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THESIS

**COLLABORATIVE ONLINE COMMUNITIES FOR
INCREASED MILSATCOM PERFORMANCE**

by

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September 2009

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**COLLABORATIVE ONLINE COMMUNITIES FOR INCREASED
MILSATCOM PERFORMANCE**

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ABSTRACT

The Department of Defense and, subsequently, the U.S. Navy have embraced a strategy of exerting influence through information dominance versus amassing a large presence. This philosophy, called Net-centric Warfare, uses sensor and network technology to leverage naval platforms towards realizing effects previously achievable only by a larger force.

In adapting this strategy, the U.S. Navy has realized many benefits, but has also increased its reliance on the technologies implementing Net-centric Warfare. One such technology is the U.S. Navy's future Military SATCOM terminal, the Navy Multiband Terminal, which will provide critical off-ship bandwidth required for these leveraging effects. The Navy plans to sustain the NMT system using the same methods as previous systems.

When considering Operational Availability, these legacy methods do not adequately address attributes affecting system performance, creating a risk the NMT system will not perform as needed to successfully execute Net-centric Warfare. This risk can be managed by transitioning away from traditional methods to those utilizing online collaborative technologies. These technologies, coined "Web 2.0," center around member participation to foster communities. Much like the philosophy of Net-centric warfare, these communities leverage the experience of individuals to the benefit of the entire community.

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EXECUTIVE SUMMARY

The Department of Defense and, subsequently, the U.S. Navy have embraced a philosophy, called Net-centric Warfare, using sensor and network technology to leverage individual naval platforms to realize effects previously achievable only through a larger force.

Adapting this strategy, the U.S. Navy has realized many benefits but has increased the reliance on technologies implementing Net-centric Warfare. One such technology is the U.S. Navy's future Military SATCOM terminal, the Navy Multiband Terminal, which replaces two systems currently providing critical off-ship bandwidth essential for implementing the Net-Centric doctrine. However, despite the increased criticality, the NMT system threshold requirement for availability—a key performance parameter for bandwidth—is 90%, commensurate with the two systems NMT is replacing. This threshold requirement is not consistent with the expectation for availability, which is closer to the NMT objective requirement of 99%. To overcome the spread between threshold and objective requirements, the NMT system is scheduled to implement the same data collection methods as these prior systems. This thesis defines this inherited system and evaluates the suitability of this system towards improving system availability. Further, the thesis examines the emergence of online collaborative communities, proposes a new system using these technologies, and evaluates this proposed system's suitability towards improving NMT availability.

The current method for performance data collection is a hierarchical system with a focus on reporting current material status rather than long-term system availability improvement. An anomaly experienced by a System Operator initiates a process of diagnosis and corrective action that extends from them to the ISEA Technicians through the System Maintainers and RMC Technicians. Along this chain, the System Maintainers and RMC Technicians predominantly utilize the 4790/2K to record information. However, this form is heavily focused on reporting current material readiness to the chain of command, critical information but of limited value to the long-term improvement of

the system. In addition to the 4790/2K, problems are reported via a Casualty Report, but again, this is focused more on readiness reporting than system improvement.

An ideal data collection system focused on improving system availability is postulated to serve as a basis of evaluation for the current system and an intermediary for comparing the current system to a proposed system. The ideal system is comprised of nine attributes, all of which if addressed would improve system availability. When evaluated against the ideal system's nine attributes, the current system is found to perform almost as well as the ideal in one attribute, marginally address five attributes, and effectively fail to address three attributes. Driving this score is the fact that the current system limits who can document information, what information can be documented and, once documented, with whom the information is shared.

These constraints run counter to the philosophy of "Web 2.0," which is the application of online Web technologies for the development and sharing of information amongst users. The broad participation in development and consumption of information has facilitated formation of communities that defy traditional geographic constraints. Deployed in various models, these technologies have resulted in well-known services, such as YouTube, Wikipedia, and Facebook, that support communities consisting of millions of users exchanging billions of pieces of information.

While the NMT user community may not number into the millions, an opportunity exists to employ these technologies to establish an NMT user community. Considering the roles of the community members, a model that combines multiple Web 2.0 technologies is proposed for the NMT community. This model provides a mechanism for members with the most frequent NMT interaction, the System Users and System Maintainer, to record their experiences and problems with the NMT system in a blog. Other members are able to assist the System Users and System Maintainers by providing comments to these blog postings. The blog postings and comments are archived, searchable and shared to all members of the community, providing an opportunity for peer-to-peer training. In addition to increasing the competency of the

users, the creation and exchange of information provides the Acquisition Program Office a broad base of information upon which to make follow-on investments affecting system availability.

In contrast to the current system that creates silos of information by restricting access, the proposed system based upon Web 2.0 technologies encourages and thrives on the broad creation and sharing of information. This difference becomes evident when the proposed system is evaluated against the ideal, which allows for a comparison between the proposed and current systems. The proposed system was found to perform almost as well as the ideal system in all nine attributes, a stark difference to the current system, which achieved this score for only one attribute.

The relative poor performance of the current system does not guarantee a failure to adequately support the NMT system, but given the potential of the proposed system, continued use of the current system does seem to be an imprudent risk. With this in mind, it is clear the NMT program should seek to exploit the opportunities created by Web 2.0 technologies to ensure the NMT system provides critical bandwidth commensurate with the expectations of its user and Net-centric Warfare.

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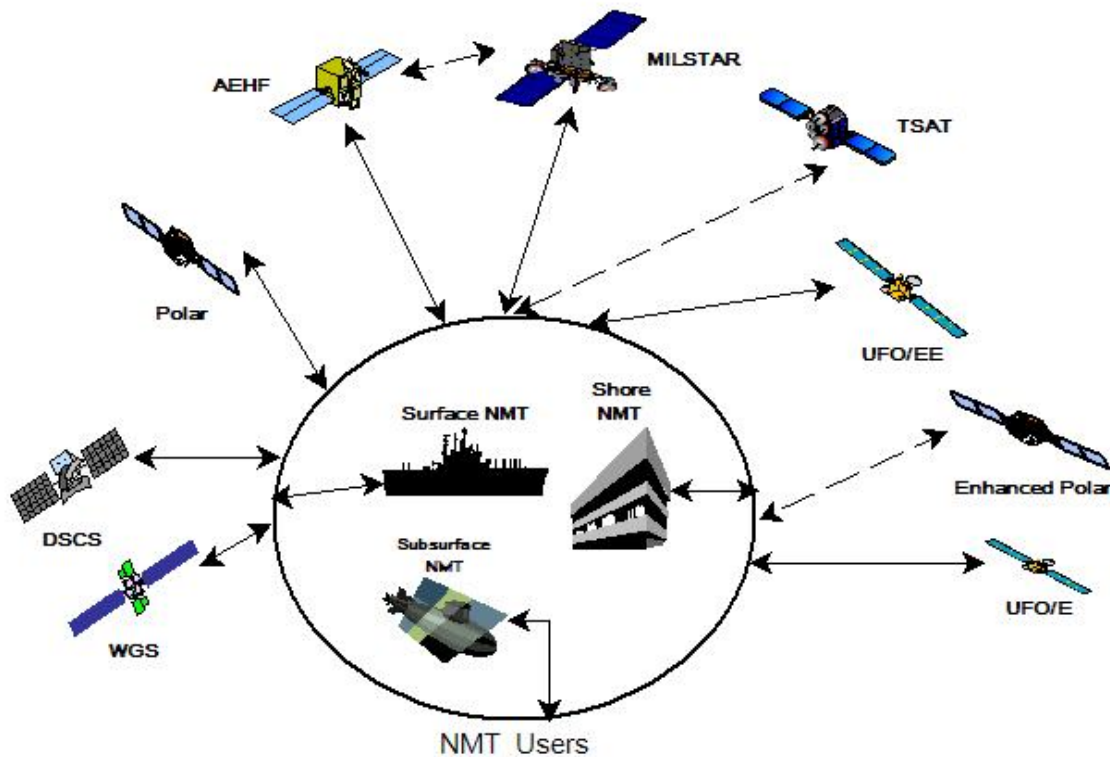
I. INTRODUCTION

A. BACKGROUND

“Future naval operations will use revolutionary information superiority and dispersed, networked, force capabilities to deliver unprecedented offensive power, decisive assurance, and operational independence to Joint Force Commanders” (Clark, 2002). This idea, often called Network-centric warfare, has represented a fundamental change in the way the Department of Defense (DoD) plans and conducts military operations. Under this idea, “the fundamental approach of warfare has changed from massing forces to massing effects” (Joint Chiefs of Staff, 1995). Through the broad collection, dissemination, synthesis, and analysis of information, the Navy is able to leverage the impact of an individual platform to exert an influence only previously achievable through a large naval presence. Employing this leveraging philosophy has provided the Navy with several benefits, the most notable being an increased lethality via a smaller, more affordable fleet. However, while providing tremendous benefit, the Navy is now critically reliant on the systems that enable this capability. One such system is the Navy Multiband Terminal (NMT).

NMT is the Navy’s next generation, and only future Military Satellite Communications (MILSATCOM) terminal. The NMT consolidates the same SATCOM capability provided by two previous systems into a single system. In a single terminal, the NMT will provide the protected Extremely High Frequency (EHF) capabilities of the AN/USC-38(V), the wideband Super High Frequency (SHF) capabilities of the AN/WSC-6(V), and the receive capabilities of the Global Broadcast System (GBS) antenna system. As depicted in Figure 1, NMT’s Department of Defense Architecture Framework (DODAF) Operational View 1 (OV-1), the NMT will provide ship, shore, and submarine communication capabilities to most of the DoD’s current and future military satellite constellations.

Figure 1: NMT DODAF OV-1



Given the obvious absence of terrestrial connectivity in the maritime environment, the Navy has a tremendous reliance on Satellite Communications (SATCOM); this reliance is compounded by the Network-centric warfare philosophy. However, the Availability (Ao) requirement, probability the system will be able to support tasking, for the NMT system has not increased commensurately with its importance. Table 1 enumerates the Ao requirements for the NMT system along with the AN/USC-38(V) and AN/WSC-6(V) systems, which the NMT system will replace. As depicted by the table, despite the increased criticality of the NMT system, the threshold requirements are essentially unchanged. However, Table 1 also shows an objective Ao of 0.99, creating an opportunity to achieve the availability levels commensurate with the reliance on NMT and shipboard expectations.

Table 1: MILSATCOM Availability Requirements

System	Threshold Ao	Objective Ao
AN/USC-38(V) Ship/Shore	0.90	0.99
AN/USC-38(V)Submarine	0.94	0.99
AN/WSC-6(V)	0.95	0.99
NMT Ship/Shore	0.90	0.99
NMT Submarine	0.94	0.99

To exploit this opportunity, and provide the Navy with high availability MILSATCOM, several factors must be taken into consideration. Specifically, the NMT must be highly reliable, easy to repair, and supported by an efficient supply chain. While these factors are heavily influenced by the initial design of the NMT and associated support systems, they are also influenced by the efficiency at which deficiencies in these initial designs are identified and corrected. In turn, deficiency identification and correction is reliant upon the quality and availability of data describing operational performance. For instance, clearly an unknown problem, one experienced but not reported, cannot be rectified. Also, the pervasiveness of the problem is also highly relevant to getting the biggest ‘bang for the buck’ when making resource decisions; frequently, as the saying goes, a mountain can be made out of a mole hill, but the inverse is also true. Simply, quality, comprehensive, operational data will be required for the NMT system to achieve Ao performance close to objective numbers and Fleet expectations.

Currently, the NMT program will receive this data through the channels and methods of its predecessors, the AN/USC-38(V) and AN/WSC-6(V) programs. This thesis examines the efficacy of this plan and explores the possibilities provided by recent developments in Web-based collaborative technologies and approaches to develop a better solution to exploit the opportunity for high NMT availability.

B. RESEARCH OBJECTIVES

The objective of this research is to define and analyze the operational performance data collection methods used on today's MILSATCOM systems, the AN/USC-38(V) and AN/WSC-6(V) programs. Further, with this understanding and analysis, evaluate the efficacy of these methods to support the NMT program in light of the increased necessity of availability brought on by both the broad DoD's strategic shift and the Navy's consolidation strategy. Lastly, the research will survey the recent developments in online, or Web-based, collaborative technologies to determine if, with these technologies, there is an opportunity to improve, augment, or replace the methods currently used.

C. RESEARCH QUESTIONS

1. Primary Research Question

What are the current methods for collecting operational performance data on the AN/USC-38(V) and AN/WSC-6(V) MILSATCOM systems, and how well do they satisfy their objectives?

2. Subsidiary Research Questions

What are the available online, Web-based, collaborative technologies?

Is there an opportunity for these collaborative technologies to improve, augment, or replace the current methods for collecting operational data to yield better results?

What would a proposed method for collecting NMT operational performance data look like given an understanding of both legacy methods and the newer Web-based technologies?

D. SCOPE

The scope of this thesis describes the current methods used to support the AN/USC-38(V) and AN/WSC-6(V) MILSATCOM systems, along with an evaluation of

their performance. This description will include the official methods, those dictated by policy, formal guidance, or generally accepted as the standard procedure. Ad hoc methods are not considered part of the current official support and data collection system for evaluation purpose. This evaluation exclusion is because ad hoc methods are neither pervasive throughout the system nor is there any accountability for their success or failure. However, these solutions will be considered when considering a proposed method for collecting NMT operational performance data. This proposed method will be built upon the survey of Web-based collaborative technologies presented in this thesis and the understanding of current methods.

E. METHODOLOGY

The methodology for this thesis consists of the following steps:

- Conduct a policy and formal guidance review along with interviews to document the method used to support the AN/USC-38(V) and AN/WSC-6(V) MLSATCOM systems.
- Postulate attributes of an ideal data collection system and evaluate the current methods against this ideal.
- Survey the landscape of Web-based collaboration technologies through a review of published and online literature, best practices documents, and case studies. From this survey, identify technologies or applications that may be beneficial in the support of the NMT system.
- Developed a proposed method of collecting NMT performance data and perform a forward-looking evaluation against the ideal.

F. ORGANIZATION

This thesis consists of six chapters.

- Chapter I serves as an introduction to the scope and objectives of the thesis

- Chapter II depicts the current methods that support and report the performance of the AN/USC-38(V) and AN/WSC-6(V) MILSATCOM systems; the methods the NMT program is currently planned to inherit.
- Chapter III postulates attributes of an ideal system for support of MILSATCOM systems and evaluates the methods identified in Chapter II against this ideal.
- Chapter IV provides a survey of the current online, Web-based, technologies available.
- Chapter V proposes a new method to support the gathering of performance data for the NMT system based upon identified deficiencies in the baseline approach and opportunities discovered in the survey of available online, Web-based technologies.
- Chapter VI presents conclusions and recommendations.

G. BENEFITS OF RESEARCH

This thesis proposes a different method for the collection of performance data during the deployment and operation of the NMT system. This different method will allow the NMT system to use applications and technologies in broad use rather than simply inherited methods. This new method will decrease the time taken to discover deficiencies in the NMT itself and its support systems. Further, this new method will facilitate more efficient allocation of NMT program resources to initiate corrective actions. Both of these, rapid feedback and efficient allocation of resources, will increase the availability of the NMT system facilitating realization of the DoD's Network Centric Warfare vision.

II. CURRENT METHODS FOR REPORTING MILSATCOM PERFORMANCE

A. BACKGROUND

The NMT system will replace the existing AN/USC-38(V) and AN/WSC-6(V) systems onboard U.S. Naval platforms to provide an array of MILSATCOM capability from high bandwidth wideband communications to protected communications. While the NMT consolidates these two missions into a single terminal, the functions, architectures, and physical components of these three systems are very similar.

Driven by the technical similarities, the NMT system is planned to inherit a similar construct for system training and operation. NMT, like the AN/USC-38(V) and AN/WSC-6(V), will train sailors utilizing a curriculum incorporated into the Navy's schoolhouses, called the Fleet Training Centers (PMW 170, 2008). Upon entering training, the new system user will assume one of two roles based upon their job classification and prior training. Trained to be operators of the system will be sailors with prior experience in networks and communications; these sailors have the Information Technology (IT) designation (PMW 170, 2008). The System Operators will be responsible for initiating, monitoring, and terminating the communication services enabled by the NMT system. Trained to be maintainers of the system will be sailors with prior experience in electronics theory and repair; these sailors have Electronics Technician (ET) designation (PMW 170, 2008). The System Maintainers are responsible for performing preventative maintenance in accordance with prescribed schedules, and, in the advent of a failure corrective maintenance. The number of sailors assigned to these roles varies between various classes of ships¹, but a deployed system must have at least one operator and maintainer assigned, and with the exception of the submarine platforms,

¹ For instance, an aircraft carrier (CVN) platform, have larger divisions dedicated the communication operations than a smaller platform such as a destroyer (DGG) platform.

this is always two different individuals². Utilizing the NMT to provide communication services to the operational Navy platform will require close coordination between these individuals.

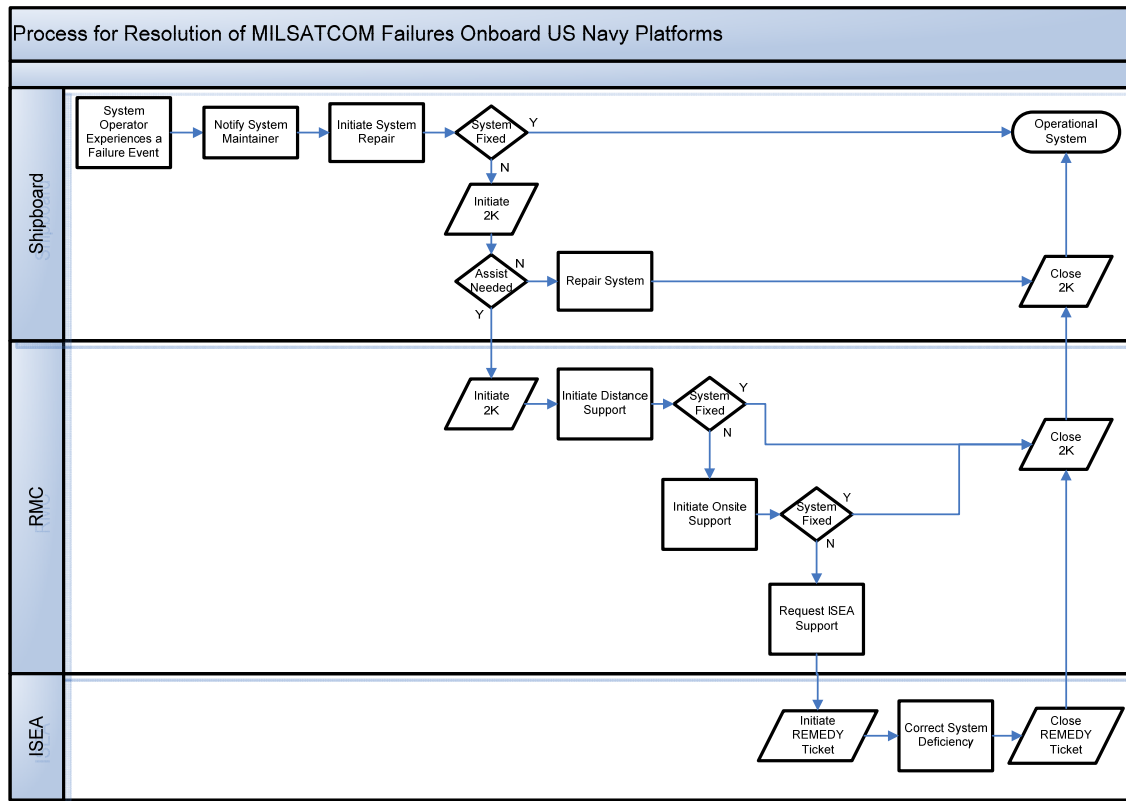
In addition to training and operation, the methods for performing corrective maintenance are also planned to be inherited from the AN/USC-38(V) and AN/WSC-6(V) systems. In these corrective maintenance procedures are the data gathering opportunities to understand and improve the NMT's performance and availability.

B. RESOLUTION OF A FAILURE ONBOARD A U.S. NAVY PLATFORM

The methods for resolving problems with the NMT system, while inherited from the AN/USC-38(V) and AN/WSC-6(V) systems, are not unique to MILSATCOM systems. These procedures are predominantly defined by two policy documents, the NAVSEA 4790.8B and the COMFLTFORCOMINST 4790.3B. The NAVSEA 4790.8B policy, titled 'Ships' Maintenance and Material Management (3-M) Manual', defines the maintenance management procedures for the Navy. The COMFLTFORCOMINST 4790.3B, titled 'Joint Fleet Maintenance Manual' defines the maintenance policies and responsibilities for the Navy. These two documents, augmented by procedures of various stakeholders, define the process for resolving problems and collecting the associated performance information about the NMT system. Figure 2 depicts this process.

² For submarines, due to obvious space constraints, these roles have been consolidated into a single individual.

Figure 2: MILSATCOM Failure Resolution Process



1. Shipboard Actions

The NMT system is installed onboard Navy platforms as a mechanism for the platform to fulfill its mission requirements. The Commanding Officer (CO), and subsequently his/her crew is responsible for the readiness and performance of that platform to fulfill its assigned mission (NAVSEA, 2003). As a result, the ship, the System Operator, and the System Maintainer are critical stakeholders in the problem resolution and documentation process.

As Figure 2 depicts, the process is initiated when the System Operator experiences a failure. The guidance documentation does not explicitly define the term failure, but broadly, this can be considered as an inability to utilize the system in its intended manner to accomplish the mission. Failure cause can range from deficient system components to operator error, both will preclude the NMT from performing as intended. Once the operator experiences a failure, keeping in mind the dual system roles

of operator and maintainer, the System Maintainer is notified to initiate corrective action. The steps taken by System Maintainer and the data recorded is dependent upon two variables, the time taken to correct the deficiency and whether the corrective action required a change in system configuration.

Short duration corrective actions completed without a change in system configuration do not require the recording of failure data. For example, a failure condition may exist where the NMT is unable to provide communication services because one of its software data files has become corrupted. With archived versions of these files stored onboard, the System Maintainer could simply reload and replace the corrupted files. Assuming reloading the file corrects the deficiency, neither the System Maintainer nor the System Operator records information about the failure incident.

Corrective actions that cannot be completed rapidly, but do not result in a configuration change, require the completion of a 4790/2K. Per the Ships' Maintenance and Material Management (3-M) Manual, "The NAVSEA 4790/2K Form is used for reporting deferred maintenance actions, and the completion of those maintenance actions that do not result in a configuration change" (NAVSEA, 2003). For instance, if the ship's NMT system experienced a hardware failure, but the ship did not have a replacement part in their spares inventory, the 4790/2K would record the outstanding corrective action; once the part is received, resulting in an operational system, the 4790/2K would be closed (NAVSEA, 2003). It is clear, the 4790/2K serves two purposes, one to document the failure event and the other to provide the ship's chain of command a status of the ship's current capabilities and deficiencies (NAVSEA, 2003).

The 4790/2K fulfills these two purposes as part of the ship's Maintenance Data System (MDS), which is the ship's central repository for maintenance information. The ship's Commanding Officer (CO) is accountable for ensuring the CMSP is current and complete. For entry into the MDS, the System Maintainer completes the 4790/2K form shown in Figure 3. Typically, this is an automated process utilizing a software application, but there are sites where the software application is not available (NAVSEA, 2003).

Figure 3: OPNAV 4790/2K

OPNAV 4790/2K (Rev. 5-76) SN 01074F-047-9011										SHIP'S MAINTENANCE ACTION FORM (2-KILO)										COMP		DEFI																	
SECTION I. IDENTIFICATION										JOB CONTROL NUMBER																													
										1. SHIP'S UIC										2. WORK CENTER										3. JOB REQ. NO.		4. APT / APL							
A. SHIP'S NAME										5. EQUIPMENT ROOM NAME										6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100.		WHO DIA. CAS. OPS.																	
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18. ALTERATIONS (REPAIRS, MODS, Etc. Chg. etc.)										19. "I" #										20. INQUIRY NUMBER		21. SUPPLY		22. U. 23. S. 24. P.															
25. SP. MHRS. EXP.										26. DEFER DATE YR.										DAY		27. SP. MHRS. REM.		28. DEADLINE DATE YR.		DAY													
SECTION II. DEFERRAL ACTION										29. ACT. TKN. 30. SP. MHRS.										31. COMPLETION DATE YR.		DAY		32. ACT. NANT. TIME		33. T. 34. METER READING													
SECTION III. COMPLETED ACTION										FOR SELECTED EQUIPMENTS ONLY																													
SECTION IV. REMARKS/DESCRIPTION										35. REMARKS/DESCRIPTION																													
36. CORP. SUMMARY										37. CORP. SUMMARY																													
38. FIRST CONTACT / MAINT. MAN (Print)										39. DATE										40. SECOND CONTACT / SUPERVISOR (Print)		41. HH		42. TA		43. INTEGRATED PRIORITY													
C. DIV. INT.										D. DEPT. INT.										E. COMMANDING OFFICER'S SIGNATURE										F. TYCOM AUTHORIZATION		SCREENING							
44. SPECIAL PURPOSE										45. SPECIAL PURPOSE										46. SPECIAL PURPOSE										47. SPECIAL PURPOSE		48. SPECIAL PURPOSE							
SECTION V. SUPPLEMENTARY INFORMATION										49. BLUEPRINTS, TECH. MANUALS, PLANS, ETC.										AVAILABLE ON BOARD YES NO		50. PREARRIVAL (ARRIVAL CONFERENCE ACTION) / REMARKS																	
51. REPAIR WK.										52. EST. MHRS.										53. ASST. REPAIR WK.										54. ASST. EST. MHRS.		55. SCHED. START DATE YR.		DAY		56. SCHED. COMP. DATE YR.		DAY	
57. REPAIR ACTIVITY UIC										58. WORK REQ. RETIME										59. EST. MANDAYS										60. EST. MANDAY COST \$		61. EST. MATERIAL COSTS \$							
62. EST. TOTAL COST \$										63. JOB ORDER NUMBER										64. LEAD P&S CODE										65. DATE OF EST. YR.		DAY							
66. FINAL ACT										67. MHRS. EXPENDED										68. DATE COMPLETED YR.										DAY		69. COMPLETED BY (Signature-Date)		70. ACCEPTED BY (Signature-Date/Rate)					

The entries in the MDS are synchronized with a central shore data repository managed by the Navy Sea Systems Command Logistics Center (NAVSEALOGCEN), providing various levels of Navy leadership visibility into the current maintenance

disposition of the fleet. As can be seen in Figure 3, the ship maintainer inputs information relevant to the failure, but the focus is on readiness reporting. However, if the System Operator desires to collect and document more information about the failure itself, a 4790/2L form can be completed. Per the Ships' Maintenance and Material Management (3-M) Manual, "The NAVSEA 4790/2L is used to provide amplifying information (such as drawings and listings) related to a maintenance action, reported on a NAVSEA 4790/2K Form. The 2L may be used to list multiple item serial numbers and locations for which identical maintenance requirements exist from an outside activity; or to provide a list of drawings and sketches that would be helpful in the accomplishment of the maintenance" (NAVSEA, 2003). Once completed, the 4790/2L form is retained by the ship; it is not loaded into the MDS system nor is it synchronized to the shore data repository (NAVSEA 2003). In summary, a deferred maintenance action, which is ultimately resolved without a change in system configuration, results in two data opportunities, the 4790/2K, which is distributed to a central repository and a 4790/2L, which is retained by the ship.

The deferred maintenance actions that do result in a change of the ship's NMT configuration produce an additional data opportunity. These instances require the 4790/2K and if desired, the 4790/2L entries, but also require the completion of a 4790/CK. "The NAVSEA 4790/CK Form is used to report completion (or partial completion) of alterations, maintenance actions that resulted in a configuration change, and to correct discrepancies and errors in the configuration files" (NAVSEA, 2008). Whereas the 4790/2K is designed to provide the chain of command with visibility into the current materiel status of the fleet, the 4790/CK is designed to provide the chain of command with visibility into the materiel capability of the fleet. For instance, different weapon systems provide different capabilities; when planning a mission, the planners must know what fleet assets have which capabilities in developing plans and assigning tasking. The mission planners will use the MDS populated by the 4790/CKs to determine the ship's capability and then query the MDS populated by 4790/2Ks to ensure the capability is operational. In this capacity, the 4790/CK covers a broad array of actions from major, planned ship alterations to minor unplanned maintenance actions (NAVSEA, 2003). A

4790/CK will be completed when a ship is outfitted with the NMT system, and another be completed when the configuration of the NMT system is changed. If, for instance, the ship experiences a failure and the corrective action requires replacement of the failed system component with a newer, different version, a 4790/CK would be completed. Since a newer system component is available, presumably updated to address the experienced failure mode, the 4790/CK provides very little novel information about the system performance.

The last scenario for the System Maintainer is corrective events that are short in duration, but result in a configuration change. The actions require the completion of 4790/CK, but do not require the completion of either a 4790/2K or a 4790/2L. These events typically occur via one of two means; the foundation of both is an understanding of the failure mechanism with updated system components available. In one instance the ship may receive the updated system component as an augment to their spares inventory with the direction to install the component in the event that the existing, older version, component fails. This scenario, typically employed when failure modes don't result in collateral damage and the criticality is low, allows the Navy to reap the most utility out of materiel procurements while mitigating an availability risk. The other instance is when a component is replaced in a proactive approach. These are scenarios where criticality is high, the collateral damage is high, or both. This is seen frequently in the aviation community, where an inventory of aircraft will be grounded until an aircraft is upgraded. For MILSATCOM equipment, these proactive, aggressive replacement of system components occur, but, unless sailor safety is involved, without the "grounding" the entire system inventory. With the completion of only a 4790/CK, these proactive actions provide very little novel information about the system performance.

Table 2 summarizes the data opportunities available based upon the characteristics of the maintenance event. All of the data from these opportunities is provided by the System Maintainer, but there are instances where the System Maintainer is unable to diagnose the failure's cause, and subsequently, unable to perform the

corrective action. In these instances the System Maintainer completes a 4790/2K to document the outstanding deficiency while waiting for outside assistance from the Regional Maintenance Center (RMC).

Table 2: Data Opportunities for Shipboard Actions

Time	Configuration	4790/CK	4790/2K	4790/2L
Immediate	No Change	No	No	Maybe
Differed	No Change	No	Yes	Maybe
Differed	Change	Yes	Yes	Not Likely
Immediate	Change	Yes	No	Not Likely

2. Regional Maintenance Center Actions

The Regional Maintenance Centers (RMCs) are, as the name implies, Navy organizations that provide corrective maintenance assistance to operational Navy platforms with responsibilities for a specific geographic area; these geographic areas are generally coincident with Navy ports or major operational areas. Operational platforms are assigned to the RMC located in their homeport, but when on deployment and in another geographic area, can request support from the local RMC, who will, in turn communicate with the platform's assigned RMC. Per Navy policy, the RMCs are the primary and first point of contact for any corrective maintenance assistance (COMFLTFORCOM, 2009). As a Navy organization, the RMCs are staffed by active duty military personnel, government civilians, and support contractors. Typically, personnel providing assistance to the ship are senior enlisted, in the case of the active military staff, and prior senior enlisted for the government civilian and contractor personnel. Support from an RMC is solicited by issuing a Fleet Technical Assist (FTA).

An FTA can be requested by telephone, e-mail, or official Navy message, all of which initiate a two stage corrective action process. Heavily motivated by cost considerations, distance support is encouraged and required (COMFLTFORCOM, 2009). In this stage of the process, the RMC representatives coordinate with the System Maintainer via e-mail, telephone, chat, or other communications means to understand the problem and assist in the failure diagnosis process. This can be a highly iterative process of measure, report, and assess, common with all troubleshooting activities, but compounded in difficulty by communication media and, in the case of large geographic separation, significant time differences. If this first stage of assistance is unsuccessful, the second stage, a visit to the operational site is initiated. The triggers to initiate the second stage are varied and without specific definition, rather the attributes of the situation and the opinion of the RMC technician to determine the necessity and appropriate time to initiate stage two (COMFLTFORCOM, 2009).

Regardless of whether the FTA is resolved via distance support or an onsite visit, support from the RMC results in single recorded data opportunity. Maintenance actions performed by the RMC will be recorded in a 4790/2K (COMFLTFORCOM, 2009). Upon receipt of an FTA, a 4790/2K will be opened for the duration of the technical assistance. Like the ship initiated 4790/2Ks, the RMC initiated 4790/2K will populate the MDS to reflect the current materiel status of the system and operational site. Once the corrective action has been successfully completed, and the system returned to an operational status, the 4790/2K will be updated to reflect a completed service action. However, if the RMC is unable to resolve the issue, and return the system to operational condition, they too can solicit additional help from the system's In Service Engineering Agent (ISEA).

3. In-service Engineering Agent Actions

United State Code (USC) Title 10 empowers a Program Manager to ensure that an acquisition program meets its cost, schedule and performance requirements throughout the lifecycle. For MILSATCOM systems in the sustainment phase of their lifecycle, a Program Manager tasks an ISEA to assist in ensuring Title 10 responsibilities are fulfilled. The ISEA supports the Program Manager through an array of tasking including

inventory management, updating technical publications, follow-on system development, and providing technical assistance. In addition, the ISEA typically has a contractual and close working relationship with the system's developer, or Original Equipment Manufacturer (OEM). With a staff of engineers and senior technicians and close ties to the OEM, the ISEA is the system expert.

To assist an operational platform in failure diagnosis and corrective action ISEA, support must be requested from an RMC (COMFLTFORCOM, 2009). There is very little guidance as to when and under what circumstances the RMC will request ISEA support, but typically it follows an onsite visit which failed to return the system to operational status. The ISEA will provide support via both distance and onsite means utilizing their and the OEM's engineers and technicians. Once tasked, the ISEA is the last line of defense, and must return the system to an operational configuration.

Once requested for support by the RMC, the ISEA begins assisting the operational platform and records the effort in their REMEDY³ data repository. Trouble tickets record the details of each instance of a technical assist and populate the REMEDY data repository. Throughout the lifecycle of an ISEA technical assist, the trouble ticket has three phases, when the ticket is opened, closed, and updated. Unlike the operational site's 4790/2Ks and the RMC's 4790/2Ks, neither the trouble tickets nor the REMEDY data repository populate a central site.

As a result of not being synchronized to a central site, the ISEA's trouble tickets are not used to document materiel status to the operational platform's chain of command. Rather, the trouble tickets document each assistance event to fulfill two objectives. The first, especially in a tight budget environment, is to document value to the operational forces. By diligently recording each technical assist, the ISEA can precisely demonstrate their value when facing budget reductions. This motivation can be seen in Figures 4 and 5, which depict the forms for opening and closing, respectively, of trouble tickets. However, the second objective is gain technical information about the failure event. This motivation is, again, seen in Figures 4 and 5, but is more evident in Figure 6, which

³ Remedy is the name of the software product developed by BMC Software and used by the ISEA.

depicts the work log to be completed by the engineer or technician supporting the operational platform in problem resolution. Through the work log, all the steps taken with ISEA support can be recorded. This includes the corrective action steps, as well as, the steps taken to diagnose the failure's cause. This recording of technical information about the failure event is a rich data opportunity, providing details about failures and the opportunities to educate ISEA technicians and engineers on their resolution.

Figure 4: Opening an ISEA Trouble Ticket

The screenshot shows a web browser window titled "NMT Fleet Support Request (Modify) - Microsoft Internet Explorer provided by NMCI". The address bar shows the URL: <https://supportweb.spawar.navy.mil/arsys/forms/supportapp.spawar.navy.mil/SSC%3AHelp+Desk+Case/NMT/7?cacheid=73ce25dc>. The browser's link bar includes "DISA Direct Home Page", "EDS NMCI", "ISIS Online-WEU5432", "MetaFrame Presentation Server", and "NMT Master Calendar".

The main content area is titled "NMT - Help Desk Case" and is marked "UNCLASSIFIED". It features a "Current mode: Modify" header with links for "New search", "New request", "Advanced search", "Status history", and "Help Home".

The form is divided into several sections:

- Case Information:** Includes "Case Number" (GDS00000117675), "Ticket Status" (Assigned), and buttons for "In Progress", "Resolved", "Close", "Pending", "Reopen", "Cancel", "Take Ticket", "Clone", "Print", "Save", and "Exit".
- Customer Contact:** Includes "Customer Contact" (Last Name and ENTER), "Rank/Title" (E6), "Designator", "Phone Type", "Customer Phone Number" (860-634-3898), "Type of Event" (Technical Assistance), "Customer Activity" (USS SPRINGFIELD), "Email Type", "Customer Email" (HAMILTTL@SPRINGFIELD.NA), "DODAAC" (R21691), "Fleet" (Atlantic F), "Assigned to Location / Group" (SSC San Diego / ISEA), and "Assigned to Individual" (Derek English).
- Log Ticket:** Includes tabs for "Log Ticket", "Work Activity", "Relationships", "Close Ticket", "Auditing", and "History".
- System Activity:** Includes "System Activity (Location of System)" (USS SPRINGFIELD), "System DODAAC" (R21691), "System Noun Name" (EHF), "Unit Assembly", "Part Number", "Serial #", "H/W Rev", "S/W Rev", "CG S/N", "APA S/N", "HPA S/N", "EBEM S/N", "A/Data", "TCF", "Terminal ID", "ROIU S/N", "ROIU Firmware Rev", "Condition at Failure", and "Diagnostic Tools".
- Brief Problem Subject:** Includes "Brief Problem Subject" (10A ISSUE: EHF NECC NT SAC4 INOP) and "Detailed Problem Description" (CONFIG: NECC 3.2.4 (WINDOWS NT 4.0) AMPN: UNABLE TO OBTAIN GREEN STATUS WITH SAC4 WHICH LIMITS TO 2.4 OR 4.8 MODU DATA PATHS. SWAPPED THE A788S RED SWITCH CARD WITH THE A15 CARDS WITH NO CHANGE. SACS 1, 2, AND 3 OBTAIN GREEN STATUS. SF).
- ILS Document:** Includes "ILS Document", "Document Title", "Document #", "Document Rev", "Problem Category" (Software - Other), "NMT Categories", and "NSN".

The bottom of the browser window shows the address bar with "jacksonia1.supportapp.spawar.navy.mil" and the "Internet" icon.

Figure 5: Closing an ISEA Trouble Ticket

WDSPT009474 Unclassified

NMT Fleet Support Request (Modify) - Microsoft Internet Explorer provided by NMTI

File Edit View Favorites Tools Help

Back Forward Stop Home Search Favorites Print Mail

Address <https://supportweb.spawar.navy.mil/arsys/forms/supportapp.spawar.navy.mil/SSC%3AHelp+Desk+Case+NMT/?cacheid=73ce25dc> Go

Links DISA Direct Home Page EDS-NMCI ISIS Online-WEBUS432 MetaFrame Presentation Server NMT Master Calendar Convert Select

Current mode: Modify

New search New request Advanced search Status history Help Home

NMT - Help Desk Case UNCLASSIFIED

Case Number: GDSC00000117675 Ticket Status: Assigned

Status Change Buttons: In Progress Resolved Close Pending Reopen Cancel Take Ticket Clone Print Save Exit

Customer Contact+ (Last Name and ENTER) Rank/Title Designator Phone Type Customer Phone Number Type of Event

HAMILTON T ES 860-694-3898 Technical Assistance

Customer Activity+ Email Type Customer Email DODAAC+ Fleet Assigned to Location / Group

USS SPRINGFIELD HAMILTTL@SPRINGFIELD.NA R21691 Atlantic F SSC San Diego / ISEA

Priority Method of Request Post-Dated Assigned to Individual

4 E-mail Email Customer Derek English

Log Ticket Work Activity Relationships Close Ticket Auditing History

Problem Resolution

Lessons Learned

Closing Problem Category

Warranty Item? PRRB Disposition

Warranty Expiration OEM FRACA # NOEF

OEM Resolution

Distance Support Costs

Total DS Hrs Expended Total DS Labor (\$) Total Material (\$) Other DS Cost (\$) Total DS Cost (\$)

0.00 0.00 0.00 0.00 0.00

Government Contractor Government Contractor Government Contractor Government Contractor Government Contractor

On-site Assistance Costs (Required only if Type of Assist includes on-site)

Total On-site Hours Total On-site Labor (\$) Total Travel Cost (\$) Total On-site Cost (\$)

0.00 0.00 0.00 0.00

Govt Contract Govt Contract Govt Contract Govt Contract

Calculate All

On-site Start Date:

On-site End Date:

On-site Performed By:

On-Site Cost Borne By:

Contains commands for working with the selected items.

Start Nov 20... Meetings Copy of... Copy of... NMT_P... NMT D... 1 Remi... SSC File... NMT FI... Remed... 8:54

Figure 6: ISEA Trouble Ticket Activity Log

WDSPT009474 Unclassified

NMT Fleet Support Request (Modify) - Microsoft Internet Explorer provided by NMCI

Address: <https://supportweb.spawar.navy.mil/arsys/forms/supportapp.spawar.navy.mil/SSC%3AHelp+Desk+Case/NMT/7/cacheid=73ce25dc>

Current mode: **Modify**

Search: New search ☐ New request ☐ Advanced search ☐ Status history ☐ Help Home

NMT - Help Desk Case UNCLASSIFIED

Case Number: GDSC00000117675 Ticket Status: Assigned

Status Change Buttons: In Progress Resolved Close Pending Reopen Cancel Take Ticket Clone Print Save Exit

Customer Contact: (Last Name and ENTER) Rank/Title Designator Phone Type Customer Phone Number Type of Event

HAMILTON T E6 860-694-3898 Technical Assistance

Customer Activity: USS SPRINGFIELD

Log Ticket Work Activity Relations

Work Log

Recommendation or Action Required

Knowledge Document Title

NMT Fleet Support Request (supportapp.spawar.navy.mil) - Work Log - Web Page Dialog

Diary History:

5/21/2008 9:28:19 AM kerwin.letiere
SOS Server changed from GDSC to SPAA

5/15/2008 9:57:29 PM john.l.vogel
STATUS: OPEN
ACTION ACTIVITY: PED CAI PMW 170
DGSIT POC: KEEFE, 757-470-7157, JKEEFE@TELEINC.COM

Diary Editor:

Attach Label

Attachment 1
Attachment 2
Attachment 3
Attachment 4

TDI Add

Table 3 outlines the full set of recorded data opportunities available when resolving MILSATCOM failures at operational sites. From the procedure depicted in Figure 2, it is possible for a failure event to realize any or all of these data opportunities. It is rare for a failure to realize all data opportunities as these represent the most difficult system problems, those that require all three support layers, System Maintainer, RMC, and ISEA to resolve. It is, however, unknown how many failure events fail to realize any of these data opportunities, as their existence is not documented.

Table 3: Total Recorded Data Opportunities from Failure Events

Source	Data Item	Distribution	Description
Ship	4790/2K	Central Site	Deferred maintenance and material status
Ship	4790/2L	Local	Optional update and description of corrective action
Ship	4790/CK	Central Site	Records change in shipboard or system configuration.
RMC	4790/2K	Central Site	Documents change in configuration to a system or deployed system.
ISEA	Trouble Ticket	Local	Number of failures requiring expert assistance and details about failure diagnosis and corrective action.

C. REPORTING A FAILURE ONBOARD A U.S. NAVY PLATFORM

In addition to the data opportunities created by the failure resolution activities, the processes planned to be inherited by the NMT program provides one additional data opportunity. The Casualty Report, or CASREP, is used to report significant equipment casualties within the Navy establishment (NSG, 2003). A significant equipment casualty is one that cannot be corrected within 48 hours and reduces the platform's ability to perform its primary or secondary mission (NSG, 2003). In addition, there are various levels of CASREP priority, levels 2 (lowest) through 4 (highest), based upon the severity of the impairment to primary and secondary missions (NSG, 2003). A platform sends a CASREP as an official Naval message to a broad distribution of stakeholders resulting in operational commanders and support personnel being advised of the status of significant equipment malfunctions that may result in the degradation of a unit's readiness. Further, the CASREP message is automatically entered into the Navy Status of Forces (NSOF)

database at each fleet commander-in-chief's site and corrected messages are forwarded to the Chief of Naval Operations' database (NSG, 2003).

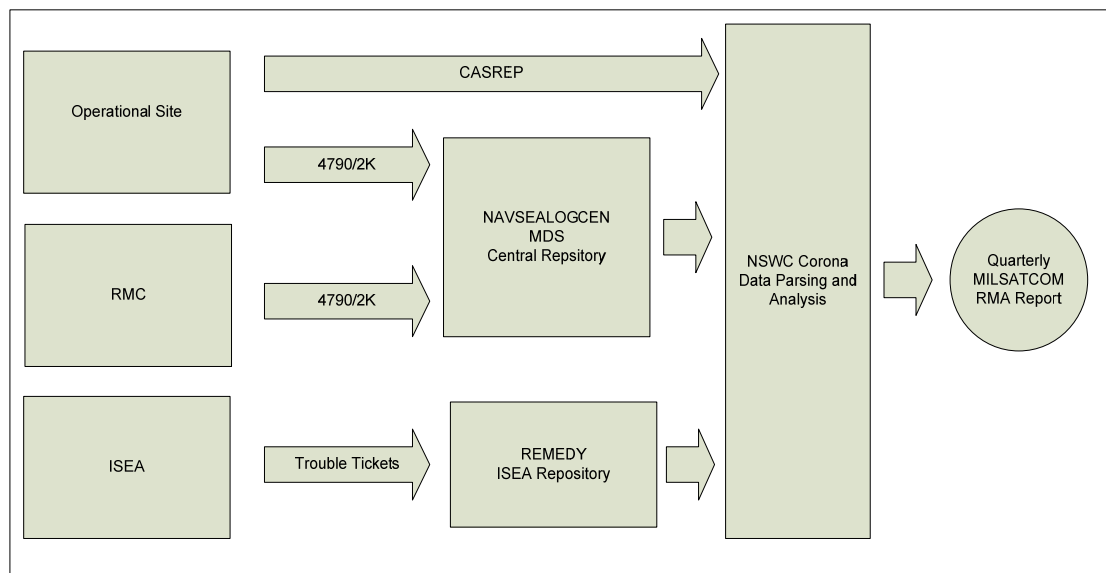
At a high level, the purpose of a CASREP is very similar to that of a 4790/2K, namely to report the operational site's material status, however a CASREP has a much higher sense of urgency. An operational site should complete a 4790/2K anytime there is deferred maintenance, but a CASREP will be completed to amplify and add urgency to the delayed maintenance when the operational site is performing an operational mission or has plans to perform an operation mission in the near future. While the CASREP will provide a request for technical assistance and a description of the problem, given the broad and senior distribution of the message, a CASREP can have powerful political implications. For this reason, CASREPs receive much more attention than 4790/2Ks or REMEDY trouble tickets. As a general rule, a Program Manager will review CASREPs on a weekly basis, despite the fact that resolution of a CASREP follows the same process as any corrective action event. Namely, the operational site will request assistance from the RMC, typically a foregone conclusion when a CASREP is sent, but the ISEA must wait to engage until tasked by the RMC. It is not uncommon for the Program Manager and the ISEA to expend time and effort watching the corrective action process unfold via CASREP messages while waiting for, and sometimes soliciting, tasking from the RMC. As the old saying goes, 'the squeaky wheel gets the grease,' the operational platform with an open CASREP is the squeaky wheel and the focus is making it quiet.

D. SYNTHESIS OF INFORMATION TO DETERMINE MILSATCOM PERFORMANCE

There are a number of data opportunities associated with resolving a MILSATCOM deficiency, but data repositories alone provide little value. Without data analysis, it is impossible to determine overall system performance. For instance, components of MILSATCOM systems will fail, but it is extremely difficult to determine if an isolated event is simply a 'fact of life' anticipated failure, or part of a broader, more severe issue. Understanding this difference is of critical importance in ensuring communication services are available to operational users.

The AN/USC-38(V) and AN/WSC-6(V) programs have tasked NAVSEA Surface Warfare Center (NSWC) Corona to develop quarterly Reliability, Maintenance and Availability (RMA) reports based upon the synthesis and analysis of corrective action data. As can be seen in Figure 7, which depicts the data pulls for producing the quarterly RMA reports, NSWC reviews the 4790/2Ks, CASREPS, and REMEDY Trouble Tickets.

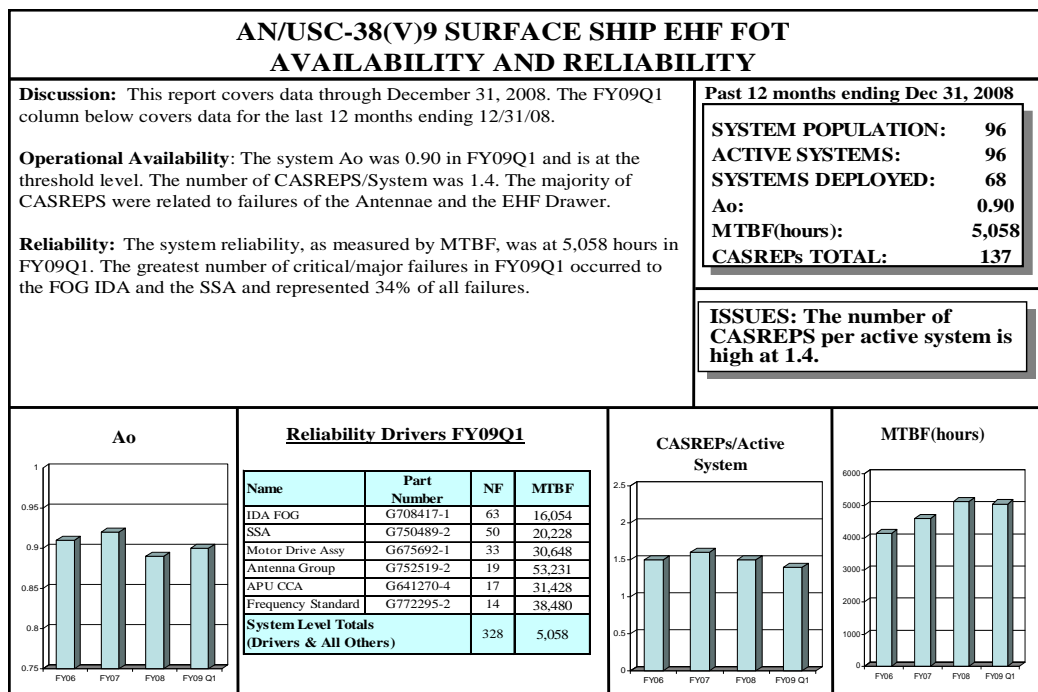
Figure 7: Quarterly MILSATCOM RMA Report



By analyzing this data, NSWC's quarterly reports give the Program Manager insight into system performance. As can be seen in Figure 8, a quarterly summary report for the AN/USC-38(V) shipboard system, the key metrics of Ao (availability), and Mean Time Between Failure (MTBF) are reported. In addition, the report identifies the system components driving the period's reliability; for the AN/USC-38(V) report depicted in Figure 8, the Internal Data Assembly (IDA) Fiber Optic Gyro (FOG) and Solid State Amplifier (SSA) had the greatest impact. Also of note, is the emphasis the report places on CASREPs. There are four instances on this single page report of CASREP associated metrics; the reasons for this are twofold. First, this is, again, a reflection the CASREP's political weight, making it a must watch item for a Program Manager. Secondly, despite potentially only recording a subset of the system failures/problems, the CASREP ends up being the best data source. As Figure 7 depicts,

NSWC reviews 4790/2Ks and attempts to extract as much data as possible, but frequently they provide little value. Too often, the 4790/2Ks identify a problem with the system, but fail to provide any data about the nature of the failure or document the true status of the system. Given the high overlap between the 4790/2K and the CASREP, why is there such a discrepancy in the quality? The speculation is that the audience and political nature of the CASREP drive in quality. The ISEA generated REMEDY Trouble Tickets overlap with the CASREPs, meaning a failure that required ISEA assistance is resolving almost always had an associated CASREP, as a result the Trouble Tickets contribute very few unique events to the analysis. However, the Trouble Tickets do provide amplifying information supporting the Program Manager's efforts to identify and understand the core issue. In summary, a highly political mechanism designed to report the failures with the greatest impact and/or most challenging corrective actions currently make up the majority of the performance assessments for MILSTACOM systems.

Figure 8: Sample AN\USC-38(V) NSWC Quarterly Report



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III. CURRENT DATA COLLECTION METHODS ON INCREASING SYSTEM AVAILABILITY

A. SYSTEM AVAILABILITY

What is system availability? Textbooks define Operational Availability (Ao) as the probability a system will be ready to perform its specified function, in its specified and intended operational environment, when called for at a random point in time (OPNAV 2003). Or, more simply, availability has been described as the percentage of time the system will be ready to perform satisfactorily in its intended operational environment (OPNAV 2003). Availability is a relevant metric to all aspects of life. For instance, mornings are planned and scheduled around the availability of a number of systems, including the automobile. The morning schedule utilizing an automobile with an availability of 25% is much different than one with 98% availability. The same calculations and risks an individual makes based upon their transportation to and from work must be made in accomplishing military objectives.

As the percentage of time a system will be ready to perform satisfactorily in its environment, Ao can be simply described by equation 1:

Equation 1

$$Ao = \text{Up Time} / (\text{Up Time} + \text{Down Time})$$

While this straight forward equation conveys the intent of the metric, this form is a trailing indicator without any predictive capability. In addition, and more troubling, this expression of Ao doesn't provide any insight as to improving a system when Ao performance is inadequate (OPNAV 2003). Rather, the following expressions provides both predictive and, more importantly for this analysis, a means to identify and address deficiencies in Ao performance.

Equation2

$$Ao = \text{MTBF} / (\text{MTBF} + \text{MDT})$$

Mean Time Between Failure (MTBF), as the name implies, is a measure of the mean operating time between successive system failures; this is a measure of system reliability. Mean Down Time (MDT) is the mean time the system is inoperable per failure incident (OPNAV 2003). As described by equation 3, MDT is the sum of two attributes associated with system downtime, Mean Time To Repair (MTTR) and Mean Logistics Delay Time (MLDT). MTTR is the average time it takes to repair a system in its operating environment, this includes both the time it takes for the System Maintainer to diagnose the failure, and the time required to perform the corrective action. MLDT is the down time associated with logistics actions, such as the time required to order and take receipt of parts. For example, if in correcting a system failure it takes the System Maintainer 1 hour to diagnose the failure, 2 hours to order a new part, 1 day to receive the part, and 2 hours to install the part, the MTTR would be 3 hours and the MLDT would be 26 hours.

Equation 3

$$\text{MDT} = \text{MTTR} + \text{MLDT}$$

B. WHAT WILL INCREASE SYSTEM AVAILABILITY

1. Increase Mean Time between Failure

As described by equation 2, an increase in MTBF increases system Ao. There are two ways to increase MTBF. The first method is to improve system reliability, i.e., decrease the frequency at which the system fails. System reliability is heavily influenced by system attributes determined early in the design process, such as the system's architecture, and, to some degree is inherent to a given design. However, while a macro change in reliability may be unachievable, the reliability of a system can be improved. Through an iterative process of identifying failure root causes, incremental improvements may be achieved. Eventually this process could reach a point of diminishing returns, but there is value in realizing optimal performance by reaching this point. The second method for increasing MTBF is to decrease the number of false negatives, i.e., reduce operator error. There is no difference in result if the system actually has a failure or the System

Operator thinks the system has a failure; in either condition, the system will fail to accomplish its mission. The pervasiveness of operator error is a function of the training and experience of the System Operator; simply, more proficient users results in less error.

2. Decrease Mean Time to Repair

Decreasing MTTR is heavily reliant on System Maintainer proficiency. The faster a system can be repaired the sooner it can support tasking. MTTR is a metric broken into two constituent parts, the time to diagnose the failure and the time required to perform the corrective action. The speed of diagnosis is a function of the System Maintainer's general troubleshooting skill, the experience with the specific system, and the quality of the supporting information. Troubleshooting, often both a science and an art, can be improved with training and experience, but also varies with individual talent. Like operating experience, working on a system increases the understanding of a system's design, behavior, and failure mechanisms. Lastly, the quality of technical documentation and other supporting materials which guide the System Maintainer have a tremendous impact on diagnosis timeline. A cliché joke is the father setting out to assemble Christmas gifts only to find the instructions are printed in a foreign language.

Once the System Maintainer has completed failure diagnosis the time to perform the corrective action is affected by both the System Maintainer and system design. Just like in failure diagnosis, the System Maintainer's general skill, and experience with the system, along with the quality of supporting information affect the speed at which the corrective action is performed. Also, the speed of repair is impacted by system design. Like MTBF, repair steps are heavily influenced by early design decisions, for instance, we have all heard stories of automobiles requiring engine removal to change spark plugs. But, again, the design can be incrementally improved. Through the process of analysis and incremental improvements, the design can be optimized, reducing repair time.

3. Decrease Mean Logistics Delay Time

MLDT is a quantification of supportability that is defined to include personnel, repair at other levels, supply support, transportation, and other logistics delays not

attributable to actual hands-on maintenance time (OPNAV 2003). There is an array of items affecting MLDT, but typically the greatest is the time associated with receipt of spare parts. When the NMT system is installed, the operational site will receive an inventory of On Board Repair Parts (OBRPs). These OBRPs is the operational site's supply of spare parts, the composition of which is based upon the system developer's best analysis and predictions. However, despite the best efforts by the system developer, a failure affecting a part not in the OPBRP inventory is possible and probable. In these instances the operational site must order a replacement part from Navy supply.

The time associated to fulfill this requisition request from Navy supply is dependent upon both the channel delay and the current inventory. Channel delay is the time required for the requisition to be completed, received, processed, and shipped. Given the global coverage of Navy ships, shipping delay can have a significant impact on MLDT. Also affecting MLDT are inventory levels within Navy supply. If the part is available on the shelf, the timeline to process the requisition is relatively short. If the part is not in inventory, the MLDT may be significantly impacted. There are several potential reasons for inventory shortfalls; common ones include procurement back orders and batch repairs. In the case of batch repairs, with cost efficiency in mind, Navy supply frequently repairs deficient parts in batches, e.g., repair parts will not be repaired until there are a certain quantity to achieve economies of scale. This can create instances where the Navy supply has an inventory of deficient parts while waiting for the batch size to trigger a repair action. Simply, for whatever reason, if there are no parts in inventory, the operational site will wait, increasing the MLDT.

C. ATTRIBUTES OF AN IDEAL DATA COLLECTION SYSTEM FOR INCREASING SYSTEM AVAILABILITY

1. Increasing Mean Time between Failure

There are two approaches to increasing MTBF: improve system reliability and increase user competency. Addressing these approaches requires data analysis and usage by different consumers.

To improve system reliability, the individual or organization responsible for making system modifications must understand the system's operational performance. There are instances where this responsibility lies with a third party, but typically, this responsibility lies with the Acquisition Program Office and System Developer. For this audience, the ideal data collection system would capture all issues associated with the operation of the system. This issue capture would cover the array of events from minor nuisances to major failure events; records would be created every time the system failed to meet expectations. In addition, the actions taken to correct the issue, both successful and unsuccessful, would be recorded. This comprehensive recording is ideal because it provides the Acquisition Program Office and System Developer the ability to identify pervasive versus anomalous problems, identify developing trends early, and document the conditions surrounding a failure. This information will facilitate application of the Acquisition Program Office's limited resources towards correcting problems with impact. In addition to problem identification, a high level of information increases the level of problem understanding, creating an opportunity to correct deficiencies more efficiently. Efficient deficiency correction, in turn, compounds into an opportunity to stretch resources further and correct more system problems. Both phenomena accelerate optimization of system reliability resulting in higher availability.

Increasing user competency and, thus, decreasing instances of operator error, requires increased awareness by current system operators and improved training for future system operators; both goals can be supported by an ideal data collection system. During their career the average NMT System Operator will have a relatively narrow experience, having only operated NMT systems at the schoolhouse where they were trained, and the one at their operational site. This limited exposure shapes the users expectation and understanding of the system and its capabilities. Individually these user's experiences provide valuable but very finite insight into the operational performance of the NMT system. However, the aggregation of these experiences provides almost total insight into the operational performance of the NMT system. By

having access to all the events associated with the operation of the NMT terminal, an individual user is exposed to information and an understanding well beyond their organic opportunity.

This data would amplify the peer-to-peer training currently taking place at Navy sites. As previously mentioned, different operational sites may have varying numbers of System Users depending on the size of the site, and these users, like any other work environment, share their experiences and knowledge through ad hoc interactions. This information exchange increases the overall competency of that site's user corps, but is confined to that site. The ideal data collection system would help transcend this proximity constraint increasing the knowledge of the entire user community. By leveraging the experience of one to the entire community, the competency of System Users will increase, reducing the instances and impact of operator error.

In addition to improving the knowledge of current users, the ideal data collection system would facilitate improved training for future users. The community of NMT System Users will have fairly homogenous demographic characteristics. For instance, the users will be of similar age, have had the same military education experience, and by virtue of having the same IT rate designation all received similar marks on the Armed Services Vocational Aptitude Battery (ASVAB)⁴. As a similar demographic group it is reasonable to assume there will be common perspectives prior to, during, and after the schoolhouse experience. The training curriculum developers are, however, not of the same demographic group. Between the curriculum developers and System Users typically exists a gap in age and education, therefore, the training curriculum is a translation attempt from one demographic to another. Like all education endeavors, this translation has historically had varying degrees of success, but is always based upon an assumption by the curriculum developers as to which concepts and material are important. The ideal data collection system will allow the schoolhouse and the curriculum developers to validate or change these assumptions. This information will allow update and refinement of the curriculum based upon real experiences and

⁴ The ASVAB is the Armed Forces Vocational Aptitude Test. Test results determine (1) whether one qualifies for military service and (2) if so, for which military service jobs.

challenges experienced by the System Users. The net result of this assumption feedback loop is more effective training, creating higher competency users.

2. Decrease Mean Time to Repair

Like increasing MTBF, there are two approaches to decreasing MTTR, increasing maintainer competency and making meaningful system improvements. Again, these approaches require data consumption by two distinct groups, the System Maintainers and the System Developers.

In isolation, System Maintainer's experiences, like System Users, provide limited opportunities to increase competency, but, in aggregate, their experiences cover the vast majority of knowledge about the system. The ideal data collection system captures rich information about the failure diagnosis process, including the symptoms experienced, rational for selected steps, and the ultimate problem resolution. This data enables peer-to-peer training, turning one maintainer's experience into a community experience. By reviewing this data, a System Maintainer is able to proactively increase his or her system knowledge, and rapidly address and apply this knowledge should their system experience a failure or, in a more reactive fashion, have a repository of documented solutions. Regardless of the proactive or reactive posture taken, the end result is ability of System Maintainers to rapidly identify and correct system deficiencies, decreasing the MTTR.

In addition, this effect is compounded when data is used and created by RMC and ISEA technicians. Despite a focused expertise on the NMT system, the RMC and ISEA technicians know far from everything, and their competency will grow from the community experiences just like the rest of the System Maintainers. With increased competency, these technicians can more efficiently assist the System Maintainers in corrective actions requiring their support. Part of this increased efficiency will be a higher success rate with distance support. High distance support success rates, translates into lower MTTR times and lower support costs, which facilitates reallocation of resources to fixing system deficiencies. In addition, the ideal data collection method would record information about the RMC and ISEA technician's failure diagnosis process including the rational for selected steps. Since the RMC and ISEA technicians

have more experience and focused system education than the System Maintainers, this data facilitates a “guru-to-expert” tutelage not previously achievable on a broad level.

The ideal data collection system facilitates ongoing peer-to-peer training and “guru-to-expert” training, but also facilitates improved initial training. Like the System User training, the System Maintainer training is based upon an assumption by the curriculum developers. These assumptions are made without the benefits of a similar demographic perspective, and feedback is highly beneficial. The net result of this assumption feedback loop is more effective training, resulting in more competent System Maintainers.

Like the training curriculum, technical manuals suffer from the same demographic disparity. Technical manuals are typically written by the System Developers whom have a different perspective and understanding than the System Maintainers. Again, this disparity is bridged via assumptions made by the System Developers. The good assumptions will result in the clear conveyance of information to the System Maintainer. The bad assumptions could leave the System Maintainer bewildered, prolonging the duration of the repair, or worse, result in further system damage, or worse yet, create a safety hazard and injure the System Maintainer. While technical manual writers are professionals and there are processes to validate and verify the content, iterative feedback on the assumption provides a great opportunity for improvement.

Lastly, the Acquisition Program Office and System Developer can use the corrective action data to improve the system maintainability. Like increasing reliability through iterative system improvements, the system repair can be made easier. While a good designer will take repair actions into consideration during the design process, they are always at a context disadvantage. For instance, without being onboard a moving ship, in the dark, standing on their tip-toes while reaching around cables, the choice of fine versus course connector threads may seem insignificant. With information about these experiences and challenges, the Acquisition Program Office and System Developer can take steps to improve these unforeseen problems.

3. Decrease Mean Logistics Delay Time

The largest contributor to MLDT is the time associated with shipping and receipt of replacement parts and avoiding this process would significantly reduce MLDT. By capturing all the issues associated with the system, the Acquisition Program Office and the System Developer can identify the truly pervasive system problems. With this information the first approach of eliminating problems through design modifications may not be feasible. In these instances, there is an opportunity to augment the operational site's spares compliment with the frequently failing components. In addition to identifying system components, an ideal data collection system would identify issues with corrupted or frequently lost computer files facilitating a modification to operational procedures for data archiving. In these instances, an ideal data collection system facilitates avoidance of the largest contributor to MLDT, channel delay.

4. Summary of an Ideal Data Collection Process

An ideal failure data collection system provides an opportunity to address and improve all components of Ao. As enumerated by Table 4, the ideal data collection system captures all system anomalies and the steps taken to resolve them. Once collected, this information is consumed by different stakeholders to improve their role in ensuring the NMT provides the required NMT capability.

Table 4: Ideal Data Collection Summary

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
1	All system anomalies	Acquisition Program Office and System Developer	System Improvement	MTBF
2	All system anomalies	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTBF
3	All system anomalies	Acquisition Program Office and System Developer	OBRP requirement updates	MLDT
4	All system anomalies	System User Community	Peer-to-Peer Training	MTBF
5	System Maintainer Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Peer- to-Peer Training	MTTR
6	RMC and ISEA Technician Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Guru-to-Expert Training	MTTR
7	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	System Improvement	MTTR
8	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR
9	RMC and ISEA Technician Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR

D. EVALUATION OF THE CURRENT DATA COLLECTION METHODS ON INCREASING SYSTEM AVAILABILITY

The NMT system is scheduled to inherit the problem resolution process and data recording process currently employed by the AN/USC-38(V) and AN/WSC-6(V) systems described in Chapter II. The problem resolution process and data recording process seeks to satisfy two goals, both pertaining to readiness. The first goal has a very short time perspective and is concerned with documenting and reporting the current readiness of a platform. This information is, obviously, very important and relevant when an operational site is executing an active mission, or preparing to execute a mission in the near future. If an NMT experiences a failure that precludes, impacts, or increases the risk for an operational platform in performing its mission, this information needs to be made available rapidly to the command chain. With mechanisms such as the CASREP, the existing system satisfies this goal very well. However, there is a second goal, one that takes the longer view of improving system performance, its users, and its support structures; this is the area being evaluated.

In the previous section, attributes of an ideal system were proposed as means against which to evaluate the current system and any proposed modifications. The ideal attributes may not be achievable in execution, so a perfect score for any system against any attribute is unlikely, but it does allow a comparison of several different systems using the ideal as an intermediary. There were nine of these ideal attributes identified that support the “longer view” of increasing system Ao. The sections below evaluate the current system against these nine attributes.

Table 5: Ideal Attribute 1

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
1	All system anomalies	Acquisition Program Office and System Developer	System Improvement	MTBF

The first attribute of the ideal system is to record information about all system anomalies for the purpose of improving the system. The current system collects information using the 4790/2K, CASREP, and REMEDY Troubles Tickets, but this information is neither as comprehensive nor as detailed as the ideal. Currently, when the System User experiences an anomaly they must make a decision about the need to alert the System Maintainer. There are a number of failures modes, predominantly software in nature, which the System User may be able to correct, such as reloading a corrupted file, restarting program, or restarting the entire system. Each one of these events could result in a loss of communications for several to many minutes, but could occur and be resolved without any documentation. Without being documented, it is possible the organizations with the ability to correct them, the Acquisition Program Office and System Developer may not know they exist. The same threshold to reporting problem exists once the System Maintainer is notified of an issue. The System Maintainer can address software issues, but can also correct hardware deficiencies that may not trigger the completion of a 4790/2K. This creates the opportunity for a class of failures that impact or temporarily impair communications that, because they are not known, could exist throughout the life cycle of the system.

In addition, for anomalies that are documented, the documentation often fails to include details that would be beneficial in the development of a correction to the deficiency. For instance, the System User experiences the failure, yet the User does not complete any of the failure documentation. Once the System Maintainer initiates a 4790/2K, potentially lost is contextual information about what the System User was trying to accomplish and expecting. This information can help the System Developer understand and fix the deficiency in a number of ways, one of which is to efficiently recreate the event. Further, whether the System Maintainer chooses to complete a 4790/2K or a CASREP or not, the primary purpose of the documentation is readiness reporting, not long-term improvement. With this in mind, the records focus on what this system cannot do, with little detail on the actual failure mode. The same is true of the RMC-generated 4790/2K, as the bulk of the dialogue used to describe and understand the failure is done via perishable means such as voice communication or ad hoc methods

such as chat or e-mail. In their REMEDY Trouble Tickets, the ISEA attempts to record richer information about the details and nature of the failure, but the ISEA sees only the worse conditions, and the REMEDY Trouble Tickets do not reconstruct the data lost by other stakeholders in the failure resolution process.

Table 6: Ideal Attribute 2

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
2	All system anomalies	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTBF

The second attribute of the ideal system is to record information about all system anomalies for the purpose of updating the training curriculum and technical publications with the goal of improving System User competency. Again, the current data recording system is hampered by both the threshold trigger for reporting and the fact that the System User does not contribute any data to the process. Without either all the instances or the input of the actual user, it is very difficult to assess the frequency and pervasiveness of operator error. With little information, the technical publications and the training curriculum typically receive little to no improvement from the failure process. Typically, the only time these documents get addressed throughout the failure process is if they are explicitly stated in a CASREP. Statements concerning these documents' specific areas for improvement are rare, but rather often read like a statement of frustration by the operational site, as if to say, "the system isn't working and we can't fix it as a result of insufficient training and poor technical manuals." With the CASREP being a highly political document, these statements may invoke a reactionary look into the publications, but, without specific information, typically yield little improvement.

Table 7: Ideal Attribute 3

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
3	All system anomalies	Acquisition Program Office and System Developer	OBRP requirement updates	MLDT

The third attribute of the ideal system is to record information about all system anomalies for the purpose of updating the operational sites' OBRPs complement. Whether via completion of a 4790/2K, 4790/CK, or CASREP, the current system does an effective job capturing the demand for replacement parts, allowing ongoing calculation and analysis of the operational site's spares inventory. There is potential that a failure could be corrected with an existing OBRP without being recorded. This situation is not desirable, however, when trying to evaluate the spares complement, understanding needed parts not currently in the spares compliment is more important than knowing the utility of the parts currently in the spares compliment. This is because the existing complement represents a sunk cost, i.e., they have already been bought, where as the Acquisition Program Office must apply its limited resources to add a spare to the inventory. The 4790/2K and perhaps 4790/CK and CASREP allows the Acquisition Program Office to evaluate the opportunities to improve availability by augmenting the OBRP package.

Table 8: Ideal Attribute 4

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
4	All system anomalies	System User Community	Peer-to-Peer Training	MTBF

The fourth attribute of the ideal system is to record information about all system anomalies for facilitating peer-to-peer training by leveraging the experiences of individual users to that of the entire community. Used for this approach, the ideal system, increases user competency and reduces the frequency of operator error by allowing other operators to learn more about the capabilities and limitations of the system through the experiences of their colleagues. The current data collection system fails to address this attribute. None of the data produced, whether in a 4790/2K, 4790/CK, CASREP or REMEDY Trouble Ticket, is shared or available to other System Users. There is opportunity for peer-to-peer education within an operational site as a result of geographic proximity, but this is where the opportunity ends.

Table 9: Ideal Attribute 5

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
5	System Maintainer Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Peer- to-Peer Training	MTTR

The fifth attribute of the ideal system records information about the steps taken by the System Maintainer when diagnosing a failure and performing the corrective action. Collecting and sharing this information amongst the community allows other System Maintainers to learn from the each other's successes and failures. With the current data recording system, the System Maintainers documents very little about the corrective action process and nothing about the diagnosis process. For instance, with a 4790/2K a System Maintainer could state replacing a certain part corrected the deficiency, but cannot record any information about performing the repair. For challenging repairs, this information would be beneficial to all System Maintainers, reducing the time and probability of collateral damage to other components during system repair. The System Maintainer can record this type of information in a 4790/2L, but, per direction, the system does not support reporting this information beyond the operational site. So, like

the 4790/2K, the information contained in the 4790/2L isn't shared to other System Maintainers, but unlike the 4790/2K, the information is not distributed to anyone; no one beyond the operational site sees the information.

With regards to information on the diagnosis process, the current system does not record any information. Again, the 4790/2K may record, at a high level, the corrective action taken, but it does not record any information about how the System Maintainer arrived to that conclusion or how many red herrings were chased until the root cause was identified.

In summary, the current data recording system does not support peer-to-peer training of System Maintainers.

Table 10: Ideal Attribute 6

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
6	RMC and ISEA Technician Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Guru-to-Expert Training	MTTR

The ideal data collection system records information to support another type of training, that being RMC or ISEA technicians training System Maintainers, or “Guru-to-Expert” training. The opportunity is similar to that of peer-to-peer training, by documenting both the diagnosis and corrective actions taken by the RMC or ISEA technicians, the entire community of System Maintainers can learn from the knowledge and expertise of these system “Gurus.” Under the current data recording system, RMC technicians document all information via 4790/2K. Whether used by the System Maintainer or the RMC technician, the 4790/2K is hampered by the same constraints of limited corrective action information, no diagnosis information, and no visibility by the rest of the System Maintainer community. With the current system, the “Guru-to-Expert” training is performed on an individual basis between the assisting technician and the

System Maintainer requiring assistance. ISEA technicians record a richer set of data, documenting both the steps taken and the rationale for doing in the log portion of the REMEDY Trouble Tickets. This information is reviewed by other ISEA technicians allowing knowledge to diffuse throughout the ISEA technicians, but this information is not shared beyond this small group.

Table 11: Ideal Attributes 7 and 8

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
7	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	System Improvement	MTTR
8	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR

In addition to facilitating peer-to-peer training, the collection of failure diagnosis and corrective action facilitates improvements to the system and its supporting infrastructure. As previously noted, seemingly insignificant items, such as thread choice, can have a disproportionate impact on the difficulty and time associated with performing a corrective action. With information, the Acquisition Program Office and System Developer may be able to eliminate these challenges. The same is true of training curriculum and technical publications; they too can be improved once the challenges are understood. With the current data collection system, the Acquisition Program Office and System Developer may be able to infer some changes to the training materials and technical publications based upon the types of failures experienced. For example, if a part in the NMT experiences frequent failures, and attempts at improving the part were unsuccessful, enough information could be gained to warrant changes to the training and technical publications notifying the System Maintainer to look at one particular

component first. However, through limited information in the 4790/2K and lack of distribution of the 4790/2L the current system doesn't support fine tuning the repair process. Lastly, much like instances of System User error, training and technical publications may be mentioned in CASREPS, but statements concerning these documents are very general, often reading like a statement of frustration.

Table 12: Ideal Attribute 9

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
9	RMC and ISEA Technician Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR

The current data collection system only uses limited information from RMC and ISEA assistance action to improve training curriculum and technical publications. The information provided in RMC technician generated 4790/2Ks provides limited information for improving either the maintainability of the system or technical publications. However, the Acquisition Program Office and System Developer does use the data recorded in the log portion of the Remedy Trouble Ticket to identify and address issues with the technical documentation. Typically these issues are technical errors or omissions. Training curriculum typically does not reap as much of a benefit from this data, but the training curriculum could be improved if an egregious error was discovered.

Table 13 is a summary of the current data recording systems performance against the ideal recorded as a score. The score was calculated on a scale of 1 through 5. A score of 5 is equivalent to the ideal, while a 1 represents a failure to address the attribute. Scores of 2 through 4 represent document increased performance relative to ideal.

Table 13: Summary Score of Current vs. Ideal System

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected	Score
1	All system anomalies	Acquisition Program Office and System Developer	System Improvement	MTBF	3
2	All system anomalies	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTBF	2
3	All system anomalies	Acquisition Program Office and System Developer	OBRP requirement updates	MLDT	4
4	All system anomalies	System User Community	Peer-to-Peer Training	MTBF	1
5	System Maintainer Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Peer- to-Peer Training	MTTR	1
6	RMC and ISEA Technician Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Guru-to-Expert Training	MTTR	1

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected	Score
7	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	System Improvement	MTTR	2
8	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR	2
9	RMC and ISEA Technician Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR	2

IV. ONLINE COMMUNITIES

A. WEB 2.0 AND ONLINE COLLABORATIVE COMMUNITIES

To many, the word community may elicit thoughts of their neighborhood or even their city. However, Web-based online technologies are facilitating new community models which break these traditional geographic constraints. These tools are accomplishing this through an unparalleled level of participation in content generation. Users are able to develop and share content around an array of topics facilitating the formation of communities. In the “Web 2.0” construct, as the application of these capabilities is coined, every user is not only a consumer of data, but also a data producer and data organizer (Sankar & Bouchard, 2009). The moniker Web 2.0 conveys this participative difference from other uses of the Web technologies coined “Web 1.0,” often disparaged as “brochure ware”; a term that highlights the unidirectional flow of information from publisher to subscriber. The Web 1.0 model of concentrated publishers providing information to the masses runs contrary to Web 2.0’s fundamental paradigm of participation.

Despite the differences in use paradigms, the underlying technologies are very similar; there is not one technology driving the deployment of Web 2.0 (Sankar & Bouchard, 2009). Web 2.0 employs the same technologies such as HTML, XML, Java, and Java Script used in previous Web applications. Some extrapolations of these fundamental tools, such as Asynchronous Java and XML (AJAX), which support ad hoc high frequency updates to portions of the user’s screen and improve usability of these capabilities, are supporting and enabling functions rather than causal technologies. Web 2.0 has also benefited from macro computing trends of increased access to bandwidth, increased computing capabilities and cheap storage. But, again, these effects are enablers vice creators. Fundamental to Web 2.0 is the philosophy that a mass of individuals can do better job of creating content than a small cadre of individuals. This participative paradigm is executed through via several Web 2.0 models

B. WEB 2.0 MODELS

1. Web Logs

Web logs, more commonly known by their contracted name, blogs, are Web-based tools that enable people to share and discuss information (Sankar & Bouchard, 2009). The blog owner initiates the discussion through a blog posting. A posting can be a written statement, a picture, a video, or a combination of all these elements, really anything the owner wishes to share. Users participate in blogs by reading the owner's postings, and contributing their thoughts, opinions, questions, or whatever they desire, as a comment. Also, the users can post comments in response to other user's comments resulting in discussions between the owner and users, as well as, among the users themselves. These dialogues are recorded allowing participants to contribute within their time constraints, i.e., participation is not required at a specific time, making blogs a relatively time insensitive method of collaboration. Recording of these postings and discussions facilitate other users passively participating in the conversation and create a reference archive of these dialogues.

Online diaries are a frequent connotation for blogs, but blogs are very pervasive sources of information with radical implications for traditional information sources. In the United States an estimated 26.4 million users have started a blog, of those that are active, 46% characterize themselves as professional bloggers (Sankar & Bouchard, 2009). These professionals typically write about a specific area such as technology, economics, or pop culture—really, the topics are endless—but one area significantly affected by blogs has been news reporting. For many news consumers blogs represent the preferred medium for information on current events and important issues. This trend has greatly affected the traditional media companies, especially newspapers, which have experienced enormous changes over the past couple of years. The first White House Press credentials issued to a dedicated blogger were given in March 2005, a symbolic inflection point in the newspaper business with almost 95% of the top newspapers now having reporter blogs and several newspapers closing or converting to an all digital format (Sankar & Bouchard, 2009).

In addition to changing industries, blogs have been embraced by companies as a means to inform customers and capture their opinions. Companies use blogs to obtain customer feedback about specific products or general initiatives. For instance, Nike uses their blog to debut new products, while General Electric uses theirs as a news reporting service to discuss their latest technical innovations. Both companies receive input from their customers; Nike is able to get explicit feedback about the likes and dislikes on a specific product, while GE can assess enthusiasm for a particular area of research.

2. Wiki

The wiki model allows users to co-create and collaboratively develop content. By contrast to blogs where the chronological order of owner postings and user comments facilitate a conversation, a wiki allows all users to create or edit content placed within the wiki page. For instance, as a simple example, driving directions posted to a wiki site by an individual could be modified or updated by another to correct errors, inform of road construction or even an accident. This mass editing function facilitates two phenomena; the first is short publishing cycles and, the second, a convergence toward quality. Users are able to update wiki content on a constant basis,⁵ ensuring the most current information is available to wiki users via incremental updates, rather than waiting for a specific or threshold to initiate a new revision. In addition, these updates performed by a community of users increases the content quality.

Based on an extrapolation of the adage that ‘two heads are better than one,’ a community of individuals reading and editing content are able to create a product of comparable or superior quality in an efficient manner. In 2005 “Nature” magazine conducted a study to determine the relative accuracy of Wikipedia, a wiki based encyclopedia, and the Encyclopedia Britannica on science topics. Forty two topics were analyzed, for which Wikipedia averaged 4 errors per topic while Encyclopedia Britannica averaged 3. With this one additional error per article “Nature” found Wikipedia to be comparable to Encyclopedia Britannica for science topics (Giles, 2005). Wikipedia’s

⁵ Wiki applications provide features that prevent users from editing information at the time. If one user is performing edits to the information others are prevented from editing until the other users have finished.

performance as an information source is even more impressive when the fact that in addition to the 42 topics analyzed Wikipedia has amassed 2.8 million more articles than Encyclopedia Britannica. In addition the Wikipedia community is able to immediately correct errors making them available to all users in a matter of minutes, whereas, Encyclopedia Britannica must publish addendum sheets or wait for a new volume.

While Wikipedia is the most famous application, many companies and organizations are using wiki's for collaboration within companies and with their customers. As a corporate user, Sun Microsystems had over 600 employees and affiliates using their wiki for collaboratively creating documentation after one month of use (Mader, 2008). The National Constitution Center, a non-profit for increasing public understanding of the constitution, uses a wiki to coordinate and collaborate on information between constitutional scholars and the general public; an annual community of 165,000 users (Mader, 2008). As a last example, fans of the Scottish Football Club are using a wiki to create the definitive history of the club in an extraordinarily rich fashion. This history includes all the traditional items such as the team's chronology and significant events, but, by using the wiki, it also records the fan's experiences and feelings associated with the club. The fans have created over 3,500 pages of content, added 7,000 images and made over 18,000 contributions, resulting in a team anthology of breadth and essence unachievable through traditional means (Mader, 2008).

3. Folksonomy

The challenge with any filing system, whether physical or electronic, is making a decision about where to place something. Once an item is placed in a location, the ability for it to be found again is based upon the seeker having similar opinions about where it belongs. As a simple example, couples in a domestic setting may have different opinions about where keys should be stored, one believing they should be kept in plain view will invariably be searching, and probably frustrated, when seeking them if they were last used by a spouse who believes they belong in a drawer. Clearly this problem increases dramatically as the number of seekers and number of items being sought increases.

Metadata, data about data, was designed to combat this problem by allowing systems to collocate information and help users find relevant information.

Metadata has historically been assigned by professionals, such as in library catalogues, resulting in two significant limitations. First, by relying on a cadre of professionals there is a capacity constraint as to how much data can be catalogued. This problem is compounded by the rapid rate at which data is being created in the Web 2.0 paradigm; there is simply no way a group of cataloguers can keep pace with the rate of creation. Secondly, albeit professional catalogers use defined taxonomies, the seeker is still removed from the process and the potential for differences of opinions and its associated problems remain. One-way to combat the first problem is having the author catalogue their data. This eliminates the capacity constraint, but compounds the second problem because most authors lack the professional training to apply taxonomies and have definite opinions about the associations of their work. Web 2.0 allows both these challenges to be addressed through folksonomy.

Folksonomy, a hybrid of folk and taxonomy, is an organic system of organization based upon tags placed by users (Pink, 2005). Tags support both data descriptions and scoring. Instead of placing electronic files into folders which, because a file can only exist in one folder is restrictive, tags are without hierarchy allowing for many different categorizations and associations (Mader, 2008). For example, a picture of skydiver could be valuable to one author writing an article titled "Life's Great Adventures" and another one writing an article titled "Stupid Things Not To Do." With tags this picture could be described as 'adventure,' 'adrenaline rush,' and 'fun' to allow one author to find it, while also being described as 'risky,' 'dangerous,' and 'death' allowing the other to find it. In addition to describing the data, tags allow for users to evaluate or score data. There are different scoring mechanisms ranging from counting the number of instances the data was accessed to actual grades. The more complex the scoring mechanism the more subjective the scores and even the attribute being scored. For instance, graded scoring systems typically ask the user to rate the data, it does not specify if the rating is an

evaluation of quality, personal interest, or some other attribute. Regardless, this scoring mechanism and descriptive tagging have supported many of the archetype Web 2.0 capabilities.

YouTube, Flickr, and Digg are three capabilities that have become synonymous with Web 2.0. YouTube allows users to upload and share videos they have generated with anyone and everyone, an activity that has proven very popular with over 100 million videos available on YouTube. As producers post and users view videos, they are described and scored via tags. When searching for a video, users can search by a descriptive term or view videos based upon their popularity. Flickr allows a similar service as YouTube, but with photographs instead of motion video. Photographers post their digital photographs, currently in excess of 3 billion, and others are able to search through them based upon descriptive terms and scores. In contrast to YouTube and Flickr, which focus on a specific data format, Digg allows users to discover and share all content across the Web. This includes videos, pictures, audio tracks, and written word, essentially, if it is available on the Web it can be tagged and used with Digg. The Digg tags can be descriptive, but the focus is heavily on scoring, which facilitates a Web popularity contest. As Web users find content, they score it with a Digg tag. Based upon how and how many users have scored the content, it will rise in popularity. The top-scoring content is placed on the Digg homepage, similar to the newspaper practice of putting the most important news on the front page.

As the examples of YouTube, Flickr, and Digg demonstrate, folksonomy based capabilities are very popular in facilitating communities with similar interests but have yet to see broad application in communities with specific goals such as corporations. YouTube, Flickr, Digg, and others do an excellent job of discovering, associating, and scoring content for a community formed around similar interests or hobbies. With these tools member of a community interested in home audio can find articles, how-to videos, and pictures. But, in these applications the penalty for missing content is very low or nonexistent, since their value is in bounding the breadth and depth of content, not isolating a specific instance. Often, this is contrary to the mission of a corporation, which spends resources for the generation and collection of its intellectual capital. With this

investment, companies currently see the value in investing in organization schemes governed by strict taxonomies. For instance, an electronics engineering firm would be uncomfortable with their designs floating in the morass of company data only discoverable by descriptive word searching. However, while a folksonomy based primary structure is unpractical in the corporate setting, as a secondary structure there is an opportunity for it to support discovery and reuse by other members within the organization. As an example, by using a folksonomy schema the electronics engineering firm could interrogate their design repositories to help with finding solutions and design reuse when faced with a difficult technical problem or a challenging cost objective

4. Aggregation

Aggregation is a mechanism for collecting a presenting content from regularly changing Websites such as blogs and news sites (Sankar & Bouchard, 2009). Staying current with interesting content via the brute force method, i.e., frequently checking sites for updates in content, rapidly becomes impractical as the number of sources being followed increases. The user would either run out of time or get annoyed with the process; aggregators solve this problem. An aggregator is an application that collects, consolidates, and displays updates from sites the user is interested. The display of the update looks very similar to an e-mail inbox, identifying the material's source, subject line or headline, and a short summary or segment of the update. Just like an e-mail inbox, the user can rapidly parse through the updates choosing which to ignore and which are of interest. Once interested the user follows a Web link provided in the content to the site containing the full update. To receive the updates to their aggregator a user proclaims their interest in the site's content by subscribing. For example, a user may have an interest in a sports blog about their favorite team, while visiting the blog the user can subscribe and will be notified when the owner makes a new posting.

Aggregation, or subscription feeds, unlike the other Web 2.0 models discussed have not resulted in capabilities unto themselves. By this, it is meant there isn't an analog to blogs, Wikipedia, YouTube or Flickr, a capability that pivots on the aggregation model. Rather, aggregation is a supporting model used widely, if not

ubiquitously, by news sites, blogs, wikis, and other content providers. However, by allowing the users to manage and rapidly parse a wider array of content, aggregation increases the value of these other content sources.

There is one emerging exception where aggregation moves from subordinate and enabling to the limelight; this exception is Twitter. Twitter is a service that allows users to receive notes, or micro-blogs, via subscriptions. However, Twitter is not a traditional aggregator. Users can only subscribe to content provided by other Twitter users, whereas, a traditional aggregator supports subscriptions to any site which supports a feed. Also, with Twitter, the updates are the content, not a headline or summary. Regardless of the differences, the subscription and timely content notification features that aggregation provides are critical to the Twitter model. With this model, Twitter has a connotation as a service allowing teenagers to keep in touch with each other, but has also proven beneficial in distributing public service announcements during natural disasters.

5. Mashup

A mashup is a new Web service created by combining two or more Web services (Sankar & Bouchard, 2009). As an example, one Web service might allow users to contribute a list of street addresses and another Web service provides mapping services, by combining these two, a new service, a tailored map depicting the location of the items of interest has been created. This exact process was performed by Starbuck's coffee chain customers to track store closings following a company announcement. From a technical perspective, mashups are enabled and heavily dependent upon Application Programming Interfaces (APIs). APIs act as an interface description or interface control document defining the input requirements along with the output requirements. Defining these input and output requirements creates a clear, loosely coupled construct for communication between the various services. The developer of a service publishes the API definition, which allows others to integrate that service into their application.

Much like the Starbuck's example, individuals and corporations have combined Web services via APIs to create a seemingly endless number of mashups for personal or corporate use. As a personal user, Cleveland Wilson integrated a wireless phone, bar

code scanner, and the Amazon.com API into a system allowing him to query selling prices for book titles on Amazon.com while visiting garage sales and thrift shops (Hof, 2003). This has facilitated a \$100,000 annual book arbitrage business for Cleveland. In a similar fashion, Zillow.com provides participants in the real estate market another, broader, source for price estimation. Zillow.com uses data from the county in which the real estate resides, such as last sale date, tax assessment, property description and last sale price, in combination with the mapping capability provided by Google.com to create a map of estimated housing prices. A Zillow.com user types in the address of an interested property to receive a price estimate. The price estimate is based upon data specific to the interested property and other properties in the area; this creates another data point for the critical “comp” when performing real estate transactions. As a last example, Salesforce.com, a Customer Relationship Management (CRM) business providing tools that allow organizations to document and manage their transactions, discussions, and overall interactions with their customers, has published an API and created an application development platform that allows system users to generate mashups based upon their specific need. Users have created mashups mapping customer locations, developed graphics based on sales performance, and many other features and combinations. By embracing the mashup model Salesforce.com has, to some extent, eliminated the essential question of product development, “what features do the customers value?” With the highly modular API mashup model, the customers select applications they value or simply develop one of their own.

From personal user to corporate strategy mashups have had a tremendous impact, but they are also the model behind what many will believe will have the largest impact yet, social networking. Social networking is another Web 2.0 archetype, which allows users to connect with other users for interaction and sharing; what the users share and interact about typically defines the social network. The two most popular social networking sites MySpace.com and Facebook.com have become, like YouTube and Flickr, almost synonymous with Web 2.0. The fundamental application for these sites is the user profile database. Users populate the database with information about themselves, such as name, age, location, hobbies etc., but this database also records

linkages to other user profiles creating a Web, or network, of associations between users; MySpace.com and Facebook.com call these associations “friends.” This database of users and associated “friends” is accessed via an API, which allows any number of mashup services to be created. Common applications are photograph and video sharing, blog subscription, note writing, schedule coordination, and passing information about favorite interests or products. It is the last use that has created the most interest amongst corporations and organizations. Via the user database, it is possible to identify individuals with the highest number of associations, and advertisers believe these high traffic network nodes disproportionately impact the exposure and opinion of all network participants, providing tremendous opportunity to distribute product messages. Advertisers believe this opportunity is relevant for an array of products from laundry detergent to political candidates; several analysts have attributed much of Barack Obama’s success in being elected President to his use of, and popularity within social networks.

With rapid growth and over 250 million users, Facebook has become the highest profile social networking site, but there are other sites. LinkedIn.com allows professionals to network based upon professional relationships. Librarything.com allows readers to share and find books based upon items they have read. Classroom2.0 allows users to collaborate and share about the uses of Web 2.0 technologies in the classroom. This is only a shortlist of the communities that have emerged using social networking, mashups, and, in general, Web 2.0 capabilities.

V. SATCOM PERFORMANCE DATA COLLECTION USING WEB 2.0 MODELS

A. CONSIDERATIONS IN DEVELOPING WEB 2.0 COMMUNITIES

When developing a system to facilitate interactions within a community it is critical to identify the community members and their roles within the community. There are three roles members can take within their online community: consumer, developer, or contributor. Consumers are a role that typically all members of the community occupy, meaning all members participate (e.g., read, listen, etc.) in the information other people have provided. This can be either a stand-alone role, or coupled with the other two roles; in the stand-alone instance, the community member is a passive recipient of information. Developers are the community members that determine the topic or focus of the community content or discussion. Using a business meeting as an analogy, the developers determine the meeting's agenda. Contributors of the community are those members that participate in community interactions once a topic has been developed. Using the meeting analogy again, these are the meeting's active participants.

With an understanding of the member roles, the proper Web 2.0 models can be chosen to support the community. For instance, in examining Web 2.0 models, both Nike and the Scottish Football Club were cited as examples, but because of differing community member roles different Web 2.0 models were used. In the Nike instance, their community consisted of two dominant members, Nike and their customers. In this community Nike developed the topic and the users provided feedback through a discussion format; both roles consumed information. The disparity between the developer/consumer role played by Nike and the contributor/consumer role played by Nike's customer is best supported through a blog model. As a contrast, the Scottish Football Club anthology relied upon the wiki model because all users occupied a developer/consumer role. Within the wiki model, all users provide the content they thought added value to the anthology.

In addition to describing the methods used to collect SATCOM system performance information, Chapter 2 also identified the process's stakeholders. Many of these stakeholder's interests will be relevant to NMT and they must be considered when developing and fostering an NMT online community. Fortunately, as was the case with the Nike and Scottish Football Club endeavors, the members of the NMT community can be identified and designated consumer, developer or contributor community roles.

1. System Operators

System Operators will be responsible for initiating, monitoring, and terminating the communication services enabled by the NMT system. As the system users with the most NMT system interaction they will be very active participants in documenting system performance. In this community, the System Operator will have their own experiences to contribute, as well as, benefit from the contributions of others. The System Operators should be developers, contributors, and consumers within the community.

2. System Maintainer

The System Maintainers are responsible for performing preventative maintenance in accordance with prescribed schedules, and, in the advent of a failure corrective maintenance. The System Maintainers will have a breadth of experience from maintaining and repairing the NMT system, but will also benefit from similar experiences of other System Maintainers and System Operators. System Maintainers should be developers, contributors and consumers within the community.

3. RMC Technicians

RMC technicians are the first line of defense for both distance and onsite technical support. In this capacity these technicians will have experiences and knowledge to share with the community, but again, also benefit from the experiences of others. However, unlike the System Operators and System Maintainers, the RMC technicians are not present when the problem is initially experienced, they, much like the customers in

Nike's blog, participate in the community after the topic has been selected. With this in mind, the RMC technicians will be contributors and consumers within the community.

4. ISEA Technicians

The ISEA and its technicians are both the last line of defense for system problem resolution and the proxy for ensuring the Acquisition Program Office's USC Title 10 sustainment responsibilities are fulfilled. In their first capacity, ISEA technicians are very similar to RMC technicians in that they have both valuable contributions and benefit from the contributions of other community members, but don't determine the discussion theme. However, as the Acquisition Program Office's sustainment proxy, the ISEA technicians will possess information pertaining to the fielding of Engineering Change Proposals (ECP). This information will describe the ECP's purpose, the process for performing the ECP, and the schedule for deploying the ECP. For these reasons the ISEA technicians will be developers, contributors, and consumers within the community.

5. Acquisition Program Office

Per USC Title 10, the Acquisition Program Office is responsible for the NMT system's total lifecycle support. As a result of this statute, the Acquisition Program Office manages the program budget and must make decisions on resource expenditures. The information collected by the data system will assist in making decisions on the expenditure of financial resources. However, the Acquisition Program Office isn't a terminal user nor do they directly participate in the resolution of system problems. Therefore the Acquisition Program Office is only a consumer within the community.

6. System Developer

With the current AN/USC-38(V) and AN/WSC-6(V) MILSATCOM systems, the System Developer, under tasking from the Acquisition Program Office, is responsible for performing system upgrades and enhancements; it is anticipated the System Developer will play the same role in the NMT program. Predominantly these upgrade and enhancement efforts are initiated to address system deficiencies experienced in an

operational environment. Frequently, the System Developer will not have experienced these deficiencies in their lab and are dependent upon field experience to recreate and diagnose the deficiency, making the System Developer a consumer. As previously discussed, the ISEA Technicians distribute information about ECPs eliminating the need for the System Developer to contribute this data to the community. Further, while the System Developer is an expert on the NMT system, they have limited knowledge about the systems that interface with the NMT, which could be the source of the user's problem. This undermines their utility in directly interfacing with the System Operator and System Maintainers for problem resolution. For this reason the ISEA Technicians, again, interface with the System Developer when detailed technical system information is required. For these reasons, the System Developer is only a consumer within the community.

7. Technical Documentation Developer

The developers of technical documentation are responsible for the initial development and updates of the system's technical documentation. Feedback on system performance and the current products is valuable information when developing an update, creating a need for the developers to be consumers. But, like ECPs, the ISEA technicians introduce documentation changes so there is little information the Technical Documentation Developers can contribute to the community; for this reason they should only consumers.

8. Training Curriculum Developers

The Training Curriculum Developers role is very similar to that of the Technical Documentation developers in that they develop and update published materials, in this case the training curriculum. Feedback on the operational performance of the system is beneficial when performing updates to the training. This feedback allows the developers to add material and augment the focus on the training based upon the operational needs of the users. Once these updates are completed, they are administered via formal instruction in the schoolhouses. There are instances that may necessitate the development of ad hoc

On the Job Training (OJT), but like ECPS and technical documentation updates, the ISEA Technicians administer this training. As a result, the Training Curriculum developers don't contribute any information to the community and participate as consumers.

Table 14 summarizes the role the different stakeholders take within the NMT community

Table 14: Data Usage Based upon Community Role

Community Role	Developer	Contributor	Consumer
System User	X	X	X
System Maintainer	X	X	X
RMC Technician		X	X
ISEA Technician	X	X	X
Acquisition Program Office			X
System Developer			X
Technical Documentation Developer			X
Training Curriculum Developer			X

B. PROPOSED DATA COLLECTION SYSTEM USING WEB 2.0 MODELS

The mashup model facilitates a tailored selection of applications for supporting a community making it a very powerful application in developing and fostering online communities. For this reason, the mashup is the model upon which the proposed NMT performance data collection system is based. The proposed NMT data collection mashup will integrate blogs, aggregation, and wiki pages with supporting folksonomies to enable interactions between the NMT stakeholders creating an NMT community. Through these community member interactions the performance of the NMT system will be collected and available for analysis to improve the availability of the NMT system.

1. Blog in the NMT Performance Data Collection System

Blogs will be the central component of the proposed NMT performance data collection system. Every NMT community member with a developer role, i.e., System Operators, System Maintainers, and ISEA Technicians, will own a blog. The blog will serve as their NMT user log, documenting their experiences and challenges with the NMT system.

In their user log blogs, System Operators will document instances of when the NMT failed to perform or anomalous behavior. As previously discussed, these instances can cover a broad range, from a simple power cycle to a catastrophic failure warranting the need to engage a System Maintainer. Regardless of severity the System Operators will be encouraged to blog about anything pertaining to the NMT system, but, at minimum will blog about every challenge they face.

System Maintainers will use their blogs to document every NMT maintenance action they perform, either preventative or corrective. For corrective action, the System Maintainers will describe the experienced problem, diagnosis process and corrective action performed. In the advent the corrective maintenance warrants completion of a 4790/2K, i.e., the maintenance action is deferred, one will be completed; the 4790/2K process will not be replaced by the blog. However, weak on improving the long-term availability of the NMT system, the 4790/2K and CASREP are part of a well-established system for reporting current material status up the command chain; this is a critical attribute of military planning, which cannot be circumvented. Also, it would be ideal if the blog posting auto populated the Maintenance Data System (MDS) when a 4790/2K was warranted, but there are sites without a software supported MDS, and those with software don't support external file loads. Since the System Maintainer will be blogging about the failure prior to making the decision to complete a 4790/2K, a template can be created in an attempt to reduce the redundant work. While the 4790/2K cannot be eliminated, the blog will eliminate the 4790/2L. In the blog the System Maintainer will record both the steps taken to diagnose the failure and the corrective actions taken; these blog entries will record the detailed information typically recorded in a 4790/2L.

As discussed during the analysis of community roles, the ISEA Technicians liaise with the community on system updates such as ECPs, technical document updates, and ad hoc training. In the proposed NMT data collection system the ISEA Technicians will use their blogs to communicate the details of these updates. For instance, for an ECP the ISEA Technicians will make blog postings describing the purpose of the ECP, the process for ECP implementation as well as its associated deployment schedule. In addition to ECP notifications, the ISEA technicians will use the blog to inform the community of highly pervasive defects for which a solution does not yet exist. Also, the ISEA Technicians can use their blog to administer ad hoc training on emergent system issues or areas needed additional attention.

The members of the community with a contributor role participate by making comments to the blog postings. These comments, and in turn the comments made in response to other comments, result in an ongoing dialogue. In the NMT community the topic of this dialogue will be operation and repair of the NMT system. For instance, if a System Operator makes a posting to their blog describing a particular problem other community members, at all levels, can provide feedback or suggestions via comments in an attempt to resolve the problem. This creates the opportunity for the entire community to assist in resolving a single site's issues. If the System Operator, with the assistance of the community member's comments, is unable to resolve the issue, they will, as in the current problem resolution process, notify the System Maintainer. Once notified, the System Maintainer will make postings to their blog describing their diagnosis and corrective action efforts. The other members of the community can assist in resolving the problem by making comments to the System Maintainer's blog. If further assistance, is required from the RMC Technician, and subsequently the ISEA Technicians, these contributions will be made via comments to the System Maintainer's blog; this will ensure the entire failure thread from discover through diagnosis to corrective action is documented in one location.

Despite their participation via comments to System Operator and System Maintainer blogs, the RMC technicians and ISEA technicians must be notified if the problem proves too challenging for the System Maintainer to resolve for a couple of

reasons. First, the real opportunity for the blog and comment architecture is that it provides the potential for every member of the community to provide their knowledge in assisting the System Maintainer, but it is not anticipated that every member of the community will contribute or even review every posting at the relevant time; this includes the RMC and ISEA technicians. Explicit RMC and ISEA notification of irresolvable problems ensures they are engaged and participative in the process. Second, there are instances where onsite support by these technicians will be required, and in order to justify the commitment of resources the RMC and ISEAs need to be positively engaged in the process. However, again, regardless of how the RMC and ISEA technicians contribute, whether through general community participation, requested distance support or onsite support, all contributions will be made as a comment to the System Maintainers blog. For instances where rich interactions take place, such as telephone calls or onsite technical assists, the blog comment will still be used to document the diagnosis and corrective action, serving as the technicians trip report. Again, this consolidated blog and comment approach ensures the entire event from initial experience to resolution is documented allowing community members to analyze the entire failure event.

Since all NMT community members are consumers, the blog postings and comment threads are available to everyone within the community for their desired purpose. For the System Operators, System Maintainers, RMC Technicians, and ISEA Technicians this repository of blog postings and comments provides a knowledge repository of problems and associated solutions to be utilized as a tool for resolving their own problems or facilitate ad hoc training. In a reactive fashion, community members can explore this repository seeking out other member blogs or comments that might add insight to the root cause and corrective action for the problem they are currently experiencing. In a more proactive fashion, community members are able to survey other member's blog postings and comments to provide their contributions or simply increase their own awareness of the NMT system's behavior and problems. Members with only the role of consumer, i.e., Acquisition Program Office, System Developer, Technical Manual Developer, and Training Curriculum Developer, will use the blog postings and

comments to understand the true performance of the NMT system. The blogs and associated comments will provide a rich trove of data for these consumer only roles to survey and identify problems with system, technical documentation, or training.

2. Aggregation in the NMT Data Collection System

The blog and comment architecture provides an opportunity to leverage the knowledge of the entire community towards the resolution of a single member's problem. However, given the temporal nature of problem occurrence and resolution this opportunity is highly perishable if the community doesn't provide support in a timely manner. This challenge is resolved through subscription and aggregation. Members will subscribe to each other's blogs. Via these subscriptions, members will receive notifications of another member's blog postings informing the community of their problems. These notifications are collected and presented for scanning by the subscriber via their aggregator. For postings, the recipient feels they contribute too or are interested in, the aggregator will provide a Web link allowing quick access to the full blog posting for reading and comment.

The number of blogs that one member subscribes to is an individual preference, but, at a minimum, a member will subscribe to the blogs within their Carrier Strike Group or Expeditionary Strike Group ⁶and those of the ISEA Technicians. Every member subscribing to every other member's blog would provide the greatest opportunity to share and leverage the knowledge of the community. However, with a community in excess of 1,000 members, it is likely the mass subscription model would overwhelm members; the intention of the data collection system is not to have members of the NMT community blogging all day.

Subscribing to the blogs within their Carrier Strike Group or Expeditionary Strike Group allows community members to actively contribute to the readiness of the NMT systems within their operational unit. A subscription to the ISEA Technician's blogs

⁶ The Carrier Strike Group or Expeditionary Strike Group consists of an aircraft carrier or amphibious air platform and its escort ships. This is the configuration that supports Navy deployment cycle and operational organization.

allows all community members to stay current on the latest system developments. It is envisioned RMC Technicians will subscribe to the blogs within their Area of Responsibility (AOR). ISEA Technicians, as the de facto system experts, will subscribe to all community blogs. Regardless of the subscription model employed, all members will be encouraged to subscribe to and participate in as many blogs as possible.

3. Folksonomies in the NMT Data Collection System

Where the subscription model allows community members to support each other in a timely fashion, folksonomies allow the community to organize and search their repository of NMT data. Again, folksonomies allow content authors and users to place descriptive tags within the content, allowing other users to search and group blog postings. For instance, one System Maintainer seeking the resolution to a specific system fault by searching on a fault ID would find every entry tagged with the fault ID. Also, another proactive community member could be trying to improve their troubleshooting skills, by searching postings tagged with an array of terms such as ‘good troubleshooting’, ‘informative’, or even ‘good job.’ With folksonomies, it is possible both the System Maintainer seeking an explicit fault and the proactive community member to discover and utilize the same posting and comment thread for different purposes. Folksonomy will also allow the Acquisition Program Office to truly understand the performance of the NMT system.

Folksonomies provides a truly powerful tool to understand trends within a community. As a first order use, the Acquisition Program Office can search the community data for pervasive system problems. For instance, the Acquisition Program Office could, like the System Maintainer above, type in an explicit problem and find every instance of a blog being tagged with this problem. The results of these queries can be used to determine how many operational sites and NMT systems are afflicted by a particular problem. Also, as a second order use, the Acquisition Program Office can study the most popular terms or tags within the folksonomy to gain key insights into community. For instance, finding ‘junk’ as one of the most frequently used tags within

the community would clearly be indicative of a broad perception problem. Folksonomies allow the Acquisition Program Office to identify and understand both the micro and macro problems within the community.

4. Wiki Pages in the NMT Data Collection System

Wiki pages will be used by the NMT community for access to, correcting of, publishing, and creation of technical documentation. As part of their ongoing use and NMT interactions, System Operators and System Maintainers will utilize the system's technical documentation. Historically, these documents were provided in a hardcopy format, but recently the trend is toward electronic formats. Electronic formats minimize storage requirements, reduce the risk and impact of being lost, and support rapidly publishing updates. The wiki pages employed within the NMT community support all these attributes with additional benefits. With wiki pages all NMT community members can correct errors or generally improve the NMT technical documentation. System Operators and System Maintainers as they use the technical documentation in conjunction with their NMT system will be able to re-articulate content in a fashion more conducive to the community or add additional information. In addition, the community members will be able to augment the technical documentation with new publications borne out of ad hoc processes. Due to the rapid publishing characteristics of wiki pages, these updates will be made available to all community members almost immediately.

While the general trend of wiki based products is towards improved quality, there is a risk of incorrect information being propagated to detriment of user safety or collateral damage to the NMT equipment. This risk will be managed via two controls within the community. First, the wiki pages will accommodate two instantiations of the technical documentation; one will be the official current revision and the second will be open for editing and updating by the community. Having these two versions allows community members to reap the benefits of documents edited with the colloquiums and practices of the community with a mechanism for comparison to the fully vetted, un-permuted version. By surveying the community updates, the Technical Documentation Developers will incorporate changes into the official version facilitating a trajectory of constant

improvement. While this construct will support more frequent revision changes to the official version than the every couple years frequency supported by the AN/USC-38(V) and AN/WSC-6(V) programs, the updates will not be as frequent as the near immediate input the community can provide. As a second precaution against detrimental dissemination of incorrect information, an ISEA Technician will be assigned as an active reader, and if need be, editor of the community updates to technical documentation. Just like blogs, wiki pages can be subscribed to, which provides a notification mechanism for the ISEA technician to follow updates to the community wiki. Upon receipt of an update notification, the ISEA technician will review the updated content looking for unsafe practices or technically incorrect information, especially information that describes practices which will cause damage to the NMT system. If such content is discovered, the ISEA technician will make appropriate edits and notify the publisher of the information the motivation for making the changes.

Lastly, like the blogs, the wiki will be supported by the community folksonomy. This, again, allows the community to tag and search the technical publications in terms and context that is relevant to their need. A community member will be able to query the blog postings and wiki pages providing a rich repository of data to assist in correcting the system deficiency.

C. EVALUATION OF THE PROPOSED DATA COLLECTION SYSTEM

The proposed NMT data collection process utilizes Web 2.0 technologies, specifically a mashup model. The method for evaluating the merits of this system's ability to improve the NMT system availability is against the ideal system. Again, this ideal is constructed by examining the parameters affecting NMT availability; the ideal system is a system whose attributes address all these parameters. Further, since the current system planned for inheritance by NMT was evaluated against the ideal in Chapter III of this thesis, the ideal is an intermediary for comparisons between the two systems. The sections below evaluate the proposed system against the ideal system's nine attributes.

Table 15: Ideal Attribute 1

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
1	All system anomalies	Acquisition Program Office and System Developer	System Improvement	MTBF

The members of the NMT community exposed to system anomalies occupy a developer role within the community. As developers, these members, i.e., System Operators and System Maintainers, own blogs to which they post their experiences with the NMT system. Other members of the community participate by providing comments to the owner's posting or other's comments. There are no constraints, e.g., field sizes, to the amount of data placed within a blog posting allowing for a detailed description of the failure event. In addition, the dialogues enabled through comments may divulge information inadvertently omitted. As a result, these blog and comment threads record rich detail about system anomalies for consumption by community members including the Acquisition Program Office and the System Developer. Further, the folksonomy tags used to describe and organize the data facilitates interrogating the repository in a multitude of fashions

The proposed system under performs the ideal in that data collection is dependant upon the System Operators and System Maintainers to make blog postings. However, this risk is managed by two factors. First, the System Operators and System Maintainers will find that assistance from the community makes their job of ensuring their NMT supports its mission easier. Member comments allow a troubled System Operator and System Maintainer to restore their NMT to operational status in a more efficient fashion, but they can't receive this assistance until the community is notified of their problem through a blog posting. This incentive competes against a tendency to forgo making a blog posting. A second, less positive factor, is that keeping a user log will be a requirement of their job as a System Operator and System Maintainer. A mandate like this certainly does not guarantee success, but it will help.

Table 16: Ideal Attribute 2

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
2	All system anomalies	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTBF

Surveying the rich repository of blogs and comments provides insights toward improving the training curriculum and technical publications. With an understanding of the real problems affecting the operation of the NMT terminal and the common mistakes make by the System Operators and System Maintainers the Training Curriculum and Technical Publication Developers can augment and improve their products. For technical publications, the community wiki pages allow the community to improve these products. Within the technical publications the community members will be able to correct errors, add additional information or simply put a process in more familiar terms. There is no constraint to the number of times these edits can be made and once made they are immediately available to the rest of the community. These community updates will further assist the Technical Publication Developers in their updates of the official revision. These updates will be based on both the analysis of the blogs, comments and user updates to the community publications. This facilitates revisions to the official publications at rates much faster than currently supported.

Table 17: Ideal Attribute 3

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
3	All system anomalies	Acquisition Program Office and System Developer	OBRP requirement updates	MLDT

When a site does not have the needed spare part in their OBRP complement, a large availability penalty is incurred as the site waits for a replacement part. The proposed data collection system retains the 4790/2K process, which documents maintenance deferrals, because of its necessity in reporting current materiel status to the chain of command. Information from the blog postings will also allow the Acquisition Program Office and System Developer identify candidate components for inclusion into the site OBRP compliment.

Table 18: Ideal Attributes 4 through 6

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
4	All system anomalies	System User Community	Peer-to-Peer Training	MTBF
5	System Maintainer Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Peer- to-Peer Training	MTTR
6	RMC and ISEA Technician Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Guru-to-Expert Training	MTTR

Community members with developer roles record their NMT experiences through postings to their blogs, and community members with contributor roles interact with developers and other community member by commenting on the blog postings. These postings and interactions facilitate training amongst all levels of the community. The initial opportunity for training is through the dialogue enabled by the blog and comment process. The blog Web 2.0 model allows community members to post their understanding of a problem and receive feedback from other community members, and, in an iterative process, provide comment back. This iterative process can continue for an indefinite period of time, allowing a rich discussion and ad hoc training session. The second opportunity is a by-product of archiving all these discussions. A community

member needs neither to participate nor be present during the original conversation to learn from it. The archived posting and comment dialogues serve as lesson transcripts available for all member of the community to discover and utilize.

Table 19: Ideal Attributes 7 through 9

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected
7	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	System Improvement	MTTR
8	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR
9	RMC and ISEA Technician Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR

The proposed NMT performance collection system facilitates the Acquisition Program Office and System Developer's efforts to improve MTTR by collecting information from all community members and allowing the same members to make revisions to the technical documentation. In their blogs, System Maintainers will discuss problems experienced while diagnosing failures and performing corrective action. The Acquisition Program Office and System Developer can survey the blogs, looking for those repair problems by frequency and/or level of intensity of frustration. In addition to the blogs, the community updated wiki pages will provide insights into areas where the system can be improved, as well as improve the official technical documentation on a much more frequent basis than currently supported. One addition users will make to the wiki pages are ad hoc work-around procedures created to circumvent either NMT system

deficiencies or inadequacies in the technical documentation; this is critical information towards improving the MTTR performance of the NMT system.

The obvious purpose of improved training is to decrease the instances of operator error and lessen the impact of these instances. With System Operators and System Maintainers documenting their NMT experiences, an opportunity is made for the Training Curriculum Developers to survey their experiences and find frequent pitfalls. This broad canvas of the user community will allow updates of the training materials. In addition, these blog transcripts could provide case studies for use in a classroom setting.

For those instances of operator error, the blog and comment model limits provide assistance to limit the impact. The entire NMT community can assist an NMT user in extremis via a comment once they post to their blog. This broad support will decrease the time the troubled user languishes trying to identify the cause of the problem. In addition, discussing and explaining the process tends to change perspectives and facilitate insights.

Table 20 scores the proposed data collection system against the ideal system using the same 1–5 evaluation scheme used in Chapter III for evaluating the current system. The proposed system scores very well against the ideal—a 4 in every attribute. Through the employment of a Web 2.0 mashup model, the proposed data collection system addresses all the attributes of the ideal system. However, the proposed system is reliant upon the contribution and participation of the users, creating a risk that a threshold of reporting will emerge. It is believed this threshold—e.g., an arbitrary severity of a problem that triggers reporting—will decrease as members see increasing value in the community, and the proposed system encourages and does not preclude full problem disclosure, but there is no guarantee all problems will be captured.

Also depicted are the scores for the current data collection, allowing for a comparison between the current and proposed system. The proposed system is equal to the current system in one attribute and superior in all others. The fundamental reason for this performance is the ethos of Web 2.0, participation. The current system places limitations on both who can contribute and with whom the information is shared. For

instance, in the current system, the users with the most interface time with the NMT, the System Operators, do not have a feedback mechanism on the performance of the system. In addition, the most detailed information about the corrective action, the 4790/2L, is seen by no one outside the operational site where it was produced and, potentially, by no one other than the System Maintainer responsible for its development. By contrast, the proposed system removes these data contribution and consumption constraints.

Also, in the spirit of participation, the proposed system respects and leverages the intelligence and knowledge of the System Operators and System Maintainers. The knowledge and expertise of these trained U.S. Navy communicators is dismissed by the hub-and-spoke architecture of the current model. The data recording and problem reporting process is purely hierarchical. A problem at one level proceeds to the next and then the next until it arrives at the final organization responsible for ensuring the system works; never are the peers encouraged or permitted to contribute. The proposed system still provides the hierarchical mechanisms, but also facilitates a “barn raising” ethos amongst the community. Community problem solving allows the Navy to leverage and utilize the investment made in these professional communicators, and increase the availability and readiness of NMT’s critical communication capabilities.

Table 20: Summary Score of Current and Proposed vs. Ideal System

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected	Current Score	Proposed Score
1	All system anomalies	Acquisition Program Office and System Developer	System Improvement	MTBF	3	4

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected	Current Score	Proposed Score
2	All system anomalies	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTBF	2	4
3	All system anomalies	Acquisition Program Office and System Developer	OBRP requirement updates	MLDT	4	4
4	All system anomalies	System User Community	Peer-to-Peer Training	MTBF	1	4
5	System Maintainer Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Peer- to-Peer Training	MTTR	1	4
6	RMC and ISEA Technician Failure Diagnosis and Corrective Action	System Maintainer Community and RMC and ISEA Technicians	Guru-to-Expert Training	MTTR	1	4
7	Failure Diagnosis and Corrective Action	Acquisition Program Office and System	System Improvement	MTTR	2	4

Item #	Data Recorded	Data Customer	Purpose	Ao Parameter Affected	Current Score	Proposed Score
		Developer				
8	Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR	2	4
9	RMC and ISEA Technician Failure Diagnosis and Corrective Action	Acquisition Program Office and System Developer	Training Curriculum and Technical Publication Updates	MTTR	2	4

VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

In employing the Net-centric Warfare strategy, the U.S. Navy and the broader Department of Defense estimate technological advances in sensor and networking technologies will result in a more flexible, efficient, and potent force than previously achievable. The process of realizing this vision has created a critical reliance on the systems that deliver these technologies or, in the case of the NMT, enabling technologies like bandwidth. With regards to bandwidth, this reliance manifests in Operational Availability; the expectation that NMT reliably provides critical off-ship bandwidth is very high. However, despite the expectation, from a requirement perspective, the availability spread from threshold to objective is quite broad: 90% and 99% respectively. To achieve operational performance closer to the objective requirement commensurate with expectations, the NMT system will use techniques employed by previous generation systems.

These techniques were developed in an environment of higher redundancy and lower criticality. When applied to NMT, they increase risk to both the operation of the NMT system and ultimately the Navy's employment of Net-centric Warfare. These current performance collection techniques make understanding and assessing the NMT performance a very opaque process. The process creates silos of information with narrow or no distribution, resulting in users who, independently and redundantly, solve system problems to the detriment of bandwidth availability. These silos also constrain the information that the Acquisition Program Office can use when making investments toward improving the NMT. Rather than making these investment decisions on a thorough understanding of the system, they will be made in response to the loudest complaints, using a politically charged feedback loop. This does not mean that these legacy techniques fail to support the NMT, but it does increase the risk and—in light of the opportunities provided by Web 2.0 technologies—this risk seems unnecessary.

The Web 2.0 mantra of individuals creating information for consumption by the masses breaks information silos, providing an opportunity to reduce the risk that NMT will fail to meet either its requirements or its expectations. For users, eliminating these silos provides peer-to-peer training and assistance in diagnosis and resolution of system errors, increasing both their knowledge and efficiency. The Acquisition Program Office is provided a much broader survey of NMT operational performance, resulting in a better investment of resources toward improving the system and its support structures. Web 2.0 technologies enable an environment for both the user and the Acquisition Program Office to contribute, well beyond the legacy methods, toward improving system performance.

B. RECOMMENDED AREAS FOR ADDITIONAL RESEARCH

Creating a community of system stakeholders presents a great opportunity for the operation and sustainment of the NMT system. As a result, it is highly recommended the NMT program pursue these opportunities to exploit the benefits available to the users, the Acquisition Program Office, and the U.S. Navy. However, the world of Web 2.0 technologies is a dynamic, rapidly evolving environment creating new twists on deployment models and lessons learned on their deployment. With this in mind, it is also recommended these evolutions be followed, and the lessons learned surveyed, to support further research prior to or part of the employment of Web 2.0 models.

1. The Appropriate Size and Scope of Online Communities

This thesis examined the employment of a mashup model to foster a community of NMT users with the objective of improving system performance. This examination demonstrated an opportunity for this model to exceed the performance of the current system. It is reasonable to assume this opportunity is not unique to the NMT system, meaning a similar benefit could be enjoyed by other systems. While the appeal of Web 2.0 technologies to systems other than NMT is clear, it is not clear how these benefits should be realized when multiple systems are considered, versus the single system, as contemplated by this thesis.

The NMT system will not be the only system its users will be responsible for; rather, the NMT is one of several systems used by these IT and ET sailors. This raises questions about the size and scope of the community when the users have multiple responsibilities. Is it better to establish a single community for each system, an overarching community encompassing all systems, or a hybrid? On one hand, participation in many communities may prove burdensome for the users and, on the other hand, a broad community may lose focus, diminishing its affectivity. It is recommended more research be performed to answer the size and scope questions of online communities such that the opportunities provided by Web 2.0 technologies can be broadly realized.

2. Methods to Initiate and Grow Online Communities

Once established, the mashup model community proposed for the NMT system provides clear incentives for user participation; it makes their job easier. Meaning—once the community has a broad membership of stakeholders sharing information and ideas—the value is clear; with these incentives, the community is self-perpetuating. Web 2.0 technologies thrive on content, the more they have the better they are. However, prior to reaching this critical mass, the value to users may not be clear, undermining the incentives and the establishment of momentum. For instance, when the community is established, the searchable archive of blog dialogues will be very anemic, as will the number of blog subscribers able to rush to the aid of a struggling colleague. As the massive size and growth of YouTube, Facebook, and the others demonstrate, these communities can be extremely self-sustaining once a critical mass is achieved. Failure to reach the critical mass will undermine the credibility of the effort and significantly diminish or eliminate the value they provide. As a result, careful research and planning must be applied to develop strategies for the initiation and growth of these communities.

3. Security Concerns with Online Communities in a Defense Application

Information is of critical importance, particularly in the context of military action. Victory is typically an unassailable result for the combatant with knowledge superiority.

Reflecting this, the key benefit within the Net-Centric Warfare doctrine is information dominance. Recognizing this criticality, a system of classifications and compartments has been established to protect information. In contrast, the Web 2.0 philosophy requires frequent and broad sharing of information to realize its benefits. The major reason the proposed NMT mashup model has the potential to exceed the performance of the current system is that it releases information from silos providing utility to all NMT community members. This sharing of information creates the potential for a dramatic improvement in the methods for supporting the NMT system, but it may also create a security risk.

As its foundation, the United States classification and compartment system is rooted in the concept of “need to know.” It is possible that, during the highly collaborative discourse of an online community, individuals without a need to know will be inappropriately exposed to sensitive information. This raises a challenging question concerning online communities: How do you ensure participants share enough to realize the available benefits, but not share too much so as to compromise critical information? Or, perhaps an even more difficult question: Can this point be determined?

With maxims like “loose lips sink ships,” information security in casual contexts has always been a challenge, but the ease of storage and dissemination made possible by electronic files compounds the challenge. The challenges presented by Web 2.0 technologies may be similar to those posed by e-mail and Web 1.0 considerations, for which there are ongoing efforts to manage the compromise of information. Regardless, to understand the problem space, as well as find the answers to the questions posed above, further research must be performed in these areas.

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