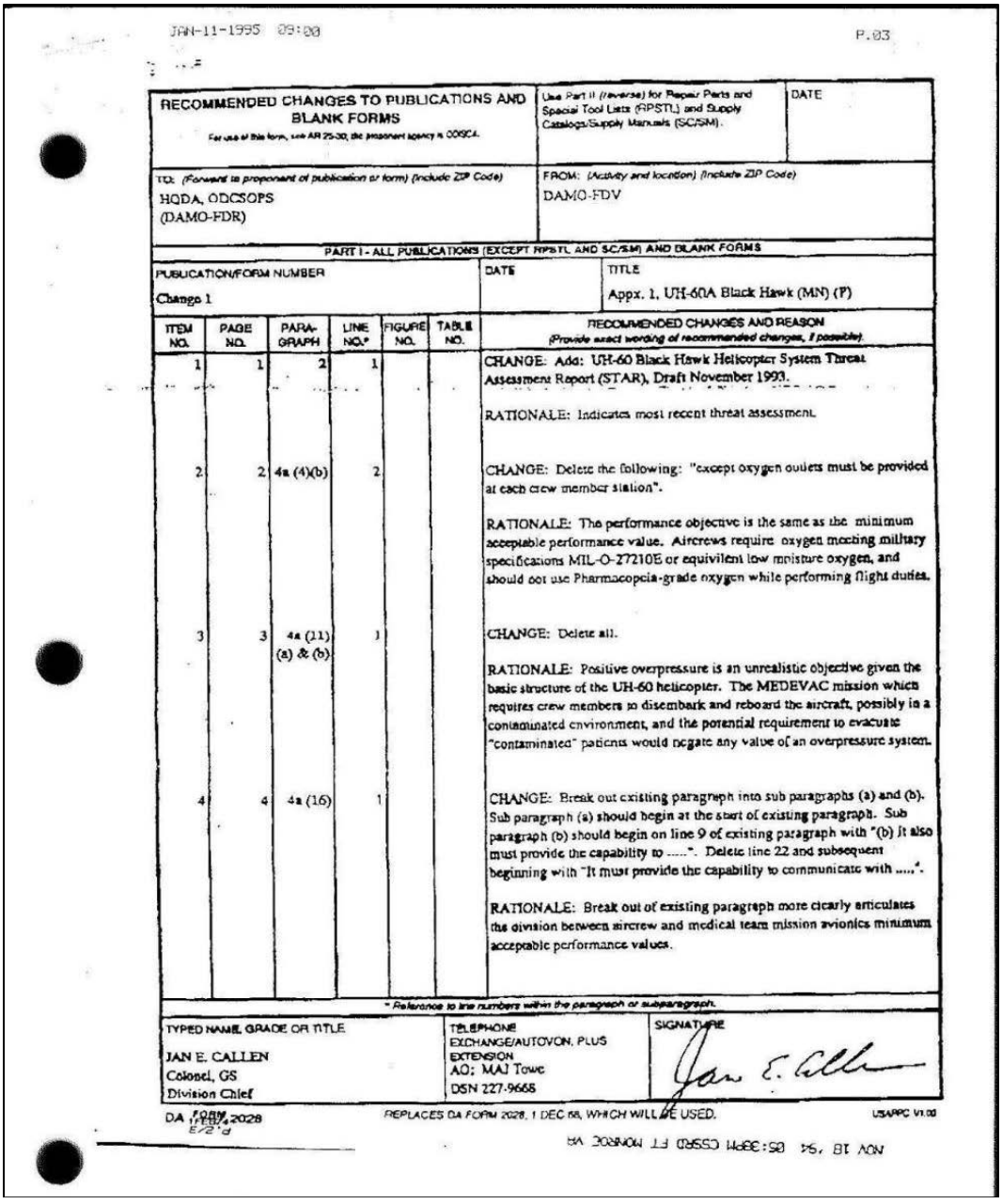
Encl

EDWARD G. ANDERSON III
Major General, GS
Assistant Deputy Chief of Staff
for Operations and Plans,
Force Development

DF:
Assistant Secretary of the Army (Research, Development and Acquisition), ATTN: SARD-SA, Wash, DC 20310
Deputy Chief of Staff for Operations and Plans, ATTN: DAMO-FDV, Wash, DC 20310
The Surgeon General, ATTN: DASG-LOP, 5109 Leesburg Pike, Falls Church, VA 22041-3258

F. APPROVED CHANGES TO UH-60Q REQUIREMENTS DOCUMENT

The following are the approved changes to the UH-60Q requirements document as referenced in the memorandum.



JAN-11-1995 09:00 P.03

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS

For use of this form, see AR 25-30; the proponent agency is ODISC4.

Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).

DATE

TO: (Forward to proponent of publication or form) (Include ZIP Code)
HQDA, ODCSOPS
(DAMO-FDR)

FROM: (Activity and location) (Include ZIP Code)
DAMO-FDV

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
Change 1		Appx. 1, UH-60A Black Hawk (MN) (P)

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Provide exact wording of recommended changes, if possible)
1	1	2	1			CHANGE: Add: UH-60 Black Hawk Helicopter System Threat Assessment Report (STAR), Draft November 1993. RATIONALE: Indicates most recent threat assessment.
2	2	4a (4)(b)	2			CHANGE: Delete the following: "except oxygen outlets must be provided at each crew member station". RATIONALE: The performance objective is the same as the minimum acceptable performance value. Aircrews require oxygen meeting military specifications MIL-O-27210E or equivilent low moisture oxygen, and should not use Pharmacopeia-grade oxygen while performing flight duties.
3	3	4a (11) (a) & (b)	1			CHANGE: Delete all. RATIONALE: Positive overpressure is an unrealistic objective given the basic structure of the UH-60 helicopter. The MEDEVAC mission which requires crew members to disembark and reboard the aircraft, possibly in a contaminated environment, and the potential requirement to evacuate "contaminated" patients would negate any value of an overpressure system.
4	4	4a (16)	1			CHANGE: Break out existing paragraph into sub paragraphs (a) and (b). Sub paragraph (a) should begin at the start of existing paragraph. Sub paragraph (b) should begin on line 9 of existing paragraph with "(b) It also must provide the capability to .....". Delete line 22 and subsequent beginning with "It must provide the capability to communicate with .....". RATIONALE: Break out of existing paragraph more clearly articulates the division between aircrew and medical team mission avionics minimum acceptable performance values.

* Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
JAN E. CALLEN Colonel, GS Division Chief	AO: MAJ Towe DSN 227-9665	Jan E. Callen

DA FORM 2028
EZ'd

REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED.

USAPPC V1.00

NOV 18 '94 08:38PM CSSRD FT MONROE VA

JAN-11-1995 09:01 P.04

RECOMMENDED CHANGES TO PUBLICATIONS AND BLANK FORMS For use of this form, see AR 25-30; the proponent agency is ODCSOPS.	Use Part II (reverse) for Repair Parts and Special Tool Lists (RPSTL) and Supply Catalogs/Supply Manuals (SC/SM).	DATE
TO: (Forward to proponent of publication or form) (Include ZIP Code) HQDA, ODCSOPS (DAMO-FDR)	FROM: (Activity and location) (Include ZIP Code) DAMO-FDV	

PART I - ALL PUBLICATIONS (EXCEPT RPSTL AND SC/SM) AND BLANK FORMS

PUBLICATION/FORM NUMBER	DATE	TITLE
Change 1		Appx. 1, UH-60A Black Hawk (MN) (P)

ITEM NO.	PAGE NO.	PARA-GRAPH	LINE NO.*	FIGURE NO.	TABLE NO.	RECOMMENDED CHANGES AND REASON (Provide exact wording of recommended changes, if possible)
5	4	4a (17)	1			CHANGE: Delete all. Add sub paragraphs as follows: (a) The UH-60Q must provide a navigation system capable of single or multi-ship, day, night, and adverse weather operation on the future battlefield. (b) Full provisions (A-Kit only) must be provided for a system that provides the ability to visually acquire casualties at night and during the day when visibility is obscured by smoke, light precipitation, or by blowing snow or sand. The system must have multiple fields of view (magnification) to allow positive identification of casualties or casualty pickup points at a range of one kilometer (four kilometers desired for threat avoidance). It also must have full look-down capability to allow the aircraft commander to control hoist operations in progress under the aircraft, day or night, or to search for injured soldiers under cover of foliage or in the water. The systems should be slaved to the search light or a navigation system such as the Global Positioning System (desired). (c) The aircraft also must have a positioning and distance measuring system for precise tactical navigation. (d) The aircraft must also have the navigational capability to locate and perform instrument approaches to U.S. Navy ships and tactical airfields established by the U.S. Air Force or allies. RATIONALE: Division of paragraph more clearly articulates the specific capabilities required by each navigational component within the required navigation system.

* Reference to line numbers within the paragraph or subparagraph.

TYPED NAME, GRADE OR TITLE	TELEPHONE EXCHANGE/AUTOVON, PLUS EXTENSION	SIGNATURE
JAN E. CALLEN Colonel, GS Division Chief	AO: MAJ Towe DSN 227-9668	Jan E. Callen

DA FORM 1 FEB 74 2028 REPLACES DA FORM 2028, 1 DEC 68, WHICH WILL BE USED. USAPPC V1.00

TOTAL P.04

APPENDIX H. MEDEVAC REQUIREMENTS WORKING GROUP RECOMMENDATIONS

The following is the October 9, 2008, MEDEVAC requirements working group recommendations to the Director of Combat Development and Doctrine (P. B. Anderson, personal communication, June 19, 2014).

DEPARTMENT OF THE ARMY
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL
DIRECTORATE OF MEDICAL EVACUATION PROPONENCY
FORT RUCKER, ALABAMA 36362-5378

REPLY TO ATTENTION OF

MCCS-FE 9 October 2008

MEMORANDUM FOR DIRECTOR OF Combat Development and Doctrine, US Army Medical Department, Fort Sam Houston, Texas

SUBJECT: MEDEVAC Requirements Working Group Recommendations

1. References.

a. UH-60A Blackhawk Mission Need for Production MN(P) document, Aug 1979.

b. UH-60Q Blackhawk Mission Need for Production MN(P) document, 21 Oct 1994.

c. HH-60M Blackhawk MEDEVAC Medical Interior Item Specification, 20 Jun 2007.

d. HH-60M Blackhawk MEDEVAC Medical Interior Item Specification, 9 May 2008.

e. Memorandum of Charter, Medical Evacuation Proponency Directorate (MEPD), 1 Jun 2008.

f. Table of Organization and Equipment (TOE) 08443G000, Air Ambulance (HH-60), General Support Aviation Battalion, Combat Aviation Brigade mission statement.

g. Aircraft Specification for the UH-60L Blackhawk Helicopter, Sikorsky Engineering Specifications SES 700700, 01 July 1997 - 30 June 2002.

h. Global Air Traffic Management System (GATM) Capabilities Production Document (CPD), Increment I, 30 June 2008.

2. Purpose. This memorandum identifies recommended UH-60 MEDEVAC aircraft mission specific requirements to update the UH-60A MN (P), dated Aug 1979, for implementation into UH-60A and UH-60L model MEDEVAC helicopter conversions. These capabilities and requirements are in addition to, and separate from the already approved UH-60L model aircraft requirements.

3. Background.

a. The UH-60A MN (P), approved in August 1979, specified basic MEDEVAC requirements for UH-60A MEDEVAC aircraft. Technology developments, and MEDEVAC aircraft employment in combat theaters, and missions in support of Homeland Defense, identified capabilities gaps and potential improvements to UH-60A aircraft during retrofit to UH-60L model aircraft.

b. The Medical Evacuation Proponency Directorate was chartered as the lead agency for the MEDEVAC Requirements Working Group (MRWG) to determine MEDEVAC aircraft specific requirements and develop appropriate requirements documents for the UH-60 MEDEVAC aircraft in support of the "A" to "L" model cascade to the Reserve Component (RC). The MRWG was comprised of user community representatives from all three components and capabilities developers from across the Army. Recommendations are enclosed. Specification details are included in the attached enclosures.

4. Required MEDEVAC capabilities summary (Threshold):

a. Configurable for 4-6 standard litter or ambulatory patient stations, or a mix of both, reconfigurable within two minutes. Litter positions shall support a load of at least 265 lbs (240 lb patient plus 25 lbs of litter, medical equipment, etc.) under crash loading as specified by the applicable aircraft specification. Ambulatory patient seating shall support passengers of up to 240 lbs under crash loading as specified by the applicable aircraft specification.

b. Must have hoist capability with a total 250' useable length cable, 600 lb strength, and 215'/min rate of movement.

c. Must be equipped with pharmaceutical grade oxygen (either bottles or AMOGS) for patients, with on-board storage capacity for four additional class "D" oxygen cylinder bottles or a back-up oxygen supply tank of equal capacity.

d. Must be configurable to carry a Crashworthy Extended Range Fuel System with a range of at least 500 nautical miles total distance without refueling.

e. Must have sensor capability to acquire personnel/casualties at night and during the day when visibility is obscured by smoke, light precipitation, or by blowing snow or sand. Must have the ability to detect/recognize human-sized targets at greater than 1 kilometer.

f. Communications must be Global Air Traffic Management System (GATM) compatible. Must be interoperable with communications necessary for tactical and Homeland Defense (HLD) missions, and operations under Instrument Flight Rules (IFR). HLD mission support communications apply to aircraft with applicable HLD mission sets. Adapting the UH-60 for use in Homeland Security Homeland Defense (HLS/HLD) missions requires a compact, agile, P25 compliant CAI system supporting conventional, trunked protocols, and encryption in narrow band FM ranges 136 – 174 MHz, 450 – 520 MHz, 764 – 869 MHz, and 806 to 960 MHz band

using a system that can be placed in the UH-60 lower console with minimal aircraft modification such that it can be easily removed for mobilization, reset or aircraft transfer.

g. The intercom system will have voice activation and private functions to facilitate patient treatment without interference with the flight crew.

h. Must have wireless, secure communications system for crewmembers to remain in contact with the aircrew while off-board the aircraft at distances of up to 500 feet.

i. MEDEVAC aircraft must be able to accurately navigate tactically over land and over water in ship-to-shore and shore-to-ship operations, and under existing and future IFR conditions, both CONUS and overseas. Navigation equipment will be GATM compatible for operations under IFR, plus an IFR certified Global Positioning System (GPS), with an off-shore navigation system interoperable with U.S. Naval vessels [such as current Tactical Navigation (TACAN) or follow-on Navy over-water navigation systems]. Navigational equipment will additionally include the Personnel Location System (PLS).

j. Internal lighting will be ANVIS compliant. All Medical Interior lighting and illuminated visual signals in crew stations and where crew members must utilize NVIS to perform their tasks shall limit spectral radiance as specified in Tables III and IIIa of MIL-STD-3009 for Type I, Class A goggles. AED has stated that per MIL-STD-3009, general guidance for general illumination is 1-20 foot-candles.

k. Electrical power shall consist of 2.4 KVA, 115 Vac., 60 cycles, with at least one outlet readily accessible by each of the litter stations.

l. Patient suction will consist of a minimum of carry-on medical suction devices.

m. External lift will have 9000 lb capacity.

n. Blackout curtains will be available to isolate the patient area of the cabin in white light, from the aircrew operating under night vision devices during periods of reduced visibility.

o. Environmental control system (ECS) with a heater output of 52,000 BTUs, or the installation of the Electric Auxiliary Heater (1660-01-332-9900) or Bleed Air Heater (1660-01-526-4097).

p. Each litter station shall have provisions for at least two intravenous bags.

q. MEDEVAC aircraft shall be equipped with an on-board hazardous weather avoidance system such as storm-scope to support operations during adverse weather.

r. The MEDEVAC configuration shall provide crash-worthy seating for the crew-chief and medic, and up to two additional passengers in addition to the patients.

s. The MEDEVAC configuration shall include modifications or kits that shall minimize the intrusion of blood and other biological fluid from patients into the airframe structure of the floor.

5. Growth capabilities (Objective Requirements):

a. Configurable for 6 standard litters, or six ambulatory patients, reconfigurable within two minutes. All patient accommodations shall support patients under crash loading as specified by the applicable aircraft specifications.

b. Shall have a brown-out landing aid system installed, available to the aircrew during operations under reduced visibility landings.

c. Shall have interoperable telemedicine capability to facilitate remote medical procedures.

d. Shall have provisions to accept off-board near real-time sensor imagery feed and display accessible to all members of the aircrew.

e. Environmental Control System shall have a heater component compliant with the threshold requirements and a cooling system capable of producing 45,000 BTU output.

f. Shall have an on-board oxygen generating system with a minimum output pressure of 50 PSI and flow rate of not less than 15 litters per minute (lpm). The system will support a minimum of four patients simultaneously, and have a back-up oxygen storage capacity of 240 liters to provide adequate oxygen flow and pressure in case of primary system failure.

g. The Medical Interior lighting system shall provide a minimum illumination of 10 foot-candles and a maximum of 40 foot-candles at maximum drive condition, measured at the surface of the litters, around the upper torso of the patient when the litters are deployed.

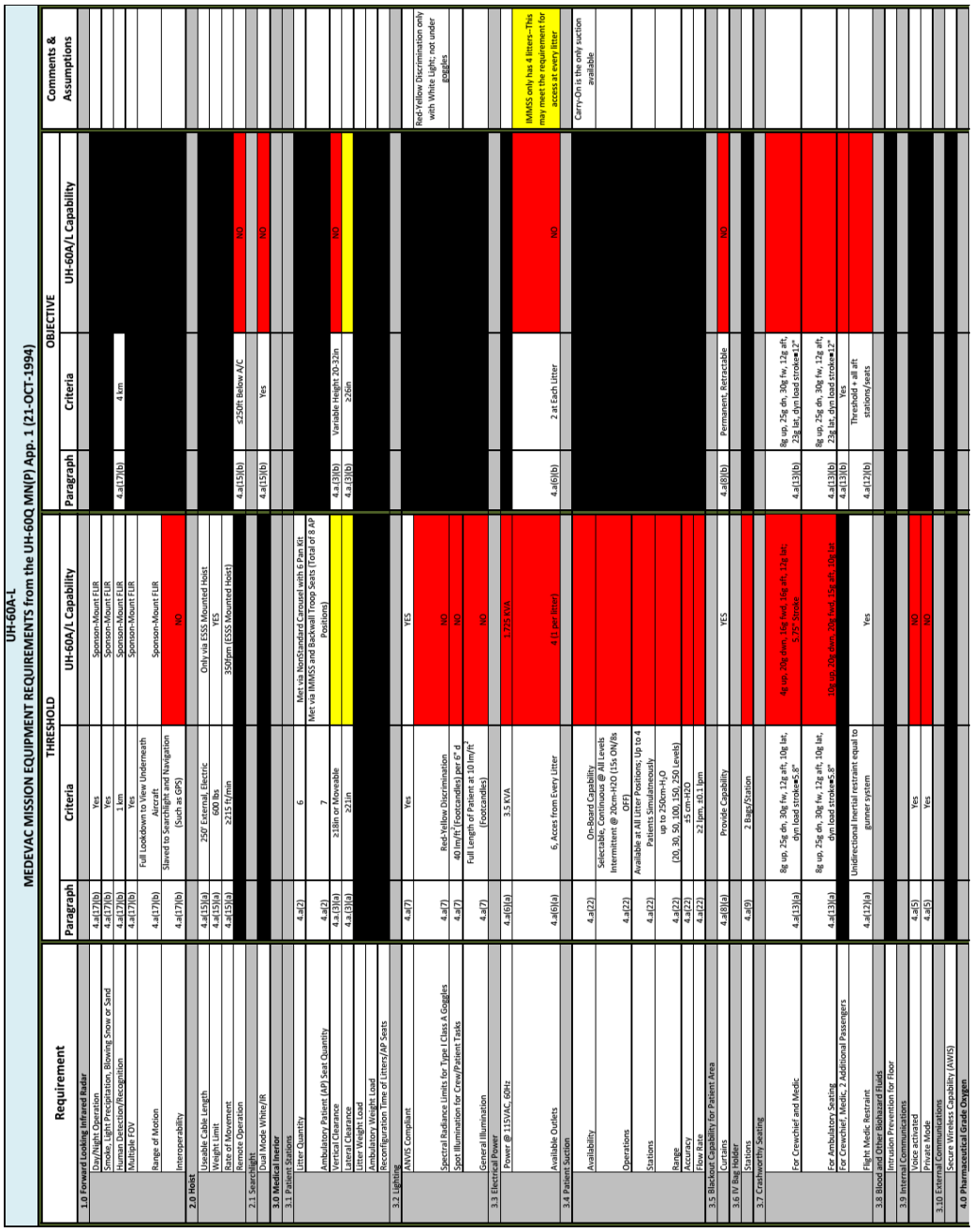
6. POC is Mr. Mark Robinson, 334-255-0585, mark.w.robinson@AMEDD.army.mil.

ROBERT D. MITCHELL
COL, MS
Director, Medical Evacuation Proponency

Encls
A to L Requirements

APPENDIX I. UH-60A/L MEDEVAC MISSION EQUIPMENT REQUIREMENT MATRIX

The following mission equipment requirements matrix depicts the formal requirements for the UH-60A/L MEDEVAC Black Hawk helicopter (P. B. Anderson, personal communication, June 19, 2014).



UH-60A-L

MEDEVAC MISSION EQUIPMENT REQUIREMENTS from the UH-60Q MN(P) App. 1 (21-OCT-1994)

Requirement	THRESHOLD Paragraph	THRESHOLD Criteria	THRESHOLD UH-60A/L Capability	OBJECTIVE Paragraph	OBJECTIVE Criteria	OBJECTIVE UH-60A/L Capability	Comments & Assumptions
1.0 Forward Looking Infrared Radar							
Day/Night Operation	4.a(17)(b)	Yes	Sponson-Mount FLIR				
Smoke, Light Precipitation, Blowing Snow or Sand	4.a(17)(b)	Yes	Sponson-Mount FLIR				
Human Detection/Recognition	4.a(17)(b)	1 km	Sponson-Mount FLIR	4.a(17)(b)	4 km		
Multiple FOV	4.a(17)(b)	Yes	Sponson-Mount FLIR				
Range of Motion	4.a(17)(b)	Full Lookdown to View Underneath Aircraft	Sponson-Mount FLIR				
Interoperability	4.a(17)(b)	Slaved to Searchlight and Navigation (Such as GPS)	NO				
2.0 Hoist							
Useable Cable Length	4.a(15)(a)	250' External, Electric	Only via ESSS Mounted Hoist				
Weight Limit	4.a(15)(a)	600 lbs	YES				
Rate of Movement	4.a(15)(a)	≥215 ft/min	350fpm (ESSS Mounted Hoist)				
2.1 Searchlight				4.a(15)(b)	≤250ft Below A/C	NO	
Dual Mode White/IR				4.a(15)(b)	Yes	NO	
3.0 Medical Interior							
3.1 Patient Stations							
Litter Quantity	4.a(2)	6	Met via NonStandard Carousel with 6 Pan Kit				
Ambulatory Patient (AP) Seat Quantity	4.a(2)	7	Met via IMMSS and Backwall Troop Seats (Total of 8 AP Positions)				
Vertical Clearance	4.a (3)(a)	≥18in or Moveable		4.a (3)(b)	Variable Height 20-32in	NO	
Lateral Clearance	4.a (3)(a)	≥21in		4.a (3)(b)	≥26in		
Litter Weight Load							
Ambulatory Weight Load							
Reconfiguration Time of Litters/AP Seats							
3.2 Lighting							
ANVIS Compliant	4.a(7)	Yes	YES				
Spectral Radiance Limits for Type I Class A Goggles	4.a(7)	Red-Yellow Discrimination	NO				Red-Yellow Discrimination only with White Light- not under goggles
Spot Illumination for Crew/Patient Tasks	4.a(7)	40 lm/ft^2 (Footcandles) per 6" d.	NO				
General Illumination	4.a(7)	Full Length of Patient at 10 lm/ft^2 (Footcandles)	NO				
3.3 Electrical Power							
Power @ 115VAC, 60Hz	4.a(6)(a)	3.5 KVA	1725 KVA				
Available Outlets	4.a(6)(a)	6, Acces from Every Litter	4 (1 per Row)	4.a(6)(b)	2 at Each Litter	NO	IMMSS only has 4 litters--This may meet the requirement for access at every litter
3.4 Patient Suction							
Availability	4.a(22)	On-Board Capability					Carry-On is the only suction available
Operations	4.a(22)	Selectable, Continuous @ All Levels Intermittent @ 20cm-H2O (15s ON/8s OFF)					
Stations	4.a(22)	Available at All Litter Positions; Up to 4 Patients Simultaneously					
Range	4.a(22)	up to 250cm-H$_2$O					
Accuracy	4.a(22)	(20, 30, 50, 100, 150, 250 Levels) ±5 cm-H2O					
Flow Rate	4.a(22)	≥2 lpm, ±0.1 lpm					
3.5 Blackout Capability for Patient Area	4.a(8)(a)	Provide Capability	YES	4.a(8)(b)	Permanent, Retractable	NO	
Curtains							
3.6 IV Bag Hooks	4.a(9)	2 Bags/Station					
Stations							
3.7 Crashworthy Seating							
For Crewchief and Medic	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat., dyn load stroke≥5.8"	4g up, 20g dwn, 16g fwd, 16g aft, 12g lat; 5.75" Stroke	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke≥12"		
For Ambulatory Seating	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat., dyn load stroke≥5.8"	10g up, 10g dwn, 20g fwd, 15g aft, 10g lat	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke≥12"		
For Crewchief, Medic, 2 Additional Passengers				4.a(13)(b)	Yes		
Flight Medic Restraint	4.a(12)(a)	Unidirectional Inertial restraint equal to gunner system	Yes	4.a(12)(b)	Threshold + aft stations/Seats		
3.8 Blood and Other Biohazard Fluids							
Intrusion Prevention for Floor							
3.9 Internal Communications							
Voice activated	4.a(5)	Yes	NO				
Private Mode	4.a(5)	Yes	NO				
3.10 External Communications							
Secure Wireless Capability (AWIS)							
4.0 Pharmaceutical Grade Oxygen							

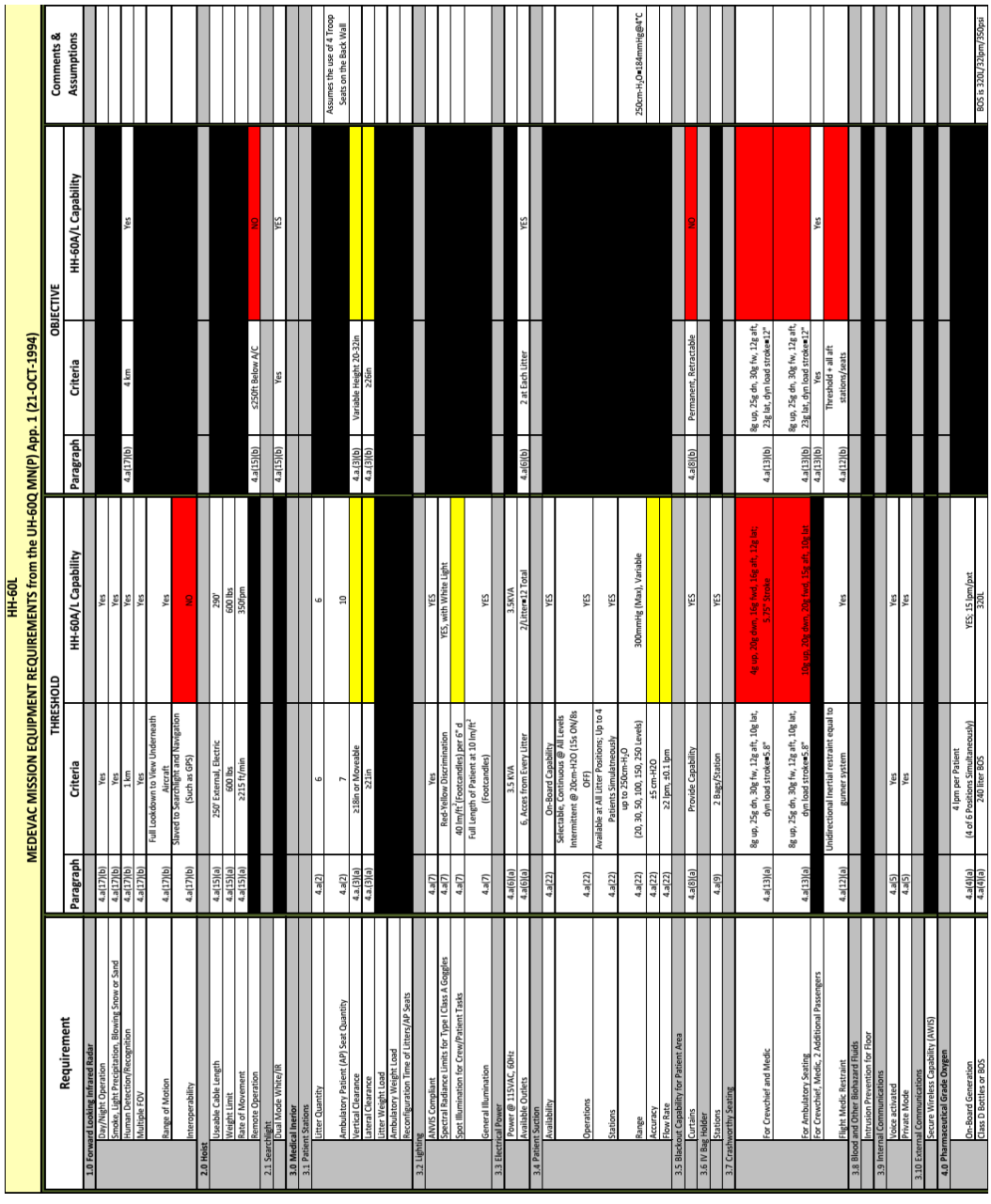
Page 1 of 2

	On-Board Generation	4.a(4)(a)	4 lpm per Patient (4 of 6 Positions Simultaneously)	NO				
	Class D Bottles or BOS	4.a(4)(a)	240 liter BOS	NO				
5.0 Cabin Environmental Control System								
	Cooling Capability	4.a(10)	+110°F to +78°F in ≤ 15 min	NO				
	Heating Capability	4.a(10)	-30°F to +78°F in ≤ 15 min					
6.0 Air Ambulance Medical Equipment Set								
	MES Storage	4.a(2)	Yes	Partial Storage				Assume that this does not mean the entire MES
7.0 Telemedicine/Digital Medical System								
	Data Capacity	4.a(16)(b)	14.4kbps per Litter	NO	4.a(16)(b)	128kbps per Litter	NO	
	Interface with Digital Medical Devices	4.a(16)(b)	Yes	NO				
	Interoperable							
8.0 Aircraft Avionics								
	Horizontal Integration with Battlefield SA	4.a(16)(a)	yes	Met via BFT/BFT-2/EDM				
	Info to Friendly forces to Prevent Fratricide.	4.a(16)(a)	yes	Met via APX-100/APX-118/BFT				
	Interface with Digital Logistics	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interface with Patient Tracking System	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interoperable Long Range NLOS Communications	4.a(16)(b)	Yes	PRC-117 (SATCOM)				Deployed as a Kit
8.1 Communication								
	Interoperable with Tactical Missions							
	Global Air Traffic Management Compatible							
	Interoperable with Homeland Defense Mission							
	Portable P25 Compliant CAI System for HLD Mission							
8.2 Navigation								
	GATM Compliant (IFR Certified)							
	On-Board Hazardous Weather Avoidance System	4.a(17)(a)	Yes	NO				
	Brownout/Reduced Vis Landing Aid System			NA			NO	
	TACAN/DME	4.a(17)(c)/(d)	Yes	NO				
	Personnel Location System (PLS)	4.a16(a)	Casualty Recovery Locations	Available				Must be installed, but available if needed
	Enhanced Situational Awareness	4.a(16)(a)	Threat, Casualty Recovery & Medical Treatment Unit Locations	Met via BFT/BFT-2/EDM				
8.3 Off-Board Sensor Data								
	Accept Off-Board Real-Time Sensor Feed							
9.0 Performance								
9.1 Mission Distance								
	Range	4.a(20)	500nm	Met Via CEFS ONLY				Cannot be met with ESSS Mounted Hoist Installed; IAFTS Not Sufficient
9.2 External Lift Capacity								
	Cargo Hook	4.a(14)	Required	YES				
10.0 Other								
10.1 Searchlight								
	Modes	4.a(19)	Dual Mode White/IR	Not Dual Mode				
	Wattage	4.a(19)	450W	White▪450W IR▪250W				
10.2 Flight Control								
	AFCS	4.a(21)(a)	Current UH-60L	YES	4.a(21)(b)	Fully Coupled with Auto Hover	NO	
10.3 Survivability								
	Equipment	4.a(18)(a)	Standard UH-60 Equipment	YES	4.a(18)(b)	Laser Detection	Met via AVR-2B	
10.4 Training Devices								
	Medical Interior Trainer	5.c	Yes	Carousel Only; No IMMSS				

LEGEND	
Black	Requirement Does Not Apply
Yellow	Unknown as of publication
Red	Requirement Not Met

APPENDIX J. HH-60L MEDEVAC MISSION EQUIPMENT REQUIREMENT MATRIX

The following mission equipment requirements matrix depicts the formal requirements for the HH-60L MEDEVAC Black Hawk helicopter (P. B. Anderson, personal communication, June 19, 2014).



HH-60L

MEDEVAC MISSION EQUIPMENT REQUIREMENTS from the UH-60Q MN(P) App. 1 (21-OCT-1994)

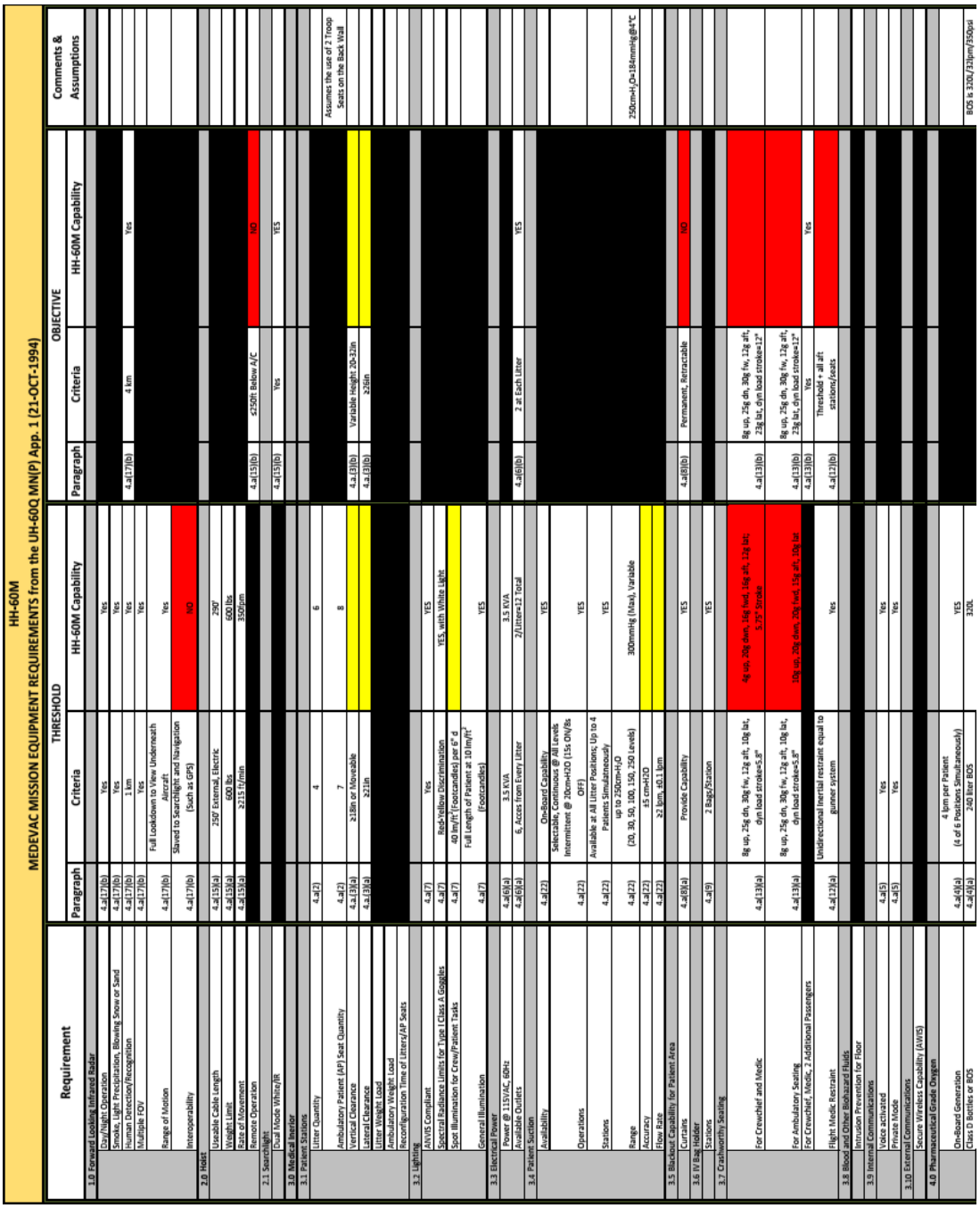
Requirement	THRESHOLD			OBJECTIVE			Comments & Assumptions
	Paragraph	Criteria	HH-60A/L Capability	Paragraph	Criteria	HH-60A/L Capability	
1.0 Forward Looking Infrared Radar							
Day/Night Operation	4.a(17)(b)	Yes	Yes				
Smoke, Light Precipitation, Blowing Snow or Sand	4.a(17)(b)	Yes	Yes				
Human Detection/Recognition	4.a(17)(b)	1 km	Yes	4.a(17)(b)	4 km	Yes	
Multiple FOV	4.a(17)(b)	Yes	Yes				
Range of Motion	4.a(17)(b)	Full Lockdown to View Underneath Aircraft	Yes				
Interoperability	4.a(17)(b)	Slaved to Searchlight and Navigation (Such as GPS)	NO				
2.0 Hoist							
Useable Cable Length	4.a(15)(a)	250' External, Electric	290'				
Hoist Limit	4.a(15)(a)	600 lbs	600 lbs				
Rate of Movement	4.a(15)(a)	≥215 fpmin	350fpm				
Remote Operation				4.a(15)(b)	≤250ft Below A/C	NO	
2.1 Searchlight				4.a(15)(b)	Yes	YES	
Dual Mode White/IR							
3.0 Medical Interior							
3.1 Patient Stations							
Litter Quantity	4.a(2)	6	6				
Ambulatory Patient (AP) Seat Quantity	4.a(2)	7	10	4.a.(3)(b)	Variable Height 20-32in		Assumes the use of 4 Troop Seats on the Back Wall
Vertical Clearance	4.a.(3)(a)	≥18in or Moveable		4.a.(3)(b)	≥26in		
Lateral Clearance	4.a.(3)(a)	≥21in		4.a.(3)(b)			
Litter Weight Load							
Ambulatory Weight Load							
Reconfiguration Time of Litters/AP Seats							
3.2 Lighting							
ANVIS Compliant	4.a(7)	Yes	YES				
Spectral Radiance Limits for Type I Class A Goggles	4.a(7)	Red-Yellow Discrimination	YES, with White Light				
Spot Illumination for Crew/Patient Tasks	4.a(7)	40 lm/ft² (Footcandles) per 6" d					
General Illumination	4.a(7)	Full Length of Patient at 10 lm/ft² (Footcandles)	YES				
3.3 Electrical Power							
Power @ 115VAC, 60Hz	4.a(6)(a)	3.5 KVA	3.5KVA				
Available Outlets	4.a(6)(a)	6, Acces from Every Litter	2/Litter▪12 Total	4.a(6)(b)	2 at Each Litter	YES	
3.4 Patient Suction							
Availability	4.a(22)	On-Board Capability	YES				
Operations	4.a(22)	Selectable, Continuous @ All Levels Intermittent @ 20cm-H2O (15s ON/8s OFF)	YES				
Stations	4.a(22)	Available at All Litter Positions; Up to 4 Patients Simultaneously	YES				
Range	4.a(22)	up to 250cm-H2O	300mmHg (Max), Variable				250cm-H2O▪184mmHg@4°C
Accuracy	4.a(22)	(20, 30, 50, 100, 150, 250 Levels)					
Flow Rate	4.a(22)	±5 cm-H2O ≥2 lpm, ±0.1 lpm					
3.5 Blackout Capability for Patient Area							
Curtains	4.a(8)(a)	Provide Capability	YES	4.a(8)(b)	Permanent, Retractable	NO	
3.6 IV Bag Holder							
Stations	4.a(9)	2 Bags/Station	YES				
3.7 Crashworthy Seating							
For Crewchief and Medic	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat, dyn load stroke▪8.8"	4g up, 20g dwn, 16g fwd, 16g aft, 12g lat; 5.75" Stroke	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke▪12"		
For Ambulatory Seating	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat, dyn load stroke▪8.8"	10g up, 20g dwn, 20g fwd, 15g aft, 10g lat	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke▪12"		
For Crewchief, Medic, 2 Additional Passengers		Unidirectional inertial restraint equal to gunner system	Yes	4.a(13)(b)	Yes	Yes	
Flight Medic Restraint	4.a(12)(a)			4.a(12)(b)	Threshold + all aft stations/seats		
3.8 Blood and Other Biohazard Fluids							
Intrusion Prevention for Floor							
3.9 Internal Communications							
Voice activated	4.a(5)	Yes	Yes				
Private Mode	4.a(5)	Yes	Yes				
3.10 External Communications							
Secure Wireless Capability (AWIS)							
4.0 Pharmaceutical Grade Oxygen							
		4 lpm per Patient					
On-Board Generation	4.a(4)(a)	(4 of 6 Positions Simultaneously)	YES; 15 lpm/port				
Class D Bottles or BDS	4.a(4)(a)	240 liter BDS	320L				BDS is 320L/32lpm/750psi

5.0 Cabin Environmental Control System								
	Cooling Capability	4.a(10)	+110°F to +78°F in ≤ 15 min					
	Heating Capability	4.a(10)	-30°F to +78°F in ≤ 15 min					
6.0 Air Ambulance Medical Equipment Set								
	MES Storage	4.a(2)	Yes	Partial Storage				Assume that this does not mean the entire MES
7.0 Telemedicine/Digital Medical System								
	Data Capacity	4.a(16)(b)	14.4kbps per Litter	NO	4.a(16)(b)	128kbps per Litter	NO	
	Interface with Digital Medical Devices	4.a(16)(b)	Yes	NO				
	Interoperable							
8.0 Aircraft Avionics								
	Horizontal Integration with Battlefield SA	4.a(16)(a)	yes	Met via BFT/EDM				
	Info to Friendly forces to Prevent Fratricide.	4.a(16)(a)	yes	Met via APX-100/BFT/EDM				
	Interface with Digital Logistics	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interface with Patient Tracking System	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interoperable Long Range NLOS Communications	4.a(16)(b)	Yes	PRC-117 (SATCOM)				Deployed as a Kit
8.1 Communication								
	Interoperable with Tactical Missions							
	Global Air Traffic Management Compatible							
	Interoperable with Homeland Defense Mission							
	Portable P25 Compliant CAI System for HLD Mission							
8.2 Navigation								
	GATM Compliant (IFR Certified)							
	On-Board Hazardous Weather Avoidance System	4.a(17)(a)	Yes	Met via WX-1000 StormScope				
	Brownout/Reduced Vis Landing Aid System							
	TACAN/DME	4.a(17)(c)/(d)	Yes	Met via ARN-153				
	Personnel Location System (PLS)	4.a16(a)	Casualty Recovery Locations	Met via ARS-6V				
	Enhanced Situational Awareness	4.a(16)(a)	Threat, Casualty Recovery & Medical Treatment Unit Locations	Met via BFT/EDM				
8.3 Off-Board Sensor Data								
	Accept Off-Board Real-Time Sensor Feed							
9.0 Performance								
9.1 Mission Distance								
	Range	4.a(20)	500nm	Met Via CEFS ONLY				
9.2 External Lift Capacity								
	Cargo Hook	4.a(14)	Required	YES				9000lb Capacity
10.0 Other								
10.1 Searchlight								
	Modes	4.a(19)	Dual Mode White/IR	Not Selectable				
	Wattage	4.a(19)	450W	White▪450W IR▪250W				
10.2 Flight Control								
	AFCS	4.a(21)(a)	Current UH-60L	YES	4.a(21)(b)	Fully Coupled with Auto Hover	NO	
10.3 Survivability								
	Equipment	4.a(18)(a)	Standard UH-60 Equipment	YES	4.a(18)(b)	Laser Detection	NO	AVR-2B installation is pending GATM Completion
10.4 Training Devices								
	Medical Interior Trainer	5.c	Yes	YES				Ft Rucker

LEGEND	
Black	Requirement Does Not Apply
Yellow	Unknown as of publication
Red	Requirement Not Met

APPENDIX K. HH-60M MEDEVAC MISSION EQUIPMENT REQUIREMENT MATRIX

The following mission equipment requirements matrix depicts the formal requirements for the HH-60M MEDEVAC Black Hawk helicopter (P. B. Anderson, personal communication, June 19, 2014).



HH-60M
MEDEVAC MISSION EQUIPMENT REQUIREMENTS from the UH-60Q MN(P) App. 1 (21-OCT-1994)

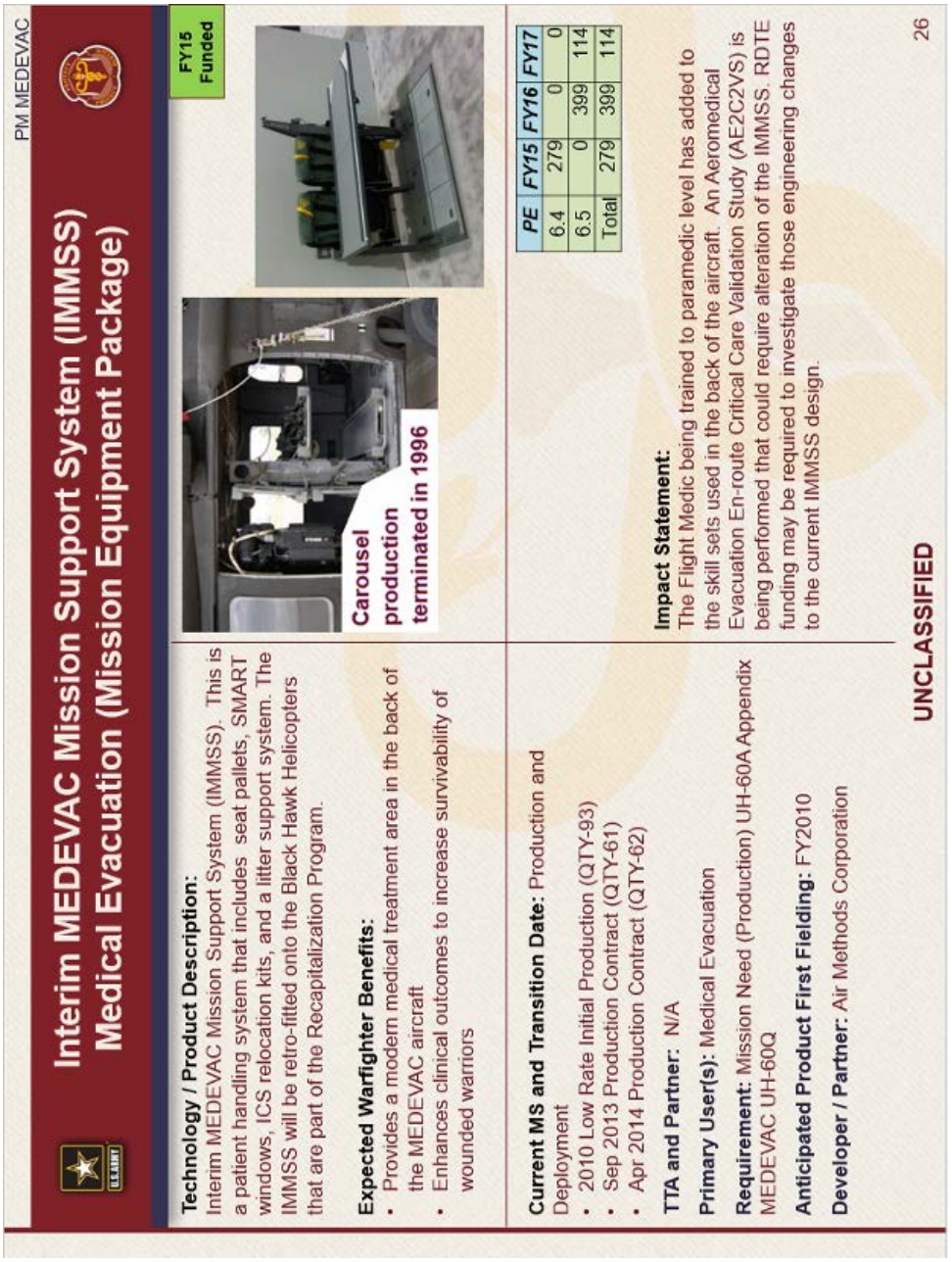
Requirement	THRESHOLD			OBJECTIVE			Comments & Assumptions
	Paragraph	Criteria	HH-60M Capability	Paragraph	Criteria	HH-60M Capability	
1.0 Forward Looking Infrared Radar							
Day/Night Operation	4.a(17)(b)	Yes	Yes				
Smoke, Light Precipitation, Blowing Snow or Sand	4.a(17)(b)	Yes	Yes				
Human Detection/Recognition	4.a(17)(b)	1 km	Yes	4.a(17)(b)	4 km	Yes	
Multiple FOV	4.a(17)(b)	Yes	Yes				
Range of Motion	4.a(17)(b)	Full Lookdown to View Underneath Aircraft	Yes				
Interoperability	4.a(17)(b)	Slaved to Searchlight and Navigation (Such as GPS)	NO				
2.0 Hoist							
Useable Cable Length	4.a(15)(a)	250' External, Electric	250'				
Weight Limit	4.a(15)(a)	600 lbs	600 lbs				
Rate of Movement	4.a(15)(a)	≥215 ft/min	350fpm				
Remote Operation	4.a(15)(a)			4.a(15)(b)	≤250ft Below A/C	NO	
2.1 Searchlight				4.a(15)(b)	Yes	YES	
Dual Mode White/IR							
3.0 Medical Interior							
3.1 Patient Stations							
Litter Quantity	4.a(2)	4	6				
Ambulatory Patient (AP) Seat Quantity	4.a(2)	7	8	4.a.(3)(b)	Variable Height 20-32in		Assumes the use of 2 Troop Seats on the Back Wall
Vertical Clearance	4.a.(3)(a)	≥18in or Moveable		4.a.(3)(b)	≥26in		
Lateral Clearance	4.a.(3)(a)	≥21in		4.a.(3)(b)	≥21in		
Litter Weight Load							
Ambulatory Weight Load							
Reconfiguration Time of Litters/AP Seats							
3.2 Lighting							
JAWS Compliant	4.a(7)	Yes	YES				
Spectral Radiance Limits for Type I Class A Goggles	4.a(7)	Red-Yellow Discrimination	YES, with White Light				
Spot Illumination for Crew/Patient Tasks	4.a(7)	40 lm/ft² (Footcandles) per 6" d					
General Illumination	4.a(7)	Full Length of Patient at 10 lm/ft² (Footcandles)	YES				
3.3 Electrical Power							
Power @ 115VAC, 60Hz	4.a(6)(a)	3.5 kVA	3.5 KVA				
Available Outlets	4.a(6)(a)	6, Access from Every Litter	2/Litter+12 Total	4.a(6)(b)	2 at Each Litter	YES	
3.4 Patient Suction							
Availability	4.a(22)	On-Board Capability	YES				
Operations	4.a(22)	Selectable, Continuous @ All Levels Intermittent @ 20cm-H2O (15s ON/8s OFF)	YES				
Stations	4.a(22)	Available at All Litter Positions; Up to 4 Patients Simultaneously	YES				
Range	4.a(22)	up to 250cm-H2O (20, 30, 50, 100, 150, 250 Levels)	300mmHg (Max), Variable				250cm-H2O=184mmHg@4°C
Accuracy	4.a(22)	±5 cm-H2O					
Flow Rate	4.a(22)	≥2 lpm, ±0.1 lpm					
3.5 Blackout Capability for Patient Area							
Curtains	4.a(8)(a)	Provide Capability	YES	4.a(8)(b)	Permanent, Retractable	NO	
3.6 IV Bag Holder							
Stations	4.a(9)	2 Bags/Station	YES				
3.7 Crashworthy Seating							
For Crewchief and Medic	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat, dyn load stroke=5.8"	4g up, 20g dwn, 16g fwd, 16g aft, 12g lat; 5.75" Stroke	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke=12"		
For Ambulatory Seating For Crewchief, Medic, 2 Additional Passengers	4.a(13)(a)	8g up, 25g dn, 30g fw, 12g aft, 10g lat, dyn load stroke=5.8"	10g up, 20g dwn, 20g fwd, 15g aft, 10g lat	4.a(13)(b)	8g up, 25g dn, 30g fw, 12g aft, 23g lat, dyn load stroke=12"		
Flight Medic Restraint	4.a(12)(a)	Unidirectional inertial restraint equal to gunner system	Yes	4.a(13)(b)	Yes	Yes	
3.8 Blood and Other Biohazard Fluids				4.a(12)(b)	Threshold + all aft stations/seats		
Intrusion Prevention for Floor							
3.9 Internal Communications							
Voice activated	4.a(5)	Yes	Yes				
Private Mode	4.a(5)	Yes	Yes				
3.10 External Communications							
Secure Wireless Capability (AWIS)							
4.0 Pharmaceutical Grade Oxygen							
On-Board Generation	4.a(4)(a)	4 lpm per Patient	YES				
Class D Bottles or BOS	4.a(4)(a)	(4 of 6 Positions Simultaneously) 240 liter BOS	320L				BOS is 320L/325lpm/350psi

5.0 Cabin Environmental Control System								
	Cooling Capability	4.a(10)	+110°F to +78°F in ≤ 15 min					
	Heating Capability	4.a(10)	-30°F to +78°F in ≤ 15 min					
6.0 Air Ambulance Medical Equipment Set								
	MES Storage	4.a(2)	Yes	Partial Storage				Assume that this does not mean the entire MES
7.0 Telemedicine/Digital Medical System								
	Data Capacity	4.a(16)(b)	14.4kbps per Litter	NO	4.a(16)(b)	128kbps per Litter	NO	
	Interface with Digital Medical Devices	4.a(16)(b)	Yes	NO				
	Interoperable			NA				
8.0 Aircraft Avionics								
	Horizontal Integration with Battlefield SA	4.a(16)(a)	yes	Met via BFT				
	Info to Friendly forces to Prevent Fratricide.	4.a(16)(a)	yes	Met via APX-118/BFT				
	Interface with Digital Logistics	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interface with Patient Tracking System	4.a(16)(b)	2kb Sent/Received as Required	NO				
	Interoperable Long Range NLOS Communications	4.a(16)(b)	Yes	ARC-231 with SATCOM				
8.1 Communication								
	Interoperable with Tactical Missions			NA				
	Global Air Traffic Management Compatible			NA				
	Interoperable with Homeland Defense Mission			NA				
	Portable P25 Compliant CAI System for HLD Mission			NA				
8.2 Navigation								
	GATM Compliant (IFR Certified)			NA				
	On-Board Hazardous Weather Avoidance System	4.a(17)(a)	Yes	Met via WX-1000 StormScope				
	Brownout/Reduced Vis Landing Aid System			NA			NO	
	TACAN/DME	4.a(17)(c)/(d)	Yes	Met via ARN-153				
	Personnel Location System (PLS)	4.a16(a)	Casualty Recovery Locations	Met via ARS-6V				
	Enhanced Situational Awareness	4.a(16)(a)	Threat, Casualty Recovery & Medical Treatment Unit Locations	Met via BFT/Moving Map Displays				
8.3 Off-Board Sensor Data								
	Accept Off-Board Real-Time Sensor Feed			NA				
9.0 Performance								
9.1 Mission Distance								
	Range	4.a(20)	500nm	Met Via CEFS ONLY				
9.2 External Lift Capacity								
	Cargo Hook	4.a(14)	Required	YES				9000lb Capacity
10.0 Other								
10.1 Searchlight								
	Modes	4.a(19)	Dual Mode White/IR	YES				Selectable (3x200W)
	Wattage	4.a(19)	450W	White=400W IR=200W				
10.2 Flight Control								
	AFCS	4.a(21)(a)	Current UH-60L	NA	4.a(21)(b)	Fully Coupled with Auto Hover	YES	
10.3 Survivability								
	Equipment	4.a(18)(a)	Standard UH-60 Equipment	YES	4.a(18)(b)	Laser Detection	Met via AVR-2B	
10.4 Training Devices								
	Medical Interior Trainer	5.c	Yes	YES				Ft Rucker (Same as HH-60A/L)

LEGEND	
Black	Requirement Does Not Apply
Red	Requirement Not Met

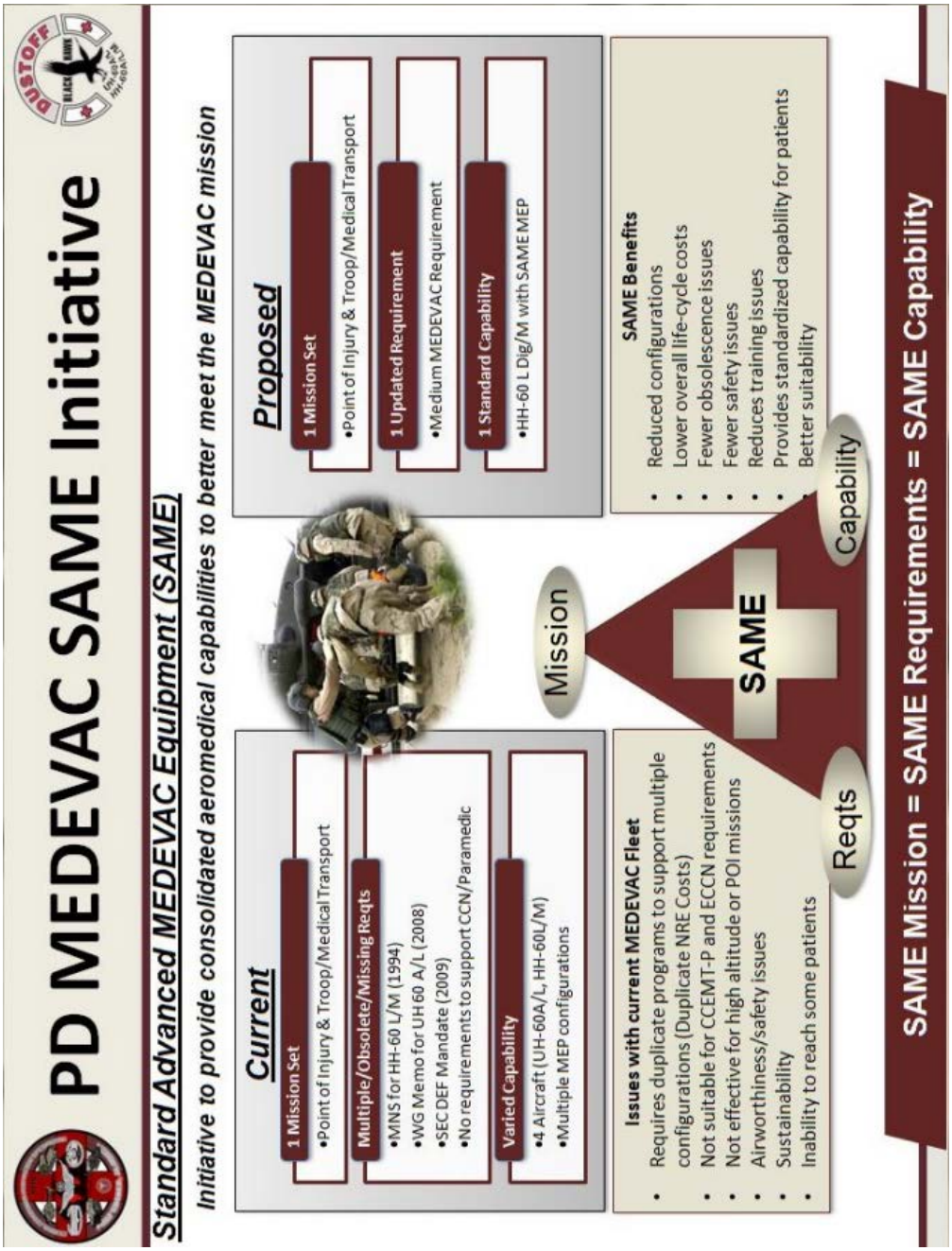
APPENDIX L. INTERIM MEDEVAC MISSION SUPPORT SYSTEM (IMMSS) MEDICAL EVACUATION (MISSION EQUIPMENT PACKAGE)

The following is the Advanced Development Board of Directors Command Budget Estimate Spend Plan for IMMSS for FY15–20, as of May 6, 2014 (C. R. Paschal, personal communication, June 18, 2014).



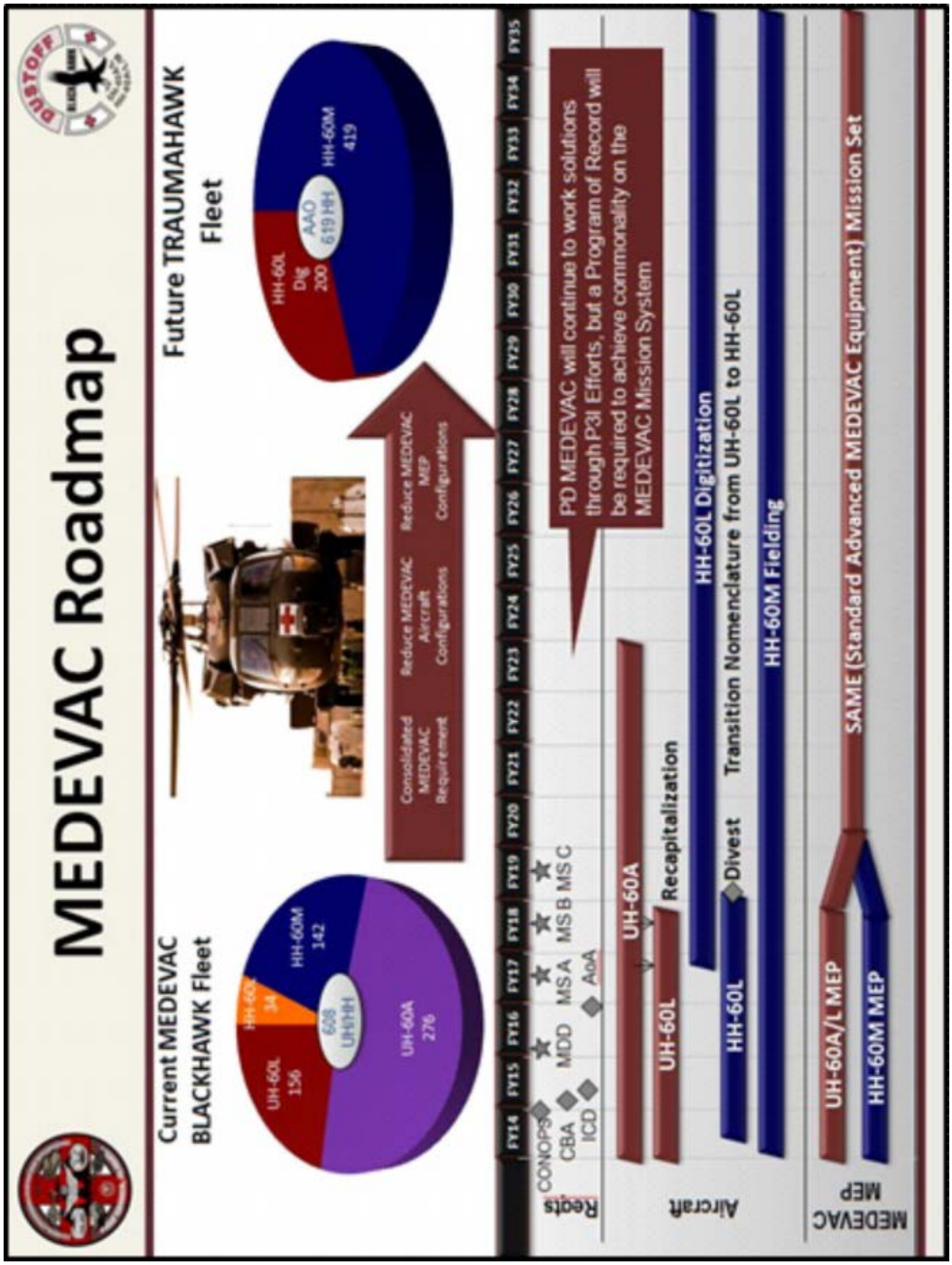
APPENDIX M. PRODUCT DIRECTORATE MEDEVAC "SAME" INITIATIVE

The following is the PD MEDEVAC "SAME" Initiative published in the *MEDEVAC Enterprise Newsletter* (MEPD, 2014b, p. 8).



APPENDIX N. PRODUCT DIRECTORATE MEDEVAC ROADMAP

The following is the PD MEDEVAC Roadmap published in the MEDEVAC Enterprise Newsletter (MEPD, 2014b, p. 9).



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