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WEB-ENABLED DATBASE APPLICATION FOR MARINE AVIATION LOGISTICS SQUADRONS: AN OPERATIONS AND SUSTAINMENT PROTOTYPE

by

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September 2006

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WEB-ENABLED DATABASE APPLICATION FOR MARINE AVIATION LOGISTICS SQUADRONS: AN OPERATIONS AND SUSTAINMENT PROTOTYPE

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ABSTRACT

This thesis analyzed the principles and concepts of Marine Aviation Logistics doctrine at the tactical level and the current Information Management Systems used to execute mission requirements. A web-enabled prototype for Marine Aviation Logistics Squadrons (MALS) was developed to optimize management and decision support for deliberate, time sensitive and crisis action planning of aviation support operations. The first iteration of the prototype was tested by two Operations (S-3) Officers formerly assigned to active-duty Marine Aviation Logistics Squadrons (MALS). The application was also subjected to a usability experiment at the Database and Web Technologies Lab at the Naval Postgraduate School. The results of this research revealed potential benefits for tactical-level aviation logistics planners and sustainers; the prototype is a viable concept, worthy of future development.

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LIST OF SYMBOLS, ACRONYMS AND/OR ABBREVIATIONS

ACE	Air Combat Element
AISD	Aviation Information Systems Division
AMMRL	Aviation Maintenance Material Readiness List
AMRR	Aircraft Material Readiness Report
ASL	Aviation Logistics Support Branch
AVLOG	Aviation Logistics
CASE	Computer Aided Software Engineering
CCSP	Common Contingency Support Package
COA	Course of Action
CONOPS	Concept ff Operation
CSP	Contingency Support Package
CSS	Cascading Style Sheet
DFD	Data Flow Diagram
DoD	Department of Defense
EMW	Expeditionary Maneuver Warfare
ERD	Entity Relationship Diagram
FDP&E	Force Deployment Planning and Execution
FISP	Fly-In Support Package
FOSP	Follow-On Support Package
FW`	Fixed Wing
GCCS	Global Command and Control System
H&MS	Headquarters and Maintenance Squadron
HQMC	Headquarters Marine Corps
HTML	Hyper Text Markup Language
IMRL	Individual Material Readiness List
IT	Information Technology
JCS	Joint Chiefs of Staff
JOPES	Joint Operational Planning and Execution System
LAMS	Local Asset Management System
LOGAIS	Logistics Automated Information System
MAG	Marine Air Group
MAGTF	Marine Air Ground Task Force
MALS	Marine Aviation Logistics Squadron
MALSP	Marine Aviation Logistics Support Program
MAPSS	Marine Aviation Planning and Sustainment System
MARFOR	Marine Forces Command
MAW	Marine Aircraft Wing
MCPP	Marine Corps Planning Process
MCTFS	Marine Corps Total Force System
MDSS-II	MAGTF Deployment Support System II
MEF	Marine Expeditionary Force

MPF	Maritime Pre-positioning Force
NALCOMIS	Naval Aviation Logistics Command Management Information System
NPS	Naval Postgraduate School
OPLAN	Operational Plan
OPORD	Operations Order
PCSP	Peculiar Contingency Support Package
PDA	Personal Data Assistant
RAD	Rapid Action Development
RESP	Remote Expeditionary Support Package
RW	Rotary Wing
S-3	Operations Department
S-4	Logistics Department
SERMIS	Support Equipment Resources Management Information System
SUAPDS-RT	Shipboard Uniform Automated Data Processing System, Real-Time
T-AVB	Aviation Logistics Support Ship
TBA	Table of Basic Allowance
T/M/S	Type/Model/Series
TOC	Theory of Constraints
TPFDD	Time Phased Force Deployment Data
TRR	Time to Rapidly Replenish
TSA	Training Squadron Allowance
UDL	Unit Deployment List
WYSIWYG	What You See Is What You Get

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I. INTRODUCTION

This chapter discusses the Marine Aviation Logistics Squadron (MALS), the doctrine for aviation logistics, and the information management systems currently used to accomplish the mission. The chapter then discusses the objectives, expected benefits, methodology, and organization of the remaining chapters of this thesis.

This chapter is organized as follows. Section A is the background information for the MALS, the Marine Aviation Logistics Support Program (MALSP) and the information management systems that MALS is currently using to execute mission requirements. Section B justifies this academic endeavor by pointing out the acute problems of the current information management systems. Section C discusses the objectives and broad system requirements for the prototype to be developed; Section D provides six ways tactical-level aviation logistics will be optimized by a web-centric application; Section E introduces the various methodologies used to analyze doctrine, and develop and test the web-enabled prototype; and Section F is a brief description of the remaining chapters of the thesis.

A. BACKGROUND

1. Marine Aviation Logistics Squadron

United States Marine Corps Aviation Logistics at the tactical level is the responsibility of the Marine Aviation Logistics Squadron (MALS). There are 11 active duty MALS units supporting 71 tactical flying squadrons and 28 non-flying squadrons. MALS directly supports the tactical flying squadrons of the Marine Air Ground Task Force (MAGTF), Air Combat Element (ACE) by providing intermediate-level maintenance, supply and ordnance support for aircraft and aeronautical equipment [1]. The role of the MALS cannot be underestimated; they are the essential link of Marine Aviation Logistics support that enhances combat readiness of the MAGTF ACE and provides the sustainment necessary for continuous combat operations.

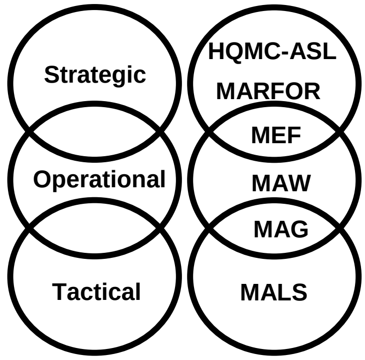

Figure 1. Levels of Aviation Logistics

Marine Aviation Logistics Squadrons vary in size, ranging between 600-800 Marines and Sailors. The organizational structure of MALS consists of Headquarters, Maintenance, Supply, and Aviation Information Systems Departments. Headquarters is similar to other aviation units with having a Commanding Officer, Executive Officer, Administrative, Operations, and Logistics Department. However, the focus of effort and most of the work performed by MALS is done by the Maintenance and Aviation Supply Departments.

The MALS Maintenance Department's core functions include repair support to aircraft, aviation support equipment, avionics, flight equipment, cryogenics, aviation ordnance, and maintenance data collection and analysis [1]. As an intermediate-level maintenance activity, MALS maintenance is responsible for monitoring all organizational-level maintenance programs of the tactical flying squadrons assigned to the Marine Aircraft Group (MAG). This oversight task protects the quality assurance of maintenance practices and ultimately leads to increased combat readiness.

The MALS Aviation Supply Department's core functions include the inventory, storage and management of aviation logistics material. MALS Supply is responsible for providing technical research for needed aircraft repair parts and material, maintaining and reporting financial data for aviation material for the MAG, and monitoring, expediting, storing, issuing, and delivering parts and material that have been requisitioned [1]. The Aviation Supply Department is a multi-million dollar facility, organized to provide focused logistics support to sustain combat operations of tactical flying squadrons and the intermediate-level repair capability of the MALS Maintenance Department.

The MALS Operations Department is responsible for identifying, planning, reviewing, coordinating and supervising all tactical-level aviation logistics necessary to support operational requirements for exercises, contingencies and other concepts of operations [1]. To execute these core functions and properly tailor support, continuous coordination is required internally with the MALS Maintenance and Supply Departments. Externally, however, the MALS Operations Department is the link between the MAG and tactical flying squadrons to ensure the appropriate level of aviation logistics support is incorporated in all deliberate, time sensitive and crisis action planning.

2. Marine Aviation Logistics Support Program

The Marine Aviation Logistics Support Program (MALSP) is the current doctrine used to rapidly deploy and sustain a task-organized MAGTF ACE. The MALSP is based on people, repair parts, support equipment and mobile maintenance facilities. Together, they form the essential "building blocks" for tailored aviation logistics support.

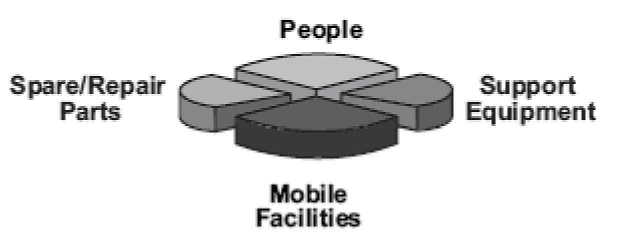

Figure 2. MALSP Building Blocks [From: 1]

Each MALS is designed to support Fixed Wing (FW) and/or Rotary Wing (RW) aircraft. However, mission requirements often require a mixed FW/RW aircraft composition, which necessitates the use of support capabilities from more than one MALS. To facilitate responsive and effective support across various Type/Model/Series (T/M/S) aircraft, standardized Contingency Support Packages (CSP) are maintained at each MALS consisting of a Common Contingency Support Package (CCSP), Peculiar Contingency Support Package (PCSP), Fly-In Support Package (FISP), Follow-On Support Package (FOSP) and Training Squadron Allowance (TSA). These predetermined packages give the MAGTF Commander the flexibility to mix and match T/M/S aircraft with the required aviation support.

In the event of a major operation or contingency where a tailored ACE is required, a host MALS is identified and marshals their Common Contingency Support Package. The host MALS will also provide any Peculiar Contingency Support Packages organic to their MAG that matches the T/M/S aircraft mix of the proposed ACE. Non-organic Peculiar Contingency Support Packages, however, are provided by another MALS. These CSPs are then airlifted or embarked on Aviation Logistics Support Ships (T-AVB). The U.S. Maritime Administration provides the Military Sealift Command with two T-AVBs, dedicated to support movement of aviation logistics ashore, or to establish a "floating" intermediate-level aviation logistics activity offshore. The CCSP is viewed as the foundation of support, while the PCSP is viewed as load-bearing pillars of the aviation logistics support structure [1].

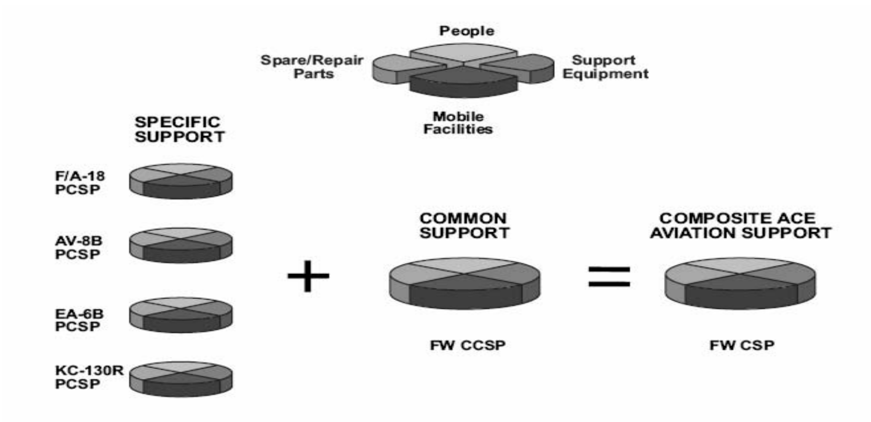

Figure 3. MALSP Employment [From: 1]

The remaining MALSP CSPs are the FISP and FOSP. The FISP is reserved stock for a time of war; therefore, it is always maintained at or near 100% stock allowances. The FISP consists of spare parts that are normally removed and replaced at the organizational (tactical flying squadron) level. The FISP is built to logistically sustain the initial 30 days of combat operations; meaning, it is usually the first building block in the theater of operations, airlifted with the initial assault aircraft. The FOSP, on the other hand, is usually the last CSP to be deployed. It consists of the heavy machinery and other large intermediate-level support equipment. The FOSP is designed to logistically support aviation units indefinitely.

The MALSP, as a whole, is "designed to be mutually supportive and fit together like blocks to form a solid aviation support foundation" [1]. The doctrine ensures that when contingencies arise, the appropriate level of aviation logistics support is mobilized to support the MAGTF ACE.

3. Information Management Systems

Marine Corps Aviation Logistics requires the use of numerous Information Management Systems to effectively manage the complexity of aviation operations. These systems include the Naval Aviation Logistics Command Management Information System (NALCOMIS), Shipboard Uniform Automated Data Processing System, Real-Time (SUADPS-RT), MAGTF Deployment Support System II (MDSS-II), Support Equipment Resources Management Information System (SERMIS), Local Asset Management System (LAMS), and Table of Basic Allowance (TBA). Additionally, the Marine Corps Total Force System (MCTFS), a personnel administration system, manages all personnel assigned to a unit, which are subsequently tasked to execute aviation logistics support operations. Although there is an array of systems currently in use, the MALS primarily uses five Information Management Systems, NALCOMIS, LAMS, MCTFS, TBA and MDSS-II, to input, process, review, report, store technical data and to develop deliberate operational plans for aviation support operations.

NALCOMIS is designed to provide timely and accurate information for day-to-day management of aeronautical assets and equipment [1]. The primary capabilities of NALCOMIS for the MALS is to requisition material, manage maintenance actions and administer to aviation supply assets. NALCOMIS includes 10 subsystems: database maintenance, maintenance activity, personnel management, configuration status accounting, asset management, local/up-line reporting, system support, material requirement processing, data off-load/on-load and technical publications. NALCOMIS is used by both Maintenance and Supply Departments within the MALS. SUADPS-RT, on the other hand, is purely an aviation supply application, which consists of three subsystems: logistics management, inventory management and financial management. Both NALCOMIS and SUADPS-RT systems interface to provide aviation logisticians with an efficient capability to accurately manage the myriad of aviation mission-related tasks.

LAMS is a standardized system for management of support equipment at all three levels of naval aviation maintenance. LAMS enhances the control of inventory through up-line reporting to SERMIS. The system contains the master database of equipment for the Aviation Maintenance Material Readiness List (AMMRL) program [1].

TBA is a database that provides the initial outfitting allowances for Marine Forces. This information system manages the authorized material and organizational property for all Marine Corps units. Specifically at the MALS, the TBA provides the quantities of mobile facilities the unit is responsible to maintain, but more importantly, it establishes the pool of available assets from which MALS can support the MAGTF ACE.

MDSS-II is the primary Information Management System used for deliberate planning of aviation support operations at the tactical level. Unlike NALCOMIS and SUADPS-RT, MDSS-II is not an aviation specific application, but a component of a larger Marine Corps enterprise system called MAGTF-II. The purpose of MDSS-II is to enable planners to *develop* force structure, tailor force lists, compute sustainment, and plan for lift requirements [1]. The product of using the MDSS-II system is the Unit Deployment List (UDL), which consists of Time Phased Force Deployment Data (TPFDD). The TPFDD is the "who, what, when, and where" of force coordination. Once MDSS-II has produced the final UDL, the data is sent to higher headquarters and imported into the MAGTF-II system, which manages and produces the TPFDD for the entire spectrum of the Marine Air Ground Task Force.

B. PROBLEMS WITH THE CURRENT SYSTEMS

The Marine Aviation Logistics community does not possess an application to effectively develop operational plans and sustain deployed logistical support forces. MDSS-II is a non-aviation specific application that is efficient in documenting and reporting operational plans to higher headquarters, but not the IT enabler or decision support tool that is needed for developing the key components (personal, parts, support equipment and mobile maintenance facilities) of an aviation logistical support plan. The problem is further magnified by the fact that each key component of an aviation logistical support plan is currently supported by a separate information management system: NALCOMIS, LAMS, MCTFS and TBA.

The lack of interoperability of currently fielded systems creates enormous challenges for the tactical-level aviation logistics planner and sustainer. Querying multiple systems to source a single operation or contingency is laborious, time consuming and inefficient. Decision support for sustaining deployed forces is also plagued by numerous manual processes, which increases the probability of information redundancy, errors, and ineffectiveness. Aviation logistics support is vital to the combat readiness of the MAGTF ACE. The current "flat-file" technology used to mitigate the lack of system interoperability is not the 21st century solution for the Marine Aviation Logistics community. It is imperative that aviation logistics planners and sustainers at the tactical–level have a robust decision support application to accomplish their mission, an IT enabler that has the capability to interface with existing fielded systems.

C. OBJECTIVE

The objective of this thesis is to develop a web-centric application for Marine Aviation Logistics Squadrons (MALS) that can be used to bridge the technology gap from the initial stages of developing deliberate, time sensitive and crisis action plans to the culmination of the Unit Deployment List (UDL) / Time Phased Force Deployment Data (TPFDD) documentation in the MDSS-II system. The intent is to design, implement and test a "four-into-one" user interface that combines the data sets of existing systems to optimize the management, decision support and sustainment of aviation logistics operations. The design of the prototype will incorporate the following broad system requirements:

- Concept of Operations (CONOPS) definition
- Course of Action (COA) definition and comparison
- Tracking of deployed Personnel, Repair/Spare Parts, Support Equipment and Mobile Facilities readiness
- Tracking of deployed aircraft readiness
- Requisition management
- UDL / TPFDD Summary

D. EXPECTED BENEFITS

A web-enabled application for deliberate, time sensitive and crisis action planning at the tactical level will provide numerous benefits over current manual processes. Management and decision support for MALS operations would be optimized by improving integrity, consistency, flexibility, efficiency, availability and maintainability.

- **Integrity:** A web-centric application would provide a centralized point of access for internal planning transactions which will eliminate data redundancy during planning and sustainment cycles. The system would provide data processes specifically tailored for Marine Aviation Logistics and MALSP concepts, and save valuable man-hours correcting and/or updating source documents.

- **Consistency:** A web-enabled application would provide an intuitive user interface and a reliable format for both internal and external planning and sustainment coordination efforts. Employing a standard web browser as the database interface would minimize the training required for personnel to use the application.

- **Flexibility:** A web-centric system would be conducive for collaborative planning and execution at work, planning conferences, or at remote sites—anywhere internet access is available. The application would also take advantage of existing and emerging wireless technologies: PDA, Pocket PC, cell phone, and other equipment that have integrated web browsers.

- **Efficiency:** A real-time web-centric system would improve the planning and decision-making time cycles by reducing the number of deployment meetings and the use of "flat-file" information technology. A system of this nature would improve visibility and response times for deployment material support requests and subsequent action of material requirements. The system would also improve data analysis by quickly searching the database for historical and current deployment data to identify trends and other relevant information.

- **Availability:** A web-enabled application would provide reliable, near real-time information on aircraft, personnel and maintenance/supply support requirements for deployed forces. A system of this nature would provide globally visible information and take advantage of widely available internet access.

- **Maintainability:** MALS (AISD) currently has the Information Technology architecture to employ and maintain a system of this nature; no additional personnel or hardware requirements would be required. The benefit of a web-enabled application is that the MALS deployment and garrison Information Technology footprint would remain the same.

E. METHODOLOGY

The analysis of capabilities and constraints of MALSP doctrine and the existing Information Management Systems used to execute mission requirements was accomplished by a literature review and by formal surveys of current MALS Operations Officers, an authoritative source and lead planners for all aviation logistics support operations at the tactical level. Aviation Maintenance and Supply Officers were also surveyed due to their vital role in the execution and sustainment phases of aviation support operations.

The system design methodology for developing the web-enabled database was Rapid Action Development (RAD), a prototyping methodology. Operations Officers from both MALS-36 and MALS-11 were active end-user in this thesis research. They provided the necessary feedback for the prototype iteration process. The web-enabled prototype was hosted on a Naval Postgraduate School (NPS) server (ebiz.nps.navy.mil), which provided the ideal environment towards a proof of concept for this research.

The Database and Web Technologies Lab, located at NPS, was used to test and analyze web interface usability features and system functionality by performing a usability experiment. There were many students assigned to NPS who had Marine Aviation Logistics backgrounds, including Aviation Supply, Aviation Maintenance, and former MALS Operations Officers. Using personnel familiar with aviation logistics processes and procedures in a lab environment was beneficial in identifying and confirming user requirements and streamlining usability features and prototype processes to ultimately produce to an efficient and effective application to plan and execute aviation logistics support operations.

F. ORGANIZATION OF THE THESIS

The remaining chapters of this thesis are organized as follows: Chapter II analyzes the strengths and weaknesses of MALSP doctrine and the current initiatives that will transform aviation logistics to meet 21st century requirements. An analysis of the existing Information Management Systems used for operational planning and sustainment is accomplished in Chapter III. Chapter IV is focused on data and logical process modeling for the development of the web-enabled prototype. The development and deployment of the prototype is discussed in Chapter V. Web interface usability features tested in the Database and Web Technologies Lab are summarized in Chapter VI. Lastly, Chapter VIII discusses lessons learned, conclusions, and directions for future research.

II. ANALYSIS OF MALSP DOCTRINE

This chapter analyzes the strengths and weaknesses of MALSP doctrine and the current initiatives that will transform aviation logistics to meet 21st century requirements.

The chapter is organized as follows. Section A describes why MALSP was originally implemented; Section B discusses the successes of MALSP since its inception; Section C analyzes the historical shortcomings of MALSP doctrine and its relevancy to today's strategic environment; and Section D discusses the transformation strategy for Marine Aviation Logistics to respond to the unpredictable challenges of 2015 and beyond.

A. MALSP DOCTRINE

Prior to 1988, Marine Aviation Logistics (AVLOG) support for the MAGTF ACE was an ad hoc process at best. Headquarters and Maintenance Squadrons (H&MS) relied upon the resident expertise of maintenance and supply personnel to determine the optimal composition of personnel, parts, support equipment, and mobile facilities to support a deployment or contingency [2]. Because of varying degrees of experience within H&MS across the Marine Corps, an inconsistent concept of operations for logistics support was a common result; both shortfalls and excess capabilities often coexisted for task-organized contingencies, which ultimately led to reduced combat readiness. These systemic issues were addressed with the introduction of MALS and MALSP doctrine.

MALS and MALSP doctrine was officially implemented in October 1988 [3]. This transformation included the structural reorganization of H&MS into MALS, which consolidated the responsibility of AVLOG support at the tactical level to one squadron. However, it was MALSP that was the key piece of the transformation process. The introduction of new doctrine led to the ability to rapidly task-organize and execute aviation logistics support operations for major theater-level war [4].

B. MALSP SUCCESSES

For nearly 20 years, MALSP doctrine has served the aviation community sufficiently. The following is summary of operations where MALSP doctrine has been used (and continues to be used today) to support MAGTF ACE missions:

Desert Shield (Kuwait)	**Desert Storm (Kuwait)**	**Fiery Vigil (Philippines)**
Provide Comfort (Turkey)	**Victor Squared (Haiti)**	**Southern Watch (Iraq)**
Restore Hope (Somalia)	**Provide Promise (Yugoslavia)**	**Deny Flight (Bosnia)**
Continue Hope (Somalia)	**Eyes of Mogadishu (Somalia)**	**Quick Draw (Somalia)**
Uphold Democracy (Haiti)	**Decisive Endeavor (Bosnia)**	**Assured Response (Liberia)**
Deliberate Guard (Bosnia)	**Silver Wake (Albania)**	**Deliberate Forge (Bosnia)**
Allied Force (Kosovo)	**Noble Anvil (Kosovo)**	**Avid Response (Turkey)**
Allied Harbor (Albania)	**Joint Guardian (Kosovo)**	**Stabilize (East Timor)**
Enduring Freedom (Afghanistan)	**Secure Tomorrow (Haiti)**	**Iraqi Freedom (Iraq)**

Table 1. MALSP Employment Since 1988

The implementation of MALSP dramatically improved AVLOG support from an improvised, makeshift process to a standardized, predetermined contingency support package concept that is capable of supporting the multitude of missions Marine Corps Aviation may be tasked to execute [1]. Although the “building block” doctrine has successfully supported combat sorties, humanitarian missions, enforcing no-fly zones and other MAGTF operations, Table 1 above also reveals a trend. With the exception of Operations Desert Storm and Iraqi Freedom, 21st century contingencies are of a smaller scale and not the major theater-level engagements that MALSP was originally designed to support.

C. MALSP SHORTCOMINGS

MALSP was developed in the Cold War era, where major theater engagements were the strategic focus. The Cold War has now ended, but the doctrine used to support the MAGTF ACE has not [5]. Since MALSP has been implemented, major theater engagements account for just 7% of MALSP utilization whereas 93% can be considered smaller scale contingencies.

Looking through the macro-level lens, the underpinnings of MALSP doctrine are no longer an efficient option for today's strategic environment. The proliferation of weapons of mass destruction, terrorism, and the global economy are all drivers of a new strategic landscape. Furthermore, nations are less likely to engage the United States in conventional, major theater-level, operations due to its overwhelming military strength and technological advantages. Smaller scale contingencies have become the norm not the exception; therefore, a doctrinal shift is, once again, required for Marine Aviation Logistics to respond to the full spectrum of events that threaten global stability and national interests.

The shortcomings of MALSP doctrine are also demonstrated at the micro-level. In 1999, MALS-31, located in Beaufort, South Carolina, was tasked to support the NATO action of stopping Serbian military aggression against ethnic Albanians in Kosovo, with the intent of restoring Kosovo's borders and promoting regional stability. The mission, Operation Noble Anvil, required MALS-31 to deploy a tailored yet self-sustaining support package for 24 F/A-18D aircraft. Although the task seemed well suited to utilize MALSP, logistics planners had significant hurdles to clear in order to effectively support the operation.

Operation Noble Anvil posed significant problems for logistics planners because support from MPF and TAV-B ships were not planned to be used for this deployment [2]. This challenged the fundamental assumption of MALSP doctrine that calls for contingency support packages to be integrated with the capabilities of MPF and T-AVB ships; the former to provide essential pre-positioned support equipment and ordnance, and the latter a means of rapid and dedicated sealift into an area of operations.

With these key components unavailable, MALS-31 had no choice but to deviate from doctrine. As a result, they developed and deployed a Remote Expeditionary Support Package (RESP): a stand-alone support capability consisting of people, parts, support equipment and mobile facilities that can sustain operational requirements independently [5]. Despite the challenges, MALS-31 was successful in maintaining an aircraft mission capability rate of 92% [2]. The development and implementation of the RESP was successful, gained acceptance, and was formally integrated within MALSP doctrine by the publication of *Aviation Logistics*, Marine Corps Warfighting Publication 3-21.2, in October 2002. Nonetheless, Operation Noble Anvil is an example where MALSP had to be revised due to its inefficiency of supporting smaller-scale contingencies.

Another problem with MALSP doctrine that is rooted from a decades-old mentality is the concept of having standardized and predetermined support packages. The foundational "building blocks" of MALSP, the Peculiar Contingency Support Package (PCSP) and Common Contingency Support Package (CCSP), supports the deployment and logistics requirements of *<u>entire</u>* squadrons or groups of squadrons during a major theater war [5]. For example, an F-18 PCSP is built to support 36 aircraft, which is equivalent to three squadrons. Theoretically, if all 36 aircraft deploy, then MALSP works as intended. However, if only two squadrons deploy, e.g., Operation Noble Anvil, with a "standardized and predetermined" PCSP, then 24 aircraft undoubtedly have a robust logistics support package, but consequently the 12 F/A-18 aircraft that remain behind in garrison have lost a significant amount of supporting personnel, parts, support equipment and mobile maintenance facilities. All of which significantly reduce the ability of those 12 F/A-18 aircraft to continue to "train as they would fight" and remain combat ready in case they are needed. Hence, MALSP is not inherently flexible or sufficient to support smaller-scale contingencies in its current state. In light of the increasing number and variability of smaller-scale contingencies in the 21st century, the Marine Corps must re-focus it aviation logistics support concepts from "standard-sized" packages to "right-sized" packages [5].

D. TRANSFORMATION OF MARINE AVIATION LOGISTICS

The shortcomings of current MALSP doctrine are well documented; Marine Aviation Logistics must respond more efficiently to the ever-increasing and unpredictable missions of the 21st century [6]. The current transformation strategy that will enable effective AVLOG support in the future consists of three concepts: AirSpeed, MALSP-II, and MALS-Future. These concepts are an integrated and multi-year undertaking that will culminate with the implementation of MALS-Future, a responsive and light-weight logistical support activity that is capable of sustaining the MAGTF ACE's warfighting requirements of 2015 and beyond. MALS-Future is currently under research by the Marine Corps Studies System with the intent of proposing a new business model and structure for the future of MALS squadrons [7].

At the core of the cultural shift is the United States Navy's new logistical enterprise philosophy of AirSpeed. This new philosophy is a blend of proven business tools including Theory of Constraints (TOC), Lean and Six Sigma [5]. The purpose of AirSpeed is to optimize the performance of logistics practices and decision-making at all levels of the logistics chain by focusing on interdependencies, constraints and variability of current practices. The end result is a new methodology of managing assets and a streamlined logistical support system.

The AirSpeed philosophy is currently being implemented on a limited basis and has already received some positive feedback. MALS-26, located at New River, North Carolina, was the first MALS squadron to put theory into action in 2004. Using the components of AirSpeed, MALS-26 noticed process improvements and increases in efficiency with their maintenance and diagnostic workbenches [8]. "Theory of Constraints (TOC) and the focus on Lean is helping to achieve our goal…AirSpeed improvement tools help to maintain and sustain our readiness," said the Executive Officer from MALS-26 [8].

The next step in the transformation process is MALSP-II, a new aviation logistics doctrine that addresses the challenges of supporting both small-scale contingencies abroad and remain-behind elements at home. Agility, flexibility, responsiveness, adaptability, sustainability, and proactiveness are the benchmark requirements for success [5]. The goal is to move away from the enormous logistical infrastructure of a forward-deployed MALS under current MALSP doctrine. Area denial and anti-access in foreign regions, Expeditionary Maneuver Warfare (EMW) and sea-basing are all factors that require a lighter more agile logistics footprint.

To accomplish these goals, MALSP-II will leverage AirSpeed concepts and incorporate emerging technologies. An essential concept of AirSpeed that is applied to MALSP-II is a system “buffers.” The purpose of the buffer system is to increase the effectiveness of logistical support while reducing infrastructure and resources [5].

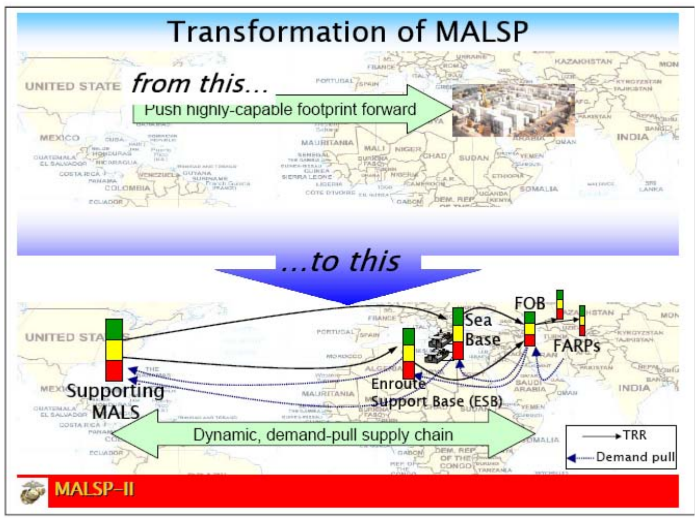

Figure 4. MALSP-II Concept of Buffers [From: 5]

Figure 4 above depicts the intended transformation from MALSP to MALSP-II and how the system of buffers is utilized to shift from “pushing” a large “standardized” infrastructure into a crisis region to a series of “right-sized” logistical support centers capable of “pulling” resources from a geographically dispersed supply chain. Buffers are identified and managed by a stop-light model, where green represents sufficient resources on-hand; yellow means resources have been used and replenishment plans should be initiated; and red means action is now needed for current and future operations. Individual buffer levels are determined by the pattern of demand and the time to rapidly replenish (TRR) the resource.

Current MALSP doctrine is constrained by Cold-War assumptions that are no longer relevant. MALSP-II is an effective transformation strategy to manage logistics assets and reduce the footprint required for smaller-scale contingencies expected in the

21st century. However, agility, flexibility, responsiveness, adaptability, sustainability, and proactiveness can only be fully realized by effectively leveraging Information Technology (IT). Clearly, the visibility and timely flow of information is critical to the success of MALSP-II. Concept of Operations (CONOPS) planning and managing multiple buffer nodes, consisting of personnel, parts, support equipment, and mobile facilities, requires a robust IT enabler.

This chapter analyzed the strengths and weaknesses of MALSP doctrine and the current transformation initiatives being pursued for naval aviation. Implicit in all past, present, and future aviation logistics actions is the vital role of information management systems, which will be discussed in Chapter III.

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III. ANALYSIS OF THE INFORMATION MANAGEMENT SYSTEM

This chapter analyzes the strengths and weaknesses of the MAGTF Deployment Support System II (MDSS-II), and quantifies the extent of the current decision support problem by analyzing formal surveys distributed to aviation logistics professionals.

The chapter is organized as follows. Section A describes the MDSS-II system and how it is integrated within the LOGAIS family of systems; Section B analyzes the shortcoming of MDSS-II for the aviation logistics community with regard to developing logistical support plans; Section C is a concise statement of the problem from which this thesis is conceived; and Section D discusses the quantifiable evidence of the need for a robust decision support tool for aviation logistics planners and sustainers.

A. MDSS-II

The MAGTF Deployment Support System II (MDSS-II) is the primary Information Management System used for deliberate planning of aviation logistics support operations at the tactical level. MDSS-II is a component of a larger Marine Corps enterprise system called MAGTF-II. MAGTF-II interfaces with the Global Command and Control System (GCCS) and the Joint Operation Planning and Execution System (JOPES), the central Information Management System where U.S. military inter-service operational plans (OPLANS) and operations orders (OPORDS) are published. JOPES is an effective system for providing the Joint Chiefs of Staff (JCS), Combatant Commanders and the U.S. Transportation Command with the information needed to manage and support deployed forces [1]. The following diagram depicts the Information Management Systems used for Force Deployment Planning and Execution (FDP&E) from the macro-perspective:

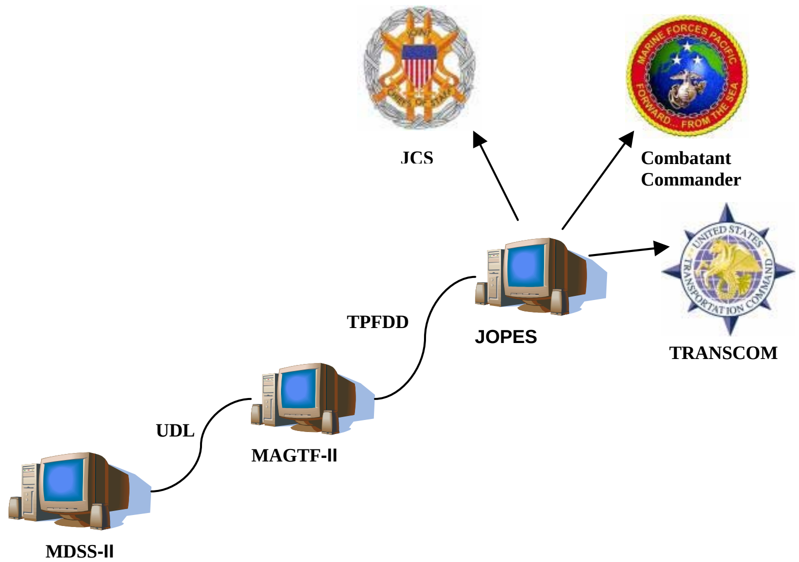


Figure 5. Information Management System Relationships

The purpose of MDSS-II is to enable tactical-level planners to *develop* force structure, tailor force lists, compute sustainment and plan for lift requirements [1]. The product of the MDSS-II system is the Unit Deployment List (UDL), which is unit specific Time Phased Force Deployment Data (TPFDD) for an operation. The TPFDD identifies capabilities; it is the "who, what, when, and where" of force coordination. One the UDL consolidated and reviewed at the squadron level is sent to higher headquarters and imported into the MAGTF-II system, which manages and produces the TPFDD for the entire spectrum of the MAGTF.

B. DOCUMENTING VS. DEVELOPING LOGISTICAL SUPPORT

From the micro-perspective, MDSS-II is an effective information management system for *documenting* capabilities—personnel, aircraft parts, support equipment, and mobile facilities—for a contingency or deployment, but not an efficient system for identifying or *developing* those capabilities. MALS squadrons do not have an effective decision support system for identifying, developing and consolidating CONOPS information for aviation logistical support. At the present time, MALS planners are required to query and consolidate data from multiple information management systems, each specifically designed to manage a single component of the logistics support package concept—personnel, aircraft spare/repair parts, support equipment, or mobile maintenance facilities. Moreover, deliberate, time sensitive and crisis action planning for contingencies, exercises and other CONOPS, where no previous support data exists, must be initiated from scratch—a significant challenge when time limited and mission critical. As a result, the MALS Operations (S-3) and Logistics (S-4) Departments are forced to expend resources and valuable man-hours manually developing and documenting the aviation logistics CONOPS due to the lack of integrated information management systems. The following figure depicts the current architecture of information management systems used to develop and document aviation logistics support for an operation or contingency.

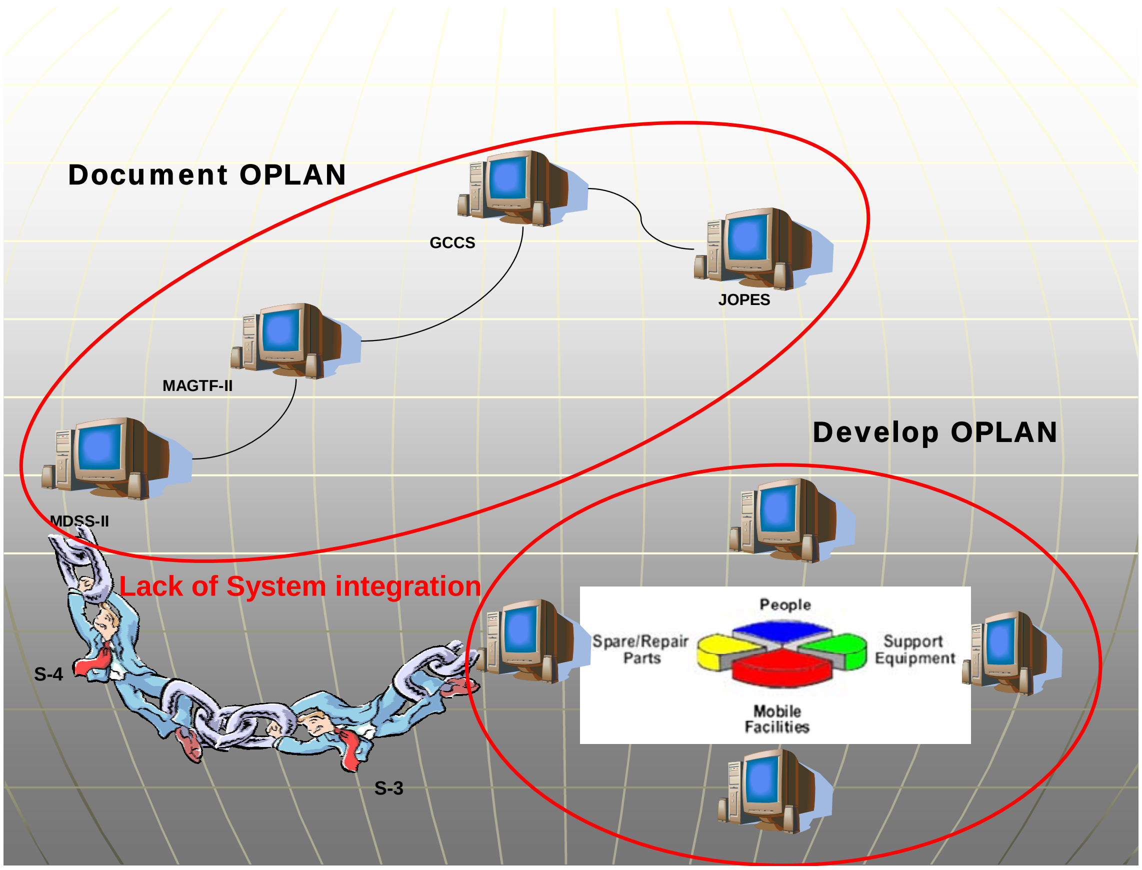


Figure 6. Developing Versus Documenting OPLANS

C. PROBLEM STATEMENT

No effective Information Management System exists for <u>developing</u> deliberate, time sensitive, or crisis action plans for <u>tactical-level</u> aviation logistics support operations that is integrated with the LOGAIS family of systems (MDSS-II/MAGTF-II/JOPES).

D. QUANTIFYING THE PROBLEM

1. Data Collection

To capture and quantify the extent of the problem, surveys were distributed to personnel currently operating at MALS units throughout the Marine Corps. There were eight respondents of the survey, which included MALS Operations Officers, Aviation Maintenance Officers, and Aviation Supply Officers. All respondents have experiences in planning and executing aviation logistics support operations from Operation Desert Storm to the current and ongoing Operation Iraqi Freedom and the Global War on Terrorism. The following is the data collected from the formal survey:

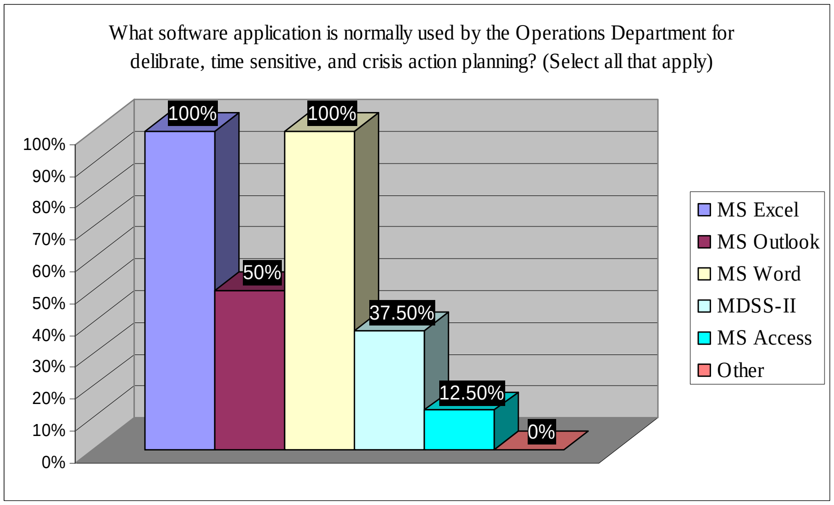


Figure 7. Survey Results: Software Used for AVLOG Planning

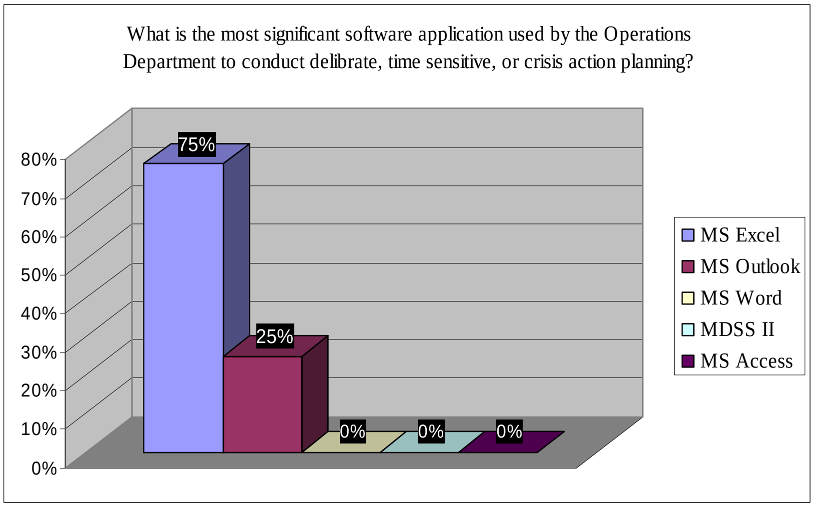


Figure 8. Survey Results: Most Significant Software Used for AVLOG Planning

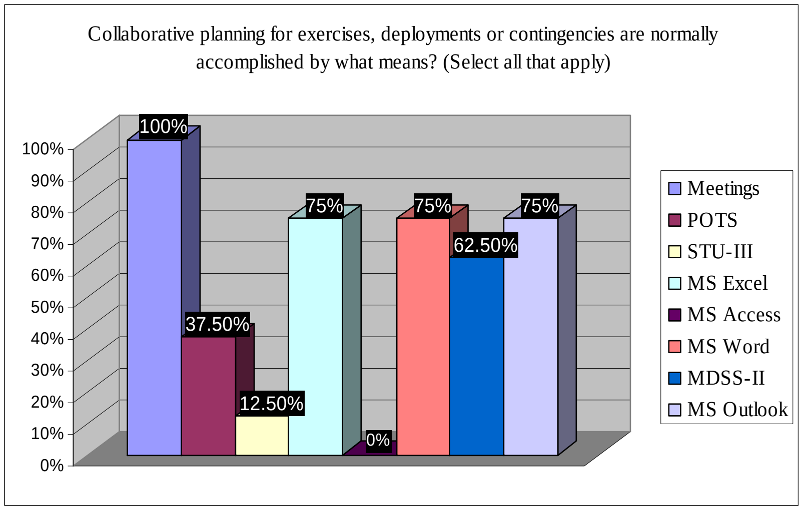


Figure 9. Survey Results: Methods of Collaborative Planning

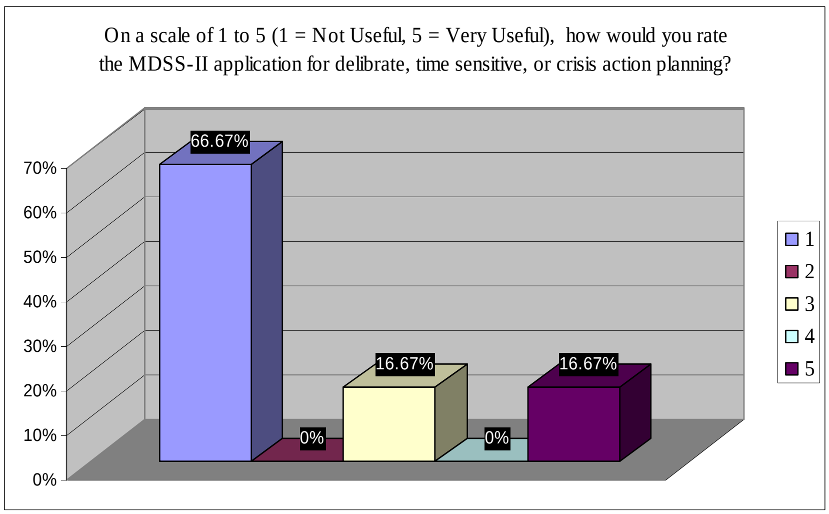


Figure 10. Survey Results: Rating of MDSS-II for Planning

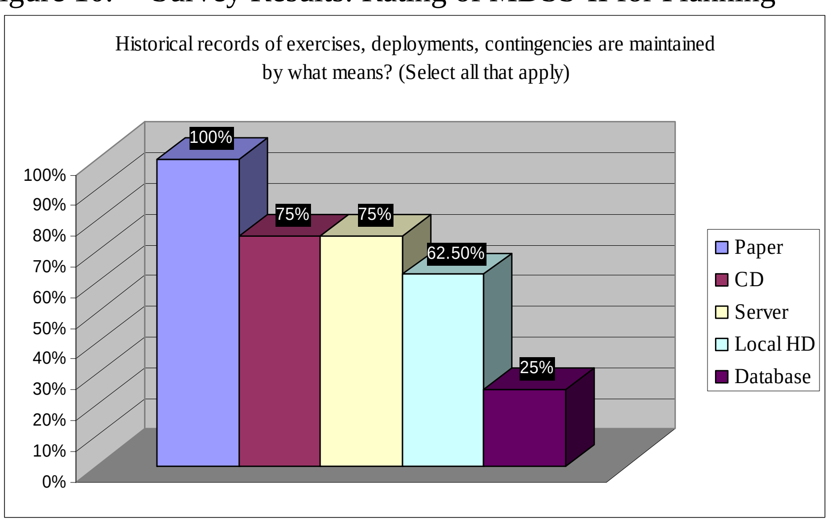


Figure 11. Survey Results: Methods of Maintaining Historical Records

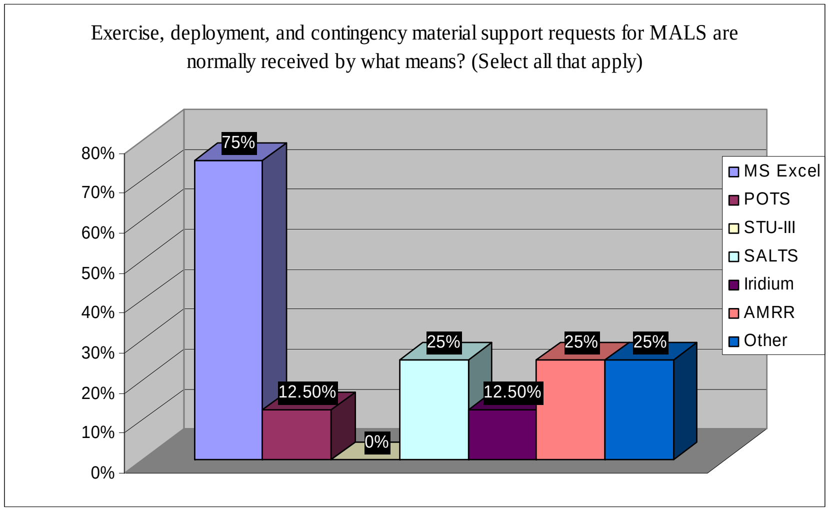


Figure 12. Survey Results: Means of Receiving Material Support Requests

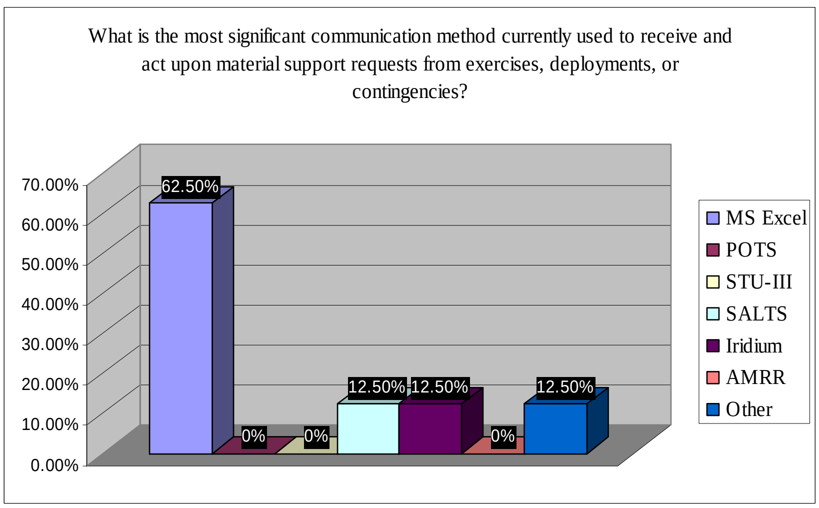


Figure 13. Survey Results: Most Significant Methods of Material Support Requests

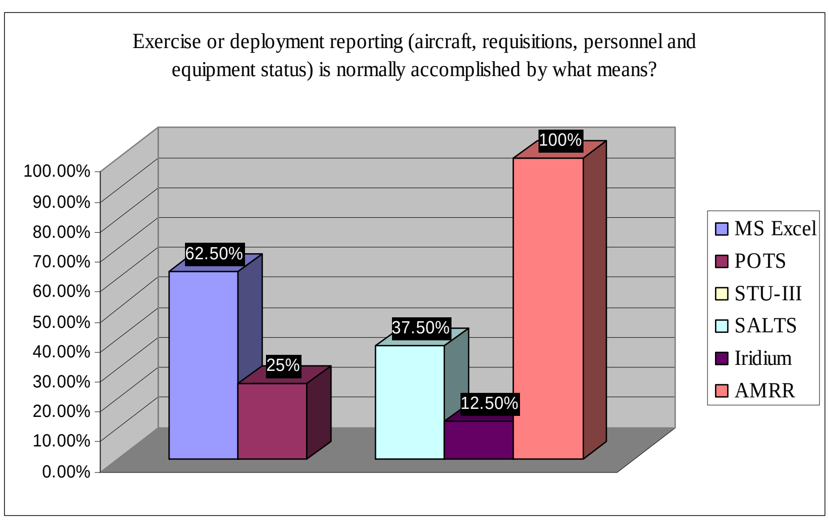


Figure 14. Survey Results: Means of Deployment Reporting

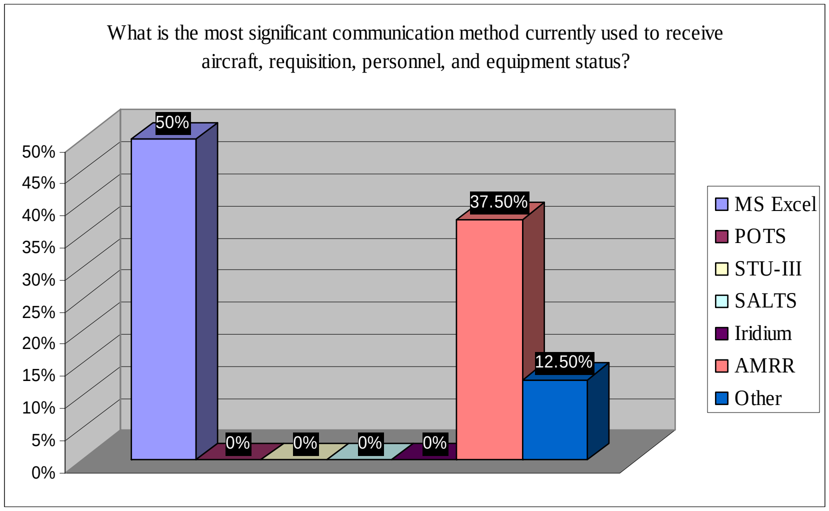


Figure 15. Survey Results: Most Significant Means of Deployment Reporting

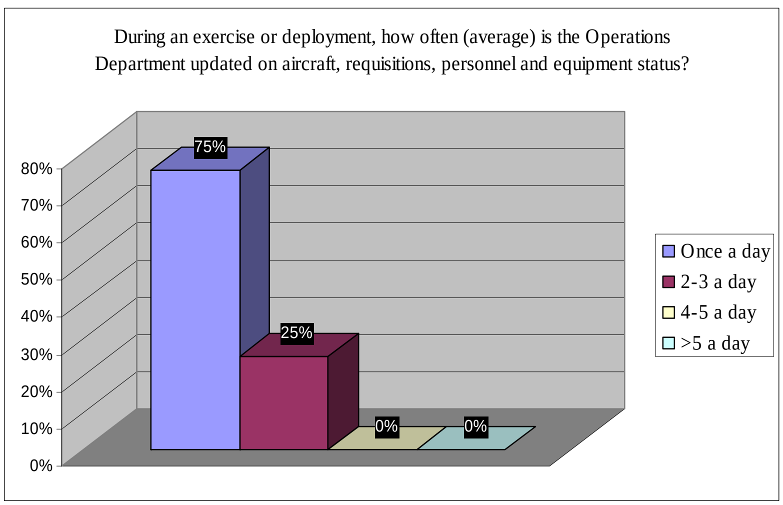


Figure 16. Survey Results: Frequency of Deployment Reporting

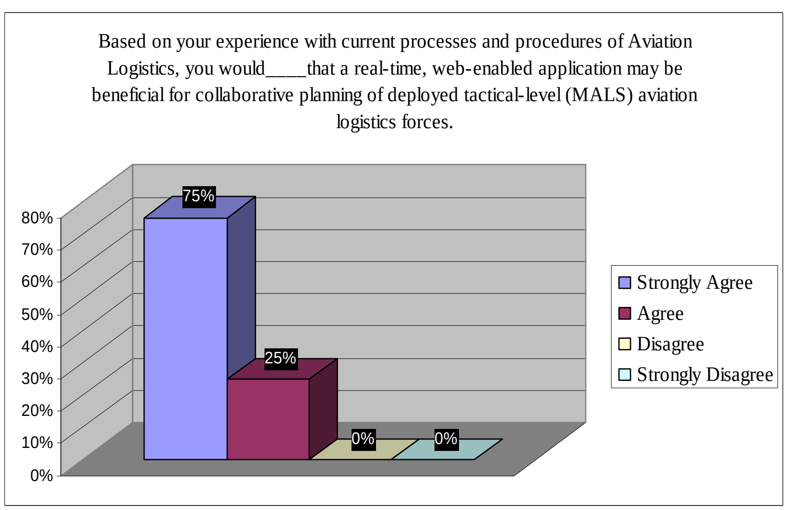


Figure 17. Survey Results: Web-Enabled Application for AVLOG Planning

2. Data Analysis

The MDSS-II application is not the robust Information Technology (IT) enabler needed for planning aviation logistics support operations, only 37% of the respondents cited MDSS-II as the application that is normally used by the Operations Department for deliberate, time sensitive, and crisis action planning. However, 100% of the respondents cited the "flat-file" technologies of Microsoft Excel and Microsoft Word as the normal applications used to execute planning requirements. MDSS-II did not fair well as a collaborative planning tool either: Microsoft Excel (75%), Microsoft Word (75%), and Microsoft Outlook (75%) all outpaced MDSS-II (62%) as the tool most commonly used to accomplish internal and external collaborative planning functions. The most significant finding from the formal survey; however, is that 67% of respondents rate the MDSS-II application as a one (1) on a sliding scale of one to five (1 to 5), with one (1) equaling "not useful" and five (5) equaling "very useful." From the survey, it is clear that MALS could benefit from the inherent value and collaborative nature of a web-enabled decision support tool.

The survey of aviation logistics professionals also revealed some current inefficiency related to sustaining deployed forces. First, Microsoft Excel (via Microsoft Outlook) is the most significant application for receiving aircraft, requisition, personnel, and equipment status updates from deployed forces. Second, Microsoft Excel is by far (75% of all requests) the most common means of receiving deployment or contingency material support requests from deployed forces. Third, Microsoft Excel is second only to the official Aircraft Material Readiness Report (AMRR) as the means of deployment reporting, with the former published just once a day. Although aviation logistics planners and sustainers have an array of available software applications, none is more vital to their mission than Microsoft Excel; 75% of the respondents cited the application as the "most significant" software application used for planning and sustaining purposes.

Hence, MALS Operations Departments are using Microsoft Excel to mitigate the shortfalls of currently fielded systems and the lack of system integration. Although Microsoft Excel is a very popular application with useful functionality, the problem with using spreadsheets as a planning tool is that they are inherently designed for personal, not collaborative, productivity. Sharing of Microsoft Excel files requires the use of email or a shared network drive, which then leads to the problem of document-version control (data integrity) as more users participate in the planning process. As a result, scarce man-hours are expended updating the source document for already time sensitive task. Furthermore, pseudo-centralization of a spreadsheet on shared network drive is not sufficient since only one user at a time can modify the document. Multi-user access is a requirement for efficient coordination with Maintenance, Supply, AISD and the Logistics Departments.

Information redundancy and inconsistent format is another problematic issue; over time, planning multiple exercises or contingencies results in multiple spreadsheets with no guarantee of a consistent format within (internal planning) MALS, let alone coordination that may be required with another MALS (external planning).

The use of "flat-file" *technology* is not the most conducive means for collaborative planning or sustaining deployed forces. The decentralized nature of spreadsheets does not provide the functionality to effectively manage the information requirements of aviation logistics planning and sustainment operations. The complexity of planning and coordination required to properly execute current and future MALSP doctrine would be better served by implementing an information management system specifically designed for aviation logistics support operations.

The requirement for such a system was validated in June 2005 at Marine Aviation Maritime Pre-Positioning Force (MPF) Pre-Tailoring Conference. At the conference, attended by key Marine Aviation logistics planners from throughout the Marine Corps, the future aviation logistics requirements workgroup identified the need for a robust decision-support tool for aviation logistics planning. The following is a summary of the discussion and recommendations [9]:

- AVLOG Planners lack integrated planning tools.
- The lack of an AVLOG plans-specific decision support tool does not allow for detailed planning and integration with the MAGTF-II/LOGAIS family of systems.

- MDSS-II data is currently entered by hand.

- Deployments are seldom based upon a notional MAGTF. Each deployment requires new embarkation data package, but planners lack the tools to quickly create new packages.

- MALS needs a decision support tool that helps to source MDSS-II by extracting supply, maintenance, and IMRL data to tailor support packages.

Hence, the goal of this thesis is to develop a web-enabled prototype that implements the support concepts of MALSP-II and optimizes CONOPS planning and management capabilities that have been identified in the survey and validated by the aviation logistics planners' discussion of future requirements. The MALS would certainly gain from a web-enabled database, as evidenced by 75% "strongly agreeing" and 25% "agreeing" that a web-enabled application may be beneficial for collaborative planning and sustainment of deployed tactical-level aviation logistics forces.

This chapter identified and quantified the problem with developing aviation logistical support plans using the current information management systems. The analysis clearly established a need for a robust application for the MALS. The development for such an application is discussed in Chapter IV.

IV. ANALYSIS AND DESIGN OF PROTOTYPE APPLICATION

This chapter discusses the methodology and tools used to develop the MAPSS prototype. This chapter then presents the conceptual data and logical process models used to design the web-enabled application.

The chapter is organized as follows. Section A describes Rapid Application Development (RAD) and why this methodology was appropriate for an aviation logistics planning and sustainment application; Section B discusses the software development tools used for building the prototype; Section C discusses the mechanics of generic conceptual data modeling and then illustrates three specific data models that were developed for the MAPSS application; and Section D discusses the importance of logical process modeling, and then illustrates the information and control flow diagrams for the three system processes.

A. PROTOTYPE METHODOLOGY

The methodology used to develop the Marine Aviation Planning and Sustainment System (MAPSS) was Rapid Application Development (RAD), a strategy that emphasizes speed and user involvement in the iterative development of software prototypes [10]. The RAD methodology was developed by Jamie Martin in 1991, which is essentially a descendent of the Spiral Development Model developed by Barry Boehm in 1986, which emphasized prototyping as an effective means of developing software [11]. RAD is an evolutionary process: develop, test, refine system requirements, and then repeat the process. Prototypes are continuously developed until users are satisfied that system requirements have been successfully *discovered* and implemented into a working system.

RAD is an appropriate methodology for developing an application for Marine Aviation Logistics Squadrons (MALS). As discussed in Chapter II, Marine Aviation Logistics is currently undergoing a transformation from MALSP doctrine to MALSP-II. As a result of the ongoing transformation, some system requirements for an operational planning and sustainment system are currently unknown and some known requirements will inevitably change as the multiyear transformation progresses.

In light of current state of the aviation logistics community, traditional software development strategies may be inappropriate, ineffective and undoubtedly expensive. RAD, on the other hand, is methodology that enables an application—an IT enabler—to be developed in parallel with the current transformation. The iterative approach to prototyping allows known requirements to be developed and tested and new or unforeseen requirements to be included with future implementations or spirals of the prototype. A decision support prototype application for aviation logistics is a win-win situation for MALS; it addresses current information technology needs and it is flexible enough to incorporate MALSP-II and MALS-Future concepts as they are developed.

B. DEVELOPMENT TOOLS

Three tools were used to develop the MAPSS prototype: Microsoft Access 2003, Microsoft Visio 2003, and Macromedia Dreamweaver MX 2004. Microsoft Access is a powerful yet user-friendly program for creating and managing relational databases that is used by both home users to create personal applications and professional software developers to create enterprise-wide applications. For the purposes of this thesis, Microsoft Access was used to create the back-end relational database for the prototype.

Microsoft Visio 2003 is a computer-aided software engineering (CASE) tool. CASE tools are an essential element in any information systems development process; they allow developers to quickly and accurately draw modeling diagrams, create prototype user interfaces, perform system specification analysis, and even generate executable code [12]. Microsoft Visio 2003 was used to create the conceptual data models and logical process models for the MAPSS prototype.

Macromedia Dreamweaver MX 2004 is a professional web development program. This tool allows both beginners and advanced web-designers to create professional web pages quickly and easily. The advantage Macromedia Dreamweaver has over other web development products is its user-friendly integration of advanced web development technologies and functionalities[13]. Dreamweaver allows beginners to design pages using the WYSIWYG interface or advanced users to design directly from code. The intuitiveness for the beginner yet the robust capability for advanced web designers are a rare combination in software. Dreamwever MX 2004 was used to create the web-based front end, the user interface, of the MAPSS prototype.

C. CONCEPTUAL DATA MODELS

Data modeling is an efficient way to document how data is organized and stored in a relational database [10]. There are many different types of data models used by developers to design and analyze data to be stored for an organization, each with its own specific notation and benefits. The type of data model used and level of detail is a product of design methodology, time available to deliver the application, and the developer's preference. One thing is certain, however; data models should always be part of the development process.

The Entity Relationship Diagram (ERD) was the type of data model used to develop the MAPSS prototype. ERD is a popular methodology for conceptual data models; it is a method that utilizes several notations to depict data in terms of entities and relationships [10]. Given that the RAD methodology calls for speed and quick development of prototypes, the level of detail and analysis for the MAPSS prototype was intentionally compressed and abbreviated. Conceptual data models for the MAPSS prototype were developed in three steps: (1) context data model, (2) key-based data model, and (3) fully attributed data model.

1. Context Data Model

The context data model was the first step of the MAPSS conceptual data modeling effort. The purpose was to identify the high-level entities and relationships for the MAPSS database. An "entity" is defined as persons, places, events, or concepts about which an organization chooses to record data [12]. A "relationship" is a natural business association between one or more entities [10]. For example, MALS, a SQUADRON is an entity, and OPERATION, an event, is also an entity, and both are elements of data that must be maintained in the database. Since SQUADRONS are tasked to execute OPERATIONS, there is a natural business or doctrinal "relationship" between these entities. In short, entities are usually nouns and relationships are usually verbs.

Before a context data model can be developed; however, an organization must be examined. A discovery process is needed to capture the relevant entities and relationships for the system. This examination of the organization can accomplished in numerous ways, such as interviews with intended users, observation of the organization, surveys and questionnaires, review of doctrine or applicable laws, or an assessment of current system capabilities, to name just a few discovery methods. Since MAPSS was designed as a decision support tool for operational planning and sustainment, the discovery process was focused on the MALS Operations Department (S-3) and their functional requirements of developing Concepts of Operation (CONOPS), Courses of Action (COA), and sustaining deployed forces. Surveys, interviews with intended users, and a review of doctrine were the discovery methods for this thesis research.

CONOPS development was one of the central requirements for the system. The key entities identified were operation, squadron, aircraft, and course of action. These entities are related in that operations are normally supported by squadrons, aircraft, and should have multiple courses of action planned to execute the operation. In addition to the above requirements, a logbook and a 782-gear list are two entities that should be maintained (albeit not essential) for an operation. There are benefits to documenting chronological events, as well as maintaining a list of items that personnel are required to deploy with.

Course of Action (COA) development was another primary consideration for the prototype. In fact, COA development is mandated by the Marine Corps Planning Process (MCPP). Developing a COA for aviation logistics support requires planners to consider multiple variables. According to aviation logistics doctrine, a COA normally consist of personnel, repair parts, support equipment and mobile maintenance facilities. As mentioned in Chapter I, these entities are the basic "building blocks" for aviation logistics support. Hence, COA development is centered on the assignment of these entities.

COA development also has natural relationships to other concepts, places and events, such as tasks, locations, vehicles, and host nation support. Tasks are the (what) actions that need to accomplished prior and during COA selection and execution. Deployment locations (where) and vehicles (how) are key entities that should be maintained and used to differentiate and facilitate COA selection. Moreover, host nation support is an essential concept that must accounted for; it determines the services and other support that will be provided to deployed forces, which reduces the logistical footprint, saves resources, and aids planners in tailoring support packages that will meet mission objectives.

The last area of discovery for the decision support system was operational sustainment. This requirement primarily involves the situational awareness and reporting requirements of the previously mentioned entities: operation, aircraft, squadron, personnel, repair parts, support equipment, and mobile facilities. Situational awareness and near real-time operational visibility are key ingredients to effective leadership and timely decisions.

Requisition management was also considered a vital concept to operational sustainment. The mission of the MALS is to maintain the combat readiness of the MAGTF ACE, and readiness is maintained by providing aircraft with the repair parts and maintenance actions they need to continue flying combat missions. Hence, an effective decision support tool must include the ability to initiate, update, complete, and track requisitions for aeronautical equipment.

The discovery process provided the means to identity the high-level entities and relationships that were used to start the MAPSS database development cycle. The following figure depicts the context data model for the MAPSS prototype that provided the base from which the key-based and fully attributed data models were developed.

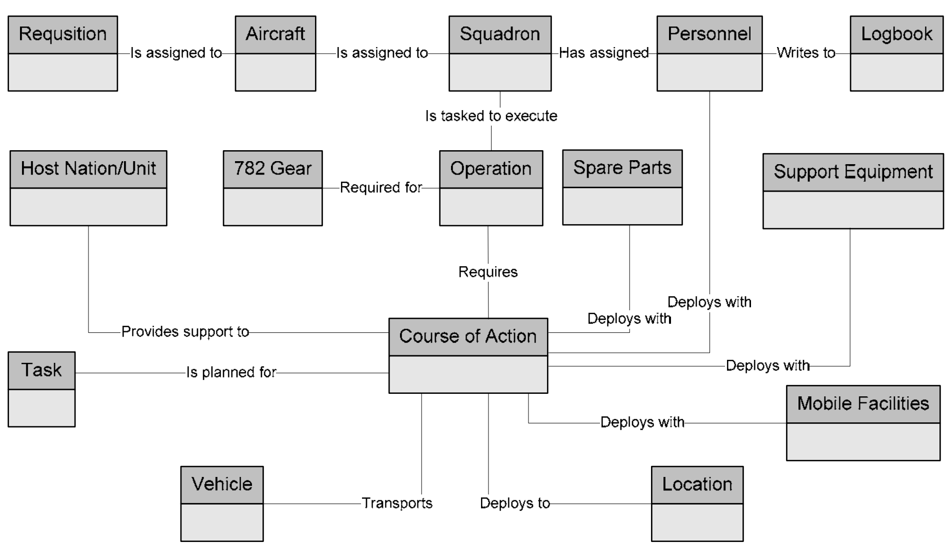


Figure 18. Context Data Model

2. Key-based Data Model

The key-based data model was the second step in the database design process. The purpose of this step was to further develop entities and relationships by documenting cardinality, an important step in the physical representation of the database. The term "cardinality" is defined as the minimum and maximum number of occurrences of one entity that may be related to a single occurrence of the other entity [10]. The following figure illustrates the most common cardinality notation and its interpretation.

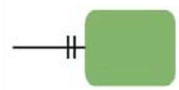
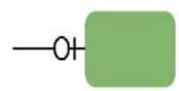
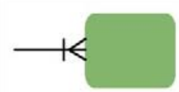
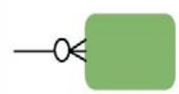
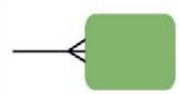
Cardinality Interpretation	Minimum Instances	Maximum Instances	Graphic Notation
Exactly one (one and only one)	1	1	 – or – 
Zero or one	0	1	
One or more	1	many (>1)	
Zero, one, or more	0	many (>1)	
More than one	>1	>1	

Figure 19. Information Engineering Cardinality Notation [From: 10]

Primary keys and foreign keys are important concepts to understand and essential to proper implementation of a relational database. A "primary key" is an attribute or a group of attributes that assumes a unique value for each entity instance [10]. A "foreign key" is a primary key of an entity that is used in another entity to identify instances of a relationship [12]. An example is the most effective way to demonstrate primary and foreign key concepts.

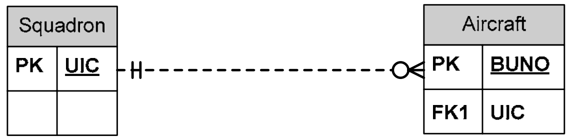


Figure 20. Primary and Foreign Key Example

HMM-265, located in Okinawa, Japan would be single instance of the SQUADRON entity. The primary key (PK) for the SQUADRON entity (data relating to the single instance of HMM-265) could be the Unit Identification Code (UIC). The UIC is a good candidate for a primary key because it uniquely identifies HMM-265 from all other squadrons in the Marine Corps and the value will never change. Moreover, a single CH-46E helicopter would be an instance of the AIRCRAFT entity. The primary key for the AIRCRAFT entity (data relating to the single instance of a helicopter) could be the Bureau Number (BUNO). The BUNO is a good candidate for a primary key because it uniquely identifies a specific aircraft and the value is permanently assigned and will not change. From Figure 20, UIC is also a foreign key (FK) for the AIRCRAFT entity, which indicates a business rule or relationship. Hence, the graphical notation above is interpreted as a SQUADRON may (optional) have one-to-many AIRCRAFT assigned and an AIRCRAFT must be assigned (required) to only one SQUADRON. Key-based models are a quick and an efficient tool for developing relational databases.

There is one more aspect of key-based models that needs to be discussed: many-to-many relationships. When designing relational databases, many-to-many relationships must be treated differently than other relationships. Developers using Microsoft Access 2003 cannot directly define many-to-many relationships; therefore, they must add a join or junction entity and relate the two entities using two one-to-many relationships [14]. The following figure demonstrates the concept.

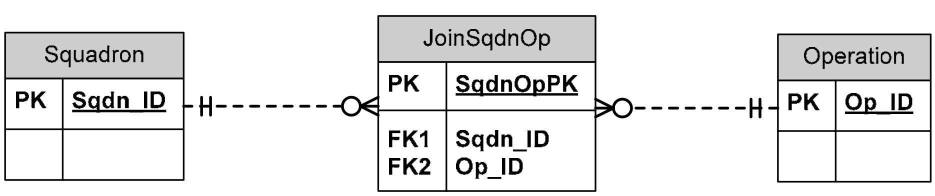


Figure 21. Many-to Many Relationship Example

Although the "real-world" relationship is one where a SQUADRON may be tasked to execute many OPERATIONS, and an OPERATION may be executed by many SQUADRONS, the logical relationship for a relational database requires the introduction of the JoinSqdnOp entity with two one-to many relationships and the foreign keys from the SQUADRON and OPERATION entities. The following figure is the key-based data model for the entire MAPSS prototype.

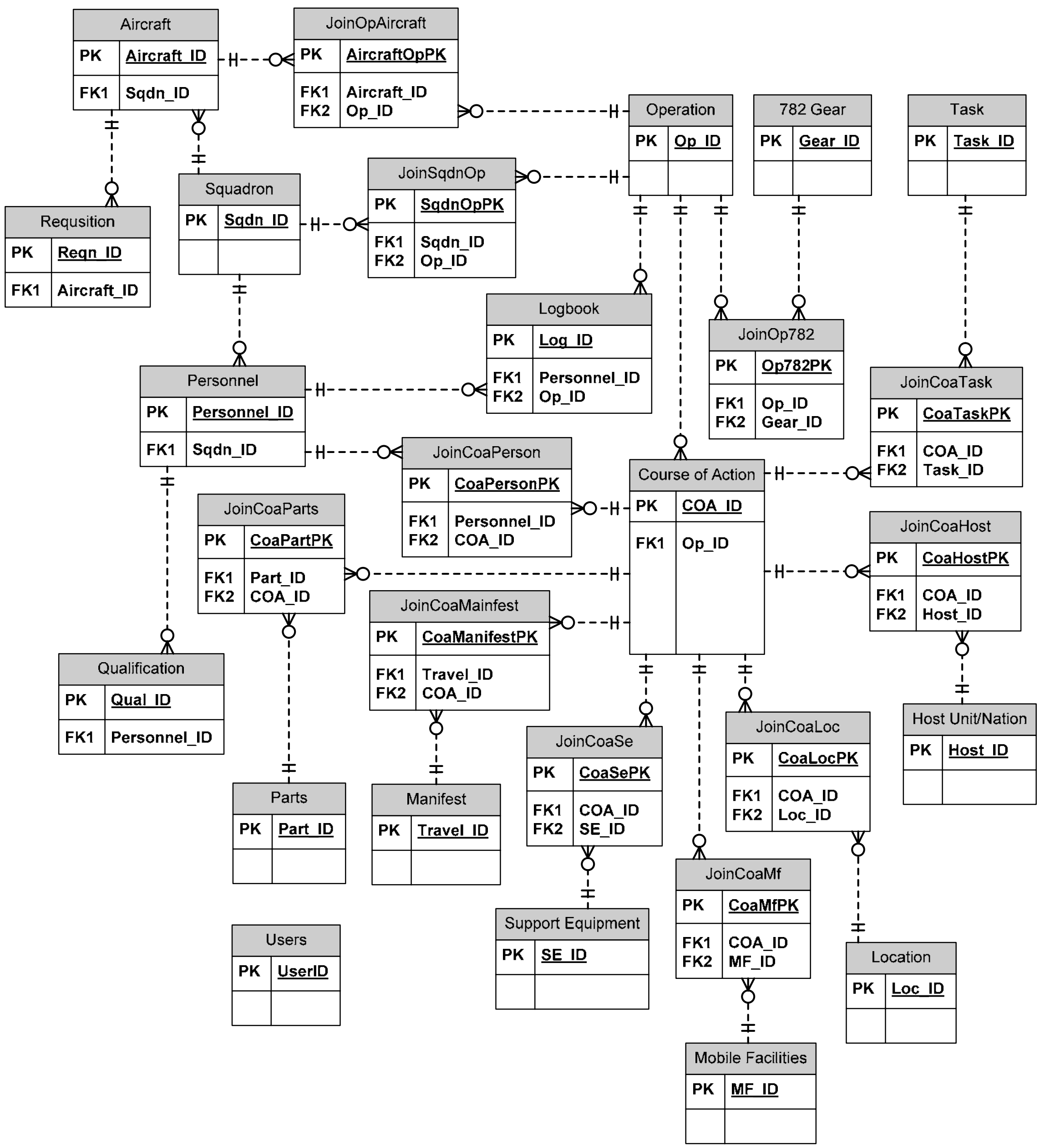


Figure 22. Key-based Data Model

3. Fully Attributed Data Model

The last step in the MAPSS conceptual data modeling process was the fully attributed data model. In addition to documenting all attributes for the entities, normalization was performed. The term "attribute" is defined as a descriptive property or characteristic of an entity [10]. For example, last name, first name, height, weight, blood type, etc., are attributes for the entity PERSONNEL. "Normalization" is defined as a data analysis technique that organizes data into groups to form non-redundant, stable, flexible, and adaptive entities [10]. The following figure depicts the fully attributed and normalized data model for the MAPSS prototype.

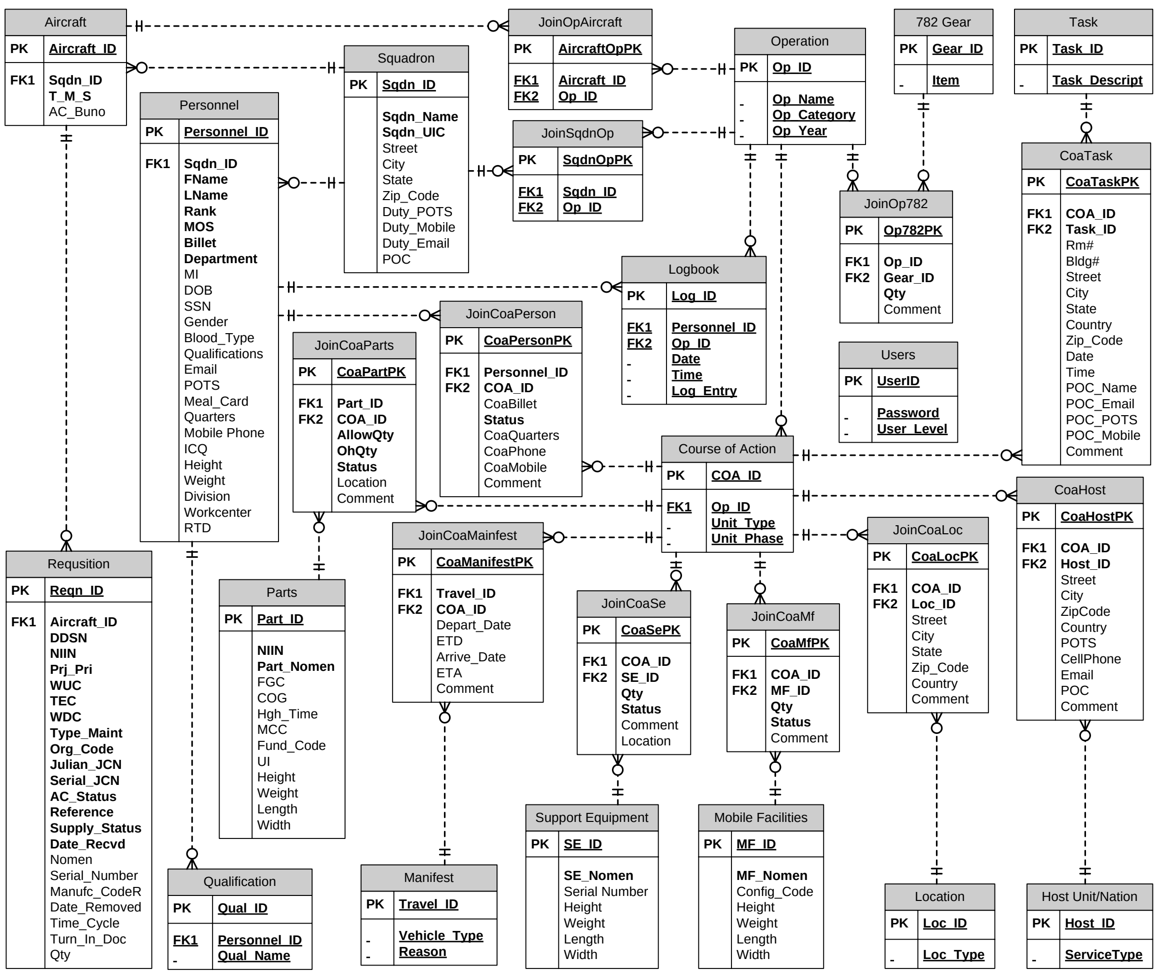


Figure 23. Fully Attribute Data Model

D. PROCESS MODELS

Process models differ from data models. Although the purpose of both is to represent a view of reality, a process model has the distinction of describing the system processes, whereas a data model represents the data needed by these processes. Process models are graphical representations of what the application was designed to accomplish. Process models are independent of data models in that process models depict what the user of the system will see and/or execute, while data models are usually transparent to intended users and used solely by developers to design and accurately develop the back-end of the system—the relational database.

1. System Requirements

Process models should be directly related to systems requirements. Since process models describe what the system will do, developers must design the application's processes with system requirements in mind. As discussed in Chapter I of this thesis, the intent of the MAPSS prototype is to be a robust application for AVLOG planners, enabling them to develop deliberate, time sensitive and crisis action plans and sustain tactical-level aviation logistics support operations. To accomplish this purpose, the MAPSS prototype was logically designed into three functional modules: (1) Concept of Operation (CONOPS) Development, (2) Course of Action (COA) Development, and (3) Operation Sustainment Dashboard. System requirements for each module were identified and validated by current doctrine, formal surveys and interviews with intended users of the system. The following system requirements were implemented into the first version of the prototype.

a. Concept of Operations Development

(1) Users shall initiate Concept of Operation (CONOPS) for aviation logistics support for Current and Future Operations, which includes assigning squadrons and aircraft to an Operation based on mission analysis and higher headquarters' Operation Order (OPORD).

(2) Users may/shall initiate multiple Courses of Action (COA) options for the Commanding Officer's decision. Types of COA options shall include Forwarding

Operating Bases (FOB), Enroute Support Bases (ESB), Sea bases, Ammunition Supply Points (ASP), and Forward Arming and Refueling Points (FARP).

(3) COA options shall be summarized by type of COA, weight (tons), footprint (square-feet), and occupying space (cubic-feet) to aid COA selection by the Commanding Officer and the development of Unit Deployment List (UDL) / Time Phased Force Deployment Data by the squadron Logistics Department.

b. Course of Action Development

(1) Users may/shall assign, update, and remove personnel, spare parts, support equipment, and mobile facilities from any COA option defined for an Operation.

(2) Users may/shall document, update, and remove location information for any COA option defined for an Operation.

(3) Users may/shall document, update, and remove transportation information for any COA option defined for an Operation.

(4) Users may/shall document, update, and remove host nation or unit support information for any COA option defined for an Operation.

(5) Users may/shall document, update, and remove COA specific planning and execution tasks for any COA option defined for an Operation.

c. Operation Sustainment Dashboard

(1) Users shall view readiness statistics for personnel, repair parts, support equipment, and mobile facilities assigned to an Operation/COA for the purpose of aiding logistics support replenishment decisions.

(2) Users shall view readiness statistics for aircraft assigned to an Operation for the purpose of aiding logistics support decisions.

(3) Users shall initiate, update, and remove aeronautical material requisitions for aircraft assigned to an Operation for the purpose of requisition management.

(4) Users shall view detailed UDL information (weight, footprint, and occupying space) for each COA in order to aid UDL/TDFDD development by the Logistics Department.

2. Information and Control Flow Diagrams

There are many different methods of modeling the logical processes of an information management system. One effective method for database driven, dynamic web-enabled applications is the Information and Control Flow Diagram. The purpose of an information and control flow diagram is to depict the control and information flow within a system. The MAPSS prototype was developed using information and control flow diagrams and used the following notation: rectangular shapes represent web pages; dash-lined arrows represent system control, i.e., hyperlinks, buttons, and/or icons that users may select; and solid-lined arrows represent the flow of information in relation to the back-end relational database.

a. MAPSS User Log-on Process

The MAPSS log-on page allows the user to log-on to the system. Users are required to enter a username and password. Both username and passwords are processed and checked against a user list in the MAPSS database. Upon successful authentication, users are automatically directed to the "start" page of the application. Users who are not authenticated are presented with a system feedback page, stating that either their username or password is invalid and then given another opportunity to enter a correct username and password.

The MAPSS "start" page has three options for users to select: Current Operations, Future Operations, and Past Operations. The current and future options allow users to access planning and sustainment functionality for active and near-future operations that the MALS is currently planning, has planned previously, or currently in the process of sustaining. The Past Operation selection is for inactive or completed operations. Maintaining historical records is a significant aspect of the MAPSS prototype; it provides a means to identify and analyze logistical trends that could benefit current and future planning requirements. Regardless of the option selected, however, system functionality and user interface remains consistent for all (current, future, or past) options. Figure 24 illustrates the log-on process.

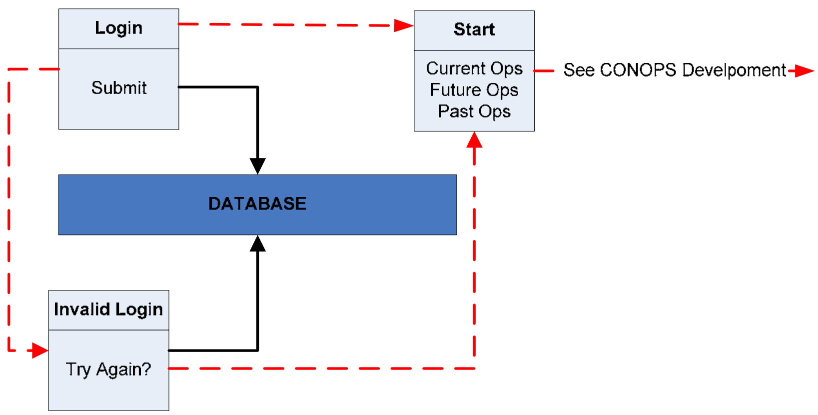


Figure 24. User Log-on Process

b. Concept of Operations Development Process

The Concept of Operations (CONOPS) development page is the first of three MAPSS processes. Defining the overarching CONOPS for a contingency or operation is a result of mission analysis and guidance from higher headquarters [15]. The primary purpose of the CONOPS development page is to allow AVLOG planners to assign squadrons, aircraft, and establish alternative Courses of Action (COA) options for the MALS Commanding Officer's decision. The CONOPS development page provides the interface to the other two processes of the system: COA Development and Operation Sustainment Dashboard.

Additionally, the CONOPS development page allows users to establish and maintain an Operation Logbook and 782 Gear List. The Operation Logbook is a function that allows users, planners, and decision-makers to chronologically document, in a central and globally visible location, the significant events of an operation throughout the planning, execution and sustainment phases. The 782 Gear List, although not as critical as the Operation Logbook, provides the means for users (especially personnel assigned to an operation) to quickly discover what personal and professional items they are required to have in their possession when they deploy for the operation.

The CONOPS development page was developed with robust functionality. In addition to assigning and removing squadrons, aircraft, and alternative COAs to and from an operation, users have the capability to add, update and delete information for an Operation, Squadron, Aircraft, COA, 782 Gear, and Logbook Entry. Although these are basic database functionalities as a stand-alone system, they become more robust; however, as system interoperability is incorporated with future versions of the MAPSS prototype. For example, Squadron and Aircraft information would be "pulled" from the NALCOMIS system, allowing drop-down menus to be populated for the CONOPS development/assignment functionality within MAPSS. Conversely, MAPSS was developed with the intent to have any added, updated, or deleted Squadron and Aircraft data "pushed" to the other interoperable systems, in this example the NALCOMIS system.

System feedback is another important functionality. Since MAPSS is a web-centric transaction-based system, users must know the status of transactions; there must be timely reactions to all user actions [16]. MAPSS offers concise and informative confirmation for all transactions. "Success" pages notify users that they have successfully assigned, removed, added, updated, or deleted data from the system. Moreover, a hyperlink is provided on each "success" page so users can quickly conduct another transaction of the same type or return to the parent process. Figure 25 illustrates the CONOPS development process.

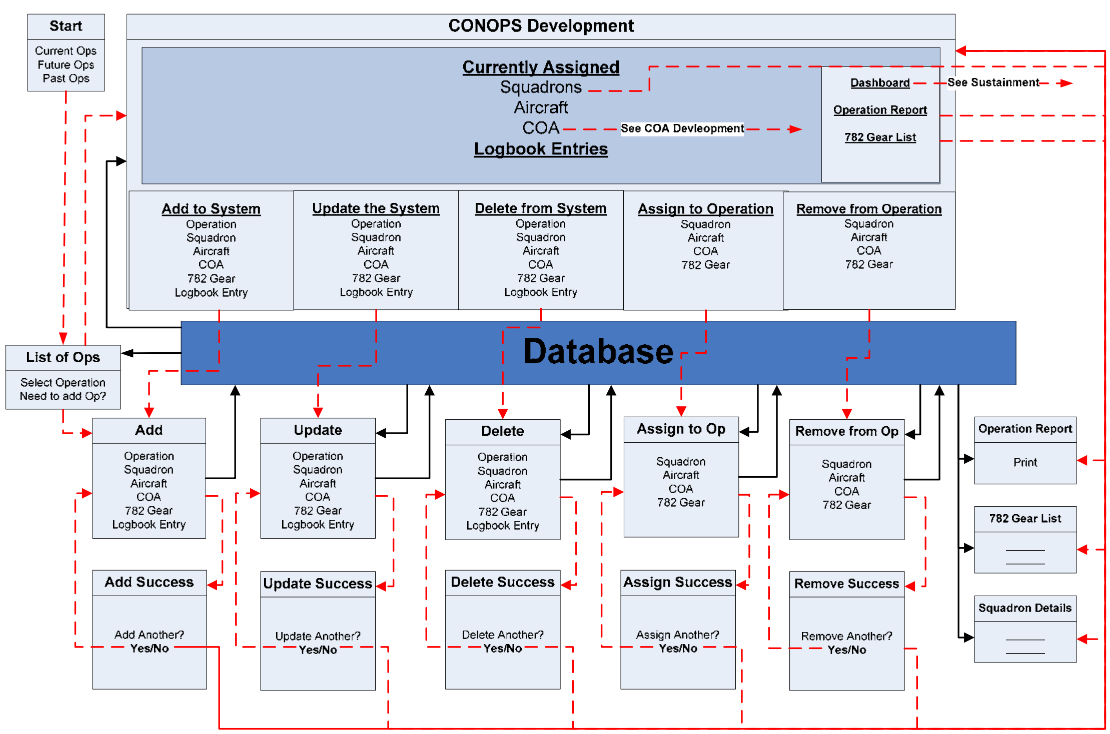


Figure 25. Concept of Operation Development Process

c. Course of Action Development Process

The Course of Action (COA) development process is the second of three MAPSS processes, and is the core capability of the MAPSS prototype. The COA development process is an essential and required step in the Marine Corps Planning Process (MCPP); the intent is to generate multiple options that will satisfy mission requirements and support the overall scheme of maneuver of the MAGTF Commander [17]. The purpose of the MAPSS COA development process is to support the decision-making process of the MALS Commanding Officer by rapidly and efficiently generating suitable and sustainable aviation logistics support packages.

As mentioned in Chapter I, the foundation of all aviation logistics support is personnel, repair parts, support equipment, and mobile maintenance facilities. Thus, MAPSS COA development is centered on the assignment and comparison of those entities. The COA Development page is designed to display all currently assigned personnel, repair parts, support equipment, and mobile facilities for the operation. Consistent with the design and purpose of the other MAPSS processes, the COA development page also has remove, add, update, and delete functionality for personnel, repair parts, support equipment, and mobile facility information.

Implicit in the development of any COA is its distinguishable elements or aspects that make one option different or superior over another given certain circumstances. Such circumstances may include logistical footprint constraints, limited available transportation in theater, time phasing requirements for deployment and execution, or host nation support, to name a few. The MAPSS COA development process was designed to allow the AVLOG planner the ability build robust and distinguishable COA options. Functionality includes the ability to assign notional host nation support, transportation to and from points of embarkation and disembarkation, multiple deployment locations, and an array of mission-specific execution tasks. Effective COA development and comparison is also hastened by aviation logistics support package metrics: weight, square-feet, and cubic-feet of each proposed COA. The COA development page is a concise yet information rich virtual workspace that allows AVLOG planners to introduce as many variables as necessary to develop an array of distinguishable aviation logistics support packages. This capability can only benefit the effectiveness of aviation logistics planning and the subsequent decision by the MALS Commanding Officer. Figure 26 depicts the logical processes of the MAPSS COA development.

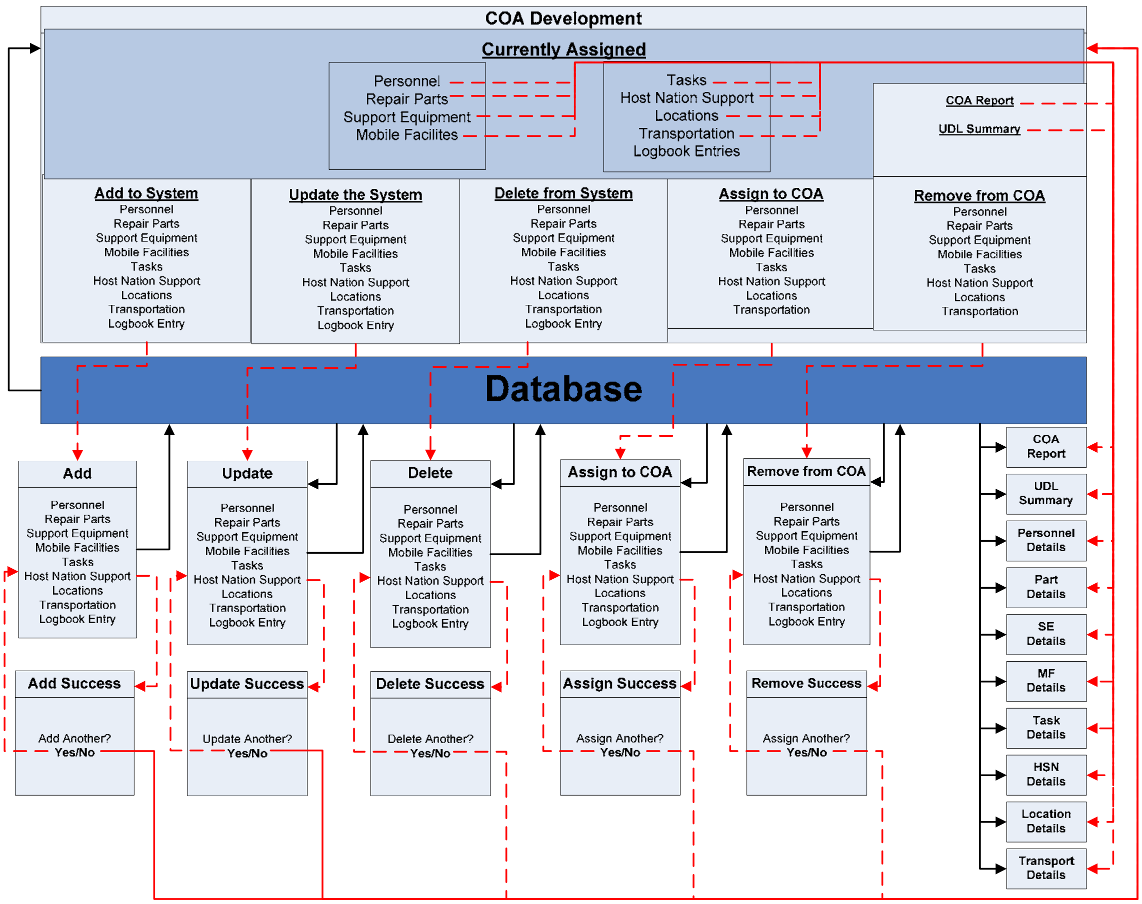


Figure 26. Course of Action Development Process

d. Operation Sustainment Process

Developing and approving plans are only half of the equation. Executing and sustaining deployed forces is vital to mission accomplishment. History is stocked full of examples where efficient and responsive logistical support was the difference between success and failure of a military campaign. The current environment of smaller scale contingencies, asymmetric warfare and distributed inter and intra-theater bases compound the challenges of effectively sustaining friendly-forces. Today's leaders and aviation logistics professionals need a robust decision support tool for today's complex sustainment requirements.

The MAPSS Operation Sustainment process, referred to as the "Operation Dashboard," was designed to provide the leaders at the MALS level with the visibility to synchronize with deployed forces, the ability project future requirements and the functionality to actively engage in logistical sustainment. The Operation Dashboard employs a stoplight model, giving users near real-time visibility on the status of personnel, repair parts, support equipment, mobile facilities, and aircraft. The watch (green), plan (yellow), and act (red) model was designed to allow users to quickly identify potential problems and prioritize any subsequent action, which saves time and valuable resources.

The MAPSS stoplight decision aid is based on mission capability percentages. For example, if a COA has a total of 100 personnel assigned and 10 personnel are currently ill, injured, or unable to perform their duties, then the mission capability for Personnel at that location is currently 90%. Based upon pre-determined criteria set for the operation, 90% mission capability could be a green, yellow, or red light situation, requiring either no action at all or immediate attention. Regardless of the criteria set by the organization, leaders will quickly and accurately know the status of deployed forces and equipment, a major improvement over current manual processes. The mission capability percentages are derived from data maintained in the MAPSS relational database. For personnel, repair parts, support equipment, and mobile facilities, "current status" is documented upon assignment to a COA and updated as required throughout the operation, a function that is provided on the Operation Dashboard interface. Aircraft mission capability percentages, on the other hand, are more complex and derived from the Aircraft Material Readiness Report (AMRR).

The combat readiness of the MAGTF ACE and the sustainment necessary for continuous combat operations is the MALS mission. Thus, the AMRR is the key readiness indicator for a MAGTF ACE and is often regarded as the MALS' report card for an operation. The purpose of the AMRR is record the material support requirements that are currently on order preventing an aircraft from full mission capability status. The AMRR includes information about the aircraft, the part ordered, and the current status of the requisition in the logistics supply chain. The MAPSS AMRR functionality allows users to quickly add, update, and delete requisition data, which in turn is reflected in updated aircraft mission capability readiness percentages and the stoplight indicators. MAPSS provides extensive requisition management features, allowing users, regardless of time and space, to actively engage in the logistical sustainment of deployed forces. This web-enabled interface is dramatic departure from the current redundant and ineffective "flat-file" technology processes used to sustain aviation logistics forces.

In addition to identifying *what* the potential issues are, the Operation Dashboard includes reports that explain *why*, providing more in depth information on each component of an operation. Continuing the above example, a Personnel Report would identify all non-mission capable personnel by name, military occupational specialty, social security number, and reason for their current status. Detailed reports are enabled for personnel, repair parts, support equipment, mobile facilities, and aircraft; an executive summary is also available. Moreover, MAPSS reports are printer-friendly, so users have the option to view them online or print them at their convenience. The MAPSS reports provide clear and relevant information and, most importantly, another layer of decision-support for the aviation logistics community.

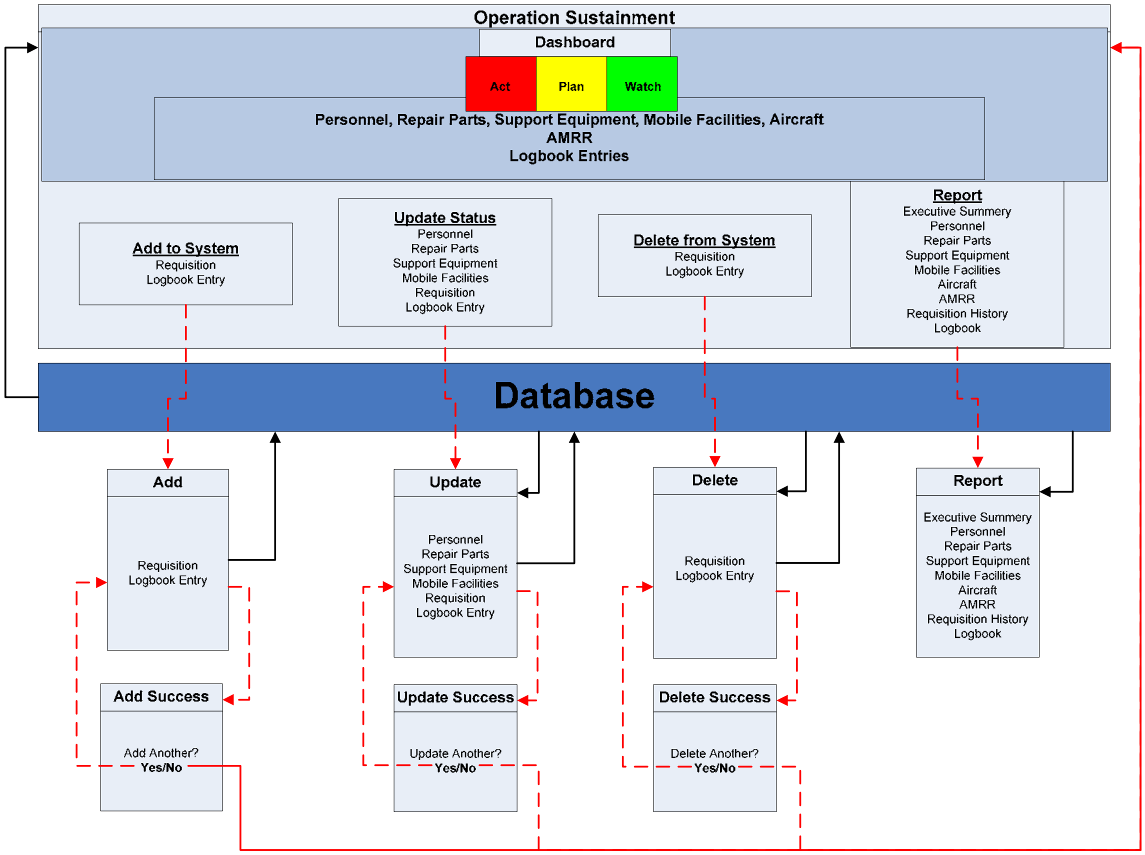


Figure 27. Operation Sustainment Process

This chapter discussed the RAD methodology and the significance of Microsoft Access 2003, Microsoft Visio 2003, and Macromedia Dreamweaver MX 2004 as development tools. This chapter also presented the graphical representations of how data is physically stored in the relational database and how data is manipulated and processed to accomplish system requirements for the aviation logistics warfighter. Although models represent a view of reality, it is the implementation and deployment of a system that determines the level of reality that has been met, which is the topic of Chapter V.

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V. PROTOTYPE IMPLEMENTATION AND DEPLOYMENT

This chapter discusses interface and web design features that were considered during the implementation of the MAPSS prototype. Deployment feedback received by the aviation logistics professionals that agreed to participate in this researched is also discussed.

This chapter is organized as follows. Section A describes the importance of typography, color scheme, cascading styles sheets, templates, navigation and information structure in web design; and Section B discusses the benefits of end-user interaction within the prototyping process, and then describes the positive feedback and constructive criticism received for the first iteration of the prototype.

A. INTERFACE DESIGN CONSIDERATIONS

Designing the user interface is vital to the success of any web-centric application; it is the difference between a system that gets used regularly, reluctantly, or not at all. In addition to the user's functional needs and system requirements, there are some universally accepted concepts of web design that should be considered: (1) clear and readable typography, (2) consistent color scheme, (3) effective navigational structure, and (4) logically organized information.

1. Typography and Color Scheme

In broad terms, typography refers to the use of typeface and font, the former is the style of text (i.e. Times New Roman, Arial and Verdana) and latter is the physical size of the typeface (i.e. 10, 12 and 14 point font). Typeface and font sizes should be considered and selected early and maintained throughout the development process, using too many techniques at one time only leads to screen clutter and the impression of confusion [16]. Both typeface and font size, if used consistently, provide an effective and legible web interface for users.

Color scheme is another important consideration. When used properly, color can enhance the presentation of your information, providing structural and navigational clues for the user. Conversely, poor use of color distracts from content and can annoy users [18]. Color schemes and the subsequent effect on the user's cognitive processes is a highly specialized and technical field, which is beyond the scope of this thesis. A good rule of thumb, however, is to select contrasting colors for text and backgrounds. To maximize legibility, light colored text against dark backgrounds or dark colored text against light colored backgrounds should normally be used.

Both typography and color scheme were a deliberate design consideration in the development of the MAPSS prototype. Verdana was selected as the typeface. It is an appropriate typeface for web applications because it is an expanded typeface, meaning that each letter takes up more horizontal space on the page making it much easier to read (and thus comprehend) compared to other typefaces. The tradeoff, however, is that it may increase the vertical length of web pages and lead to the use of the scroll bar to see all of the presented information. For the MAPSS prototype, the positives outweighed the negatives; dark colored (#990000) Verdana typeface against a light colored background (#FFFFCC) was chosen. The following figure illustrates the typography and color scheme for MAPSS prototype.

Figure 28. Typography and Color Scheme

Font sizes were also considered in the development of the prototype with the purpose of maintaining consistency. Font sizes are important not only for legibility purposes, but also because they provide hierarchical structure and act as navigational clues for users to effectively traverse the system. Font sizes can be used to separate major sections of text such as headings and sub-headings or be used to display system functionality such as hyperlinks.

The basics of web design, clear and readable typography and a consistent color scheme, is easily implemented and maintained by recent improvements in web development technology. Two examples are the use of templates and cascading style sheets (CSS). Templates are used to maintain static or unchanging aspects of pages within a site (i.e., graphics, images, and navigational links) while allowing developers to add content to "unlocked" sections of pages [19]. The end result is a consistent intra-site web design and not the perception of multiple web pages linked together. Dreamweaver MX 2004 provides excellent functionality for using templates, which includes creating, updating, and, if needed, quickly removing templates from web pages. The following figure depicts the MAPSS template that was used throughout the development process to create the consistent "look and feel" for the prototype.

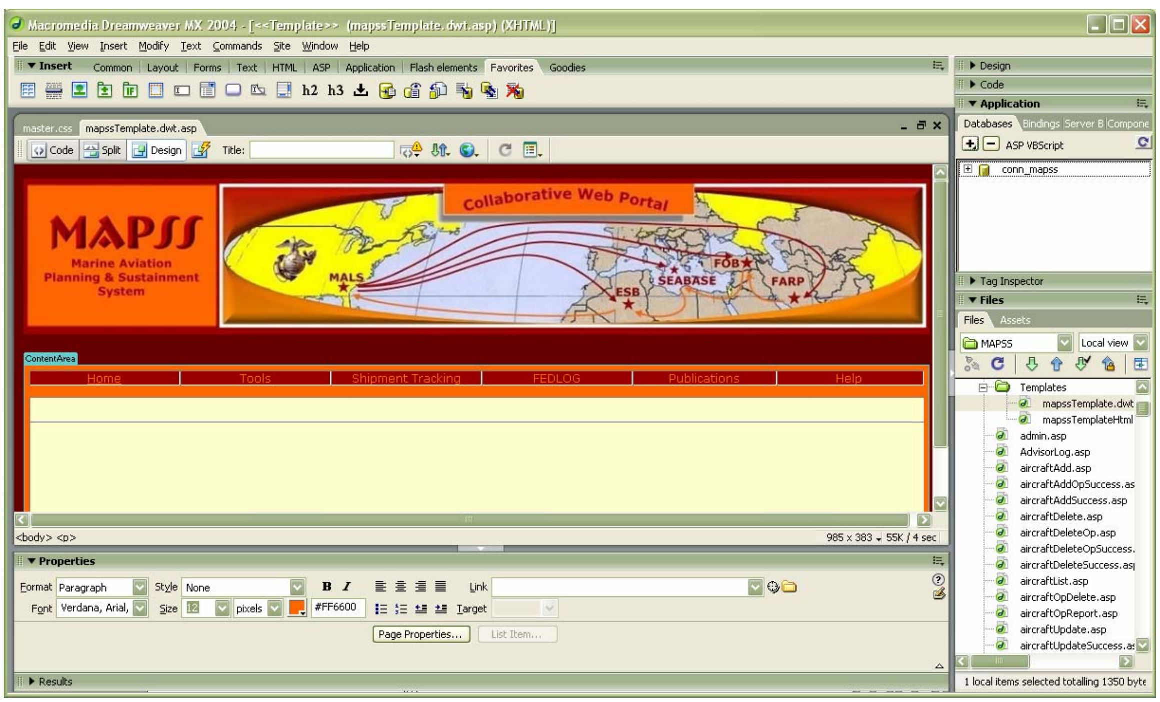

Figure 29. Template Displayed in Dreamweaver MX 2004

Another important web technology is Cascading Style Sheets (CSS). In fact, "CSS is the preferred method of controlling the layout and design features of a modern web site" [19]. CSS is best described as an external set of rules that can be applied to as many web pages as needed—literally thousands. CSS are the blueprints of how information is displayed on a user's screen. This is a powerful and extremely efficient tool for web developers. For example, an organization may want to update or change its theme on all of its web pages, maybe change from a Times New Roman to an Arial typeface. Using CSS, this can be done in a matter of minutes simply by editing a single style sheet. Comparing this process to those in the past, where changes were laboriously made to each and every web page, the benefits and efficiency of using CSS quickly become apparent. CSS is rapidly revolutionizing web design and site maintenance; it allows organizations to efficiently control the style and theme of their web presence in a dynamic environment, which in today's highly competitive atmosphere can be the difference between prosperity and mere survival. CSS was used in the development of MAPSS. All regular text, headings, hyperlinks, menus, textboxes, forms and tables for the prototype were developed and maintained using a master style sheet. Although all web developers can benefit from the use of CSS, it is especially conducive for developing prototypes where numerous changes are expected and expected often.

2. Navigation and Information Structure

Typography and color scheme are only one aspect of user interface design; a well-organized navigational structure and logically organized information are vital attributes for an effective web-centric application. In *Principles of Web Design*, Joel Sklar outlines the requirements for creating usable system navigation: (1) users should always know where they are, (2) users should always know where they can go, (3) users should always know how to get there, and (4) users should always know how to get back to where they started. The author also leaves little doubt about the importance of logically organizing information on the web page: "information design is the single most important factor in determining the success of your site" [18].

As discussed in Chapter IV, MAPSS consists of three modules; therefore, the navigational structure of the application is aligned with the functional requirements of developing Concepts of Operation (CONOPS), Courses of Action (COA), and sustaining deployed aviation logistics forces. An intentional development strategy for the prototype was to incorporate a navigational structure that was consistent with the natural workflow of current planning and sustaining processes of the MALS. The following figures illustrate the interfaces of the three modules of the MAPSS prototype.

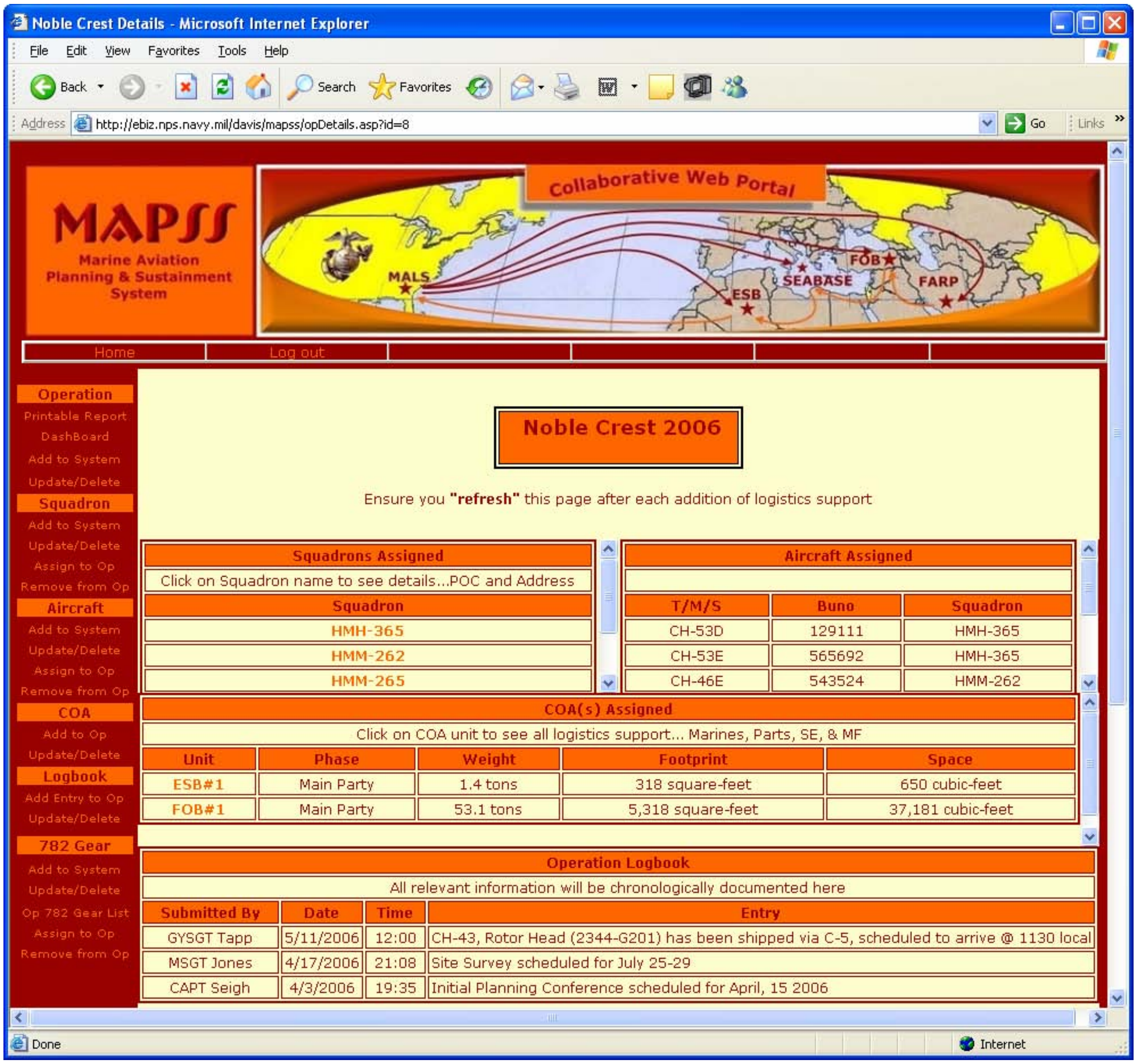

Figure 30. Concept of Operations Development Page

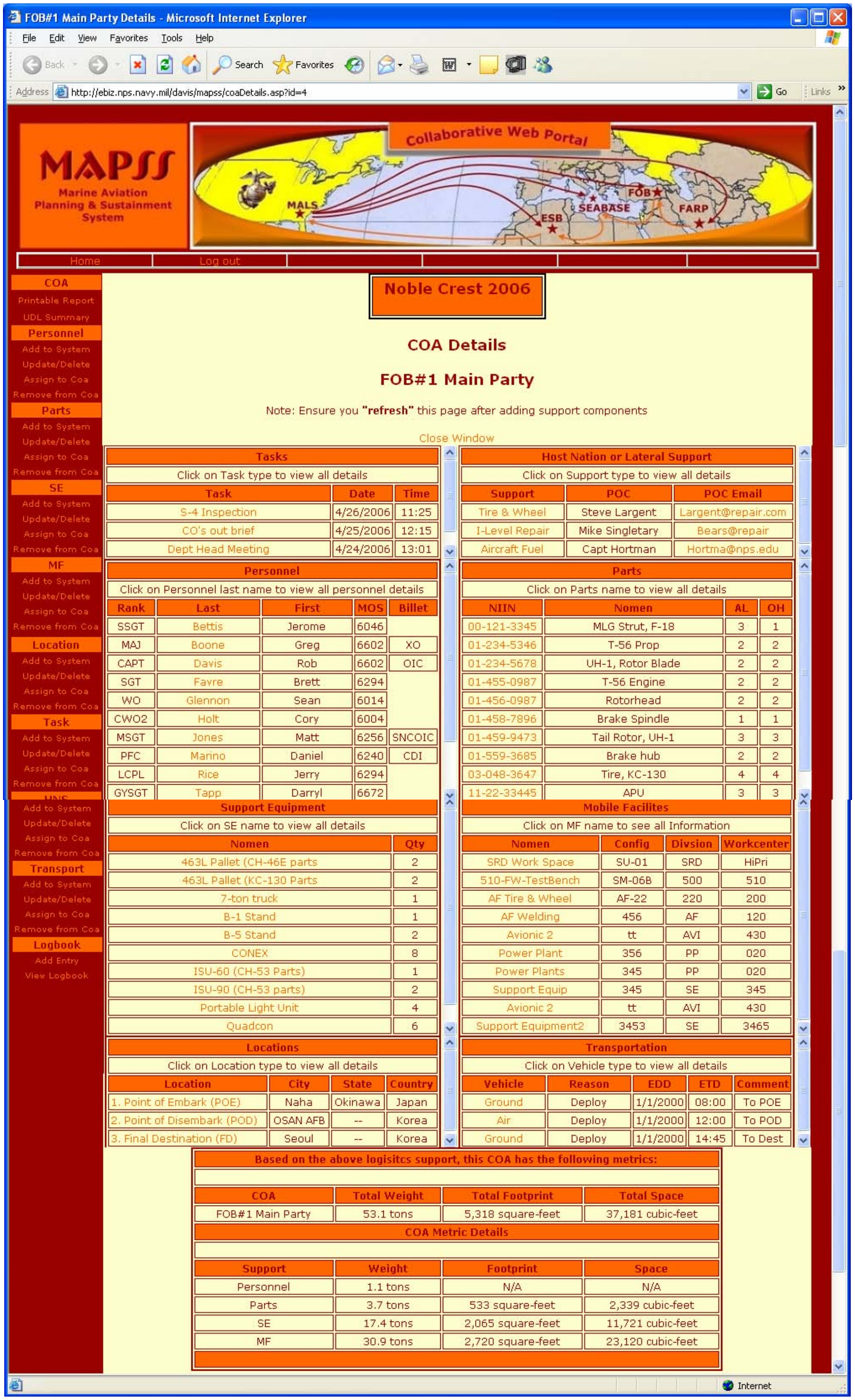

Figure 31. Course of Action Development Page

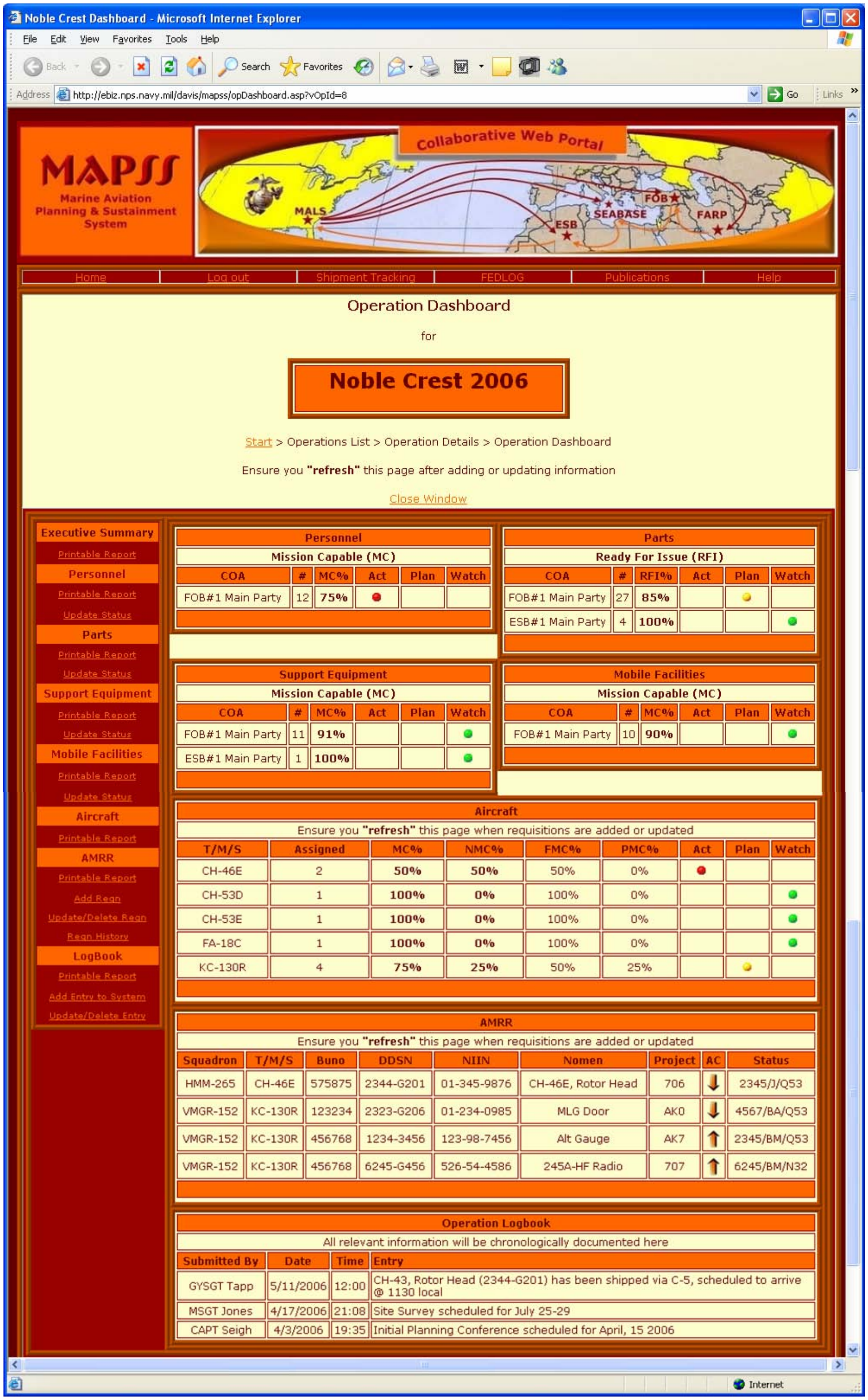

Figure 32. Operation Sustainment Dashboard

The figures above reflect a coherent navigational structure and a logically organized text-based informational design. All three modules are consistent, each having a navigation side-bar on the left side of the page and relevant text-based information arranged in table format, which is neatly framed within color-coded blocks with appropriate headings describing the enclosed content. The position of the navigation bar on the left side of the page is a proven web usability technique. In a recent usability study of both novice and experienced web users, over 60% of the users *expected* internal links to be positioned on the left side of the page [20]. Hence, the design of the MAPSS system takes advantage of a familiar web navigation convention for both novice and experienced users.

The MAPSS prototype also measures well against Sklar's criteria for usable system navigation. First, users of MAPSS should not have a problem identifying "where they are" in the system. Every web page has clear headings at the top of the page which describes its purpose. Location paths are also employed to assist users in maintaining their orientation within the system. The following figure depicts the concept.

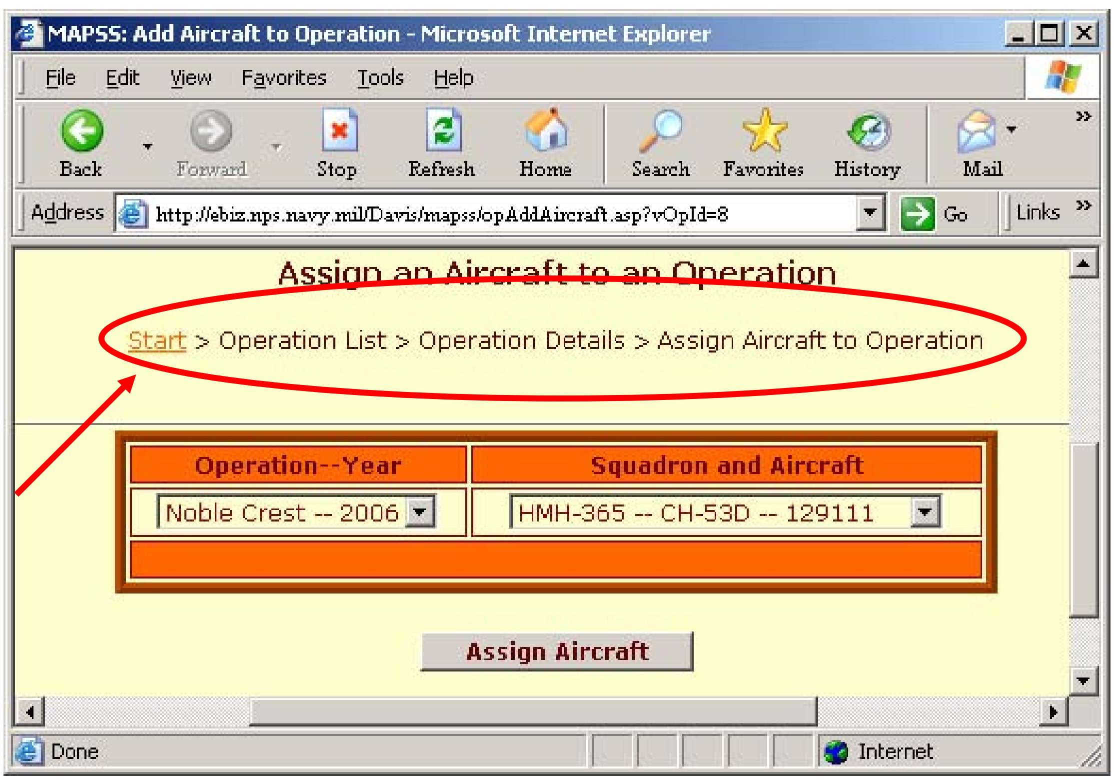

Figure 33. Use of Location Paths

Location paths are an effective design technique to aid users with system situational awareness. In the example above, the user has navigated from the Start page, to the Operations List, Operation Details, and currently working with the Assign Aircraft to Operation page. The location path in the figure above also serves a dual purpose, which conforms to Sklar's fourth criteria: "Users should always know how to get back to where they started." Part of the location path is a hyperlink back to the Start page of the system, the launching point for all modules of the MAPSS prototype. In addition to location paths, a "home" hyperlink is also provided on each page under the MAPSS banner.

Sklar's other two measures of effectiveness, users should always know "where" they can go and "how" to get there, are accomplished as well. As previously discussed, each system module has a navigational side bar located on the left side of the web page that contains all relevant "where" information for that module's functionality. The fact that all the "where" information is also a hyperlink inherently provides the "how" information as well. Furthermore, all of MAPSS' functionality is accessed from just three web pages, so the user's situational awareness is easily maintained and any "where" and "how" information that users may need is just a mouse-click away.

The last two design considerations are related to efficient information structure. As discussed in Chapter III, current aviation logistics planning is a manual and time consuming process resulting from the lack of systems integration; planners are required to access multiple information management systems to source aviation logistics support plans. By far, the most significant aspect of the MAPSS prototype is the four-into-one system integration design; MAPSS combines the data sets from four different systems into one logically organized user interface. The COA development page, depicted in Figure 31 above, demonstrates the systems integration concept, where information on the page represents integrated data for entities (from system): Personnel (MCTFS), Repair Parts (NALCOMIS), Support Equipment (IMRL), and Mobile Facilities (TBA). This functionality alone has the potential to be a mission multiplier and increase the efficiency of planning and sustaining deployed forces.

The last design consideration is the presentation of the information. System requirements are essential for any system design; however, location of the user and how he/she interfaces with the system is equally important. With this in mind, MAPSS was designed as a low-bandwidth system; the interface is predominately text-based. Although detailed graphics, multimedia and other interactive features attract and make web sites more aesthetically appealing, these features come with a cost—bandwidth. Bandwidth is a precious commodity in the armed forces, especially for deployments in austere locations. As result, the MAPSS prototype was intentionally designed to maximize the bandwidth-friendly characteristics of text. The prototype was designed for a baseline 56K bps data connection, which is a common constraint in today's environment using organic communications such as the INMARSAT system, aboard an LHA/LHD with a MEU, or operating on a T-AVB ship. MAPSS, as a text-based system, allows users to quickly access and complete necessary transactions which lead to an increased combat readiness of the MAGTF ACE. Deployed aviation logistics personnel cannot be hindered by time-consuming downloads of images, graphics or multimedia in their march for mission accomplishment.

B. PROTOTYPE DEPLOYMENT AND FEEDBACK

The benefit of the RAD methodology is the iterative process of designing, testing, and refining the potential system. User involvement is the cornerstone requirement for every prototype. Both developers and users benefit from the interaction. Developers can identify and solve design and functionality issues earlier in the system development process, which is conducive to delivering a system on time and on schedule. Users, on the other hand, can identify and refine actual system requirements before the system is delivered and does not do what was expected or needed. "The basic principle behind prototyping is that users know what they want when they see it working" [10].

1. Prototype Deployment

The active end-users for the first iteration of the prototype were Operations Officers from MALS-11 and MALS-36. Both field-grade officers agreed to participate in this research and provide the necessary feedback on the prototype. As mentioned in Chapter III, MALS Operations (S-3) Officers are the lead planners for aviation logistics at the tactical-level; hence, they are primary intended users of the system.

The ideal situation for any prototype implementation is face-to-face interaction between the developer and the user. Face-to-face interaction allows developers to clearly explain and demonstrate the system and provide any necessary training. For much of the same reasons, users benefit from face-to-face interaction because it is an opportunity to get important questions answered quickly and clearly express any issues, problems or suggestions that arise with the system. Overall, face-to-face interaction is beneficial to all involved and sets the tone for smooth transitions of future prototype iterations. Unfortunately, face-to-face interaction was not a possibility for the MAPSS prototype. Funding, operational tempo and the geographic divide made face-to-face interaction for this iteration improbable. Considering the prototype is a web-enabled application, however, the impact was lessened considerably. Users accessed the system via the Internet, which was a test of system design and capability in and of itself.

The MAPSS prototype was hosted on a web server in the Database and Web Technologies Lab at the Naval Postgraduate School. The web server provided unlimited and uninterrupted access during the development and deployment of the prototype. Before access (username and password) was granted to users, a pre-deployment brief was provided to both squadrons. The intent of the brief was to explain the purpose of the prototype, discuss the design of the system, and define all system functionality. Conceptual data models, logical process models, and multiple screenshots of the system were provided. Users were encouraged to get all questions answered when arisen, either prior to accessing the system or during the evaluation period.

The deployment of the first version of the MAPSS prototype had the following objectives: (1) confirm initial systems requirements, (2) collect any new or refined system requirements, and (3) test the usability features of the prototype. To facilitate the evaluation of the prototype, the MAPSS web-enabled application contained several fictitious operations, all in various stages of development. Some operations were fully developed, meaning all modules (CONOPS, COA and Dashboard) contained data while other operations were in the initial or definition stage of development. Users were instructed to browse and test all functionality of the system. They were given the freedom to add, update, delete, assign, and remove data as they saw fit. Users were given a two-week period to evaluate the first version and provide the necessary feedback on the system. Although face-to-face interaction did not occur, the evaluation period was considered a success: concise, insightful, and constructive feedback was attained that can be used to further improve the system.

2. Prototype Feedback

a. Positive Feedback

Overall, the feedback received for a first version of the prototype was positive, which was very encouraging. The overarching design concept of using three different modules (CONOPS Development, COA Development, and Operation Dashboard) was favorably received. The following are some positive comments received about the MAPSS prototype:

(1) The ability to compare COA by weight, square-feet, and cubic feet is good feature because limited availability for lift is always an issue for getting AVLOG in theater.

(2) The Operation Dashboard is a nice function for distinguishing problems or areas of concern for personnel, parts, support equipment, mobile facilities, and aircraft. It is a needed element, especially for other horizontal and vertical commands to quickly grasp current status.

(3) The ability to perform material requisition management is a nice feature.

(4) The system is easy to navigate.

(5) The font and color scheme combine to make the system easy to read.

(6) Information was very logically organized.

(7) The low-bandwidth design is a must for operational forces. The interface should be as simple as possible due to the possibility of having extremely low-bandwidth at deployed sites.

b. Constructive Criticism

Like most first version prototypes, there was no shortage of constructive criticism. Successfully implementing all system requirements and having a completely functional system is highly unlikely and simply unrealistic with the first iteration of any prototype. Constructive feedback is essential; it is one of the primary benefits that prototyping has over other system development methodologies. Feedback should be collected, considered, and used to further improve the system. The following is the constructive criticism received on the MAPSS prototype:

(1) Assigning the same personnel, parts, support equipment, and mobile facilities to multiple COA options is a tedious process. The system needs the capability to assign individual support components to multiple COA options with one transaction.

(2) The system should automatically generate a generic COA shell based upon initial CONOPS development. The system needs the capability to import logistics pack-ups or groups of personnel, parts, support equipment, and mobile facilities.

(3) Course of action comparison would be more efficient if displayed side-by-side on a single web page instead of toggling back and forth.

(4) Mouse-over messages are needed for red and yellow lights on the Operation Dashboard, which would explain why mission-capability is low.

(5) Suggest a different but consistent color scheme for each logistics support component. For example, the color blue for parts, gray for support equipment, and orange for personnel information. Color-coding would allow users to quickly identify a particular section of interest.

(6) The CONOPS Development module needs the functionality to add more narrative for an operation, such as commander’s intent, type of mission, and operational assumptions.

(7) The UDL/TPFDD summary needs some refinement to make it MDSS-II compatible.

The evaluation of the first iteration of the MAPSS prototype was beneficial. It revealed that the web-centric application is a viable product that should be further developed to meet the needs of the aviation logistics warfighter. It was an opportunity to assess what the system did well and what areas need improvement. The evaluations by both Operations Officers were instrumental in paving the future direction of the system. The road ahead involves more analysis, more development, more refinement, and more testing. This version is just the first of many prototypes that will ultimately lead to a system that satisfies tactical-level aviation logistics planning and sustainment requirements. Prototype development must continue in parallel with the current aviation logistics transformation of the Marine Corps. In short, the road ahead is long but necessary.

This chapter discussed the user interface and web design features that were considered during the implementation of the MAPSS prototype as well as the deployment feedback received by the aviation logistics professionals of MALS-11 and MALS-36. The deployment and subsequent feedback on the first prototype iteration was an essential step in the application's development cycle. Another key research activity accomplished for thesis was a usability study, which is the subject of Chapter VI.

VI. USABILITY TESTING

This chapter describes the methodology, experimental design, and test metrics of the usability study that was accomplished on the MAPSS prototype. The results of the usability study and its contribution towards improving system effectiveness, efficiency, and user satisfaction are also discussed.

This chapter is organized as follows. Section A describes the "who, what, when, where, and why" of the usability study; Section B describes the interaction between test equipment, participants and administrators; Section C describes the test metrics that were captured during the study; and Section D is the analysis of system effectiveness, efficiency, and user satisfaction.

A. METHODOLOGY

The primary objective of the usability study was to evaluate the effectiveness, efficiency, and satisfaction with which specified users can achieve specified goals in a particular environment [21]. The usability test was focused on user interaction as it relates to system functionality, navigation, design, and information architecture, which could then be used as a baseline for future prototype iterations.

The usability test was conducted at the Database and Web Technologies Lab, Naval Postgraduate School, Monterey, California, on May 17, 2006, between the hours of 0800-1300. The study was facilitated by a test administrator and two observers, whose primary responsibilities were to collect test metrics of the study. Five participants were selected on a voluntary basis to participate in the study. Three participants (60%) were Marine Corps Officers with primary military occupational specialties (MOS) in Marine Corps Aviation; two of which were Aviation Logistics Officers, intended users of any future fielded system for aviation logistics planning and sustainment. One participant was a Marine Corps Communications Officer with extensive deployment experience and intimately familiar with the Marine Corps Planning Process (MCPP). The fifth participant was an international officer from the Hellenic Navy. The value of including an international officer in the study, where the English language was not his/her native language, was to capture the overall intuitiveness and ease of use of the prototype.

The usability study was approved by the NPS Institutional Review Board, an entity that maintains oversight when human subjects are involved in any research at the Naval Postgraduate School. Test equipment for the usability test consisted of the following:

- The MAPSS prototype application and supporting Database running under Microsoft Access 2003.
- Client Computer: Pentium III/600 MHz processor, 512 Mb RAM, Microsoft Windows NT 2000 Professional operating system, 15” LCD monitor with resolution settings of 1024 x 768 pixels.
- Host Computer: Dual Pentium IV/2.8 GHz processor, 2 Gb RAM, Microsoft Server 2003 Enterprise Edition operating system.
- Web-browser(s) on Client: Microsoft Internet Explorer v6, Mozilla Firefox v1.5.
- Network: 100 Mbs Ethernet; Client IP address: 131.120.178.78; Host IP address: 131.120.251.70; Domain: ebiz.nps.navy.mil.
- Two Digital video cameras with tripod.

B. EXPERIMENTAL DESIGN

The client workstation was setup with one digital video camera recording the on-screen transactions of the participant, and a second digital video camera was setup to record the facial expressions of the user. Both digital video cameras were equipped with microphones; audio was recorded to capture user comments. All participants signed a consent form and privacy act statement, authorizing audio/video recording for educational purposes and to ensure the identity of each participant was protected against unauthorized disclosure.

Figure 34. Usability Test Experimental Design

The experiment consisted of three phases: Concept of Operation Development, Course of Action Development, and Operation Sustainment. All participants were given scenario-based tasks to complete for each phase of the experiment. Participants were also encouraged to "think aloud," verbalizing their actions, thoughts, and any aspects of the task that may have been troubling to complete. Prior to starting the first phase of the experiment, participants were given five minutes to familiarize themselves with system functionality and navigation.

The administrator was on hand to facilitate the overall experiment and to provide user assistance with the system, if necessary. Participants were instructed to make three attempts at completing a task before requesting assistance from the administrator. Observers were also on hand to record the metrics for the experiment. After attempting/completing all scenario-based tasks, participants completed a post-experiment user survey.

C. TEST METRICS

The following test metrics were captured during the study as a means to analyze the usability and functionality features of the prototype.

1. System Effectiveness

a) Did the participant complete the task successfully? (Yes/No)

b) Did the participant require assistance from the administrator to complete the task? (Yes/No)

c) What type of assistance was provided? (e.g. definition of a term or acronym, clarification of a requirement related to the scenario-based task, and/or correctly navigating to complete the scenario-based task)

d) Number of occurrences for assistance required for completing a task.

e) Number of application or system errors (e.g. incorrect data displayed or a page failed to load).

2. System Efficiency

a) Time (seconds) to complete an individual scenario-based task.

b) Number of mouse-clicks to complete an individual scenario-based task. (e.g. clicks on hyperlinks, web page or browser buttons or icons) Note: a double-click to initiate an action was equivalent to one click.

3. System Satisfaction

a) All participants completed a post-experiment survey.

D. USABILITY TEST RESULTS

1. System Effectiveness

The usability test was designed to examine the major functionality components of the system: CONOPS Development, COA Development and Operation Sustainment. User participation for the study was designed for one-hour duration. Each participant was asked to complete 19 scenario-based tasks encompassing the most significant system requirements. As a result, with five participants in the study, there were a total of 95 (19 x 5) possible tasks to be assessed.

The results of the first metric for system effectiveness were very encouraging. All participants of the study were able to successfully complete all 19 scenario-based tasks. Although 100% of the tasks were completed successfully, assistance from the administrator was required for 20% of the tasks attempted; there were a total of 19 scenario-based tasks, an average of one task per participant where assistance from the administrator was required. Hence, 80% of all scenario-based tasks were completed without assistance. The majority of assistance occurred during the first phase of the experiment: CONOPS Development. Assistance required at the beginning of the experiment was mainly attributed to the general unfamiliarity participants had with the system and its navigation architecture. All participants had never seen or used MAPSS previously and only received five minutes to familiarize themselves with the system prior to the experiment. As the experiment progressed, however, less assistance was required due to the participant's increased knowledge of the system and its functionality.

The next system effectiveness metric that was captured during the study was system errors. The intent was to capture any system bugs or errors in the web-enabled database which would prevent participants from successfully completing a task. Ninety-four (94) of 95 scenario-based tasks were completed without a system error. The single (1) system error occurred during the COA Development phase of the experiment, where a participant attempted to assign a part to a COA. The correct procedure for the task called for assigning a particular part to a COA with both "on-hand" and "allowance" quantities having a numeric value, since both "on-hand" and "allowance" quantities are required fields in the database schema. However, the participant submitted the "assign to COA" form without inputting a value for the "allowance" quantity which resulted in the system error.

The system error was result of the "assign part to COA page" not having the proper form validation procedures implemented, an oversight in the development of the web page. To prevent system errors of this nature, the active server page should first validate that all required fields on the form have acceptable values, and only then submit the data to append the database. This error was quickly corrected by implementing the proper form validation code to the active server page, ensuring that both "on-hand" and "allowance" values had acceptable numeric values before submitting the data to append the database. Nonetheless, the study was completed with just a 1% error rate, very acceptable for a first-version prototype.

2. System Efficiency

The purpose of capturing the time and number of mouse-clicks (amount of effort) it took for participants to complete the scenario-based tasks was to identify trends and potential navigation problems with the usability of the system. In the analysis of the data, three navigation issues were identified by the high standard deviation of time and number of mouse-clicks it took the participants to complete the scenario-based task. Table 2 illustrates the three potential issues identified during the usability test.

Phase	Task	Time (seconds)	Mouse-clicks
CONOPS Development	Assign Squadron to Operation	81.8	6.9
CONOPS Development	Assign Aircraft to Operation	102.3	4.5
COA Development	Assign Personnel to COA	75.5	14.6

Table 2. Potential Issues Identified During The Usability Experiment

The first two issues occurred during phase one (CONOPS Development) of the experiment. Aside from initially logging into the system to start the experiment, assigning squadrons and aircraft to the operation were the first two scenario-based tasks to be attempted/completed. The third issue, assigning personnel to a COA, was the first scenario-based task in phase two (COA Development) of the experiment.

Two factors may explain these potential issues. First, as previously discussed, each participant was given just five minutes to familiarize themselves with the system; hence, initial tentativeness, apprehensiveness and caution were expected and experienced in each phase of the usability test. As the study progressed and participants became more comfortable with the navigation of the system, the standard deviation of time and mouse-clicks to complete each task decreased significantly. For example, scenario-based tasks in phase two required participants to assign personnel, repair parts, support equipment, and mobile facilities to a COA. The standard deviation for assigning personnel alone was 75.5 seconds and 14.6 mouse-clicks, but the average standard deviation for assigning the remaining repair parts, support equipment, and mobile facilities decreased to 22.2 seconds and 5.4 mouse-clicks, a decrease in time and amount of effort of 71% and 63% respectively. This decrease is a clear indication that participants of the usability study were learning the navigation architecture of the system and beginning to use it effectively.

System navigation architecture is another factor that may explain the potential issues identified in Table 2. As mentioned in Chapter V, each module of the system is designed with a navigation side-bar on the left side of the web page that includes hyperlinks to all relevant functionality for that module.

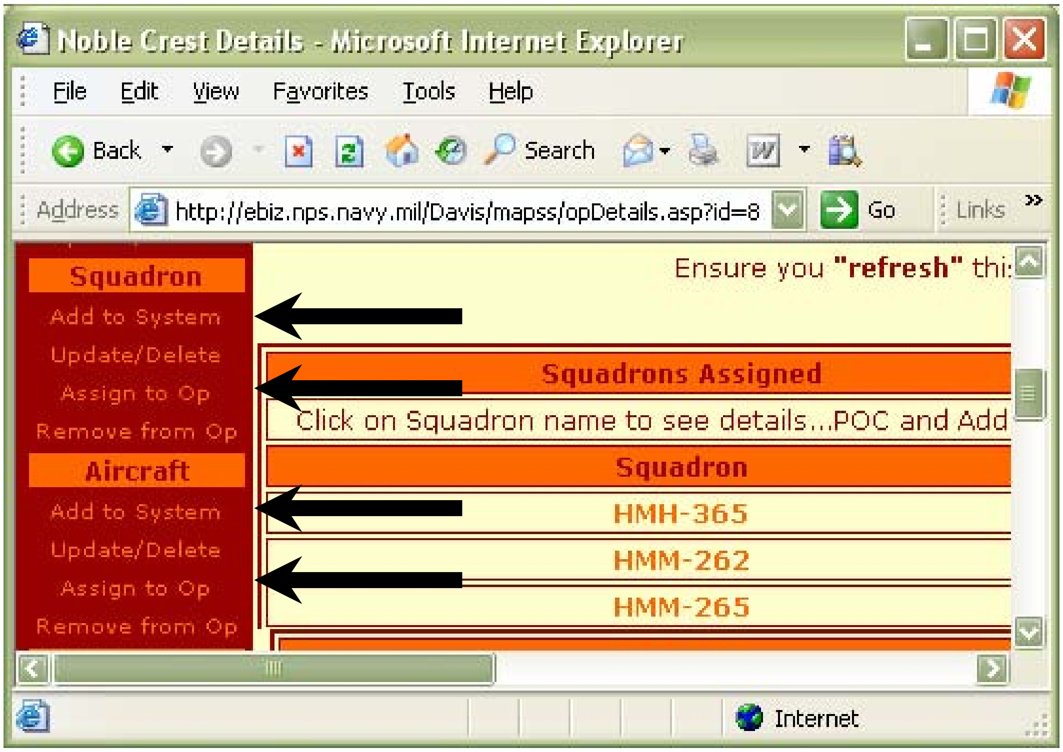

Figure 35. CONOPS Development usability issue

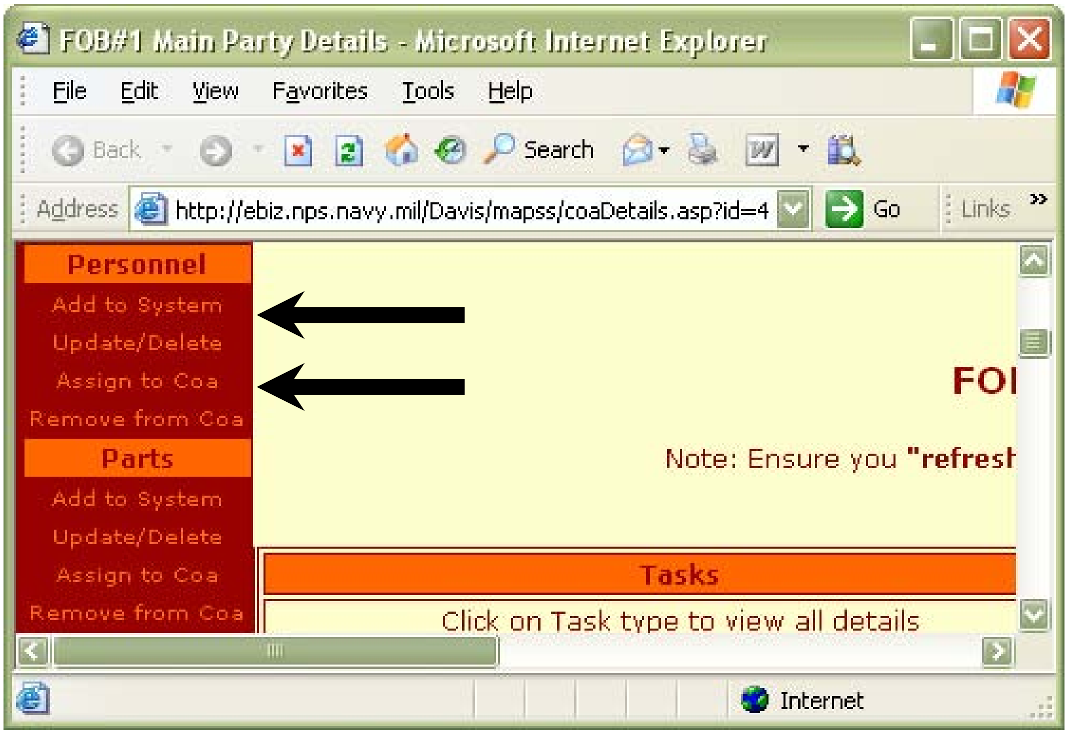

Figure 36. COA Development usability issue

As depicted in Figures 35 and 36, multiple hyperlinks are provided for each component of the module. Although all modules are consistently designed, participants of the usability study experienced problems differentiating between the “add” and “assign” functionality of the system; therefore, a few participants of study spent a considerable amount of time and mouse-clicks incorrectly “adding” personnel to the system instead of correctly “assigning” personnel to the COA.

Future iterations of the prototype may benefit from a re-design of the navigation architecture. One potential solution is to develop a fourth module, a “System Administration” module where basic database management functionality (for all interoperable systems) is included on one web page. This redesign would eliminate all system management functionality from the three primary modules, which could potentially reduce any visual and/or logical ambiguity for users. The trade-off, of course, is a fourth module to design, create, update and maintain. This redesign, however, would have minimal impact on the current data and logical process models of the system. Most importantly, the redesign would be largely transparent to the intended users of the system.

3. System Satisfaction

All participants of the usability study completed a post-experiment survey. The survey was designed to capture the participant's degree of satisfaction with the prototype's functionality and usability features. The survey consisted of 23 questions: 15 pertaining to system functionality and nine questions relating to the general usability features of the system. Participants were asked to indicate their level of satisfaction using a four-point rating scale.

Scale	**Rating**
1	Extremely Dissatisfied
2	Dissatisfied
3	Satisfied
4	Extremely Satisfied

Table 3. Post-Experiment Survey Metrics

Although data from such a small pool of participants did not provide the basis for any significant statistical analysis, it did provide valuable and insightful information that can be used for implementing future enhancements to the prototype. The results from the post-experiment survey were overwhelmingly positive: the average score for system functionality was 3.59 and system usability received a score of 3.40. Both scores indicate that users were "satisfied" with the first version of the prototype. The following illustrations indicate the level of satisfaction from each functionality/usability aspect that was assessed during the study; all respondents completed the survey immediately following the usability experiment.

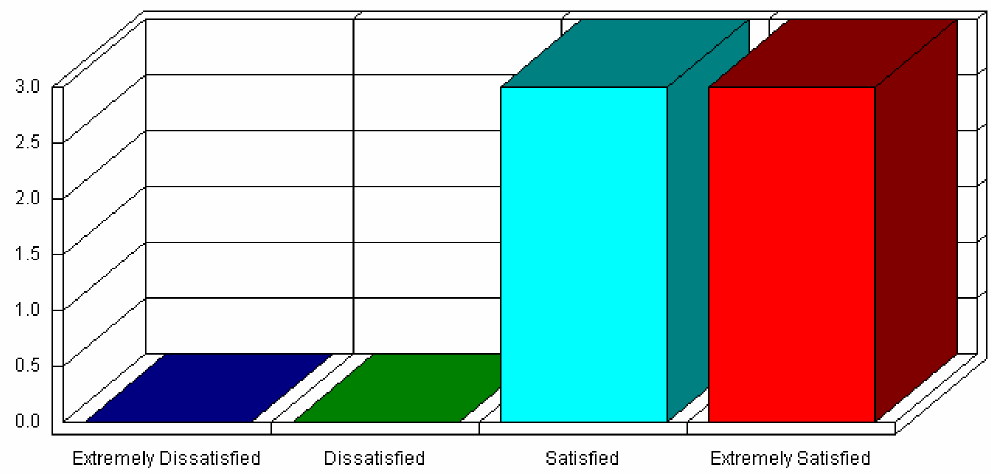

Figure 37. Survey Results: Initiating CONOPS

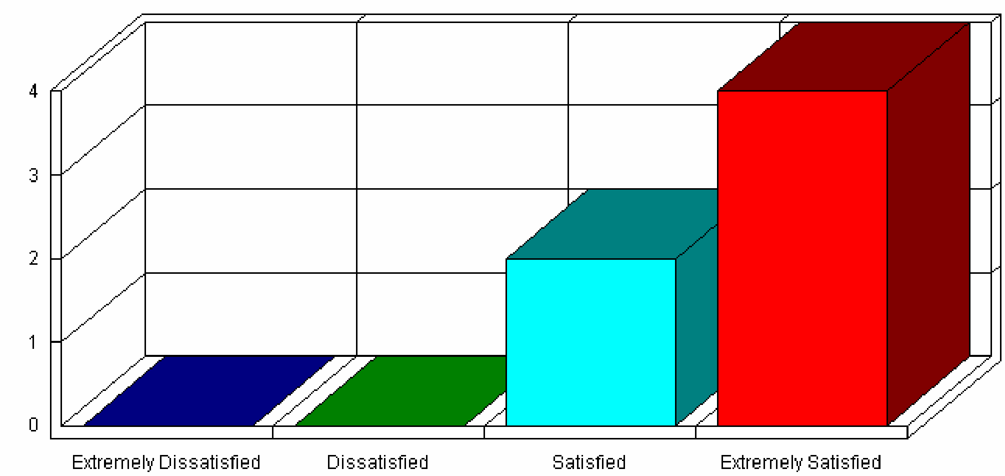

Figure 38. Survey Results: Assigning Squadrons to Operation

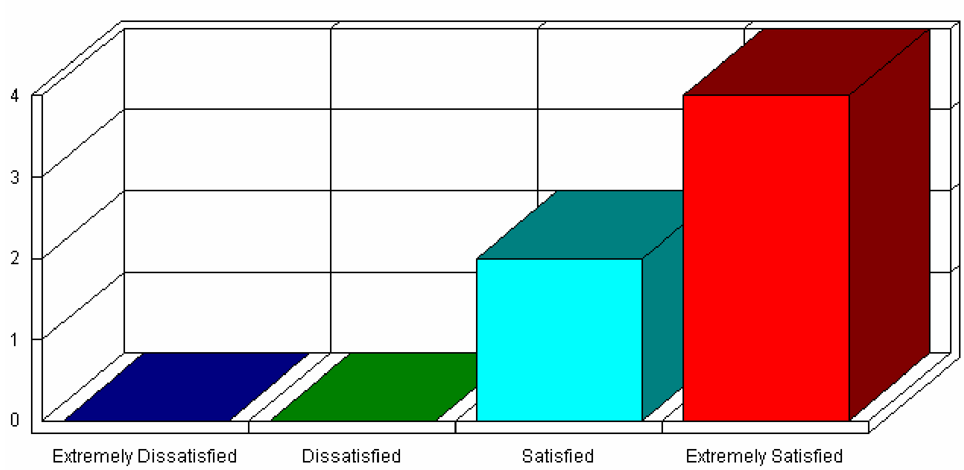

Figure 39. Survey Results: Assigning Aircraft to Operation

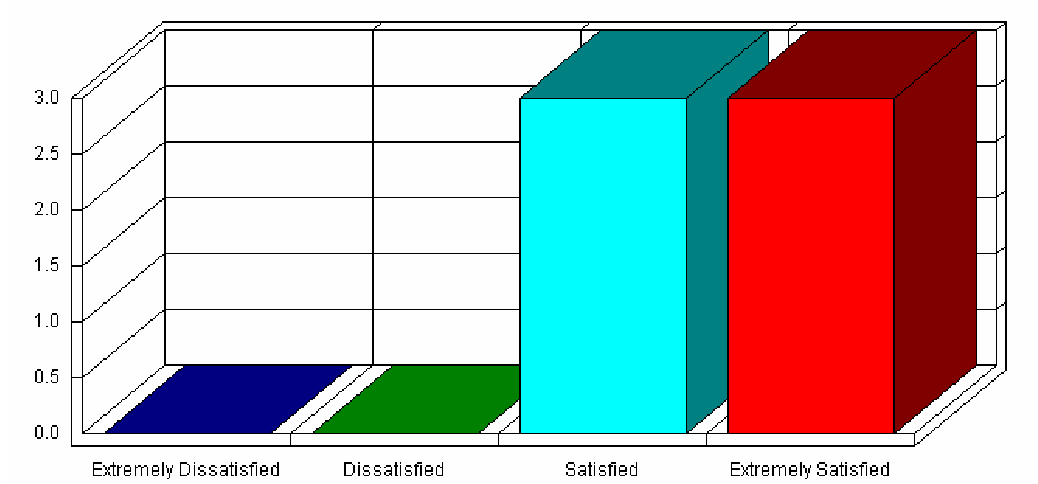

Figure 40. Survey Results: Establishing Multiple COA for Operation

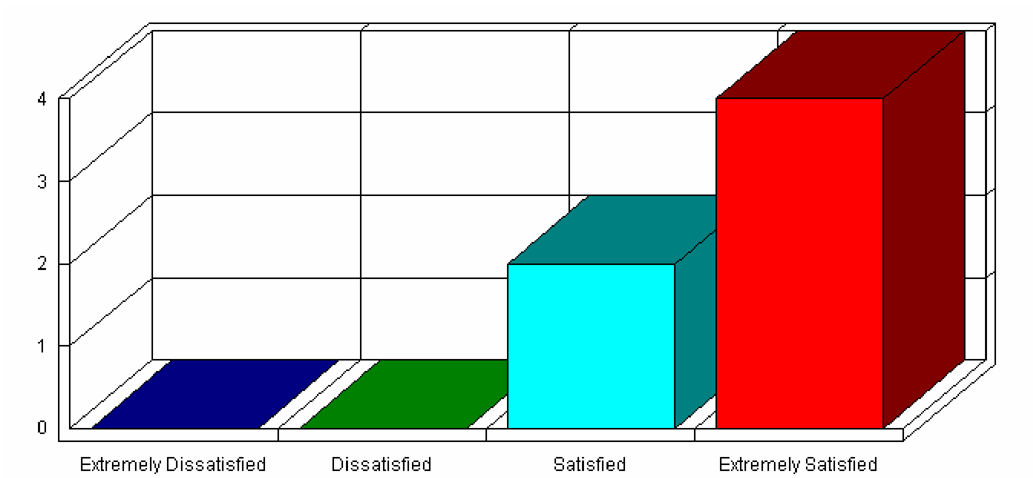

Figure 41. Survey Results: Assigning Personnel to COA

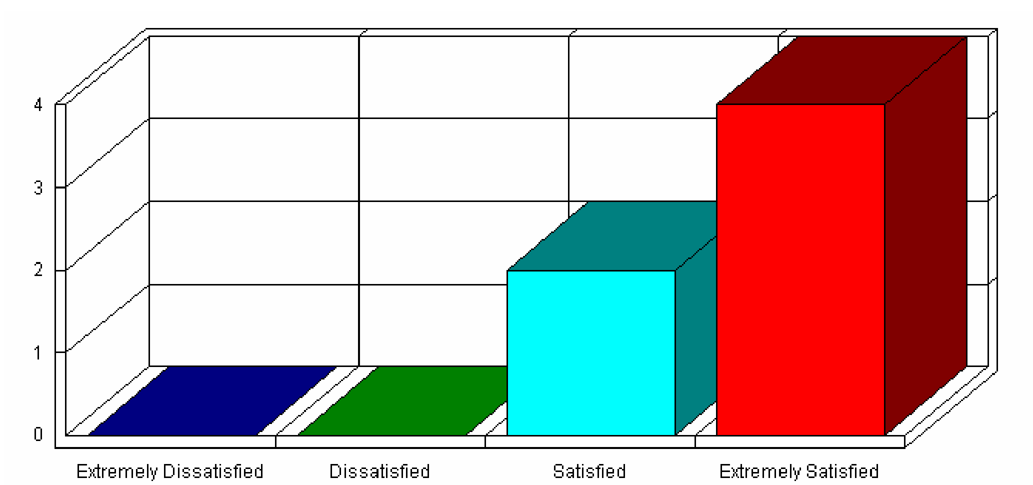

Figure 42. Survey Results: Assigning Parts to COA

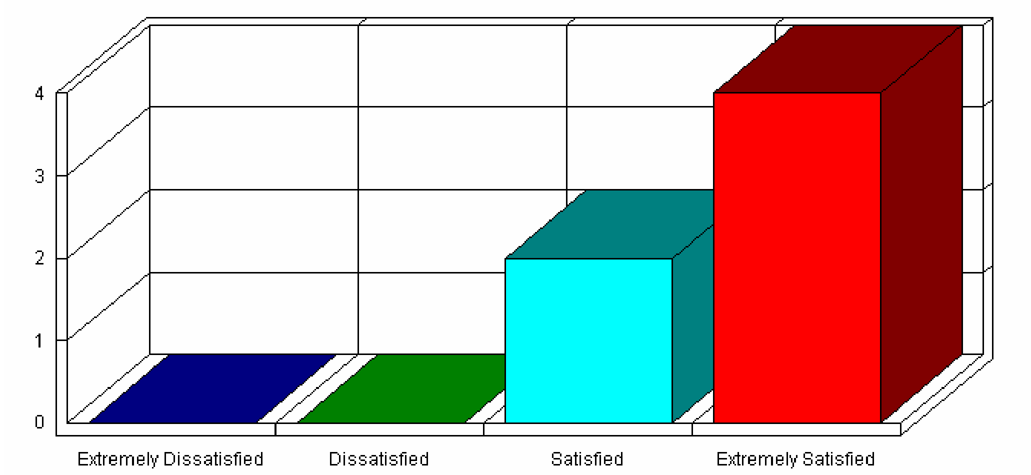

Figure 43. Survey Results: Assigning Support Equipment to COA

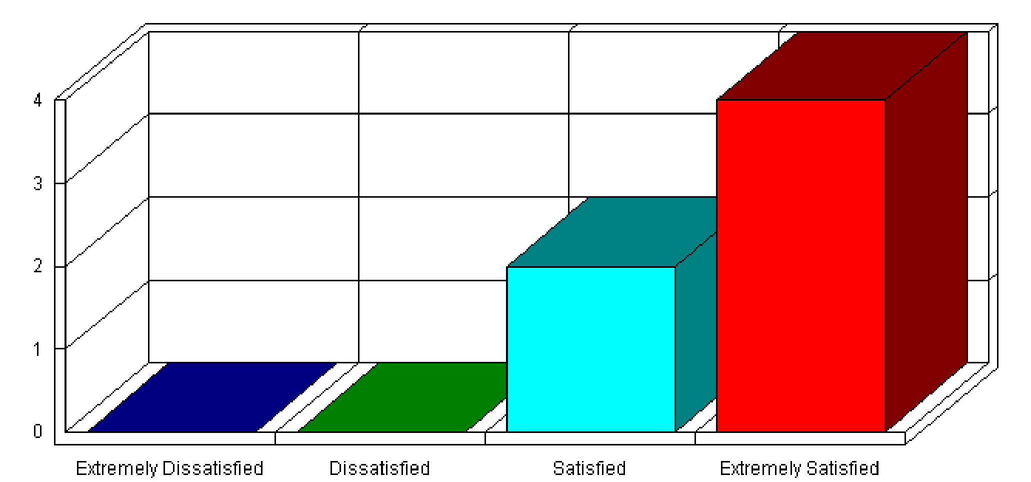

Figure 44. Survey Results: Assigning Mobile Facilities to COA

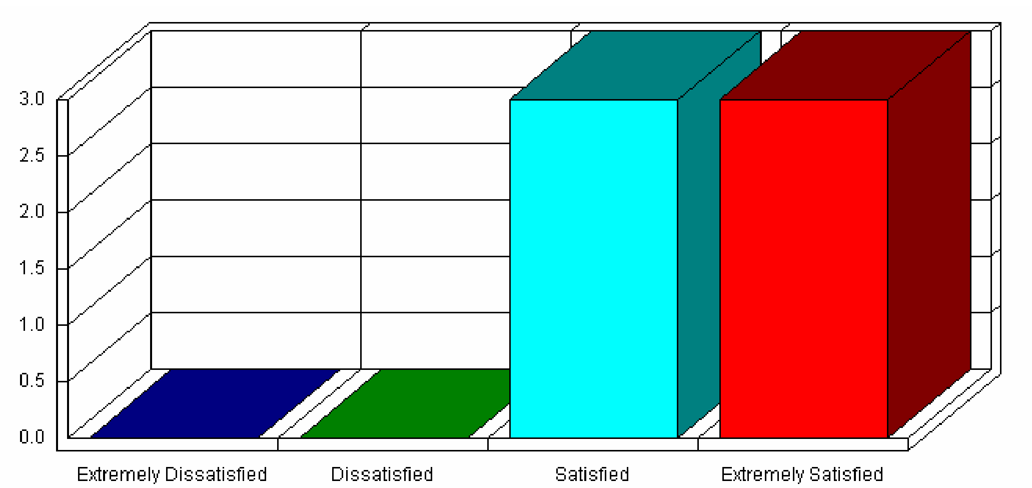

Figure 45. Survey Results: Ability to Compare Multiple COA

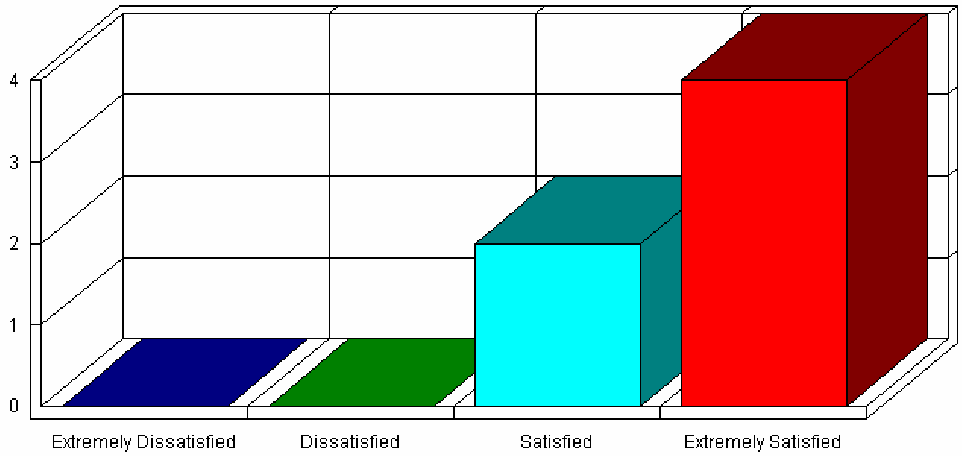

Figure 46. Survey Results: Ability to Distinguish Problems

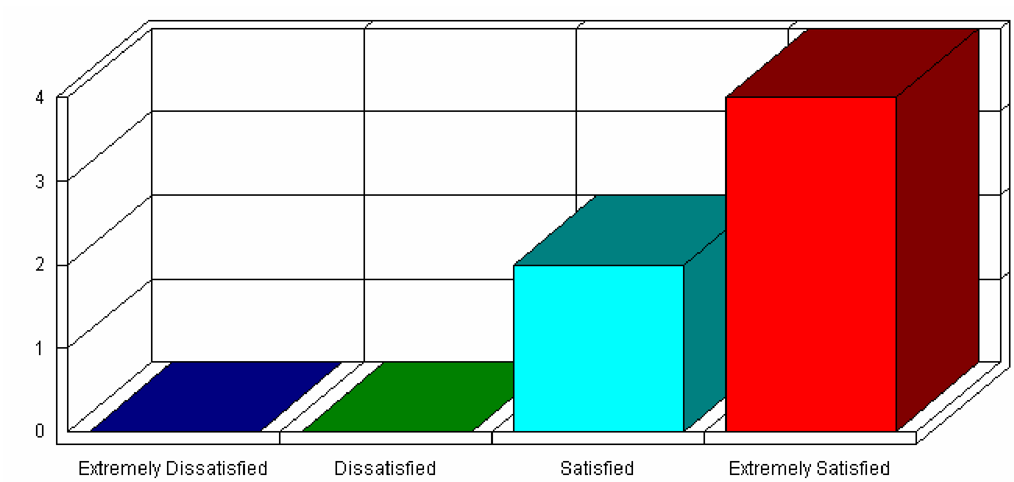

Figure 47. Survey Results: Ability to Determine Causes of Problems

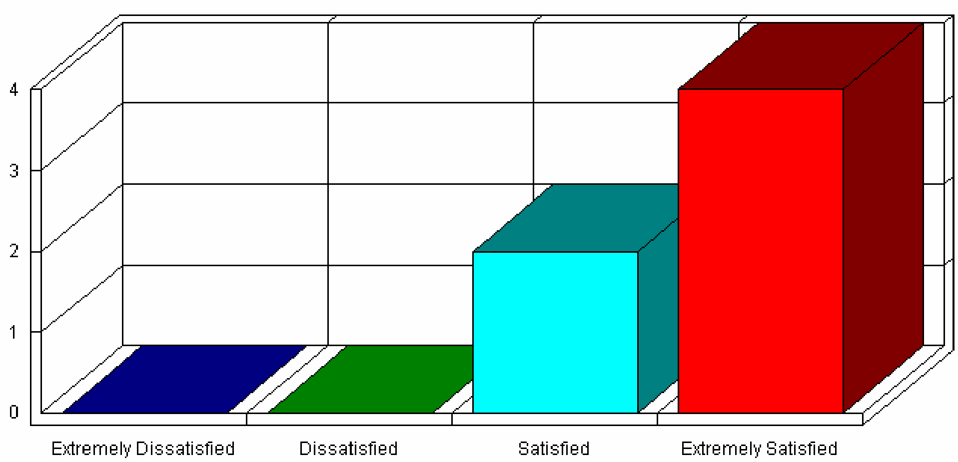

Figure 48. Survey Results: Ability to Identify Mission Capability Percentages

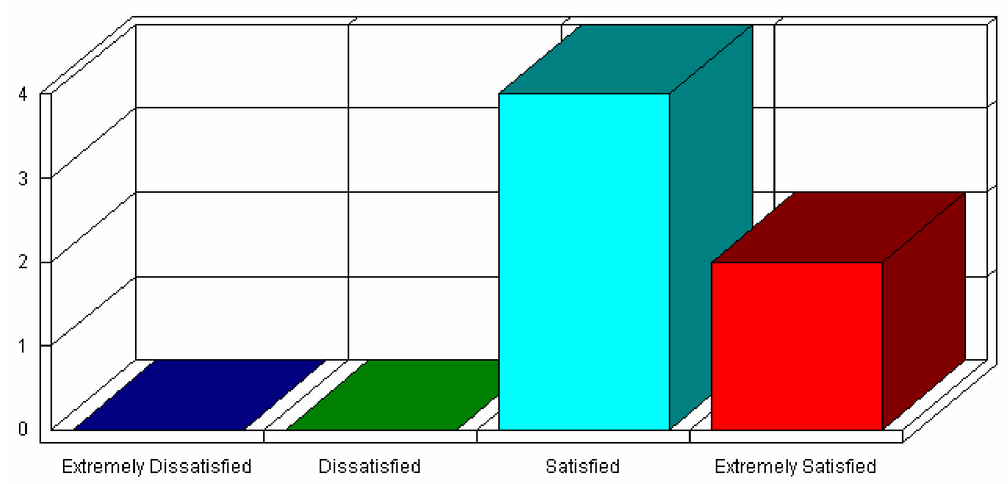

Figure 49. Survey Results: Ability to Modify Material Requisitions

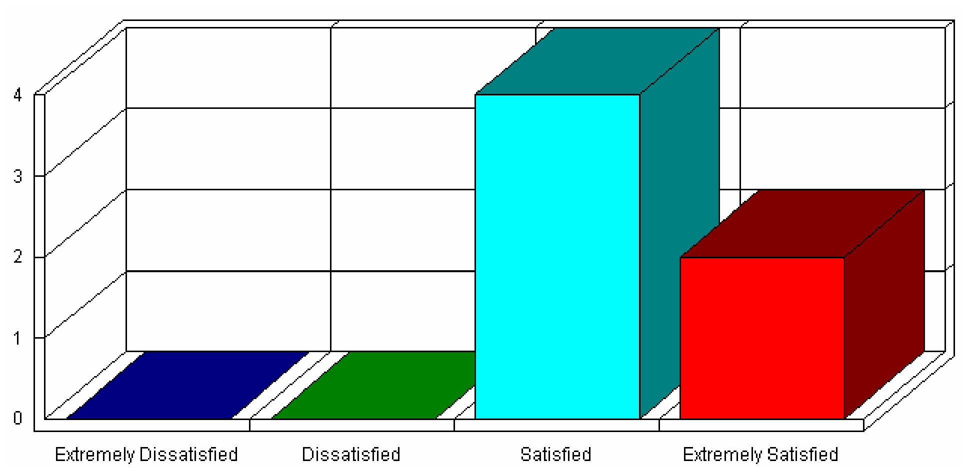

Figure 50. Survey Results: Ease of System Navigation

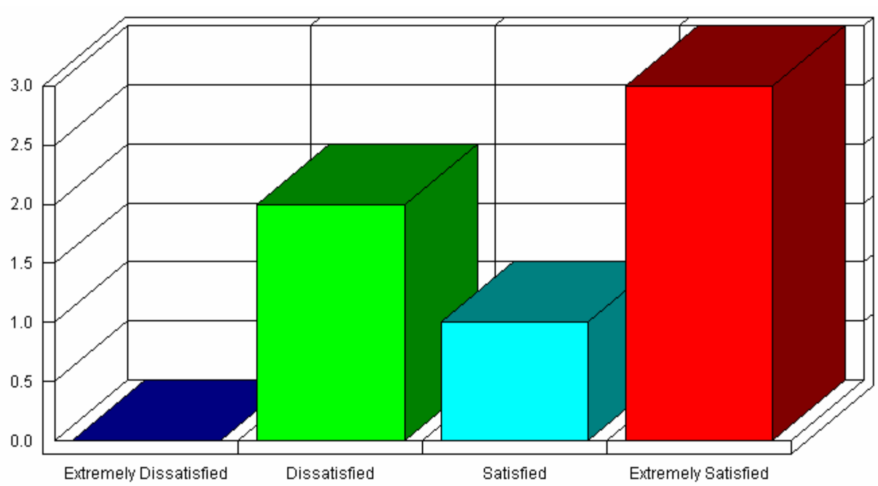

Figure 51. Survey Results: System Feedback Methods

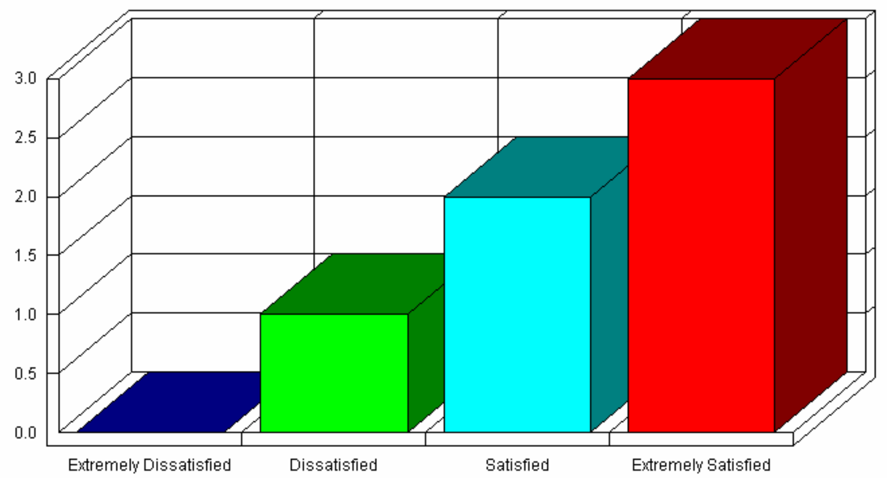

Figure 52. Survey Results: System Typography

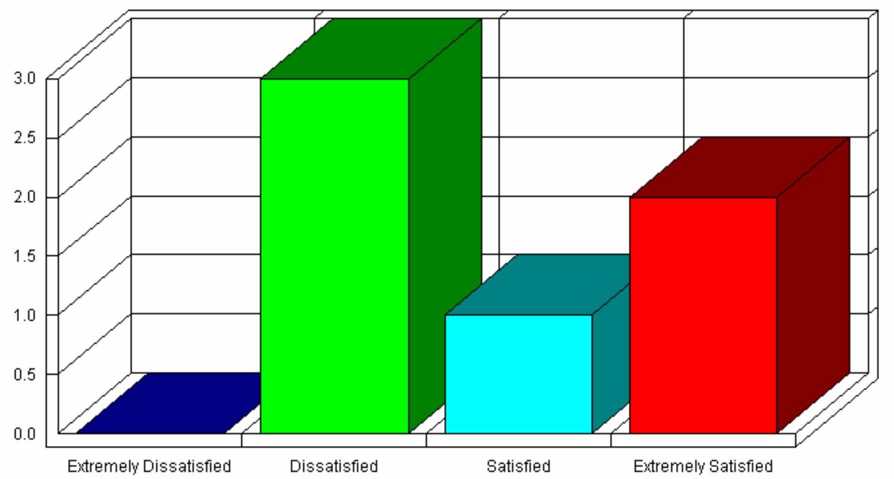

Figure 53. Survey Results: System Color Scheme

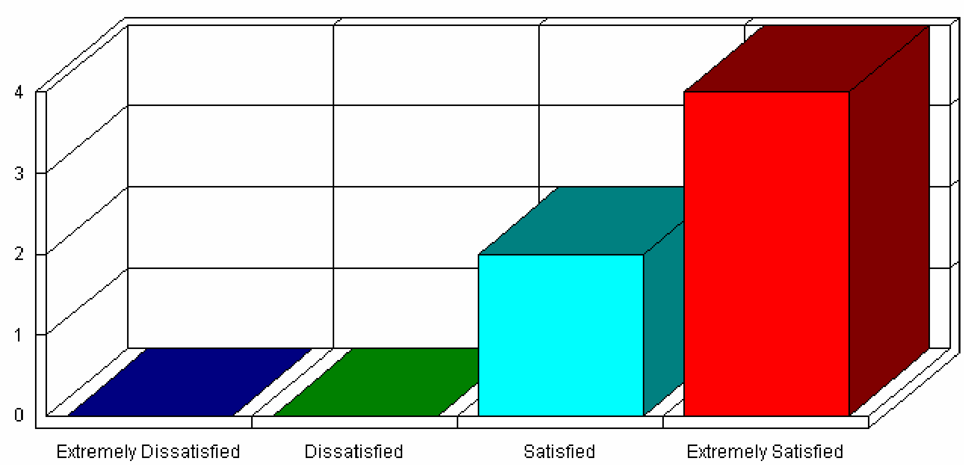

Figure 54. Survey Results: System Structure and Theme

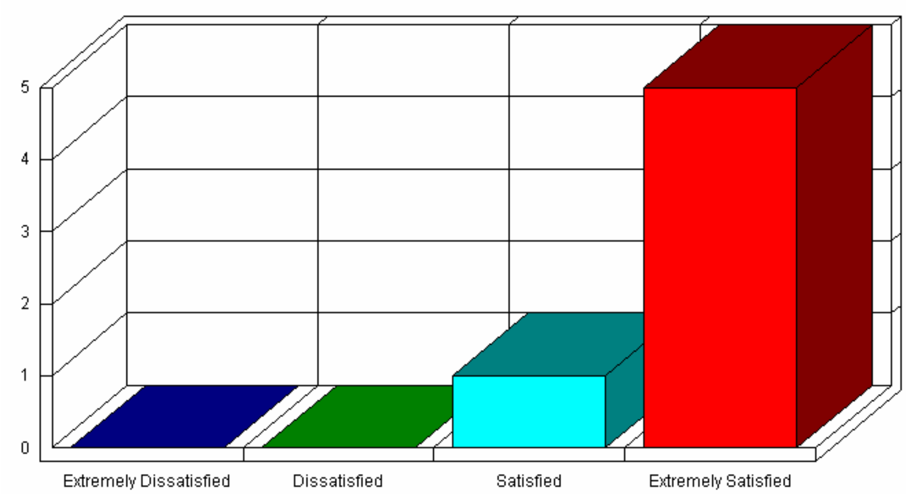

Figure 55. Survey Results: Consistent System Design

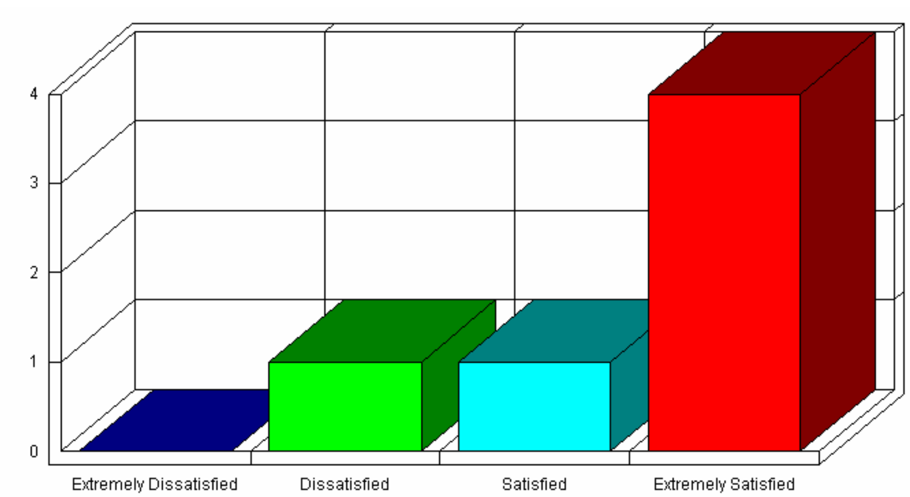

Figure 56. Survey Results: Organization of Information Presented

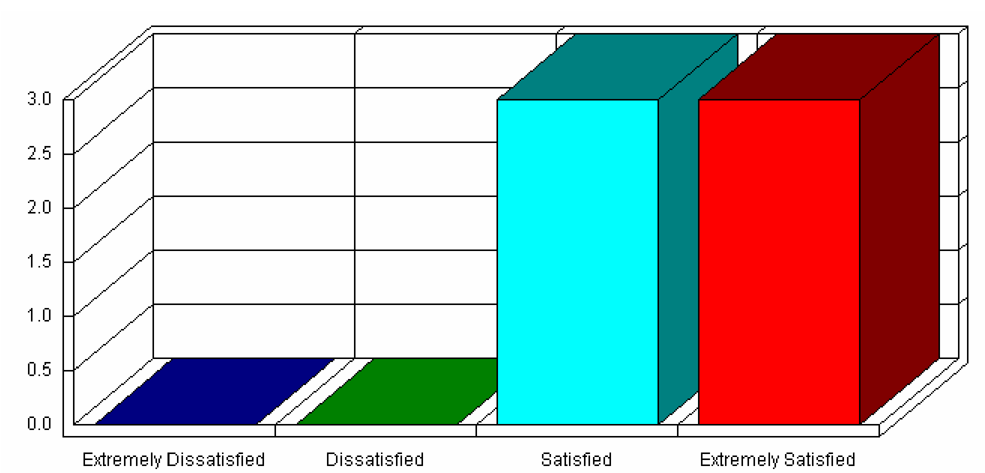

Figure 57. Survey Results: Ability to Drill-Down for Additional Information

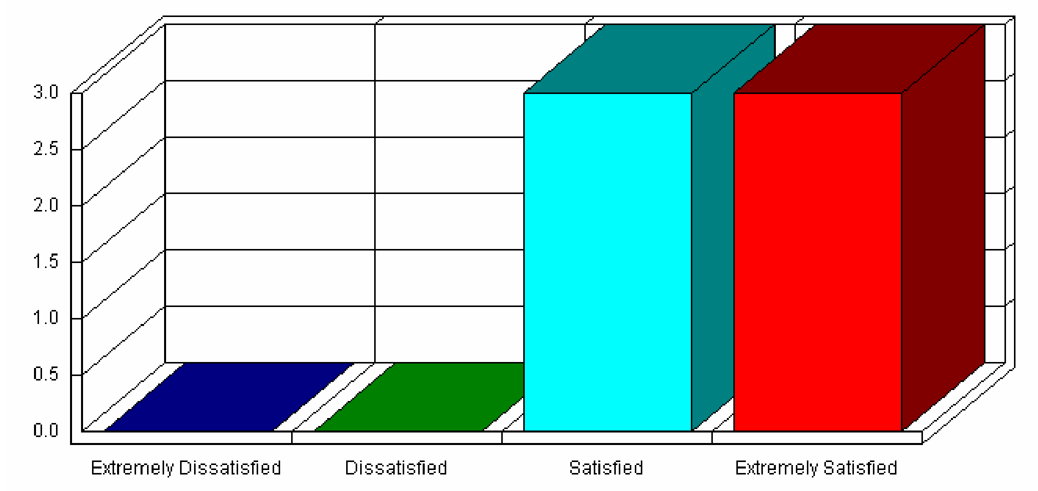

Figure 58. Survey Results: Low-Bandwidth Design

All participants of the usability experiment were either "satisfied" or "extremely satisfied" with the basic functionality processes of prototype. However, four usability aspects received at least one "dissatisfied" response. The four potential usability problem-areas discovered were: (1) color scheme, (2) typography, (3) organization of information and (4) system feedback methods. Video and audio recordings of the experiment coupled with open-ended feedback on the post-experiment survey were essential in not only identifying potential usability problems, but also providing potential usability solutions.

The prototype's problem with color scheme and typography referred to the navigation side-bar on the three modules of the system: CONOPS Development, COA Development, and Operation Sustainment. Feedback from participants revealed that color scheme and font size (typography) for the navigation side-bar made hyperlinks particularly hard to read. In the past, correcting color schemes and typography involved a significant amount of effort on the developer's part—tediously changing hundreds of html tags to reflect the new color and/or font style. Today, however, cascading style sheets (CSS) allow many aspects of the system to be changed instantly with minimal effort [19]. Color scheme and typography are important aspects of any system design, but since they are easily manipulated using the latest web technology, these potential problem-areas are considered minor issues. Moreover, the MAPSS prototype was developed using CSS; therefore, the developer of future iterations of the prototype can quickly manipulate the color scheme and typography to satisfy intended users of the system.

The other two areas of the prototype that received negative feedback were “organization of information” and “system feedback methods.” The feedback on the organization of information was particularly disconcerting since any effective decision support system is largely dependent upon logically arranged information. Organization of information should be a primary system design consideration; it could be the difference between a system that gets used regularly and a system that gets abandoned by intended users.

The usability experiment also uncovered a design flaw with the MAPSS prototype: user interaction and the level of effort to accomplish a task were dependent upon monitor resolution. The following figures illustrate the problem:

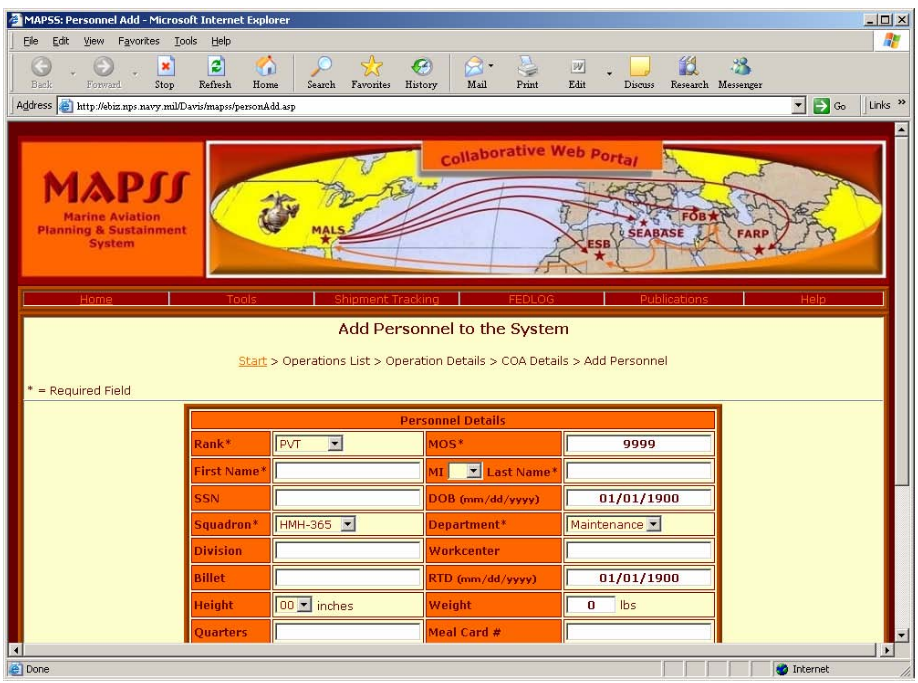

Figure 59. Information Display on 1024 x 768 Resolution Monitor

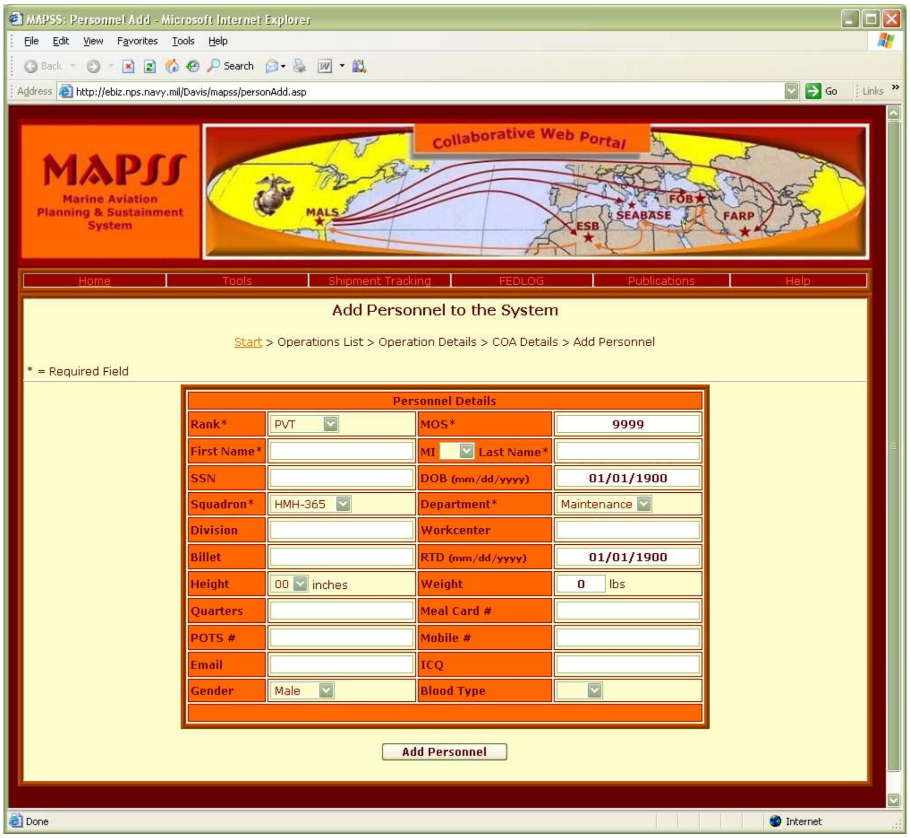

Figure 60. Information Display on 1280 x 768 Resolution Monitor

In Figures 59 and 60, the difference in user interaction and level of effort was significant for usability participants using a monitor with resolution setting of 1024 x 768 versus a monitor with a 1280 x 768 resolution. Users with the lower resolution monitor are required to use the scroll bar to input data in all required data fields and submit the form. On the other hand, users with the higher resolution monitor have full access to all data fields and the ability to submit the form upon initial load of the web page. The core functionality remains unchanged, but users with a high resolution monitor use significantly less effort to perform the same operation in the system. Although this issue may seem like a minor inconvenience to users with a low resolution monitor, the problem is compounded by the repetition of the task (e.g. a user is required to add 50 or 100 personnel to the system).

Good system design dictates that user interfaces should be designed to fit the most common window or monitor resolutions, not just optimized for a specific sized monitor or resolution setting [16]. MAPSS was designed, developed and optimized for 1280 x 768 resolution; it was not until the usability experiment that the prototype was extensively used and tested with a 1024 x 768 resolution monitors. As a result, future iterations of the prototype will require some redesign so effective usability is not resolution dependent. Fortunately, not all web pages for the system need to be redesigned. Changes are limited to pages that currently require a lot of vertical space to display all the data fields. The following system functionality is affected and should be a priority for future prototype iterations.

1. Add Squadron to the System
2. Update Squadron to the System
3. Add Personnel to the System
4. Update Personnel to the System
5. Add Parts to the System
6. Update Parts to the System
7. Assign Transportation to COA
8. Assign Host Nation Support to COA
9. Assign Task to COA

Although multiple pages are affected, data and logical process models remain unchanged for the system. Redesign would be focused on changing the structure of presented information to a more horizontal orientation. Figures 59 and 60, display a significant amount of "white-space" available for the redesign. This redesign would definitely benefit users with lower resolution settings.

The last aspect of the prototype to receive constructive criticism was "system feedback methods." MAPSS is web-based transaction-oriented application; therefore, system feedback is an essential element of the system and was implemented into every module of the system. Users are notified via system feedback messages anytime data is successfully added, updated, or deleted from any web page within the system. The following figure is an example of MAPSS system feedback.

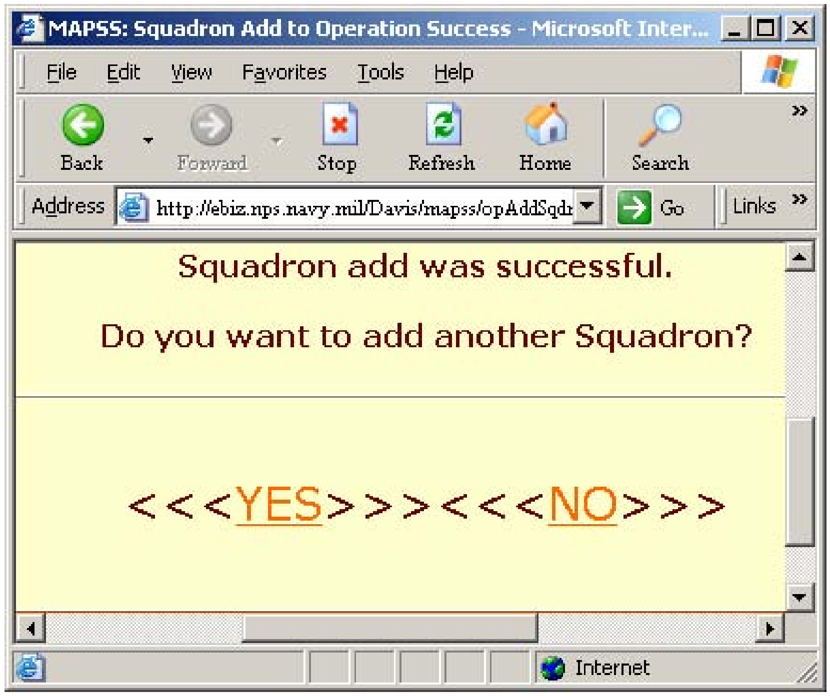

Figure 61. System Feedback Methods

The critique received during the usability experiment was more a result of MAPSS being a text-based and first-version prototype. Two participants of the study noted that system feedback methods were effective, but wanted to see buttons instead of hyperlinks, and wanted keyboard shortcuts to select the “YES” or “NO” options. Keyboard shortcuts are an effective means for experienced users to perform routine actions, and both buttons and keyboard shortcuts should be included in any fielded aviation logistics planning system in the future. However, for a first-version prototype, keyboard shortcuts (at least in this author’s opinion) is an advanced feature better suited for when all system functionality is firmly cemented and aligned with customer requirements. System feedback methods will evolve as the prototype evolves into a more efficient system.

The prototype also received positive feedback from the usability experiment. Participants of the study noted that the prototype was very easy to use with just a couple of minutes of instruction, a good decision support tool for the commander, an extremely user-friendly application, and a viable product that the aviation logistics community can expand upon.

This chapter described the methodology, experimental design, and test metrics of the usability study that was accomplished on the MAPSS prototype. The results of the usability study and its contribution toward improving system effectiveness, efficiency, and user satisfaction are also discussed. The development of the MAPSS prototype was a challenging and rewarding academic experience; a summary of the experience, conclusions and directions for future research are provided in Chapter VII.

VII. SUMMARY, CONCLUSIONS, AND FUTURE RESEARCH

This chapter summarizes the analysis of MALSP doctrine and the information management systems used to execute mission requirements. Conclusions are then drawn on the viability of the prototype to optimize multi-level decision-support for deliberate, time sensitive, and crisis action planning for tactical–level aviation logistics. Directions and opportunities for future research are also discussed.

The chapter is organized as follows. Section A summarizes where Marine Corps Aviation Logistics has been, where it is going, and why a web-enabled application is needed to support the transformation; Section B discusses the conclusions of this thesis research and frames the progress and accomplishments; and Section C provides direction for future research with the MAPSS prototype, focusing on improvements and refinements that will ultimately to an effective decision support system for the 21st century logistics warfighter.

A. SUMMARY

This thesis analyzed the principles and concepts of Marine Aviation Logistics doctrine at the tactical-level and the current information management systems used to execute mission requirements. The Marine Aviation Logistics community is currently undergoing a multi-year doctrinal transformation from MALSP to MALSP-II. Although current MALSP doctrine has served the community well for over 20 years, a new strategic landscape has emerged which requires more flexibility in developing and deploying aviation logistics support forces and equipment. Small-scale contingencies have become the norm not the exception; therefore, the Marine Corps must refocus it aviation logistics support concepts from "standard-sized" to "right-sized" support packages.

Executing aviation logistical operations will require a robust decision support system to effectively leverage the concepts of MALSP-II. The current IT architecture for planning and sustaining deployed forces and equipment are s*ufficient*, but not the IT enabler and force multiplier needed for the twenty-first century battlefield. To mitigate the shortcomings of currently fielded systems, MALS planners use flat-file technology that requires extensive resources and the expenditure of valuable man-hours. The lack of system integration and the need for a web-centric application was validated by formal surveys that were distributed throughout the Marine Corps, and identified as an “action-item” from a conference attended by key aviation logistics planners from the Marine Corps’ operating forces. The purpose of this thesis was to develop a web-enabled prototype to fill the current and projected technology gap that was identified.

This thesis used the RAD methodology to develop the Marine Aviation Planning and Sustainment System (MAPSS), a prototype designed to optimize management and decision support for deliberate, time sensitive, and crisis-action planning at the tactical-level. Prototyping was an appropriate system development methodology because of the current and on-going transformation of Marine Aviation Logistics; it allowed known system requirements to be designed and implemented with the first iteration, and allows new and unforeseen requirements to be implemented in the future. Microsoft Access 2003, Microsoft Visio 2003, and Macromedia Dreamweaver MX 2004 were the tools used to develop the prototype. The back-end relational database was designed with Microsoft Access 2003. The front-end web-enabled interface was designed using Macromedia Dreamweaver MX 2004. Microsoft Visio 2003 was used to create the conceptual data and logical process models for the system. The first iteration of the prototype was subjected to a usability study conducted at the Naval Postgraduate School, and also tested by Operations Officers that were assigned to MALS-11 and MALS-36, both of which provided valuable feedback.

B. CONCLUSIONS

MAPSS is a viable prototype that has the potential to optimize multi-level decision support for deliberate, time sensitive, and crisis action planning for aviation logistics. The MAPSS prototype consists of over 130 web-pages, all consistently designed and logically integrated within three system modules: CONOPS Development, COA Development, and Operation Dashboard. The navigational structure of the three modules was designed to be consistent with the natural workflow of the current planning and sustaining processes of MALS. Furthermore, the use of templates and cascading style sheets were instrumental in the development of the unified “look and feel” of the prototype.

The first version of the prototype was favorably received by both squadrons that agreed to “test-drive” the system. The most significant aspect of the system was the four-into-one system integration design; MAPSS combined the data sets from four different systems into one logically organized user interface. Another important distinction was the low-bandwidth design. The text-based system allows users to quickly complete transactions, circumventing the bandwidth constraints that normally plague deployed forces. The prototype also received positive feedback for its ease of navigation, COA comparison techniques, and use of the stoplight model on the Operation Dashboard.

The MAPSS prototype was also subjected to a usability study, which consisted of five participants performing scenario-based tasks. The usability study was an opportunity to evaluate the effectiveness, efficiency, and satisfaction with which specified users can achieve specified goals. In short, it was opportunity to test the prototype in a controlled environment, and the results used to improve the next iteration of the prototype. The results for system effectiveness were very encouraging; all participants of the study were able to successfully complete all scenario-based tasks. Moreover, the usability study was completed with just a 1% system error rate; very acceptable for a first version prototype. System efficiency was another important aspect of the study. Collecting the time and number of mouse-clicks were instrumental in identifying three potential issues related to the navigational side-bar located on each main page of the system. Lastly, user satisfaction was determined by a post-experiment survey that measured the level of satisfaction with system functionality and usability features. The results were overwhelmingly positive: the average score for system functionality was 3.59 and system usability received a score of 3.40, both scores were from a 4.00 rating scale. Clearly, users were “satisfied” with the first version of the prototype.

C. FUTURE RESEARCH

There are multiple avenues of research that can be pursued as a result of this thesis that would contribute to the overarching goal: a fielded information management system that optimizes decision support for deliberate, time sensitive and crisis action planning for tactical-level aviation logistics forces. The most immediate opportunity is to continue the evolutionary process of the prototyping methodology; the current prototype must be refined and a second iteration developed and deployed.

Although MAPSS is a viable concept and was well received, there were numerous issues identified that have the potential to make the system more effective and user-friendly. The following are some areas that should be researched:

- Ability to assign multiple personnel, repair parts, support equipment and mobile facilities to multiple COAs with one user input transaction. This functionality would require complex Structured Query Language (SQL) statements to be coded for the COA Development page.

- Ability for the system to automatically generate a COA shell or template (personnel, parts, support equipment and mobile facilities) based on user input of the CONOPS Development page. This functionality would require a complex algorithm and some statistical analysis of past operations.

- Optimizing the user interface for both 1024 x 768 and 1280 x 768 resolution monitors and designing a fourth module (System Administration) with future prototype iterations.

Another essential area that needs to be addressed is the back-end data interface with existing information management systems. The current version of MAPSS (given the scope of one thesis) admittedly only addresses half of the problem domain. This thesis was primarily focused on how data from existing systems could be integrated and logically organized into one user interface that was conducive to AVLOG planner's needs and requirements. Hence, future research needs to address the other half of the problem domain: the physical data link connection of MAPSS with the NALCOMIS, MCTFS, SERMIS, TBA and MDSS-II back-end databases. The need to push and pull data from existing systems is a basic system requirement for any future AVLOG decision support system. The current processes are time consuming and manually intensive. Planning logistics support and sustaining deployed forces would only be improved by an efficient and interoperable four-into-one web-enabled user interface.

The last area of research for a system of this nature is database security. MAPSS is an operational planning system; hence, it inherently contains sensitive information that should be protected against unauthorized disclosure. The web-centricity of the application increases the effectiveness and convenience, but it equally increases the risks and vulnerabilities. Database security is a never-ending process, constantly requiring the implementation of the latest tactics and techniques to safeguard the confidentiality, integrity, and availability of an organization's information. Future research in this area could include the analysis of authentication and accreditation techniques for DoD web-enabled databases. Furthermore, vulnerability and penetration testing of the current MAPSS database could accomplished, with the intent of improving and strengthening the security measures for future iterations of the prototype. The 21^{st} century battlefield will require a robust decision support system to execute mission requirements. Such a system is meaningless, however, without equally robust information security measures.

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