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THESIS

EVALUATION OF CURRENT AIRBORNE MINE COUNTERMEASURES MISSION PLANNING, MESSAGE TRAFFIC, POST MISSION ANALYSIS AND POTENTIAL ALTERNATIVES

by

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September 2023

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13. ABSTRACT (maximum 200 words)

This thesis recommends improvements in airborne mine countermeasures (AMCM) mission planning, analysis, and reporting to reduce human error and decrease time to completion. AMCM missions are evaluated on how long it takes to complete tasking and how well tasking has been performed. Compared to many other mission sets, these metrics are almost entirely based off probability and offer very little room for subjectivity. Despite the precision suggested by these quantitative metrics, several of the tactics, techniques, and procedures (TTPs) employed by the Navy during AMCM often conflict with these goals. Among those conflicting TTPs are inefficiencies in mission planning, message traffic, and post mission analysis that directly increase estimated time to completion (ETC). Hours to days of work can be wasted due to errors in message traffic that are largely input manually, and post mission analysis (PMA) being performed by inexperienced or fatigued aircrew. This thesis presents a solution for modernizing these processes to increase mission accomplishment. This is accomplished by evaluating current processes for inefficiencies and potential for human error, developing requirements for an improved system, and architecting and analyzing current and improved systems through the application of model-based systems engineering (MBSE). This thesis recommends funding and development of improved AMCM mission planning systems utilizing modern technology to address operational requirements.

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ABSTRACT

This thesis recommends improvements in airborne mine countermeasures (AMCM) mission planning, analysis, and reporting to reduce human error and decrease time to completion. AMCM missions are evaluated on how long it takes to complete tasking and how well tasking has been performed. Compared to many other mission sets, these metrics are almost entirely based off probability and offer very little room for subjectivity. Despite the precision suggested by these quantitative metrics, several of the tactics, techniques, and procedures (TTPs) employed by the Navy during AMCM often conflict with these goals. Among those conflicting TTPs are inefficiencies in mission planning, message traffic, and post mission analysis that directly increase estimated time to completion (ETC). Hours to days of work can be wasted due to errors in message traffic that are largely input manually, and post mission analysis (PMA) being performed by inexperienced or fatigued aircrew. This thesis presents a solution for modernizing these processes to increase mission accomplishment. This is accomplished by evaluating current processes for inefficiencies and potential for human error, developing requirements for an improved system, and architecting and analyzing current and improved systems through the application of model-based systems engineering (MBSE). This thesis recommends funding and development of improved AMCM mission planning systems utilizing modern technology to address operational requirements.

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TABLE OF CONTENTS

LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

AFCS	Automatic Flight Control System
ALMDS	Airborne Laser Mine Detection System
AMCM	Airborne Mine Countermeasures
AMNS	Airborne Mine Neutralization System
AoA	Analysis of Alternatives
DA	Density Altitude
DIM	Daily Intentions Message
DOD	Department of Defense
DTD	Data transfer device
EABO	Expeditionary Air Base Operations
EEOB	Enemy Order of Battle
ENARG	Enabling Naval Aviation Requirements Group
FOB	Friendly Order of Battle
GPC	Great Power Competition
INCOSE	International Council of System Engineering
JMPS	Joint Mission Planning System
KBC	Kneeboard Card
LCS	Littoral Combat Ship
LHS	Launch Handling System
LML	Life cycle Modeling Language
MBSE	Model Based System Engineering
MBSE MEASA	MBSE Methodology for Employing Architecture in System Analysis
MCM	Mine Countermeasures
MDA	Mine Danger Area
METOC	Meteorology and Oceanography Center
MIW	Mine Warfare

MNT	MINEnet Tactical
MOB	Mine Order of Battle
MOE	Measures of Effectiveness
MTDB	Mine Threat Database
NIPR	Non-classified Internet Protocol Router
NMW	Naval Mine Warfare
OAT	Outside air temperature
OPDIR	Operational Direction
OPTASK	Operational Task
PMA	Post Mission Analysis
PA	Pressure altitude
RSA	Reacquisition Search Area
SIPR	Secret Internet Protocol Router
SSO	Safety Stand Off
SysML	Systems Modeling Language
TPDB	Tactical Performance Database

EXECUTIVE SUMMARY

The objective of this thesis was to perform an analysis of alternatives (AoA) and recommend improvements in Airborne Mine Countermeasures (AMCM) mission planning, Post Mission Analysis (PMA), and message traffic to reduce human error and decrease time to complete tasking. The current communication structure, mission planning, and PMA procedures utilized during AMCM introduce too many opportunities for human error and severely reduce efficiency. This can lead to commanders accepting unnecessary risk in the form of lower mine clearance thresholds before ships are allowed to transit an area or unrecognized risk due to human error in planning or analysis.

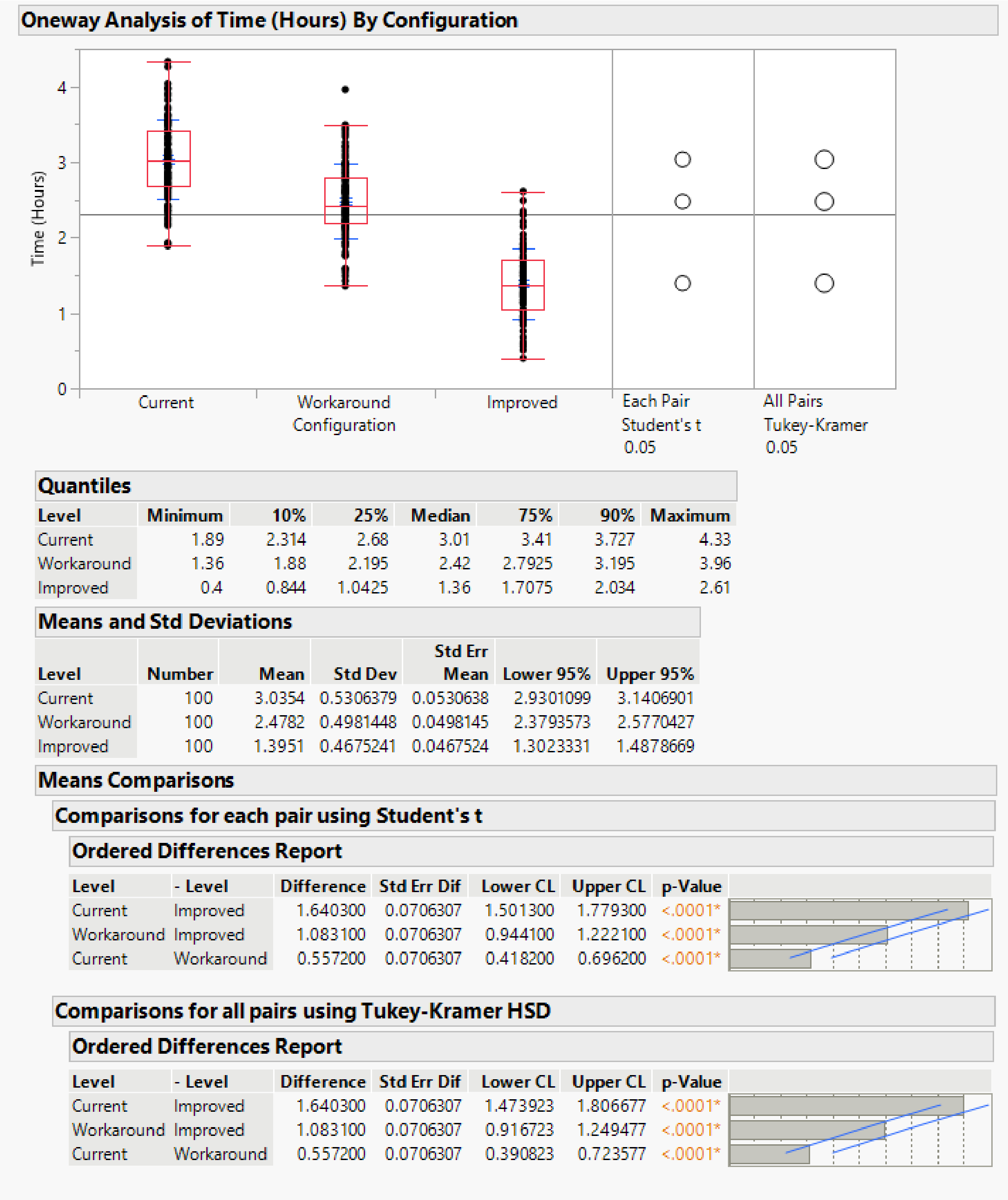
This research was accomplished using an analysis method that focuses on quantitative evaluation of the problem statement to inform design of follow-on systems (Giachetti 2016). Model Based Systems Engineering (MBSE) diagrams for current and improved systems were developed in Innoslate to aid in this analysis.

This thesis recommends that MCM mission planning systems be updated to take advantage of modern technology and user needs. A framework for updating these systems is presented by identifying problems with current systems, developing operational requirements for an improved system, translating system architecture into a common MBSE language, and completing an analysis of alternatives (AoA).

The current status of MCM mission planning systems and deficiencies were the basis for operational requirements to guide concept generation for an improved system. These systems were translated into MBSE action diagrams to establish a common architectural language and provide models for simulation. Metrics compared include the number actions requiring manual data inputs, actions requiring data transfers using removable storage, and the total number of actions required to complete mission planning.

Simulations of these models were used to analyze the time required to complete the mission planning cycle for each system using normal distributions and fixed values for each action. The total time includes all aspects of mission planning, post mission

analysis, loading mission plans to aircraft, and reporting but does not include events away from mission planning systems (pre-flight, flying sorties, etc.). The results of hypothesis testing using data from these simulations is depicted in Figure 1.



Oneway Analysis of Time (Hours) By Configuration

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Current	1.89	2.314	2.68	3.01	3.41	3.727	4.33
Workaround	1.36	1.88	2.195	2.42	2.7925	3.195	3.96
Improved	0.4	0.844	1.0425	1.36	1.7075	2.034	2.61

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Current	100	3.0354	0.5306379	0.0530638	2.9301099	3.1406901
Workaround	100	2.4782	0.4981448	0.0498145	2.3793573	2.5770427
Improved	100	1.3951	0.4675241	0.0467524	1.3023331	1.4878669

Means Comparisons

Comparisons for each pair using Student's t

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Current	Improved	1.640300	0.0706307	1.501300	1.779300	<.0001*
Workaround	Improved	1.083100	0.0706307	0.944100	1.222100	<.0001*
Current	Workaround	0.557200	0.0706307	0.418200	0.696200	<.0001*

Comparisons for all pairs using Tukey-Kramer HSD

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Current	Improved	1.640300	0.0706307	1.473923	1.806677	<.0001*
Workaround	Improved	1.083100	0.0706307	0.916723	1.249477	<.0001*
Current	Workaround	0.557200	0.0706307	0.390823	0.723577	<.0001*

Figure 1 Mission Planning Systems Box Plot

These results showcase a statistically significant improvement when using the workaround process over the current process, confirming the value of these workarounds. Additionally, the improved process exhibits a statistically significant improvement over the workaround process, demonstrating that there is still untapped potential for further improvement beyond what has been achieved user workarounds.

Criteria were developed to complete an AoA of these systems based on operational requirements derived from deficiencies in current systems. These include time to plan, ease of use, reduction of human error, maintainability, and connectivity. The improved mission planning concept performed the highest in all categories while requiring no instances of manual data entry or data transfer via removable storage. This thesis recommends funding and development of improved MCM mission planning systems utilizing the presented concept to increase the warfighting capability of the U.S. Navy and defend global commerce.

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I. INTRODUCTION

According to the Chief of Naval Operations (2018), control of the seas is a top priority for maintaining maritime superiority, but an inability to effectively complete Mine Countermeasures (MCM) risks this objective if not addressed. Current Airborne MCM (AMCM) mission planning and post mission analysis (PMA) does not meet the requirements of its users and is detrimental to this objective. This is accomplished using four standalone computers with no network capability. Additionally, reliance on manual inputs for data entry introduces potential for human error, and redundant tasks increase time outside the aircraft. During conflict, time constraints can force commanders to accept a lower threshold for mine clearance, making reduced timelines for mission planning and post mission analysis vital for maintaining freedom of navigation. With a dwindling competitive advantage in the Great Power Competition (GPC), the U.S. Navy cannot waste valuable time on legacy mission planning equipment (Chief of Naval Operations 2018).

A. PROBLEM STATEMENT

MCM is often overlooked during many of the Navy's battle problems and not addressed sufficiently during planning for potential conflict (Tadjdeh 2020). Offensive mining is one of the key ways an inferior fighting force can control the seas and prevent follow on operations from a superior fighting force. The current communication structure, mission planning, and PMA procedures utilized during AMCM introduce too many opportunities for human error and severely reduce efficiency. This can lead to commanders accepting unnecessary risk in the form of lower mine clearance thresholds before ships are allowed to transit an area or unrecognized risk due to human error in planning or analysis. Improvements in any of these areas has the potential to improve the timeline and effectiveness of MCM operations and thus reduce the risk of a mine strike.

B. RESEARCH OBJECTIVE

The objective of this thesis was to perform an analysis of alternatives (AoA) and recommend improvements in AMCM mission planning, PMA, and message traffic to reduce human error and decrease time to complete tasking. Modernizing these processes could provide increased mission accomplishment while decreasing costs and risk to force. This thesis provides the most significant design and operational factors associated with mine warfare (MIW) that would allow for the successful planning and conduct of AMCM missions.

C. RESEARCH APPROACH

An analysis research method is used to provide a solution that focuses on quantitative evaluation of the problem statement to inform design of follow-on systems (Giachetti 2016). This begins with stakeholder analysis and background reading to gather the required data. According to Brady (2021), this data can be used to "understand the problem domain, develop a set of system alternatives, and develop evaluation criteria for performing a comparative analysis of the alternatives." This analysis evaluates each system's ability to reduce time to complete tasking and risk as the result of human error.

Specifications were developed for each alternative and goals were established to compare them. Concept scoring is utilized, to include a concept selection matrix, to identify the best solution. Model Based Systems Engineering (MBSE) is used to architect current systems and improved systems to aid in this analysis. Innoslate is used to generate requirements and activity diagrams to, as Beery and Paulo (2019) describe, "define the mission comprehensively from a functional perspective." Life cycle considerations are also discussed and aid in overall recommendations. The findings are presented in the form of time savings and human error reduction.

D. MBSE TOOLS

MBSE provides many benefits over the course of a project including improved communication, ability to manage complex systems, improved product quality, and the ability to reuse information (International Council on Systems Engineering 2015). MBSE is used to create diagrams that are connected and dependent on one another, so updates to one diagram are reflected appropriately across all diagrams. This also provides a means of validation and can make simulation easier to accomplish (Acheson, Dagli, and Kilicay-Ergin 2013).

This thesis focuses on behavior diagrams to illustrate user interactions, inputs and outputs, and sequence of events with MCM mission planning systems. These highlight the cumbersome nature of current mission planning systems and show potential improvements if a streamlined system was adopted. Innoslate is a web based MBSE software tool that is used to generate diagrams and conduct simulation.

E. BENEFITS OF THESIS

The Navy and Department of Defense are the primary benefactors of this thesis. MCM is a fundamental defense mission required to allow freedom to maneuver for military vessels and is an essential step for any amphibious assault. Effective MCM dissuades adversaries from placing mines in the water through power projection and prevents blockade of domestic or partner waterways. Any means of making this a more effective and efficient process directly benefits the defense interests of the United States.

Commercial shipping that supports the global economy also benefits from this thesis. Recent conflicts have shown isolated warfare can drastically impact global trade of food, energy products, and other essential goods that rely on unrestricted use of waterways. By dissuading adversaries from laying minefields and being able to quickly clear areas of potential mining the United States can protect global shipping for partner nations and neutral parties.

F. THESIS OUTLINE

Chapter II of this thesis provides the necessary background of MCM to support an understanding of its importance to global prosperity. The current state of mission planning systems and common problems are discussed, as these augment the problem statement and are the source of overall requirements. The Chapter also includes a description of MBSE to introduce basic concepts that will assist with understanding of diagrams in the thesis.

Chapter III describes how MCM missions are conducted with a focus on AMCM performed by a Navy MH-60S. Figure 4 is a visual representation of the mission planning flow and inputs to each step. These inputs and the mission planning process are discussed in the Chapter. System upkeep and common workarounds developed by users are introduced. Figure 8 depicts the mission planning process with the inclusion of these workarounds.

Chapter IV uses the processes and deficiencies previously discussed to create requirements for an improved system. These requirements supported the creation of Figure 9 which represents the potential improved system. The visual representations for current, workaround, and proposed systems were the basis for MBSE diagrams that are introduced in this Chapter. Analysis and simulation of these diagrams then aids concept screening/scoring to complete the AoA.

Chapter V offers a conclusion of the thesis where research objectives and solutions to the problem statement are reviewed. Future work and recommendations are discussed.

II. BACKGROUND

Section A of this chapter includes an introduction to MCM and recent consequences of MIW. Section B addresses the current state of mission planning systems shortcomings. Section C discussed the benefits of MBSE and Section D introduces MBSE diagrams that form the architectural foundation for action diagrams in Chapter IV.

A. MCM INTRO

Modern MCM began during the Korean war where Rear Admiral Allen “Hoke” Smith stated “The U.S. Navy has lost control of the seas in Korean waters to a nation without a Navy, using pre-World War I weapons, laid by vessels that were utilized at the time of the birth of Christ. The strongest Navy in the world had to remain in the Sea of Japan while a few minesweepers struggled to clear Wonsan” (Melia 1991). According to Marolda (2020), by the end of the war “enemy mines caused 70 percent of all U.S. Navy casualties and sank the only four U.S. naval vessels lost in combat.”

During the Iran-Iraq War, the USS *Samuel B. Roberts* struck a $1500 mine which caused an estimated $90 million in damage. Two additional mine strikes occurred during the Gulf War with the USS *Tripoli* and USS *Princeton*, causing approximately $20 million in damage (United States General Accounting Office 1996).

Moving into the modern era, Fermin (2022) estimates that near peer competitors like China have an inventory between 50,000 and 100,00 mines. This includes “30 varieties of contact, magnetic, acoustic, water pressure and mixed reaction sea mines, remote control sea mines, rocket-rising, and mobile mines” (Fermin 2022). Further complicating matters, these mines will likely be employed by civilian fishing vessels in China’s Maritime Militia “because they offer sufficient numbers, ‘small targets,’ reasonable mobility, and unsuspicious profiles” (Erickson, Goldstein, and Murray 2009).

B. CURRENT MISSION PLANNING SHORTCOMINGS

Mission planning using the Joint Mission Planning System (JMPS) is noted from users and studies as not intuitive, cumbersome, and requiring more time than necessary to complete planning. Once the mission is loaded onto the Data Transfer Device (DTD) for mission execution it is largely unchangeable and unable to ingest real time updates (Raytheon 2017). These same issues are present in the systems used for MCM mission planning. While internal processes in MINENet Tactical (MNT) are more intuitive, the lack of a networked input capability for raw data limits the benefit. Both Non-classified Internet Protocol Router (NIPR) and Secret Internet Protocol Router (SIPR) connectivity, according to Raytheon (2017) "would provide a broad set of tools for collaboration across the fleet." They also highlight other difficulties users face:

> Unable to use a single system to create MCM mission plans increasing mission planning time, Unable to plan AMCM mission on JMPS, Unable to do comprehensive MCM planning on the JMPS computer, No effective method of pulling bathymetric data during PMA to use for subsequent mission planning

Raytheon (2017) concludes the user request for "combining functions of current MCM planning systems ([MNT] and JMPS) into a single system."

The numerous shortcomings of MNT are not documented in any source material and rely heavily on the author's personal experience instructing AMCM for seven years. Transferring data between multiple computers and burning DTDs for mission execution is not intuitive and requires substantial experience with various software, hardware, and workarounds. This often makes qualified aircraft commanders the only member of the crew capable of executing the mission planning process. For example, coded message traffic can only be expected to be understood and decoded by this crewmember. Environmental data must be queried from external sources and manually input to complete many steps. A minimum of four separate computers are required to plan and analyze AMCM missions and data must be burned to removable storage for transfer between them.

Once complete in MNT, the user must utilize JMPS to create files that are taken to the aircraft. Errors that cause failure of the program or a corrupted DTD are common and troubleshooting is often beyond the capability of a standard operator (Brady 2021). Networking is wrongly viewed as higher risk to sensitive information, but transfer via removable storage is not adequately outlined in current procedures and lacks standardization. There is always a chance that sensitive information on physical storage can be misplaced or plugged into computers with lower classification which highlights another benefit of a networked system. Raytheon (2017) identifies wireless connectivity as the best solution while acknowledging the cyber security risks this could introduce. Overall, they recommend that systems "should be 'plug and play' with any NIPR/SIPR infrastructure" and rely on minimal setup from system administrators.

To augment data files taken to the aircraft, pilots generate Kneeboard Cards (KBCs) as a physical reference to important information. These are generated using Micrsoft Excel and have no import capability of data for MNT or JMPS. Submissions to various Enabling Naval Aviation Requirements Groups (ENARGS) include the desire for mission planning programs that run off a single tablet and provide a network capability to not only transfer data, but receive real time updates from aircraft during the mission (Raytheon 2017).

Operators are also responsible for updates and upkeep of both MNT and JMPS computers. A pilot is assigned as the JMPS officer for each squadron, but this role does extend to MNT. Upkeep of JMPS is estimated at 35 hours per week which leaves little time for this individual to complete tasks for their primary job of flying (Brady 2021). With MNT, the largest time commitment comes in the form of software updates. These updates are shipped to the squadron via compact disk (CD) and must be installed in sequential order one machine at a time. Multiple patches are shipped at the same time and require approximately one hour each to install. Computers must be individually updated. This results in squadrons operating with outdated software while waiting for hours of updates to be installed. Ideally, updates could be pushed via a network and installed automatically between workdays. Additionally, dedicated tech support would ensure up to date mission planning systems and enable pilots to focus on their primary jobs.

C. MBSE OVERVIEW

According to The International Council on Systems Engineering (INCOSE) (2007), MBSE can be defined as "the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases.” The 2015 INCOSE Systems Engineering Handbook lists the following benefits:

- Improved communications among the development stakeholders (e.g., the customer, program management, systems engineers, hardware and software developers, testers, and specialty engineering disciplines)
- Increased ability to manage system complexity by enabling a system model to be viewed from multiple perspectives and to analyze the impact of changes
- Improved product quality by providing an unambiguous and precise model of the system that can be evaluated for consistency, correctness, and completeness
- Enhanced knowledge capture and reuse of the information by capturing information in more standardized ways and leveraging built-in abstraction mechanisms inherent in model-driven approaches. This in turn can result in reduced cycle time and lower maintenance costs to modify the design
- Improved ability to teach and learn SE fundamentals by providing a clear and unambiguous representation of the concepts (International Council on Systems Engineering 2015)

Other general benefits identified by the design team of the Wendelstein 7-X experimental fusion reactor include: “structured documentation of design decisions, the traceability of design decisions to requirements, consensus building among stakeholders, avoiding misinterpretation of system structure or behavior during internal and external communication, clear representation of complex interdependencies between system elements, and supporting holistic considerations such as system safety and operational concerns” (Scharff et al. 2022).

Beery (2016) expands on this with the concept of MBSE methodology for employing architecture in system analysis (MBSE MEASA). MBSE MEASA “transforms operational needs into preferred system configurations through the analysis of detailed simulation models.” The major steps include requirements analysis, functional architecture development, physical architecture development, model definition, and model analysis. These steps allows both architecture and analysis to be conducted methodically to improve traceability between requirements and results. This thesis incorporates these steps in the design and analysis of systems for use in an AoA.

MBSE was utilized in this thesus to provide uniformity from use of a common language and aid in understanding for those who have limited exposure to MCM. The dependency lends itself to future work through easy revisions and as a basis for other mission planning systems. The primary tool used in this thesis was Innoslate, a web based MBSE program that uses Life cycle Modeling Language (LML) and can translate into Systems Modeling Language (SysML).

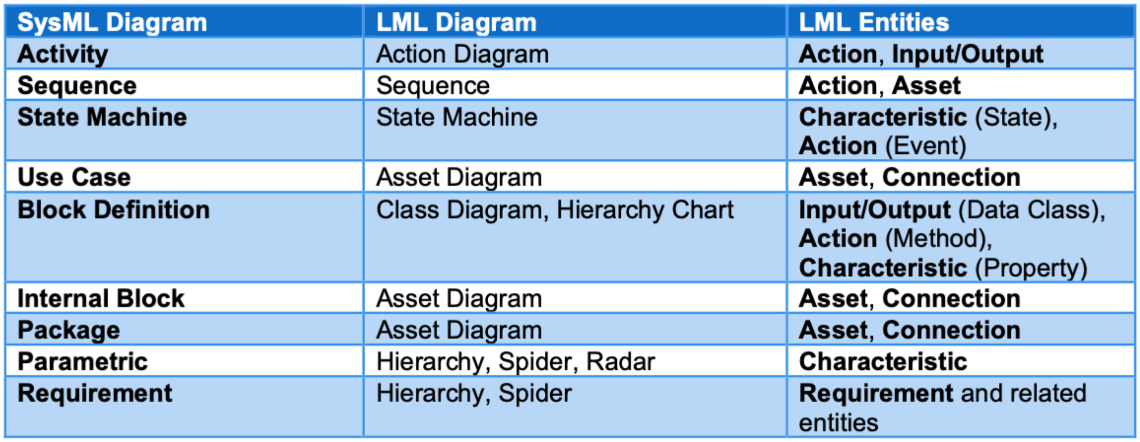
D. MBSE DIAGRAMS INTRODUCTION

Innoslate uses the Life cycle Modeling Language (LML) which has similar capabilities to SysML with several added benefits. LML utilizes an entity-relationship-attribute data structure which simplifies underlying model structures. This allows diagrams to be developed in either LML or SysML and rapidly translated into similar diagrams in the other language. Figure 1 provides a visual reference for comparison between LML and SysML.

Action diagrams are similar to activity diagrams in SysML and provide a flow of actions and related inputs and outputs. Three special actions are included in LML that are LOOP, SYNC and OR. LOOP allows actions to be repeated in a cycle until certain criteria is met (number of cycles, unique input, etc.). SYNC is a way of ending two parallel branches or swimlanes. OR precedes several actions and forces one to be selected. This decision can be based off probability or specific criteria (Dam 2022).

Asset diagrams are a variation on physical block diagrams. They provide a physical depiction of the system that corresponds to the functional description provided by action diagrams. Asset diagrams were used in this thesis in place of use case diagrams which, according to INCOSE, typically “provide a high-level description of the system functionality in terms of how users and external systems use the system to achieve their goals” (International Council on Systems Engineering 2015).

The last LML specific diagram used in this thesis is the spider diagram which depicts how entities are related to one another. The Innoslate Help Center describes this as a “hierarchical organizational chart used as a means of visualizing traceability” and provides "visualization for traceability beyond what a typical hierarchy type diagram can offer" (Innoslate Help Center n.d.).



SysML Diagram	LML Diagram	LML Entities
Activity	Action Diagram	**Action**, **Input/Output**
Sequence	Sequence	**Action**, **Asset**
State Machine	State Machine	**Characteristic** (State), **Action** (Event)
Use Case	Asset Diagram	**Asset**, **Connection**
Block Definition	Class Diagram, Hierarchy Chart	**Input/Output** (Data Class), **Action** (Method), **Characteristic** (Property)
Internal Block	Asset Diagram	**Asset**, **Connection**
Package	Asset Diagram	**Asset**, **Connection**
Parametric	Hierarchy, Spider, Radar	**Characteristic**
Requirement	Hierarchy, Spider	**Requirement** and related entities

Figure 1. SysML Diagram Mapping to LML Diagrams and Ontology.
Source: Dam (2022).

SysML diagrams were used in this thesis when there is no equivalent diagram in LML, specifically for sequence and state machine diagrams. In LML, state use diagrams depict how an asset will transition between different states (Innoslate Help Center n.d.). INCOSE (2015) adds on to this by stating "a state machine diagram (stm) describes the states of a system or its parts; the transitions between the states; the actions that occur within states or upon transition, entry, or exit; and the events that trigger transitions." According to Beery (2016), they also "ensure that no conflicting responses to events are prescribed" and "specify how transitions between states should occur."

According to INCOSE (2015), "A sequence diagram (sd) represents interaction in terms of the time-ordered exchange of messages between collaborating parts of a system." This is expanded when used in conjunction with LML "to represent the sequential message flow (Input/Output entities) between Lifelines (Asset entities)" (Innoslate Help Center n.d.).

III. AIRBORNE MINE COUNTERMEASURES MISSION PLANNING

Section A of this chapter includes an overview of the MCM mission that discusses commonalities between all surface, subsurface, and air platforms. It then expands on AMCM in Section B, specifically search and neutralization missions for the MH-60S. Sections C through G introduce the tools used to accomplish AMCM mission planning. Section H contains a visual representation and summary of current AMCM mission planning flow.

Sections I and J discuss the workarounds and techniques developed by users in response to the inefficiencies of current mission planning systems. The Chapter concludes with a visual representation and summary of workaround AMCM mission flow.

A. MCM MISSION OVERVIEW

Mission planning is essential to MCM and when conducted properly provides commanders information to make critical decisions by combining intent with real time factors. Success is more often the result of planning instead of execution. commanders must trust that their systems are reliable, effective, and operated by proficient personnel in order to make well informed risk decisions. This Chapter discusses an overview of AMCM mission planning, considerations for mission planning inputs, and phases of the planning process.

The operational objective of MCM is to reduce the risk of mine strikes to military vessels and commercial shipping. The Measures of Effectiveness (MOE) to determine mission accomplishment are time to complete tasking and probability of remaining mines in the tasked area in the form of risk. Mission planning for AMCM is predicted on four inputs: tasked area, specific mine threats and locations, potential operating environment, and equipment to be used. Tasking is determined at the staff level and sent to units to complete. Areas can be Sea Lines of Communication (SLOCs) for ship transit, Fleet Staging Areas (FSTs) for loitering, or Amphibious Operation Areas for landing littoral forces on a coastline. The assessed mine threat parameters are pulled from a database and cross referenced with equipment capabilities to ensure the tasked unit can locate and if required destroy the mines. Environmental considerations including water temperature, salinity, visibility, bottom type, and currents which are important to reference as they can impact equipment performance. These four inputs are analyzed by software to estimate MOE before they are transferred to the aircraft for sorties (Office of Naval Research 2015).

Aircraft sorties include routing to the objective area while avoiding any threats to the aircraft. Once on station the aircraft can conduct a search mission to localize mines or a neutralization mission to destroy mines that were previously located. After landing, PMA is conducted to determine if actual MOE surpassed the estimated MOE calculated in mission planning. Units report the results of their sorties to the staff who track overall progress and provide follow on tasking. Time spent generating tasking, mission planning, conducting PMA, and reporting results directly increase time to complete tasking and opportunities for human error which can increase risk above acceptable thresholds.

B. AMCM

During a search mission aircraft launch from an operating base or ship and begin routing to their objective area. Routing may include going around other airspace in use and threats or using standard checkpoints instead of direct routing. Distance of inbound and return routing, as well as movement of a landing vessel, will determine overall time on station in the objective area. Once on station, aircraft complete system checks and begin to fly tracks or “mow the lawn.” The Airborne Laser Mine Detection System (ALMDS) on the MH-60S uses LIDAR to scan the surface and near surface portions of the water column. This requires multiple passes to fuse contacts with the same localization. Contacts seen on only one pass may be drifting (sea life, kelp, etc.) and are filtered out during the PMA process. Once the search pattern is complete, or the aircraft must return to base for fuel (referred to as “bingo”) or to meet a landing time, return routing is started. The same considerations apply to return routing; however, airspace and threats can shift over the course of a sortie and aircraft should reach out to controlling agencies for updates. Figure 2 illustrates a basic search mission to provide a visual representation of the description.

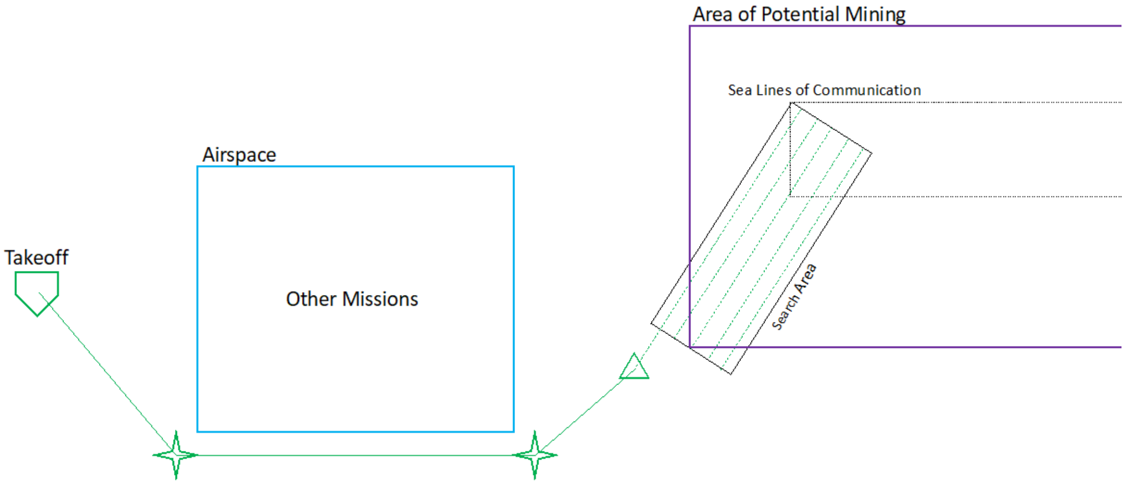


Figure 2. Search Mission Overview

During a neutralization mission aircraft complete the routing to the objective area by using the same considerations as a search mission. Once on station the aircraft establishes a hover outside the SSO (Safety Stand Off) and streams (lowers) the neutralization system into the water. In the AMNS (Airbone Mine Neutralization System) on a MH-60S this includes a LHS (Launch Handling System) and four neutralizers. On an MH-53 this is be reduced to one neutralizer. Hover locations are selected based of water currents and wind direction. The aircraft should be positioned down current of the mine to weathervane the LHS which improves sonar performance. The helicopter should face into the wind to reduce power requirements. Accepting an indirect headwind may be required so that the plume of a mine destruction can be seen from the cockpit. Once equipment is streamed and passes all BITs (Built in Tests) one of the neutralizers is launched and driven to the mine location. Sonar from the LHS is combined with GPS data from the aircraft to help determine relative neutralizer position in the water. As the neutralizer approaches the RSA (Reacquisition Search Area) a search patter in started to locate the mine. Neutralizers use their own onboard forward-looking sonar to scan for mine shapes. Once a shape is picked up on sonar the neutralizer is driven closer to see the object so onboard video can confirm the object is "mine-like." Weapon systems are armed and the mine is neutralized. The LHS is then recovered and the aircraft can proceed to another mine if time/fuel permits or return to base. Figure 3 depicts a basic neutralization mission to provide a visual representation of the description.

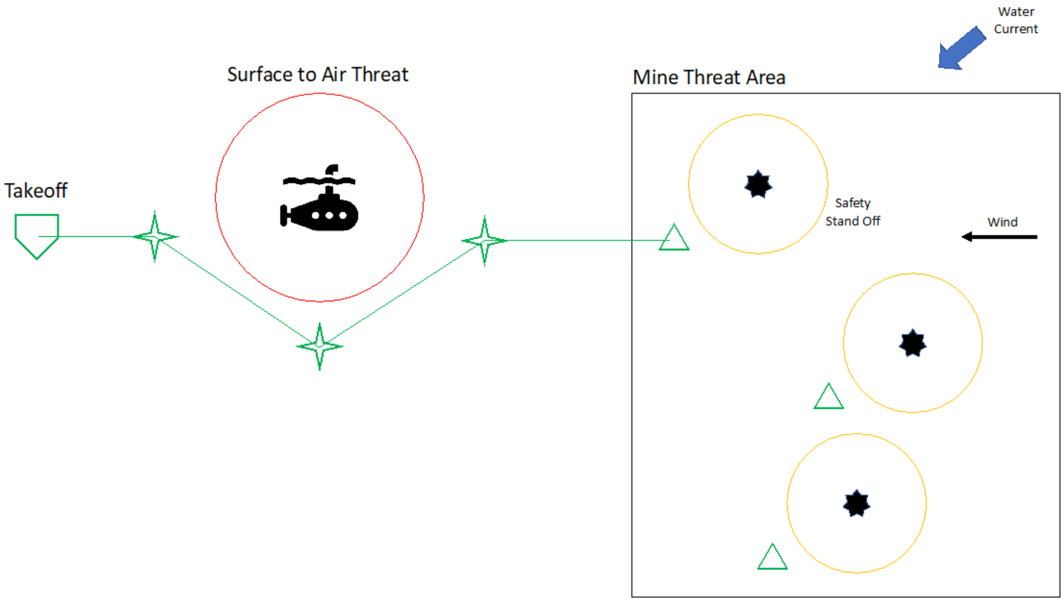


Figure 3. Neutralization Mission Overview

C. TASKING

Tasking comes in the form of Operational Directions (OPDIR), Operational Tasks (OPTASK), and Daily Intention Messages (DIMs). OPDIRs include overall commander's intent, authority for Mine Danger Area (MDA) establishment, breakdown of units available for tasking, situation overview, area coordinates, basic environmental data, general tasking for each unit, reporting requirements, communication standards, equipment standoff, and any other information that may be useful to all participating units.

OPTASKs are addressed to an individual unit or a smaller group of units that may require coordination. They are generally much shorter and provide specific parameters like desired effort, tasked area, additional communication requirements, and specific contacts or mines if applicable. The OPTASK will reference information in the parent OPDIR.

Tasking and responses use coded messages that require translation to use the contained information. Users must reference the APP-11(D) OPTASK NMW (Operational Tasking for Naval Mine Warfare) to decode these messages. Experienced operators may be able to roughly translate messages to get a general understanding of what is sent, but still require the use of the APP-11(D) for complete manual translation. MNT does not include any ability to ingest coded messages, assist the user in translating these messages, or create coded messages to report mission results. Example message traffic is included in the Appendix.

D. PLANNING CONSIDERATIONS

A description of considerations for MCM mission planning is provided in this chapter. An overview of threats, friendly capabilities, and environmental data is accomplished as these form the foundation for data inputs during planning.

1. Enemy Order of Battle (EOOB)

EOOB includes the expected inventory of mines an adversary can employ and the characteristics of those mines to aid in mission planning. Depth range, size, type, counter-countermeasure capability, and color are all important inputs to determine if mission planning is even appropriate (is the tasked asset effective against the mine threat). This data is stored in a Mine Threat Database (MTDB) on MNT which contains contains "a collection of mine threat data used in the creation of Mine Order of Battle (MOB) threats. Mine threat data includes known mine types and their physical characteristics, operational limits and characteristics, and firing systems" (Office of the Chief of Naval Operations 2021).

If selected threats in mission planning are different than threats encountered during sorites "measures of effectiveness (MOEs), time and risk, will be grossly misrepresented" which can lead to a "false sense of the effectiveness achieved and the risk remaining" (Office of the Chief of Naval Operations 2021).

Current MCM mission planning systems do not have the ability to import any threats from tasking. Threats must be manually selected from the MTDB to build the MOB.

2. Friendly Order of Battle (FOB)

To less experienced users, FOB simply provides the correct selections in the Tactical Performance Database (TPDB) which serves as "a collection of the effectiveness of various types of equipment with specific settings in specific modes or configurations" (Office of the Chief of Naval Operations 2021). When follow on systems are unknown it is important that the most conservative systems are selected to account for overall probability across the detect to engage sequence. For example, if the probability of neutralization for a follow-on system is over estimated, a lower detection threshold may be assumed to be acceptable. If the planned neutralization system becomes unavailable (new tasking, broken equipment, etc.) you may have to return to detection to meet overall required clearance. Since system performance can change due to different operating environments and threat characteristics "tactical performance data is usually defined for a specific mine threat within a defined set of environmental and operational parameters" (Office of the Chief of Naval Operations 2021).

3. Meteorological and Oceanographic (METOC) Data

Weather and environmental parameters are required for each mission to aid in proper planning and real time decision making. Air, surface, and subsurface conditions are gathered from separate sources and current mission planning systems do not have the ability to automatically fetch relevant data. According to The Naval Surface Warfare Center Panama City Division (2022), these include all standard weather data for normal flights and the following MCM specific parameters:

- Water current
- Water salinity
- Water temperature
- Water visibility
- Water depth
- Sea floor bottom type
- Sea floor clutter level
- Solar Light Levels
- Sea State

Water current, salinity, temperature, visibility, sea state, bottom types, and bathymetry (depth) all play a vital role in proper selections during mission planning. These inputs are cross referenced with threats and system capabilities to determine overall MOE. Water salinity and temperature are used to determine the speed of sound in water that is important for any sonar system. Bathymetry is referenced to determine the depth of bottom mines or the length of tethers for moored mines. Bottom type can increase the noise when reacquiring mines for neutralization. Water current is used to determine the best hover point to allow equipment to traverse up current. Sea state dictates whether detection equipment will be degraded from surface waves and if neutralization equipment can be streamed/deployed into the water without risking damage. Water visibility provides a good estimation of when a contact can be picked up visually by onboard cameras. These inputs are important because "system performance from the TPDB is, in almost all cases, dependent on METOC critical performance parameters (CPPs)" (Office of the Chief of Naval Operations 2021).

MNT does provide an input capability for METOC data, but because computers are operated in a standalone configuration this feature is not utilized. This forces the user to “manually select those entries within the Plans and Effectiveness workflows” (Office of the Chief of Naval Operations 2021).

4. Weather

Weather is an important consideration for any aviation mission and includes pressure altitude (PA), density altitude (DA), outside air temperature (OAT), cloud ceilings, prevailing visibility, winds, adverse conditions, current conditions, and forecast conditions. These allow pilots to determine if operations can be conducted along their route of flight and in their objective area. Additionally, these are inputs for weight and balance and engine power calculations that are conducted for each part of the sortie (Brady 2021). During AMCM, aircraft are fitted with different Automatic Flight Control Systems (AFCS) and generally operate close to their maximum allowable weight. Helicopters usually hover facing into the wind to reduce power requirements, however during neutralization missions this may not be possible if the crew has to watch for a water plume indicating mine destruction.

Mission planning systems do not have any ability to gather relevant weather data. This information from official Department of Defense (DOD) weather sources is usually briefed to the crew by a duty officer or pulled from civil aviation smartphone applications.

E. MNT PLANNING

MNT is advertised to provide data Management (assets, threats, environment, etc.), MCM planning, MCM evaluation, and data synchronization and sharing with other units (Office of the Chief of Naval Operations 2021). In reality, data synchronization and sharing does not occur due to how the system is employed by operational units or limited system functionality. Network capabilities are not utilized because individual units are often overly cautious with their information technology and the Navy lacks standard procedures. Even if the ability exists to connect different systems that would streamline processes like mission planning, commanders are quick to dismiss such connectivity when working with any classified system.

This lack of connectivity results in numerous manual inputs which increase time to plan and introduce opportunities for human error.

F. JOINT MISSION PLANNING SYSTEM PLANNING

JMPS serves as the primary mission planning tool for Naval Aviation and is designed to support “weapon system employment by providing the information, automated tools, and decision aids needed to rapidly plan aircraft, weapon, or sensor missions, load mission data into aircraft and weapons, conduct mission rehearsal, execute missions, and conduct post -mission analysis” (Brady 2021). Mission planning on JMPS is assessed to take 6–18 hours as a result of “high amount of manual and repetitive tasks, lack of interoperability, unfriendly user interface, and unreliability of JMPS hardware and software” (Brady 2021).

G. MNT ADMINISTRATOR

One of the major problems with the current standalone systems is that maintenance and upkeep are the responsibility of the user. For an entire Wing of nine squadrons there may be one contractor assigned for mission planning IT support. This individual is historically hired to support JMPS and has no experience with MNT. When major issues occur computers must be sent in for service. While this can slow down squadron training, it can be a single point of failure for detachments on deployment.

Users are responsible for installing updates on machines. This is accomplished by CDs that are sent to the squadron at their home base or detachments that are on deployment in various parts of the world. Multiple pages of instructions are included which often include adjusting settings in an administrator account. These steps do not allow the user to leave the computer once the install process is started so minimal other work can be accomplished simultaneously. Only one set of CDs are provided meaning computers must be updated one at a time. Sometimes multiple updates are sent at the same time and must be installed in order. With each update taking at least one hour to install, this work becomes a full-time job for one of the pilots in a squadron. Automatic updates provided by network connection would eliminate this problem, but the Navy should strongly consider hiring dedicated MNT support so these responsibilities do not fall on operators.

H. CURRENT MISSION PLANNING OVERVIEW

A current status of AMCM mission planning was developed and provided to the Mission Planning Systems Enablers Naval Aviation Requirements Group (MPS ENARG) to summarize current procedures and shortcomings. Figure 4 visually depicts this mission planning.

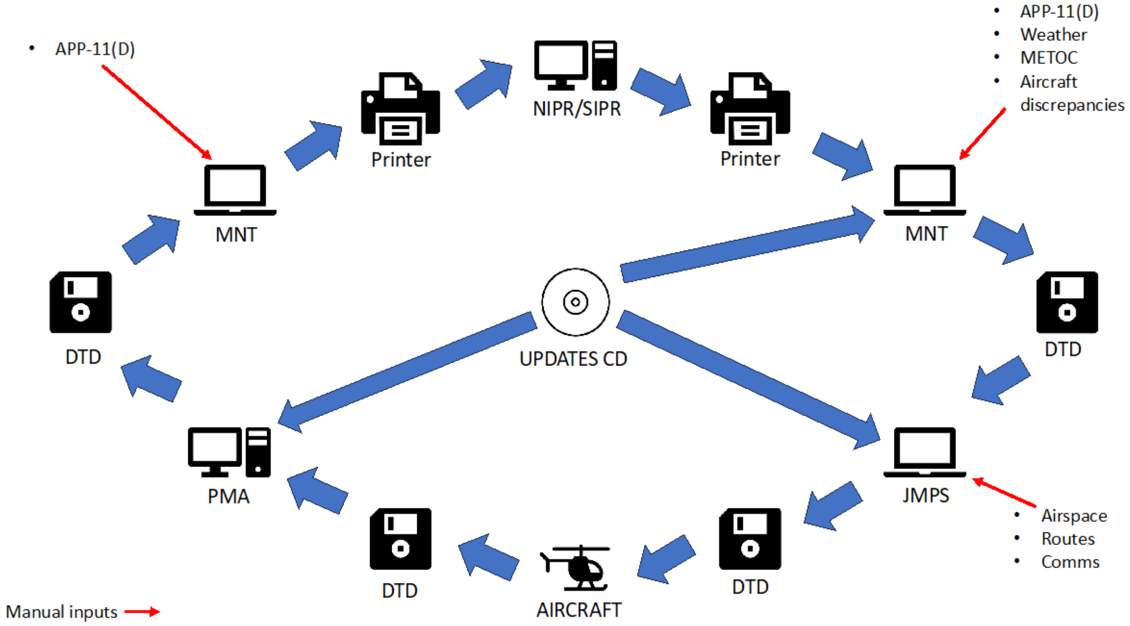


Figure 4. Current AMCM Mission Planning Overview

AMCM Mission Planning requires aircrew to use multiple standalone computers that support discrete planning and PMA capabilities. After receiving initial tasking, planners use MNT software to manually input parameters for mine search, reacquisition, or neutralization plans. These plans must be transferred to a second computer that uses JMPS software to convert MNT plans into helicopter specific plans recognized by aircraft software. Transfer of the MNT plan to JMPS is facilitated via removable storage, and ultimately requires replanning the mission in JMPS. At the completion of AMCM event execution, PMA data must be reviewed on a third standalone computer, transferred and ingested back to MNT, assessed for effectiveness, then manually transcribed into message traffic for release to Higher Headquarters. Neither MNT, JMPS, or PMA software supports the import or export of standard MIW message formats (OPDIR/OPTASK), requiring mission planners to manually transcribe data from message source to computer, or vice versa. At a minimum, MNT assets must have the ability to connect to SIPR networks to download current bathymetry, EEOB, TPDB, and send/receive tasking messages to prevent the necessity of a fourth SIPR computer during AMCM mission planning evolutions.

This submission included the recommendation that AMCM equipped squadrons ultimately require consolidated mission planning software that eliminates the use of multiple software programs, computer-to-computer transfers, redundant replanning, and errors in manual data entry. As some AMCM aircrew are required to plan, execute, debrief, and report post-mission results organically, a one-stop software/hardware solution that supports the import and export of standard MIW message traffic formats is expected to quicken AMCM mission planning cycle.

I. TECHNIQUES AND TACTICS

Users have developed several techniques to aid in maximizing time in the aircraft. When manning allows, crews can be split responsibilities between mission planning and checking aircraft systems during preflight and startup. When commanders desire a quick turnaround from tasking to mission accomplishment (time to kill) this can expand to multiple people working on separate parts of a mission plan, drivers to deliver DTDs to the aircraft, a watch stander to send and receive message traffic, multiple crews to check a primary and backup aircraft, and crews standing by to conduct PMA. During a large enough operation all these events could occur simultaneously as different missions are executed by multiple units.

Legacy platforms such at the MH-53E employ an entire group of Minemen in a tactics shop that are responsible for mission planning and PMA. Current platforms operate in a system of systems off Littoral Combat Ships (LCS) where limited berthing does not allow this level of support. Likewise, Expeditionary Advanced Base Operations (EABO) may also be limited by berthing and supplies. While a reduced footprint and multiskilled crews are desirable for some missions, MCM during a conflict would likely require a more robust task force. This has forced the Navy to explore other ways of conducting MCM "from the shore or from vessels of opportunity" (Eckstein 2023). Improvements to mission planning would directly support large MCM efforts and are necessary for any employment with a small manning footprint.

During the ALMDS mission, operators must decide the best order to fly their tracks. Three methods are commonly used: sequential, center out, and spiral. Figure 5 provides a visual representation of an ALMDS plan to aid in understanding these methods. The numbered labels in Figure 5 are a naming convention for each track and do not indicate the order of tracks flown. The most common method is flying tracks is in sequential order from one side to the other (1, 2, 3…). Pros include the least complex flight profile and ease in tracking progress while cons include the most time outside the minefield maneuvering the aircraft.

Figure 5. Basic ALMDS Plan

The second method is center out (4, 3, 5, 2, 6, 1, 7) which focuses on the center of a potential shipping channel first. If the mission is interrupted for any reason, analysis could still potentially be completed on this center portion to allow vessels with better navigational capabilities to transit. This limits the feasibility to only SLOCs. This method is also more efficient than sequential because as distance between flown tracks increases the ease in maneuvering the aircraft for the next track also increases. Negative aspects are an increased complexity of the flight and of information pass down to follow on crews.

The last method is the spiral method (1, 5, 2, 6, 3, 7, 4) which relies on a fixed aircraft turn radius to maneuver between each track. When executed properly this is the most efficient method, however it greatly increases the workload for pilots. Performance charts normally used to calculate turn radius are not provided for aircraft in AMCM configurations and therefore can only be used to estimate aircraft performance. This method shares the same negative aspects as center out.

The sequential method is the only implied method from official procedures, but details are not discussed in any formal text. The center out and spiral methods remain techniques and are not formal procedures. MNT has no ability to aid operators in selecting the best search method.

AMNS mission planning procedures imply that a stream/recovery point be identified for each mine target and does not discuss mines in close vicinity to each other. Figure 6 depicts a scenario where there is no water current (or very weak) and two mines are adjacent to one other. In this situation operators could select a hover location to neutralize both mines. Current can be artificially provided to weathervane the LHS by intentionally drifting the aircraft slowly. Following the flight path shown in Figure 6, the lower mine in could be neutralized first followed by the top mine without the need to stream/recover the LHS twice.

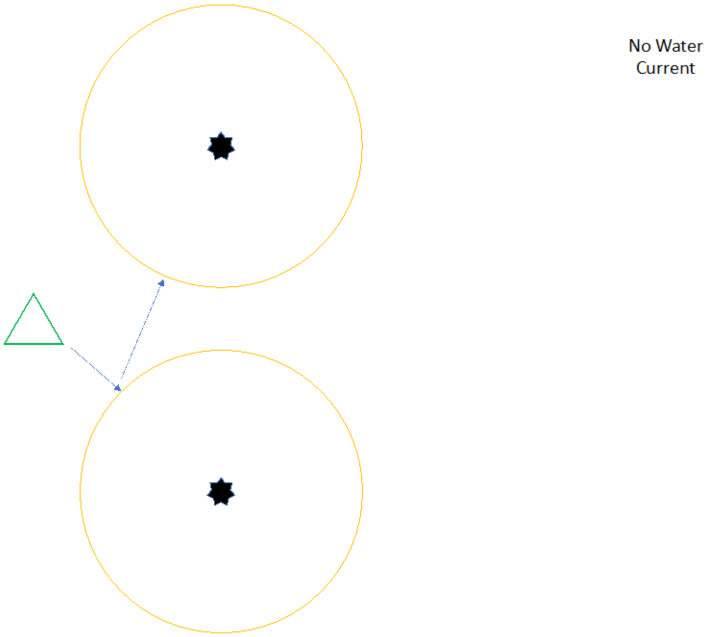


Figure 6. Mines in Close Proximity with No Water Current

The same technique can be utilized in scenarios where there is a water current as depicted in Figure 7. In this scenario the operator must decide whether to recover the LHS and reposition the aircraft to neutralize the top mine or remain in the hover and accept driving the neutralizer the extra distance. Operating specification of AMNS neutralizers cannot be discussed at this classification level, but it is clear there is a break-even point for this decision. MNT does not provide any assistance to users for the decision making required by these two scenarios.

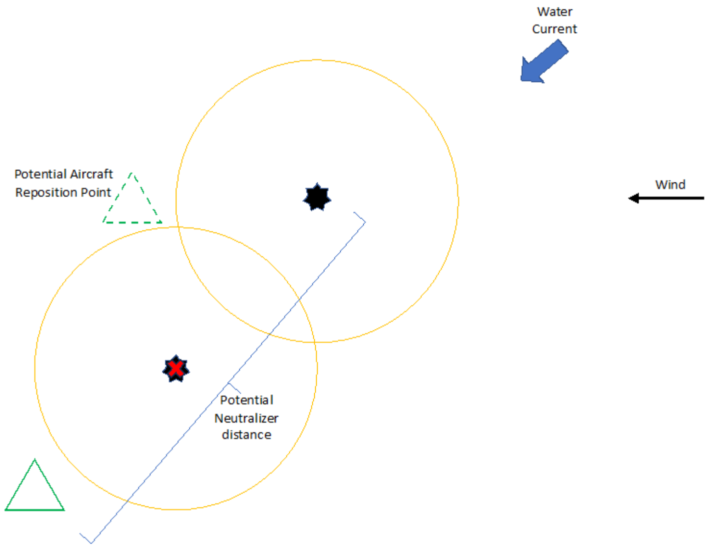


Figure 7. Mines in Close Proximity with Water Current

J. WORKAROUND MISSION PLANNING OVERVIEW

In response to the frustrations of burning data to physical storage for any transfer, some users have created an Apache server hosted on one of the MNT computers. This allows other MNT computers, JMPS computers, and secure physical storage to be connected via ethernet to allow for easy transfer of data. Because MNT is a browser-based planning tool, JMPS computers are also able to access MNT. This allows multiple people to delegate certain areas of mission planning and allows for easier collaboration. Apache servers rely on a pilot with background computer knowledge to setup and maintain. When this individual leaves the squadron or goes on deployment this capability is lost. There are no formal procedures for setting up an Apache server and no IT support provided to assist in maintaining it. Figure 8 depicts a visual representation of mission planning accomplished using these workarounds.

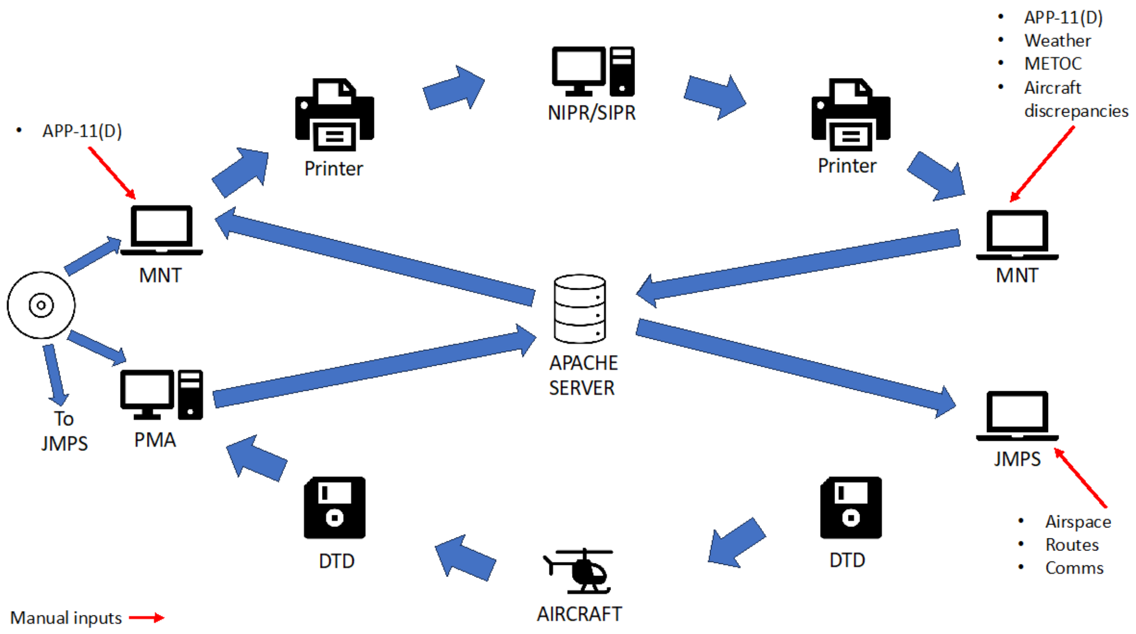


Figure 8. Workaround Mission Planning Overview

MINEnet Global is a shore-based variation of MNT hosted on SIPR. This has historically been only used at the staff level, but recently units have started using it during exercises. Some limitations of this system are the higher bandwidth required to host this service when compared to sending message traffic. While network capabilities are improving for DOD, bandwidth is not currently allotted to support the use of MINEnet Global in the shipboard environment. In its current state MINEnet Global provides the ability to collaborate but does not provide any ability over MNT to fetch data for mission planning. If utilized in the future proper permissions to burn any mission plans from SIPR to a DTD would still be required so they could be imported into JMPS.

IV. ANALYSIS OF ALTERNATIVES

Section A of this chapter reviews and summarizes the deficiencies of current systems to serve as the basis for operational requirements of an improved system. These requirements form the basis of concept generation accomplished in Section B. Figure 9 depicts an overview of mission planning using this improved system.

Section C contains translations of Figures 4, 8, and 9 into MBSE diagrams. A description of each diagram is provided with metrics that aid in comparison of performance. Innoslate formatting restricts readability of these diagrams in this section, but focus should be on quantifiable metrics and general architecture. Higher resolution MBSE diagrams are provided in the appendix.

Section D includes simulation of the diagrams depicted in Figures 10, 11, and 12. Normal distributions and fixed times are used for each action to analyze performance with time to complete planning. A box plot of the results is shown in Figure 13 to provide visual comparison of this performance.

Evaluation criteria are established in Section E with descriptions for each. Time to plan, ease of use, reduction of human error, maintainability, and connectivity were the five criteria established for analysis. An analysis of alternatives is completed in Section F with the results displayed in Table 2.

A. OPERATIONAL REQUIREMENTS GENERATION

The requirements for an alternative system were based on the deficiencies outlined in Chapter II and III from various sources and the author’s experience. The corresponding requirements address these deficiencies. Table 1 consolidates these deficiencies and requirements to help generate alternative system concepts.

Table 1. Operational Requirements for Improved MCM Mission Planning Systems

Deficiency	Operational Requirement
Four standalone computers	Full correspondence, planning, and PMA conducted from a single machine
No network capability No wireless connectivity No ability to fetch data (METOC, Weather, Threat parameters) No automatic software updates	Plug and play connectivity with both NIPR and SIPR. Wireless strongly preferred. Automatically fetch data required for planning and push to computer/tablet Auto download and install of updates and databases
No import capability for tasking parameters (EOOB, FOB, Threats, desired MOE/MOP) No export capability for results in message traffic	Auto ingest of tasking parameters Auto generate results in message traffic format
Not intuitive Cumbersome Time consuming	Intuitive and short time to plan No manual input of data (only operator decisions)
No real time updates to mission once flying No KBC generation	Tablet that interfaces with aircraft and allows real time updates to mission KBC equivalent run off of tablet Tablet can conduct all planning and PMA using intuitive touch screen controls
No ability to assist planning complex scenarios	System can suggest an optimized plan for complex missions

B. CONCEPT GENERATION

The requirements from Table 1 generate the concept for an improved mission planning system, which Figure 9 depicts. This concept utilizes wireless connectivity with appropriate encryption for classified data to interface between the different assets. NIPR/SIPR would still receive tasking before it is automatically translated into plain text with parameters, and then pushed to a planning asset. NIPR/SIPR would also automatically fetch the requisite data to complete mission planning. Communication, planning, and PMA could all be accomplished from either a computer or tablet with appropriate user interface. Variations of mission planning software would be optimized for mouse and keyboard for computer planning or touchscreen on a tablet. With all the appropriate data automatically pushed to either of these assets, the operator would only need to make decisions on how they want to accomplish the mission.

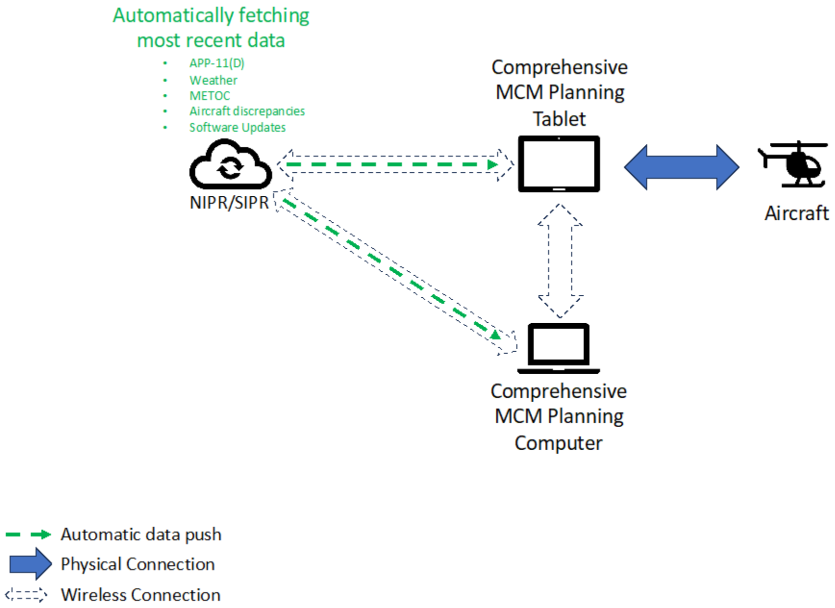


Figure 9. Improved Mission Planning Overview

At the completion of planning, information historically brought the aircraft on KBCs would be autogenerated as a quick reference guide for a more cockpit-friendly interface. The tablet would be brought out to the aircraft where it would be used to load the mission and monitor progress. This would also allow operators to update the mission in real time if new information was received via datalink or radio communications. A physical interface between the tablet and aircraft is utilized due to limitations of the legacy aircraft currently conducting AMCM. If future aircraft possessed the ability for wireless connectivity this would be utilized. The tablet would also store the mission data.

At the completion of the sortie, PMA could be conducted on the tablet or computer. Once complete, message traffic to report results would be automatically generated and able to be sent via NIPR/SIPR appropriately. If only working with other DOD assets, the connectivity offered by this system could result in message traffic being unnecessary and redundant. Staff could review all aspects of the planning, PMA, and results directly and could only require notification that tasking has been completed. If working with NATO allies the ability to automatically generate message traffic would still save time and offer no opportunity to for error due to a mistype. Software updates would be automatically downloaded and installed whenever assets are in range of wireless connectivity.

C. MBSE DIAGRAM GENERATION

This section includes three parts that each contain an action diagram of mission planning cycles along with a discussion of highlights. Figures 4, 8, and 9 should be referenced with Figures 10, 11, and 12 respectively to aid in understanding these more complex MBSE diagrams. A primary takeaway from these action diagrams are the number of assets and actions required to complete a mission planning cycle. This data is the basis for evaluating ease of use in concept scoring completed in Section E. Actions with a filled yellow background represent portions of mission planning where manual inputs are required by operators. Upkeep of systems is not a standard action during the mission planning cycle and therefore not included in these action diagrams. If updates are required to be installed manually, as in the current and workaround mission planning processes, this would introduce two additional assets: administrators and update CDs. If updates are installed automatically no additional assets are required. Higher resolution action diagrams are provided in the Appendix Section C.

1. Current Mission Planning

The current mission planning process includes 9 assets performing 33 actions with 34 inputs/outputs to accomplish the mission planning cycle depicted in Figure 10. There are four actions where operators (assets) must manually enter inputs. The DTD is used as physical storage to transfer classified information on four occasions. The planner must accomplish 13 actions to complete the mission planning cycle for one sortie.

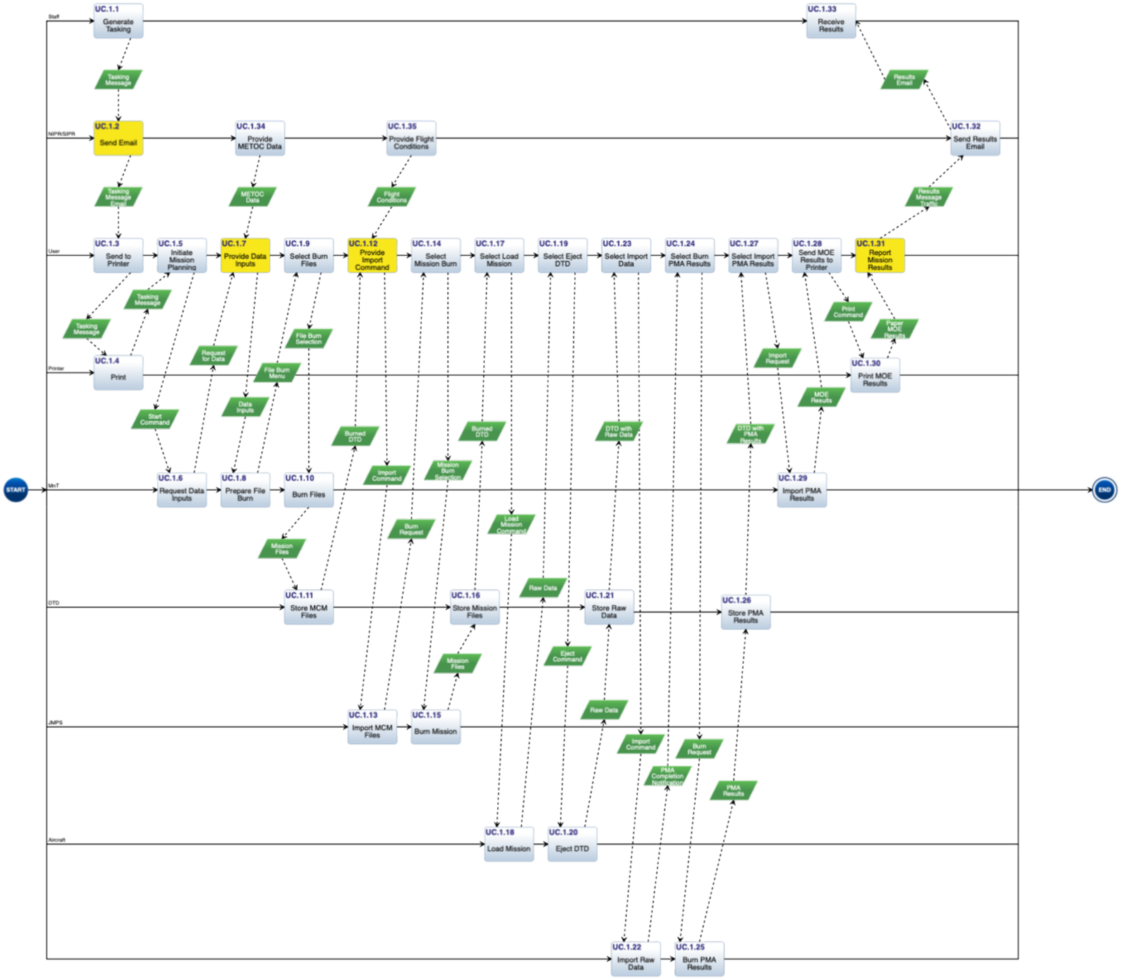


Figure 10. Current Mission Planning Action Diagram

2. Current Mission Planning with Workarounds

The current Mission Planning process with workarounds includes 9 assets performing 31 actions with 31 inputs/outputs that is depicted in Figure 11. The number of actions requiring manual input remain the same as in Figure 10, but the number of times the DTD is used for physical storage is reduced to two. The planner must still conduct the same number of actions to complete the mission planning cycle. Overall, the workaround process slightly decreases complexity.

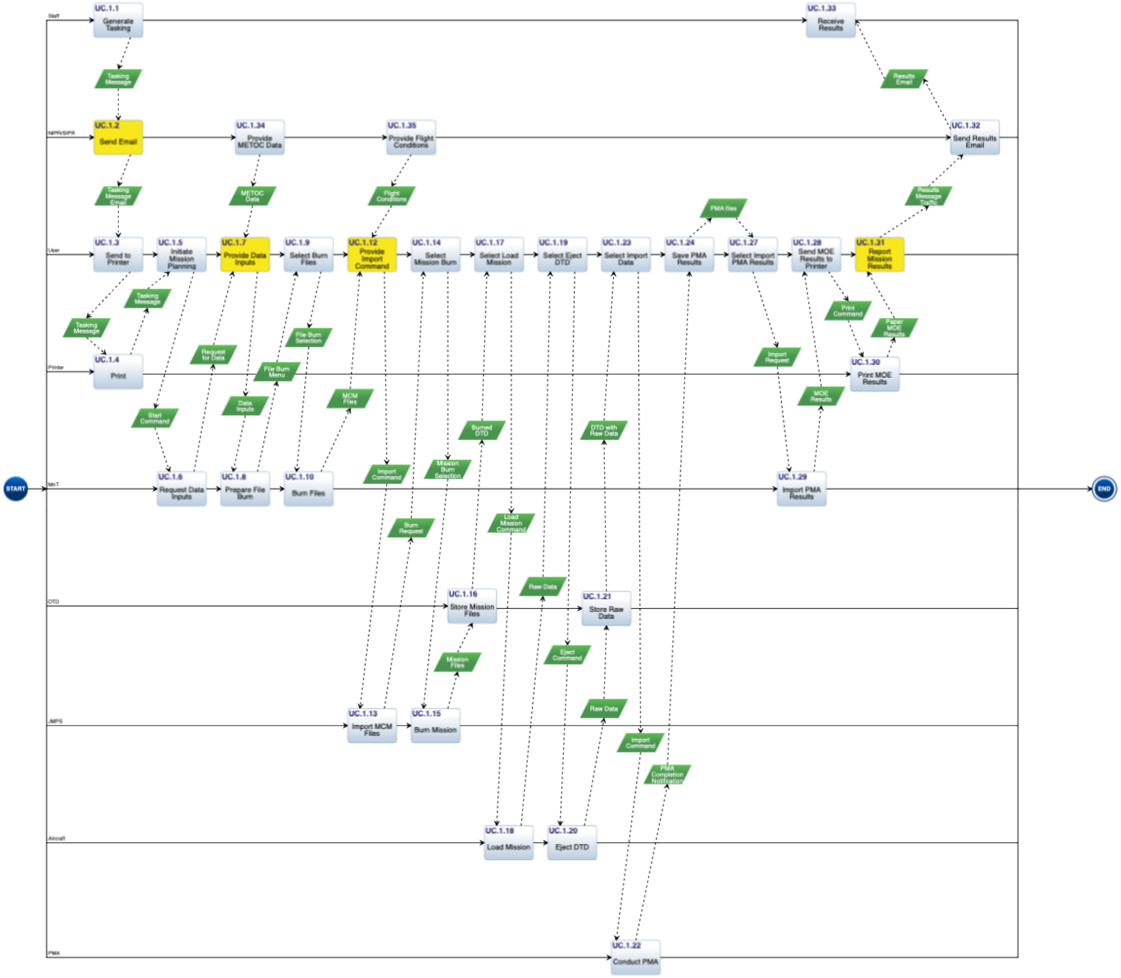


Figure 11. Current Mission Planning with Workarounds Action Diagram

3. Improved Mission Planning

The improved mission planning process includes 5 assets performing 12 actions with 11 inputs/outputs as shown in Figure 12. There are no instances that require manual inputs or that use physical storage to transfer classified data. The planner must conduct three actions to complete the mission planning cycle. This method substantially decreases in complexity when compared to the previous methods.

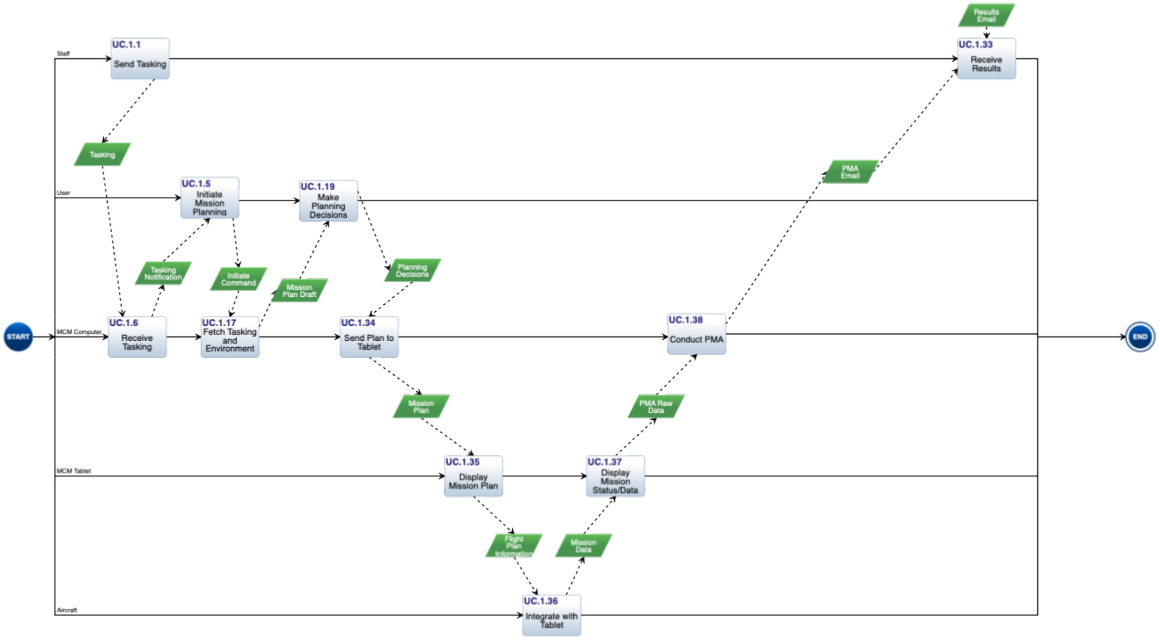
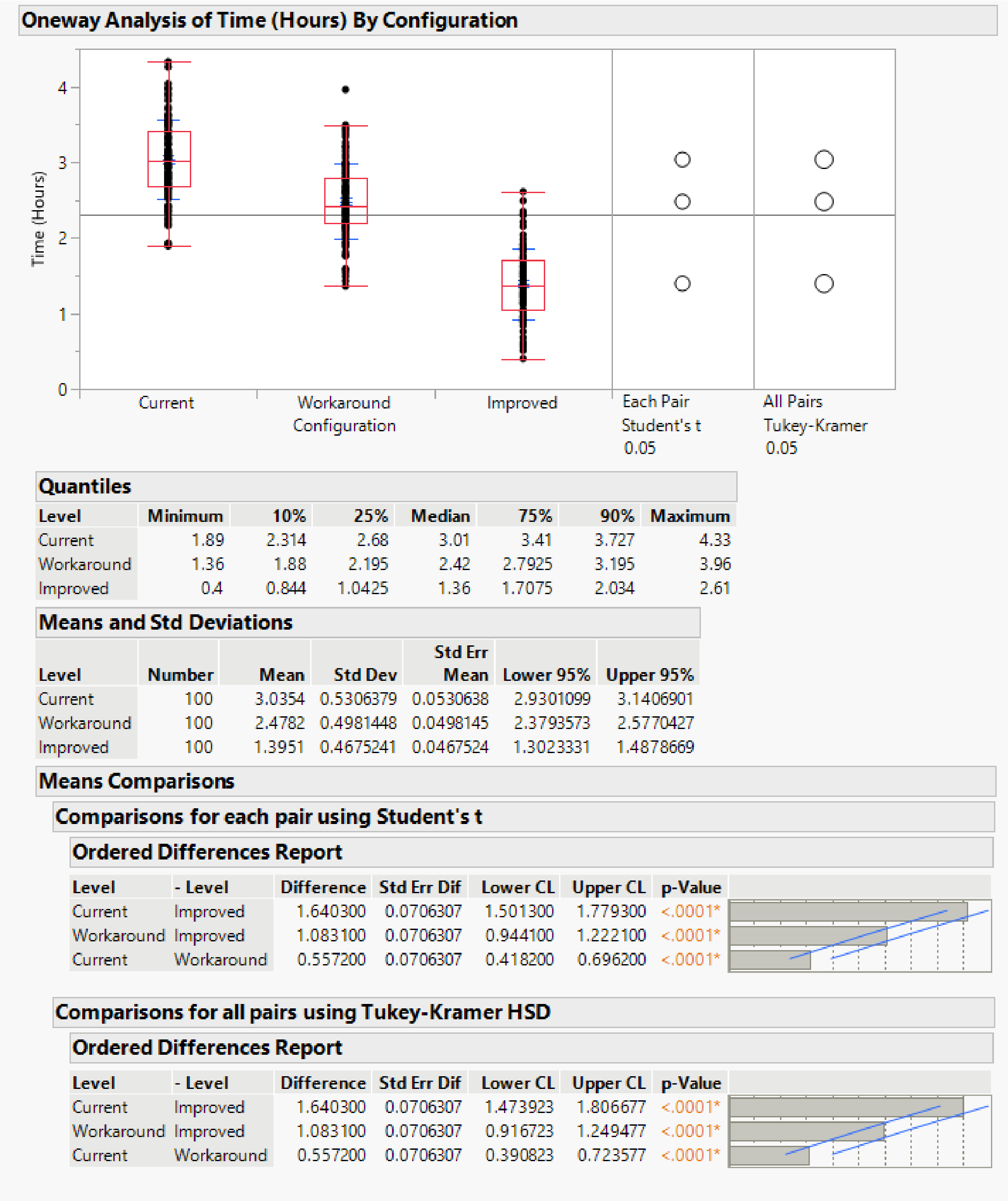


Figure 12. Improved Mission Planning Action Diagram

D. MBSE SIMULATION

Monte Carlo simulation was accomplished using internal tools in Innoslate. All time values for actions requiring user interface or computation were input as normal distributions with mean and standard deviation based off the author's experience. Other times were constant values. The total time includes all aspects of mission planning, PMA, loading mission plans to aircraft, and reporting but does not include events away from mission planning systems (pre-flight, flying sorties, etc.). Each Monte Carlo simulation includes 100 iterations. Hypothesis testing was conducted using the results of these simulations using JMP Pro 16. Figure 13 illustrates the outcome of this analysis showcasing key metrics such as quantiles, means, and standard deviations for each system.

All systems exhibit statistically significant differences, with p-values falling below the 0.001 threshold. Notably, the workaround process demonstrates a statistically significant improvement when compared to the current process, confirming the value of workarounds employed by operators. The improved process exhibits a statistically significant improvement over the workaround process, demonstrating that there is still untapped potential for further improvement beyond what has been achieved user workarounds.



Oneway Analysis of Time (Hours) By Configuration

Quantiles

Level	Minimum	10%	25%	Median	75%	90%	Maximum
Current	1.89	2.314	2.68	3.01	3.41	3.727	4.33
Workaround	1.36	1.88	2.195	2.42	2.7925	3.195	3.96
Improved	0.4	0.844	1.0425	1.36	1.7075	2.034	2.61

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Current	100	3.0354	0.5306379	0.0530638	2.9301099	3.1406901
Workaround	100	2.4782	0.4981448	0.0498145	2.3793573	2.5770427
Improved	100	1.3951	0.4675241	0.0467524	1.3023331	1.4878669

Means Comparisons

Comparisons for each pair using Student's t

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Current	Improved	1.640300	0.0706307	1.501300	1.779300	<.0001*
Workaround	Improved	1.083100	0.0706307	0.944100	1.222100	<.0001*
Current	Workaround	0.557200	0.0706307	0.418200	0.696200	<.0001*

Comparisons for all pairs using Tukey-Kramer HSD

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
Current	Improved	1.640300	0.0706307	1.473923	1.806677	<.0001*
Workaround	Improved	1.083100	0.0706307	0.916723	1.249477	<.0001*
Current	Workaround	0.557200	0.0706307	0.390823	0.723577	<.0001*

Figure 13. Analysis or Configuration Differences

E. EVALUATION CRITERIA

The methods used to evaluate JMPS and non-AMCM alternatives from Brady (2021) will be also be used in this thesis. Some evaluation criteria will be common and some will be added to highlight the reduction of human error and maintainability of the system. Other criteria were developed from the author's experience and from the comparison of deficiencies to requirements outlined in Table 1. Time to plan, ease of use, reduction of human error, maintainability, and connectivity were the five criteria established.

According to Brady (2021), "Time to plan (TTP) is defined as the time it takes from first task of mission planning to completion of mission planning to include creating briefing products, flight products, and data export to aircraft." For MCM, time to conduct PMA is included in this criteria.

Ease of use is defined as how intuitive the system is and whether low experience users can still be successful during mission planning. Brady (2021) includes "how much time is required to learn the system and how much time is required for a new user or returning user to use the system to create a useful product." He also highlights that mission planning systems should "provide easy data transfer of any required items." For MCM, this criteria includes the number of manual inputs, data transfers using removable storage, ability to generate and digest raw information, and intuitiveness.

Reduction of human error is defined as limiting or removing data inputs that could be fetched from another source. For example, if weather is automatically imported from the network instead of having to be manually typed in by the user this will result in a higher score. A higher score reflects less manual and redundant input of information.

Maintainability includes how often the system requires updates, how long updates take to install, and the amount of administrator input required to maintain the system. Additionally, the ratio of time the system is operational versus the time it is being utilized is contained in the criteria.

Connectivity is defined as the ability to send and receive tasking, fetch data, send reports, and collaborate during mission planning. Ideally this is conducted via the fewest number of computers possible. This also includes the ease of data transfer, the number of data transfers, and whether this is completed via removable hardware. The ability for mission planning systems to interface with the aircraft and provide real time updates was also considered.

F. CONCEPT SCORING

The criteria established in Section E was used to score each concept in Table 2. A score of 1–3 was awarded to each system for all criteria with 1 representing poor performance and 3 representing high performance. Table 2 assumes equal weight for all evaluation criteria.

Table 2. Concept Scoring

Criteria	Current Mission Planning	Workaround Mission Planning	Improved Mission Planning
Time to plan	1	1	3
Ease of use	1	2	3
Reduction of human error	1	1	3
Maintainability	1	1	3
Connectivity	1	2	3

Current mission planning scores a 1 for time to plan with an approximate average completion time of 3 hours as seen in Figure 13. For ease of use it scores a 1 due to the requirement of 9 assets and 34 actions. Manual inputs from the operator are required on four occasions which introduce many opportunities for human error resulting in a 1 for that category. As noted in Chapter III, the system cannot be adequately maintained by one individual even if they were to use their entire work week resulting in a score of 1 for maintainability. For connectivity the need for physical storage on four occasions, no network capability, and no interface with the aircraft results in a score of 1.

Workaround mission planning shows marginal improvements with time to plan, taking approximately 0.5 hours less to complete tasking and still resulting in a score of 1.

The number of manual inputs and maintainability requirements remain unchanged from current mission planning resulting in the same score. Ease of use has improved with only 31 actions being required which increases the score to 2. The ability to connect MNT and JMPS computers and only two instances of physical storage being used for data transfer improve connectivity to a score of 2.

Improved mission planning requires on average 1.5 hours of mission planning, improving the score to a 3. Only 12 actions performed by 5 assets are required to complete planning resulting in a score of 3 for ease of use. There are no requirements for manual input of data, since all relevant information is automatically fetched, which scores a 3 for reduction of human error. All software updates are completed via automatic download and install requiring no operator action to maintain the system which scores a 3 for maintainability. Connectivity scores a 3 with planning systems having full wireless network capability, full integration with aircraft systems, and no requirement for removable storage. This analysis concludes that improved mission planning is the strongest system for conducting MCM mission planning.

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V. CONCLUSION

U.S. Navy mission planning systems for MCM require too much time to utilize and introduce opportunities for critical human errors. This drastically extends the timeline to complete MCM that allows U.S. ships and global commerce to freely navigate. Sailors and defense assets are unnecessarily exposed to increased chances of a mine strike due to frequent instances of redundant manual data inputs. Current systems like MNT should be updated with modern technology to address these shortcomings. This thesis provides the framework for updating these systems by identifying problems with current systems, developing operational requirements for an improved system, translating system architecture into a common MBSE language, and completing an analysis of alternatives. It recommends the U.S. Navy fund and develop major improvements to MCM mission planning and apply the same considerations to other mission areas. The DOD cannot risk failing in modern warfare, including in the GPC, by depending on legacy platforms for AMCM mission planning.

This thesis recommends the following future work on this topic:

- Expand the architectural model of improved mission planning systems.
- Analyze the benefits of wireless, networked, and intuitive all-in-one systems for planning in other mission areas.
- Analyze planning system integration with aircraft systems to facilitate real-time updates via tablets.
- Expand the scoring system for MCM mission planning with additional criteria. Weight the criteria to reflect user priorities.

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APPENDIX

A. SAMPLE OPDIR

R 161700ZAPR2021
FM CTG 78.7
TO CTU 78.7.1
CTU 78.7.2
CTU 78.7.3
CTU 78.7.4
CTU 78.7.5
INFO CTF 78
BT
UNCLAS
EXER/BLACKJACK AMCM TAV/BK-21//
MSGID/OPTASK NMW/APP-11(D)/1/CTG 78.7/001/APR/INI/-
/USA/UNCLASSIFIED/
REL TO BK-21//
REF/A/TYPE:MSG/NAVY WIDE OPTASK
MIW/COMTHIRDFLT/131523ZOCT2017//
REF/B/TYPE:DOC/APP-11(D)(1), NATO MESSAGE
CATALOGUE/NATO/NOV2015//
REF/C/TYPE:DOC/NTTP 3–15.2, NAVY MINE COUNTERMEASURES/-/FEB2014//
REF/D/TYPE:MSG/PLANORD BLACKJACK AMCM TAV/CTF
78/250000ZMAR2021//
GEODATUM/WGE//
NMWTASKQ/OPDIR/INI//
DTLPRD/16ZAPR2020/300200ZAPR2021//

EXERCISE EXERCISE EXERCISE

GENTEXT/MISSION/CONDUCT MINE CLEARANCE OPERATIONS IVO IMPERIAL BEACH ANCHORAGE IOT REDUCE RISK TO COMMERCIAL AND MILITARY TRANSITORS FROM SEA MINES WITHIN DESIGNATED ROUTES.//

GENTEXT/CTF 78 COMMANDERS INTENT/CONDUCT MCM OPERATIONS TO CONFIRM AND EVALUATE THE EXTENT OF THE MINE THREAT IN/OUT OF THE IMPERIAL FSA.//

GENTEXT/CTG 78.7 COMMANDERS INTENT/CTG 78.7 WILL CONDUCT MCM OPERATIONS IN MTA CORONADO IN ORDER TO REDUCE DANGER FROM SEA MINES TO COMMERCIAL AND MILITARY TRANSITORS IN ASSIGNED Q-ROUTES AND ANCHORAGE AREAS.//

GENTEXT/MDA POLICY/IAW REF D CTG 78.7 IS THE DESIGNATED MDA ESTABLISHING AUTHORITY. UNITS WILL REPORT MINEFINDS TO CTG 78.7 VIA NIPR NMCI EMAIL. MDAS WILL BE ESTABLISHED VIA MESSAGE TO ALL PARTICIPATING UNITS. ANY MDA CLEARANCE WILL BE CONDUCTED ONLY WITHIN DESIGNATED ROUTES.//

NMWUNIT/CTG 78.7-HSCWSP/CTU 78.7.1-HSC-21/CTU 78.7.2-LCS-18/CTU 78.7.3-HM-14 DET 2A/CTU 78.7.4-HM-15 DET 1/CTU 78.7.5-EODMU1//

GENTEXT/GENERAL SITUATION AND INFORMATION/FOLLOWING UNITED STATES SANCTIONING OF THE DEMOCRATIC PEOPLE'S REPUBLIC OF RED (DPR), IN RESPONSE TO THE DPR'S ANNEXATION OF REPUBLIC OF GRAY (GR), THE DPR HAS CLOSED THE BORDER WITH THE GR. THE BLOCKADE AT THE BORDER ONLY PERMITS RESUPPLY OF GR VIA THE PORT OF IMPERIAL BEACH. LIMITED NATURAL RESOURCES AS WELL AS THE REDUCED SIZE OF THE AIRFIELDS AVAILABLE SEVERELY HINDER THE RESUPPLY EFFORTS OF THE LARGER INTERNATIONAL COMMUNITY. THE HUMANITARIAN CRISIS REMAINS THE MOST PRESSING CONCERN FOR THE U.S. AND ITS NATO ALLIES. THE DENSELY POPULATED GR IS ASSESSED TO HAVE ONLY ENOUGH FOOD AND WATER FOR APPROXIMATELY 30 DAYS. AIRLIFT EFFORTS WERE INCLUDED IN THIS TIMELINE DETERMINATION. THE CRISIS HAS TRIGGERED A STRONG RESPONSE FROM NATO THAT INCLUDES MINE COUNTERMEASURE OPERATIONS. WHILE PLANNING FOR A FULL-SCALE CONFLICT IS UNDERWAY, THE GOAL OF THE U.S. AND ITS ALLIES IS TO AVOID AN OVERT WAR AS AN UNBRIDLED CONFLICT WITH DPR COULD PRODUCE HEAVY CASUALTIES. INITIAL PHASE-2 OPERATIONAL EFFORTS HAVE BEGUN IVO OF THE LOMA STRAITS, WHERE DPR IS BELIEVED TO HAVE EXPANDED ITS ISOLATION OF MAGENTA BY MINING APPROACHES TO THE PORT OF IMPERIAL BEACH.//

GENTEXT/MINE THREAT SITUATION/ON 12 MAR, A CONFIRMED MINE STRIKE WAS REPORTED IN THE LOMA STRAITS RESULTING IN THE SINKING OF A COMMERCIAL VESSEL. ON 14 MAR, SATELLITE IMAGERY SHOWED SEVERAL DPY VESSELS CAPABLE OF MINELAYING MISSING FROM THEIR RESPECTIVE PIERS IN PORT CATALINA, DPY. ON 17 MAR, ISR ASSETS OBSERVED THESE VESSELS CONDUCTING POSSIBLE MINELAYING OPERATIONS IVO IMPERIAL BEACH PORT APPROACHES. BASED ON ISR IMAGERY POTENTIAL MINE THREAT IS LIMITED TO MOORED CONTACT MINES, CLOSE-TETHERED INFLUENCE MINES, AND BOTTOM INFLUENCE MINES.//

SMINETYP/MINE1/M01/5/D/J/-/-/-//
SMINETYP/MINE2/M02/6/D/J/-/-/-//
SMINETYP/MINE3/M03/1/A/-/-/-/-//
SMINETYP/MINE4/M03/-/-/-/-/-/-//

SMINETYP/MINE5/M03/-/-/-/-/-/-//

AREANAME/MTA//
POLYGON/3246.2500N-11725.1500W/3243.5500N-11710.6400W/3229.4583N-11717.1433W/3232.0566N-11707.5066W//
AMPN/INCLUDES SAN DIEGO BAY WATERSPACE.//
AREANAME/IMPERIAL BEACH FSA//
POLYGON/3234.2938N-11714.8183W/3234.2935N-11712.7735W/3233.3535N-11712.7735W/3233.3538N-11714.8183W//
AMPN/FOR DECONFLICTION WIH EXTERNAL ASSETS, REFER TO IB FSA AS MIW C.//

GENTEXT/ENVIRONMENTAL ISSUES/AIR TEMPERATURES ARE MODERATE DURING MONTH OF APRIL IN OPAREA, RANGING FROM 65–72 DEGREES FAHRENHEIT. SEA SURFACE TEMPERATURE IS 59–63 DEGREES FAHRENHEIT. UNDERWATER HORIZONTAL AND VERTICAL VISIBILITY BETWEEN 2.5 AND 6 METERS ARE EXPECTED NEAR SHORE. IN OPEN WATER HORIZONTAL AND VERTICAL VISIBILITY ARE EXPECTED BETWEEN 8 AND 10 METERS. MINIMAL TIDAL CURRENTS ARE EXPECTED IN OPEN WATERS. EXPECTED BOTTOM COMPOSITION IS SAND/ROCK WITH BURIAL LESS THAN 10 PERCENT. A1 TO B1 DBTs EXPECTED WITHIN THE OPAREA.//

MCMTASK/NTD:CTU 78.7.1/-/-/50A/-/-/TBD//
AMPN/BPT CONDUCT NEAR-SURFACE EXPLORATORY HUNT AND NEUTRALIZATION OPERATIONS.//
MCMTASK/NTD:CTU 78.7.2/-/-/-/-/-/-//
AMPN/BPT FACILITATE AMCM FLIGHT OPERATIONS AND ORDNANCE SUPPORT.//
MCMTASK/NTD:CTU 78.7.3/-/62/50A/55/-/-//
AMPN/BPT CONDUCT MECHANICAL SWEEP, BOTTOM HUNT, AND NEUTRALIZATION OPERATIONS.//
MCMTASK/NTD:CTU 78.7.4/-/-/-/-/-/-//
AMPN/BPT CONDUCT MECHANICAL SWEEP, BOTTOM HUNT, AND NEUTRALIZATION OPERATIONS.//
MCMTASK/NTD:CTU 78.7.5/-/-/-/-/-/-//
AMPN/BPT CONDUCT MINE POUNCE AND NEUTRALIZATION OPERATIONS.//

AREAPARA/IMPERIAL BEACH ANCHORAGE/M02/-/-/M01/M02/M03/M04//
AREAPARA/IMPERIAL BEACH FSA/M02/-/-/M01/M02/M03/M04//

MCMEFFRT/95-2/95/-/-/-//
MCMPRIOR/1/AREA: IMPERIAL BEACH FSA//
AMPN/NEAR SURFACE EXPLORATORY HUNT, NEUTRALIZATION AS DIRECTED//
MCMPRIOR/2/AREA: IMPERIAL BEACH ANCHORAGE//

AMPN/NEUTRALIZATION AS DIRECTED//

MCMDIR/ALPHA//
GENTEXT/RISK DIRECTIVE AMPLIFYING INFORMATION/SPECIFIC RISK DIRECTIVE AUTHORITIES WILL BE PROMULGATED SEPCOR IN THE RISK DIRECTIVE MATRIX PUBLISHED IN THE CONOPS IN ACCORDANCE WITH ATP-6 VOLUME II.//
NARR/TRANSITORS WILL BE FRIENDLY COMBATANT AND SUPPLY VESSELS//

MREPREQR/OPREP NMW/PERREP/-/1200Z//
AMPN/PERREP TO CONTAIN AT A MINIMUM THE FOLLOWING LINES AS APPLICABLE: MCMRSLT, MCMEQUIP, MILCOREP, SURFCOND, WATRCOND, AND BOTMCOND. DUE TO THE MESSAGES REQUIRED TO BE UNCLASSIFIED, DO NOT INCLUDE CLASSIFIED DATA IN ANY REPORTS. CLASSIFIED INFORMATION WILL BE RELAYED SEPARATELY USING SECURE COMMS. MINREPS WILL BE INCLUDED WITH DAILY PERREP AND ONLY CONTAIN MINES FROM THE PREVIOUS DAY. DO NOT INCLUDE MINES THAT HAVE BEEN REPORTED PREVIOUSLY.

MREPREQR/OPREP NMW/TASKREP/START//
AMPN/WHEN FIRST ASSET COMMENCES OPERATIONS WITHIN TASKED AREA.//
MREPREQR/OPREP NMW/TASKREP/INTRPT//
AMPN/WHEN REQUIRED TO COME OFF TASK MORE THAN THREE HOURS, WITH INTENTION TO RESUME ASSIGNED TASK. DO NOT SEND FOR BREAKS IN TASKING DUE TO SUNLIGHT HOURS.//

MREPREQR/OPREP NMW/TASKREP/RESMD//
AMPN/WHEN APPLICABLE.//
MREPREQR/OPREP NMW/TASKREP/STOP//
AMPN/WHEN STOPPING ASSIGNED TASK WITH NO INTENTION TO RESUME. TO CONTAIN AT A MINIMUM THE MCMRSLT LINE. DO NOT INCLUDE THE MCMPEDAT LINE.//

MREPREQR/OPREP NMW/TASKREP/CPT//
AMPN/WHEN COMPLETE WITH ASSIGNED TASK. TO CONTAIN AT A MINIMUM THE MCMRSLT LINE. DO NOT INCLUDE THE MCMPEDAT LINE.//

GENTEXT/REPORTING INSTRUCTIONS/1. ALL MESSAGES WILL BE WRITTEN IAW REF B, APP-11(D)(1) FORMAT.
2. ALL TASKREP START, INTRPT, AND RESMD MESSAGES REQUIRE REPORT OF ESTIMATED TIME OF COMPLETION (ETC).
3. A LIST OF IDENTIFIED MILCOs AND MINES SHALL BE REPORTED DAILY IN CTU PERREP. PERREPS SHALL ONLY CONTAIN MINES FROM THE

PREVIOUS DAY. DO NOT INCLUDE MINES THAT HAVE BEEN REPORTED PREVIOUSLY.
4. LATITUDE AND LONGITUDE SHALL BE IN THE FOLLOWING FORMAT: DEGREES MINUTES DECIMAL OUT TO FOUR PLACES. EXAMPLE: 1234.5678N-01234.5678E
5. DEPTH OF WATER WILL BE REPORTED IN METERS
4. RANGE WILL BE REPORTED IN NAUTICAL MILES (NM) AND METERS
6. CTUS WILL UTILIZE THE FOLLOWING FORMATS FOR TIME SENSITIVE INITIAL REPORTS TO CTG 78.7. PRIMARY METHOD OF COMMUNICATIONS IS VIA J-CHAT IF AVAILABLE, ALTERNATE EMAIL. DO NOT DELAY INITIAL REPORT IF LINE ITEM INFORMATION IS NOT AVAILABLE:

DIVE CASUALTY
LINE 1: LOCATION OF CASUALTY
LINE 2: UNIT INVOLVED
LINE 3: TIME OF CASUALTY
LINE 4: TYPE OF CASUALTY
LINE 5: LOCATION WHERE DIVER IS BEING TRANSFERRED
LINE 6: METHOD OF TRANSPORTATION
LINE 7: COMMENTS

HELO MISHAP
LINE 1: LOCATION OF MISHAP
LINE 2: UNIT INVOLVED
LINE 3: TIME OF MISHAP
LINE 4: TYPE OF MISHAP
LINE 5: DISPOSITION OF AIRCRAFT/PERSONNEL
LINE 6: MEDICAL OR EMERGENCY RESPONSE ACTIONS
LINE 7: COMMENTS

MINE STRIKE
LINE 1: LATITUDE/LONGITUDE OF MINE STRIKE
LINE 2: UNIT INVOLVED
LINE 3: TIME OF CASUALTY
LINE 4: EXTENT OF DAMAGE
LINE 5: PERSONNEL CASUALTIES
LINE 6: STATUS OF MINE DANGER AREA (MDA) ESTABLISHMENT
LINE 7: COMMENTS

OPFOR INTERACTION/ATTACK
LINE 1: LATITUDE/LONGITUDE OF INTERACTION
LINE 2: TPYE OF INTERACTION/ATTACK (HARRASSMENT/ENGAGEMENT/WEAPON TYPE)
LINE 3: OPFOR ACTIONS
LINE 4: UNIT RESPONSE ACTIONS

LINE 5: ASSISTANCE REQUIRED
LINE 6: COMMENTS/RESULT

GENTEXT/REPORTING INSTRUCTIONS/COMMANDERS CRITICAL INFORMATION REQUIREMENTS (CCIR):

PRIMARY INTELLIGENCE REQUIREMENTS (PIRS)
PIR 1 – INDICATIONS OF OPFOR IMMINENT THREAT / INTENT TO TARGET MIW FORCES
PIR 2 – MINE FOUND OUTSIDE OF ESTABLISHED MTAS OR OUTSIDE OF EXPECTED ENEMY ORDER OF BATTLE
PIR 3 – INDICATIONS OF MINING OR INTENT TO MINE
PIR 4 – INDICATIONS OF OPFOR MINE MOVEMENT, LOADING OR HANDLING
PIR 5 – CHANGES IN OPFOR EOOB MINE TYPES, CAPABILITIES, AND AMOUNT
PIR 6 – CHANGE IN COMMERCIAL/FISHING MARITIME TRAFFIC PATTERNS
PIR 7 – ANY INDICATION THAT THE OPERATIONAL ENVIRONMENT (BOTTOM TYPE, WATER, CHARACTERISTICS, ETC.) VARIES SIGNIFICANTLY FROM WHAT WAS PREDICTED
PIR 8 – I&W OF 3RD COUNTRY INTERFERENCE WITH OR PRESENCE NEAR CTU OPERATIONS

FRIENDLY FORCE INFORMATION REQUIREMENTS (FFIR):
FFIR 1 – DEGRADATION OF AIRCRAFT AO
FFIR 2 – LOSS OF MCM GEAR
FFIR 3 – SIGNIFICANT PERSONNEL INJURIES OR MEDICAL CONCERNS; INCLUDING MEDEVAC OR ANY REPORT OF MOVING PERSONNEL WITHIN THE FORCE TO RECEIVE MEDICAL TREATMENT
FFIR 4 – LOSS OF FORCE PROTECTION CAPABILITY FOR HELOS
FFIR 5 – SIGNIFICANT CASUALTY (WEAPONS, COMMS, ENGINEERING) TO CTF ASSET THAT PROVIDES SUPPORT TO HELOS
FFIR 6 – ANY CANCELLATION OR DELAY IN SCHEDULED FLIGHT PLAN
FFIR 7 – ANY DIVE OPS EXPECTED TO EXCEED DAYLIGHT HOURS
FFIR 8 – ASSIGNED UNIT UNEXPECTEDLY OFF TASK OR NOT ON STATION
GENTEXT/SPECIAL INSTRUCTIONS/PERREP, STOP AND CPT SENT VIA NAVAL MESSAGE. ALL OTHER REPORTS WILL BE SENT VIA INTELINK CHAT. EMAIL POC WILL BE GIVEN SEPCOR.//

GENTEXT/SPECIAL INFORMATION/ WATERSPACE DECONFLICTION IN GENERAL WILL BE IAW REF A. STANDOFF AND PRIORITIES ARE: MINIMUM STANDOFF DISTANCES BETWEEN ASSETS.

ALMDS TO ALMDS:	1000YDS.
AMNS TO EOD:	2000YDS.
Q-24 TO Q-24:	380YDS.
SONAR TO EOD:	2000YDS.

MAG INFL SWEEPS:	2000YDS
ACOU INFL SWEEPS:	4000YDS

MCMC TASKING HAS TAKEN INTO ACCOUNT THE POSSIBILITY OF UNITS OPERATING WITHIN RELATIVELY CLOSE PROXIMITY; HOWEVER, THE FOLLOWING DECONFLICTION PLAN WILL BE REFERRED TO WITH UNITS LISTED IN DESCENDING ORDER OF PRIORITY. THE MCMC SHALL BE CONSULTED IF FURTHER CLARIFICATION IS REQUIRED IN A SPECIFIC INSTANCE.

A. EOD PLT WITH DIVERS IN THE WATER
B. UUV TEAM LAUNCHING OR RECOVERING UUV
C. AMCM UNDER TOW
D. EOD TEAM WITHOUT DIVERS IN THE WATER.//
PRIMARY CONTACT DBM IS MCMDIV 31. SECONDARY DBM IS HSC-21. HSC-21 WILL BECOME PRIMARY DBM UPON SIGNAL FROM MCMC.//
ANKLDG/YES/INST:VIA EMAIL//

EXERCISE EXERCISE EXERCISE

BT

B. SAMPLE OPTASK

R 161900ZAPR21
FM CTG 70.7
TO CTU 70.7.1
INFO CTU 70.7.2
CTU 70.7.3
CTU 70.7.4
CTU 70.7.5
BT
UNCLAS
EXER/BLACKJACK AMCM TAV/BK-21//

MSGID/OPTASK NMW/APP-11(D)/1/CTG70.7/001/APR/-/-/USA/UNCLASSIFIED//

REF/A/TYPE:MSG/NAVY WIDE OPTASK
MIW/COMTHIRDFLT/131523ZOCT2017//
REF/B/TYPE:DOC/APP-11(D)(1), NATO MESSAGE CATALOGUE/NATO/NOV
2015//
REF/C/TYPE:DOC/NTTP 3–15.2, NAVY MINE COUNTERMEASURES/-/FEB 2014//
REF/D/TYPE:DOC/CTF52 MIW OPORDER 001/CTF52/15JUN2016//
REF/E/OPTASK NMW/CTG 70.7 BLACKJACK AMCM TAV OPDIR/CTG
70.7/161900ZAPR21
/001//

GEODATUM/WGE//
NMWTASKQ/TASK/INI//

MCMTASK/NTD:CTU 70.7.1/IMPERIAL BEACH FSA-CH01/57/-/-
/AREA:IMPERIAL BEACH FSA/ASAPAFT:191200ZAPR2021//
AMPN/ASSIGNED MINES ARE LISTED BELOW.
AREAPARA/AREA:IMPERIAL BEACH FSA/MK52/-/MK52/MK55/MK49//
MCMEFFRT/-/95/-//
MCMPRIOR/1/AREA:IMPERIAL BEACH FSA//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR51/3234.2483N-
11715.2033W/142315ZAPR2021 /-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK52 MINE. MRN: QZR51;
MINE STATUS: LIPLA; MINE CASE TYPE:5C; FIRING SYSTEM INFO:
COMBINED MAGNETIC ACOUSTIC; OTHER COMMENTS: CASE DEPTH
204FT,62.18M. CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR54/3234.0040N-
11714.4750W/142315ZAPR2021 /-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK52 MINE. MRN: QZR54;
MINE STATUS: LIPLA; MINE CASE TYPE:5C; FIRING SYSTEM INFO:

COMBINED MAGNETIC ACOUSTIC; OTHER COMMENTS: CASE DEPTH 144FT,48.89M. CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR55/3233.1550N-11714.0000W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR55; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 144FT, 48.89M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR56/3234.0000N-11713.4700W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR56; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 120FT, 36.58M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR57/3233.3020N-11712.9840W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR57; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 114FT, 34.75M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR41/3234.0000N-11710.2183W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR41; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 66FT, 20.12M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR42/3233.7517N-11710.5117W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR42; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 72FT, 21.95M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR43/3233.3150N-11710.5117W/131400ZAPR2021/-/-/49//
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR43; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 90FT, 27.43M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR44/3233.4633N-11711.5533W/131400ZAPR2021/-/-/49//

AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR44; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 108FT, 32.92M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR46/3233.9583N-11712.0000W/131400ZAPR2021/-/-/49//

AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK55 MINE. MRN: QZR46; MINE STATUS: LIPLA; MINE CASE TYPE: 6C; FIRING SYSTEM INFO: COMBINED MAGNETIC ACOUSTIC; CASE DEPTH 108FT, 32.92M; OTHER COMMENTS: CYLINDRICAL MINE//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR52/3234.2583N-11714.9050W/131400ZAPR2020/-/-/49//

AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK49 MINE. MRN: QZR52; MINE STATUS: LIPLA; MINE CASE TYPE: 3C; FIRING SYSTEM INFO: CONTACT; CASE DEPTH 174FT, 53.04M; BOTTOM DEPTH 204FT, 62.18M; OTHER COMMENTS: SPHERICAL//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR52/3234.2583N-11714.9050W/131400ZAPR2020/-/-/49//

AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK49 MINE. MRN: QZR52; MINE STATUS: LIPLA; MINE CASE TYPE: 3C; FIRING SYSTEM INFO: CONTACT; CASE DEPTH 174FT, 53.04M; BOTTOM DEPTH 204FT, 62.18M; OTHER COMMENTS: SPHERICAL//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR45/3233.6333N-11712.0000W/131400ZAPR2020/-/-/49//

AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK49 MINE. MRN: QZR45; MINE STATUS: LIPLA; MINE CASE TYPE: 3C; FIRING SYSTEM INFO: CONTACT; CASE DEPTH 78FT, 23.77M; BOTTOM DEPTH 108FT, 54.86M; OTHER COMMENTS: SPHERICAL//

MILCOINF/AIR:HELO/HSC-21/WGE/QZR47/3234.2400N-11712.1967W/131400ZAPR2020/-/-/49//

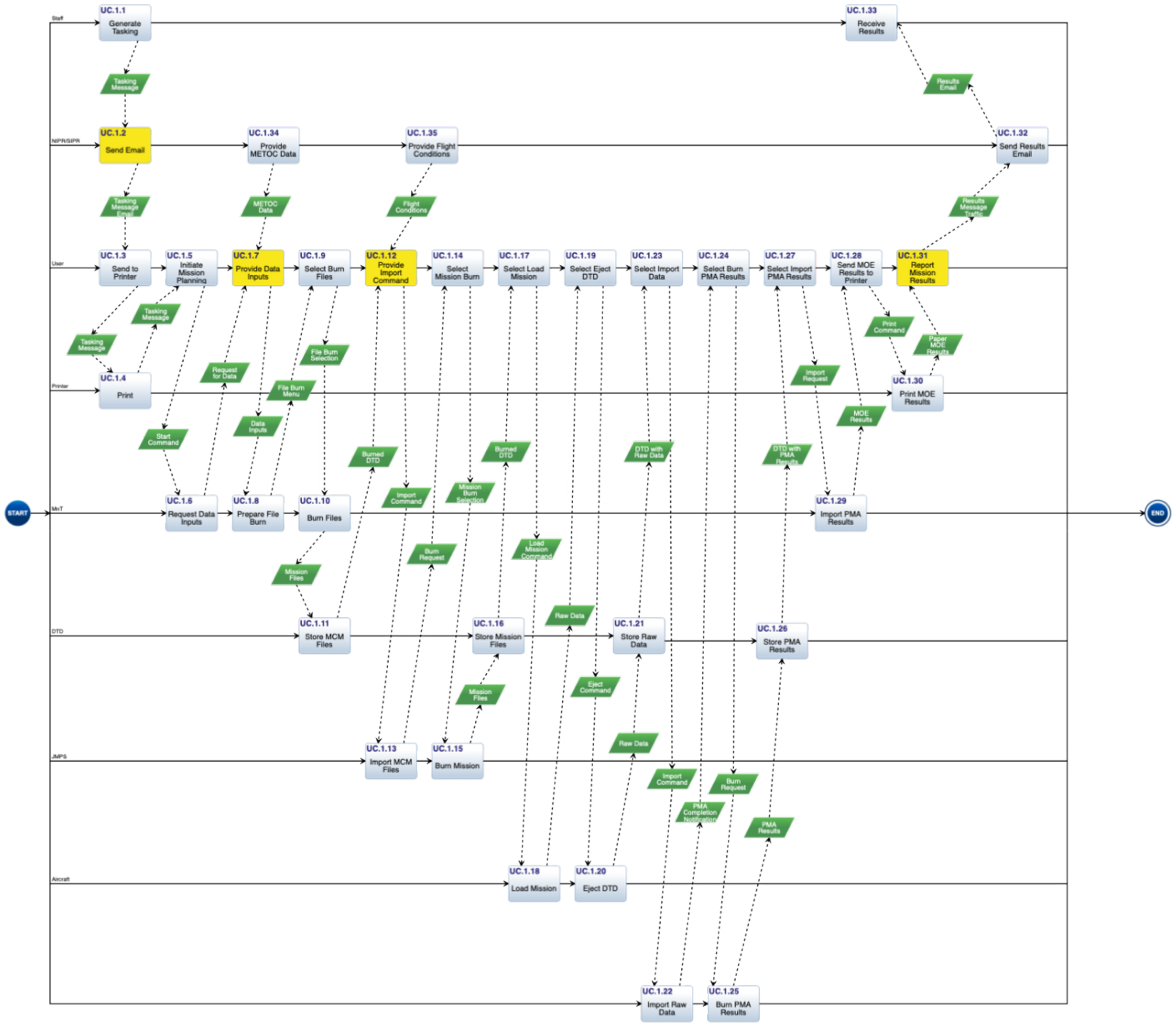
AMPN/CONTACT HAS BEEN IDENTIFIED AS A MK49 MINE. MRN: QZR47; MINE STATUS: LIPLA; MINE CASE TYPE: 3C; FIRING SYSTEM INFO: CONTACT; CASE DEPTH 84FT, 25.60M; BOTTOM DEPTH 114FT, 34.75M; OTHER COMMENTS: SPHERICAL//

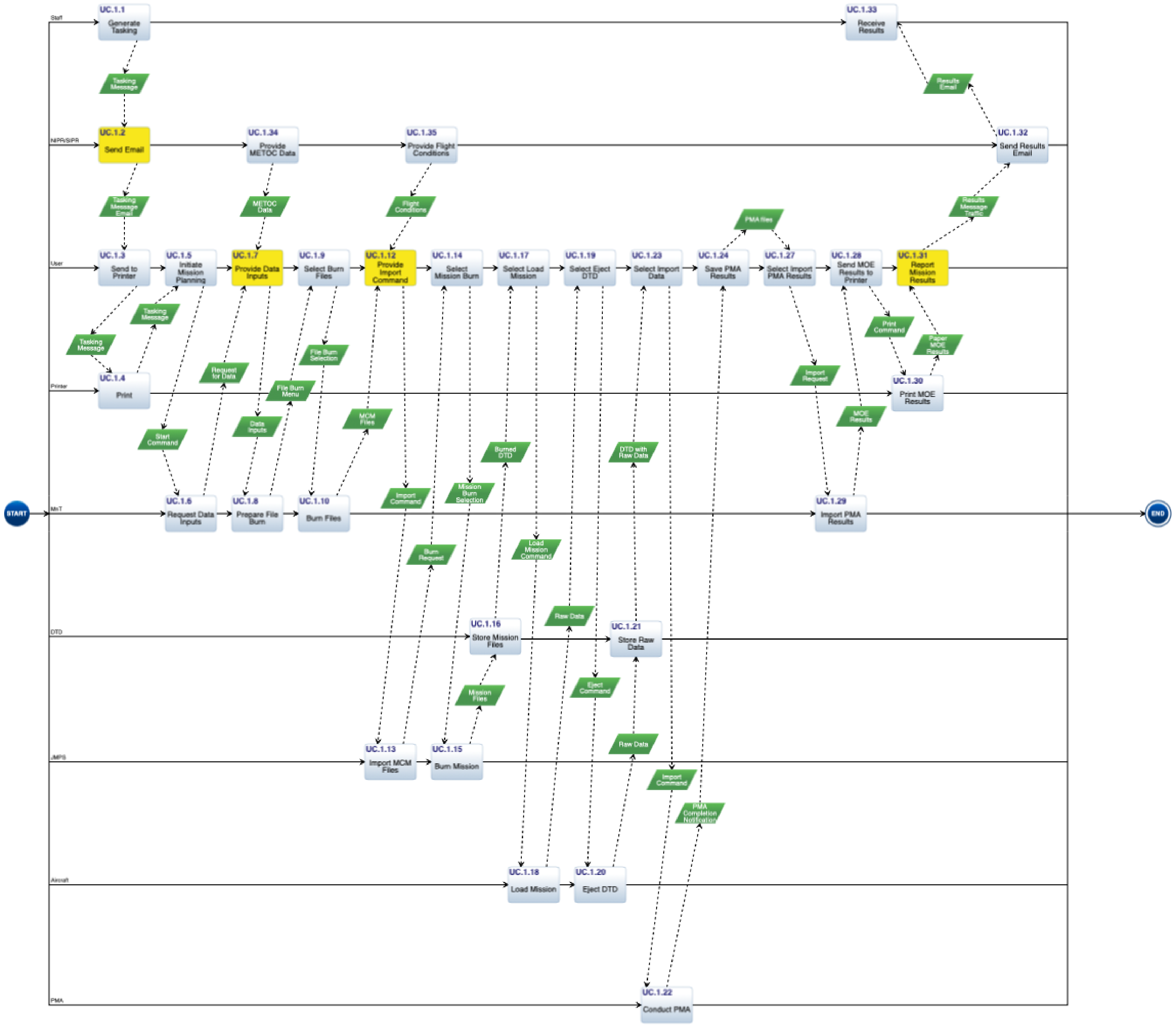
GENTEXT/SPECIAL INSTRUCTIONS/GOOD LUCK BLACKJACKS!//

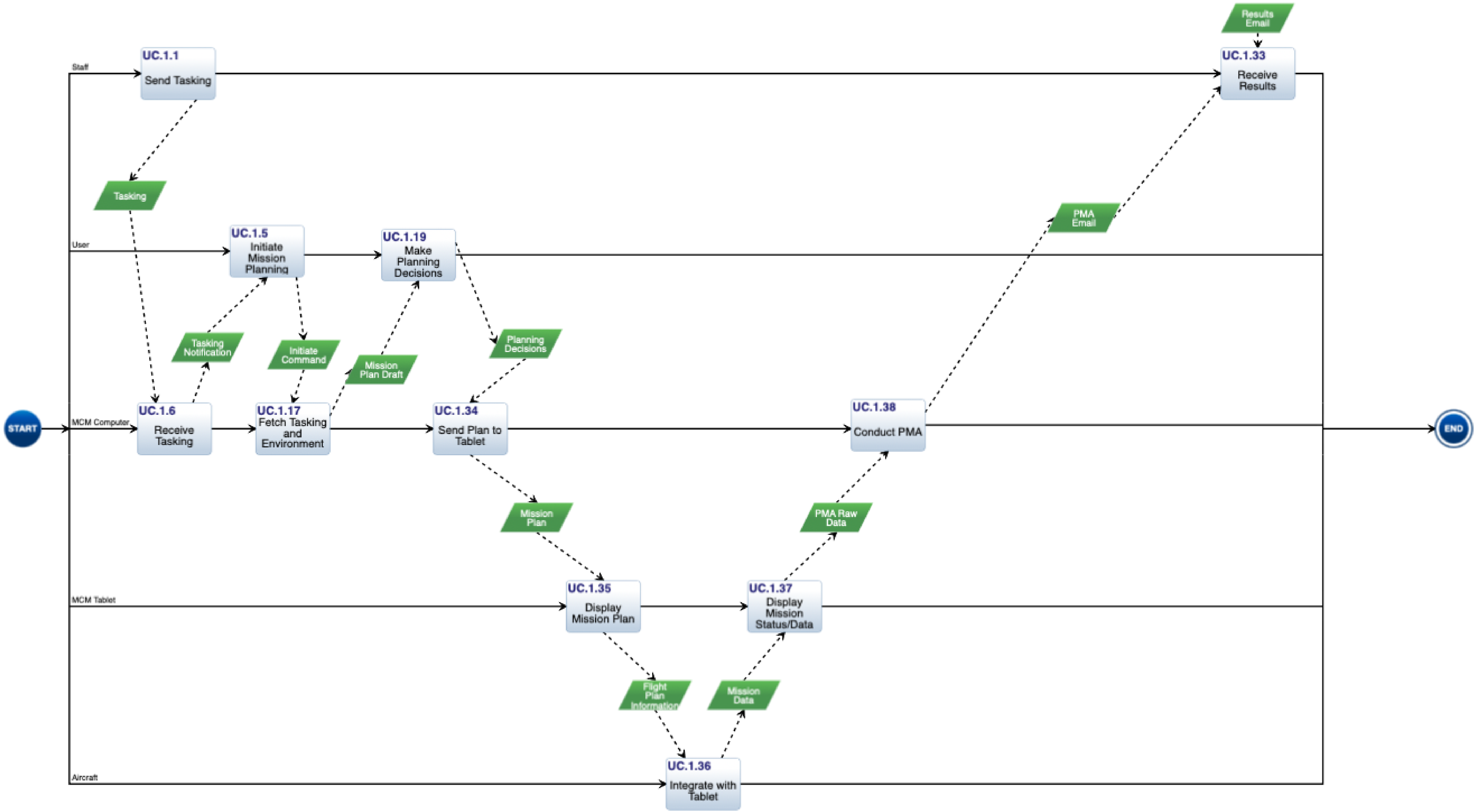
AKNLDG/YES/VIA EMAIL//

BT

C. HIGH RESOLUTION MBSE DIAGRAMS




Staff
UC.1.1 Generate Tasking
Tasking Message
UC.1.33 Receive Results
Results Email
NIPR/SIPR
UC.1.2 Send Email
UC.1.34 Provide METOC Data
UC.1.35 Provide Flight Conditions
UC.1.32 Send Results Email
Tasking Message Email
METOC Data
Flight Conditions
PMA files
Results Message Traffic
User
UC.1.3 Send to Printer
UC.1.5 Initiate Mission Planning
UC.1.7 Provide Data Inputs
UC.1.9 Select Burn Files
UC.1.12 Provide Import Command
UC.1.14 Select Mission Burn
UC.1.17 Select Load Mission
UC.1.19 Select Eject DTD
UC.1.23 Select Import Data
UC.1.24 Save PMA Results
UC.1.27 Select Import PMA Results
UC.1.28 Send MOE Results to Printer
UC.1.31 Report Mission Results
Tasking Message
Tasking Message
File Burn Selection
Request for Data
File Burn Menu
Print Command
Paper MOE Results
Import Request
Printer
UC.1.4 Print
UC.1.30 Print MOE Results
MCM Files
Start Command
Data Inputs
MOE Results
Burned DTD
DTD with Raw Data
Import Command
Mission Burn Selection
START
MnT
UC.1.6 Request Data Inputs
UC.1.8 Prepare File Burn
UC.1.10 Burn Files
UC.1.29 Import PMA Results
END
Burn Request
Load Mission Command
Raw Data
DTD
UC.1.16 Store Mission Files
UC.1.21 Store Raw Data
Mission Files
Eject Command
Raw Data
JMPS
UC.1.13 Import MCM Files
UC.1.15 Burn Mission
Import Command
PMA Completion Notification
Aircraft
UC.1.18 Load Mission
UC.1.20 Eject DTD
PMA
UC.1.22 Conduct PMA


Results Email
UC.1.33
Receive Results
Staff
UC.1.1
Send Tasking
Tasking
User
UC.1.5
Initiate Mission Planning
UC.1.19
Make Planning Decisions
PMA Email
Tasking Notification
Initiate Command
Mission Plan Draft
Planning Decisions
START
MCM Computer
UC.1.6
Receive Tasking
UC.1.17
Fetch Tasking and Environment
UC.1.34
Send Plan to Tablet
UC.1.38
Conduct PMA
END
Mission Plan
PMA Raw Data
MCM Tablet
UC.1.35
Display Mission Plan
UC.1.37
Display Mission Status/Data
Flight Plan Information
Mission Data
Aircraft
UC.1.36
Integrate with Tablet

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