2013-03

# Increasing Fleet Readiness through Improved Distance Support

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# NAVAL POSTGRADUATE SCHOOL

**MONTEREY, CALIFORNIA**

# SYSTEMS ENGINEERING CAPSTONE PROJECT REPORT

**INCREASING FLEET READINESS THROUGH IMPROVED DISTANCE SUPPORT**

by

Distance Support Team
Cohort 311–113O

March 2013

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**Disclaimer: No human subjects research informed this project.**

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| **REPORT DOCUMENTATION PAGE** | | | *Form Approved OMB No. 0704–0188* |
|---|---|---|---|
| Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202–4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704–0188) Washington DC 20503. | | | |
| **1. AGENCY USE ONLY** ***(Leave blank)*** | **2. REPORT DATE** March 2013 | | **3. REPORT TYPE AND DATES COVERED** Capstone Project Report; July 2012–March 2013 |
| **4. TITLE AND SUBTITLE** Increasing Fleet Readiness through Improved Distance Support | | | **5. FUNDING NUMBERS** |
| **6. AUTHOR(S)** Briza Alatorre, Jason Bickford, Richard Cruise, Stacie Jue, Masato Taniguchi, Felipe Tolentino, Hai Tonthat, Jack White | | | |
| **7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)** Naval Postgraduate School Monterey, CA 93943–5000 | | | **8. PERFORMING ORGANIZATION REPORT NUMBER** **N/A** |
| **9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES)** N/A | | | **10. SPONSORING/MONITORING AGENCY REPORT NUMBER** **N/A** |
| **11. SUPPLEMENTARY NOTES** The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government. IRB Protocol number ______N/A______. | | | |
| **12a. DISTRIBUTION / AVAILABILITY STATEMENT** Approved for public release; distribution is unlimited | | | **12b. DISTRIBUTION CODE** A |

**13. ABSTRACT (maximum 200 words)**

The Navy has developed Distance Support tools to support specific naval systems. These tools often do not facilitate knowledge retention and reutilization; to resolve this problem, a Data Aggregation System (DAS) was recommended to aggregate and integrate data to improve fleet readiness. A systems engineering (SE) process, derived from the 2009 Department of Defense (DoD) SE Model, was used to develop the DAS. Based on past Navy lead Distance Support studies and completed surveys, the team determined the stakeholders needed a data aggregation system that provides 1) easily accessible data, 2) high quality information, 3) current data, 4) well organized information, and 5) information reported on demand. The team conducted requirements analysis to trace and prioritize the system requirements to stakeholders' needs. The requirements were then mapped to functions. The high level system functions identified were 1) obtain data, 2) process data, 3) analyze data, 4) report data, and 5) display data. An analysis of Alternatives (AoA) using gap analysis yielded two feasible solutions, 1) modify the Engineering and Supportability Decision System (ESDS) and 2) develop a new system. The results of cost and risk recommended the modified ESDS solution. The solution architecture was documented using Vitech's CORE® software suite.

| **14. SUBJECT TERMS** | | | **15. NUMBER OF PAGES** |
|---|---|---|---|
| Distance Support, Fleet Readiness, Data Aggregation, Systems Engineering, Architecture, Gap Analysis | | | 283 |
| | | | **16. PRICE CODE** |
| **17. SECURITY CLASSIFICATION OF REPORT** | **18. SECURITY CLASSIFICATION OF THIS PAGE** | **19. SECURITY CLASSIFICATION OF ABSTRACT** | **20. LIMITATION OF ABSTRACT** |
| Unclassified | Unclassified | Unclassified | UU |

NSN 7540–01–280–5500

Standard Form 298 (Rev. 2–89)
Prescribed by ANSI Std. 239–18

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# INCREASING FLEET READINESS THROUGH IMPROVED DISTANCE SUPPORT


Cohort 311–113O/Distance Support Team

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN SYSTEMS ENGINEERING**
and
**MASTER OF SCIENCE IN ENGINEERING SYSTEMS**

from the

**NAVAL POSTGRADUATE SCHOOL**
**MARCH 2013**

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# ABSTRACT

The Navy has developed Distance Support tools to support specific naval systems. These tools often do not facilitate knowledge retention and reutilization; to resolve this problem, a Data Aggregation System (DAS) was recommended to aggregate and integrate data to improve fleet readiness. A systems engineering (SE) process, derived from the 2009 Department of Defense (DoD) SE Model, was used to develop the DAS. Based on past Navy lead Distance Support studies and completed surveys, the team determined the stakeholders needed a data aggregation system that provides 1) easily accessible data, 2) high quality information, 3) current data, 4) well organized information, and 5) information reported on demand. The team conducted requirements analysis to trace and prioritize the system requirements to stakeholders' needs. The requirements were then mapped to functions. The high level system functions identified were 1) obtain data, 2) process data, 3) analyze data, 4) report data, and 5) display data. An analysis of Alternatives (AoA) using gap analysis yielded two feasible solutions, 1) modify the Engineering and Supportability Decision System (ESDS) and 2) develop a new system. The results of cost and risk recommended the modified ESDS solution. The solution architecture was documented using Vitech's CORE® software suite.

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# TABLE OF CONTENTS

# LIST OF FIGURES

# LIST OF TABLES

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# LIST OF ACRONYMS AND ABBREVIATIONS

| Acronyms/ Abbreviations | Meanings |
|---|---|
| 3M | Maintenance and Material Management |
| AAP | Approved Article Package |
| ACCESS | Aegis Configuration Control and Engineering Status System |
| ACS | Aegis Combat System |
| ACSRMS | Aegis Combat System Reliability Maintainability and Supportability Database |
| ADA | Albridge Data Aggregation |
| AEL | Allowance Equipment Lists |
| AHP | Analytic Hierarchy Process |
| $A_i$ | Inherent Availability |
| AIDA | Adaptive Independent Data Application |
| AMPS | Afloat Master Planning System |
| $A_O$ | Operational Availability |
| AoA | Analysis of Alternatives |
| AOR | Area of Responsibility |
| APL | Allowance Part Lists |
| ASD (R&E) | Assistant Secretary of Defense Research and Engineering |
| AWS | Aegis Weapon System |
| BCA | Business Cost Analysis |
| BMD | Ballistic Missile Defense |
| C4I | Command, Control, Communications, Computers & Intelligence |
| C&D | Command and Decision |
| CAGE | Commercial and Government Entity |
| CAPT | Captain |
| CASREP | Casualty Report |
| CBA | Capability Based Assessment |
| CD | Compact Disk |

| Acronyms/ Abbreviations | Meanings |
|---|---|
| CDMD-OA | Configuration Data Managers Database - Open Architecture |
| CD-ROM | Compact Disk–Read Only Memory |
| CFFC | Commander, U.S. Fleet Forces Command |
| CHENG | Chief Engineer |
| CIM | Command Issues Management |
| CLASSRON | Class Squadron |
| CM | Configuration Management |
| CNO | Chief of Naval Operations |
| CNSF | Commander of Naval Surface Forces |
| COSAL | Coordinated Shipboard Allowance List |
| COSBAL | Coordinated Shore Based Allowance List |
| COSYSMO | Constructive Systems Engineering Cost Model |
| COTS | Commercial Off-the-Shelf |
| CS | Combat System |
| CSSQT | Combat System Ship Qualification Trial |
| DAS | Data Aggregation System |
| DAU | Defense Acquisition University |
| DCO | Defense Connect Online |
| DLA | Defense Logistics Agency |
| DLIS | Defense Logistics Information Service |
| DoD | Department of Defense |
| DoDAF | Department of Defense Architecture Framework |
| DOTMLPF | Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities |
| DMS | Diminishing Manufacturing Sources |
| DMSMS | Diminishing Manufacturing Sources and Material Shortages |
| DPIA | Docking Planned Incremental Availability |
| DS | Distance Support |
| DSRA | Docking Selected Restricted Availability |

| Acronyms/ Abbreviations | Meanings |
|---|---|
| DTIC | Defense Technology Information Center |
| DVD | Digital Video Disc |
| EFFBD | Enhanced Functional Flow Block Diagram |
| EIS | Engineering Information System |
| ESDS | Engineering and Supportability Decision System |
| FAQ | Frequently Asked Questions |
| FEDLOG | Federal Logistics Data |
| FISC | Fleet and Industrial Supply Center |
| FLTMPS/EPM | Fleet Training Management Planning System/Enterprise Performance Management |
| GIDEP | Government-Industry Data Exchange Program |
| GDAPL | General Distribution Allowance Parts List |
| GDSC | Global Distance Support Center |
| HM&E | Hull, Mechanical and Electrical |
| HOQ | House of Quality |
| HSI | Human Systems Integration |
| I&S | Interchangeability and Substitutability |
| IA | Information Assurance |
| IDEF0 | Integration Definition for Function Modeling |
| INSURV | Board of Inspection and Survey |
| ISEA | In-Service Engineering Agent |
| IT | Information Technology |
| IT-21 | Navy Information Technology for the 21$^{st}$ Century |
| IWS | Integrated Warfare Systems |
| JCIDS | Joint Capabilities Integration and Development System |
| KPI | Key Performance Indicator |
| KPP | Key Performance Parameters |
| LCC | Life Cycle Cost |
| LCS | Littoral Combat Ship |

| **Acronyms/ Abbreviations** | **Meanings** |
| --- | --- |
| LRU | Lowest Replaceable Unit |
| MB | Megabyte |
| MDA | Missile Defense Agency |
| MDT | Mean Down Time |
| MFOM | Maintenance Figure of Merit |
| MIP | Maintenance Index Page |
| MLDT | Mean Logistics Delay Time |
| MMD | Mean Maintenance Downtime |
| MMH | Maintenance Man Hours |
| MOE | Measure of Effectiveness |
| MOP | Measure of Performance |
| MPT&E | Manpower, Personnel, Training and Education |
| MRDB | Material Readiness Database |
| MRDB-NG | Material Readiness Database - Next Generation |
| MS | Microsoft® |
| MSSE | Masters of Science in Systems Engineering |
| MTB(EMCE) | Mean Time Between Equipment Mission Critical Events |
| MTB(EME) | Mean Time Between Equipment Malfunction Events |
| MTBF | Mean Time Between Failures |
| MTTR | Mean Time To Repair |
| NANOOS VS | Northwest Associate of Network Ocean Observing System Visualization System |
| NAVSEA | Naval Sea Systems Command |
| NAVSUP | Naval Supply Systems Command |
| NDE | Navy Data Environment |
| NDE-AMPS | Navy Data Environment - Afloat Master Planning System |
| NDE-NM | Navy Data Environment - Navy Modernization |
| NF | Norfolk |
| NIIN | National Item Identification Number |

| Acronyms/ Abbreviations | Meanings |
|---|---|
| NIPRNet | Non Secure Internet Protocol Router Network |
| NMCI | Navy Marine Corps Intranet |
| NPS | Naval Postgraduate School |
| NSLC | Naval Sea Systems Command (NAVSEA) Logistics Center |
| NSN | National Stock Number |
| NSWC | Naval Surface Warfare Center |
| NSWC DD | Naval Surface Warfare Center, Dahlgren Division |
| NSWC PHD | Naval Surface Warfare Center, Port Hueneme Division |
| O&S | Operating and Support |
| OEM | Original Equipment Manufacturer |
| OET | Office of Engineering Technology |
| OOL | Office of Logistics |
| OPNAV | Office of the Chief of Naval Operations |
| ORTSTARS | Operational Readiness Test System Tech Assist Remote Support |
| OV | Operational Views |
| PDDB | Problem Description Database |
| PDF | Portable Document Format |
| PEO | Program Executive Office |
| PHD | Port Hueneme Division |
| PMP | Project Management Plan |
| PMS | Preventative Maintenance |
| PMS 452 | Program Manager, Sea Navy Theater Wide Program Office |
| POC | Point of Contact |
| Pp | Probability of No Human Error |
| PRISMS | Program Information System Mission Services |
| PTB | Part To Block |
| Q&A | Questions and Answers |
| QFD | Quality Function Deployment |
| RDAM | Regional Data Archiving and Management |

| Acronyms/ Abbreviations | Meanings |
|---|---|
| RMA | Reliability, Maintainability, and Availability |
| RMC | Regional Maintenance Center |
| ROH | Regular Overhaul |
| ROI | Return on Investment |
| S2E | Sailor To Engineer |
| SATCOM | Satellite Communication |
| SD | San Diego |
| SE | Systems Engineering |
| SEA 21 | Naval Sea Systems Command (NAVSEA) Deputy Commander for Surface Warfare Enterprise |
| SEAR | Safety Effective and Affordable Review |
| SHAR | Safety Hazard Alert Report |
| SIPRNet | Secret Internet Protocol Router Network |
| SLOC | Source Lines of Code |
| SME | Subject Matter Expert |
| SOE | System Operational Effectiveness |
| SoS | System of Systems |
| SPCC | Ships Parts Control Center |
| SQL | Structured Query Language |
| SRA | Selected Restricted Availability |
| SV | System Views |
| T&E | Test & Evaluation |
| TA | Technical Assistance |
| TAVR | Technical Assist Visit Report |
| TBD | To Be Determined |
| TCP/IP | Transmission Control Protocol/Internet Protocol |
| TFBR | Trouble Feedback Reports |
| TOC | Total Ownership Cost |
| TOR | Test Observation Report |

| Acronyms/ Abbreviations | Meanings |
|---|---|
| TYCOM | Type Commander |
| U.S. | United States |
| USC | University of Southern California |
| USFFC | United States Fleet Forces Command |
| USMC | United States Marine Corps |
| USN | United States Navy |
| VADM | Vice Admiral |
| VAMOSC | Visibility and Management of Operation and Support Costs |
| WCS | Weapon Control System |

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# EXECUTIVE SUMMARY

The Navy has developed several Distance Support tools to support specific naval systems. These tools often do not facilitate knowledge retention and reutilization. A Data Aggregation System (DAS) was proposed to aggregate and integrate data as well as to capture knowledge to improve fleet readiness. The team's recommendation is to implement a Data Aggregation System (DAS) which modifies the existing Engineering and Supportability Decision System (ESDS), to retain technical and supportability data as well as aggregate and integrate information in a timely manner.

This report describes the requirements and parameters necessary to provide a technically feasible, cost effective, and efficient solution that Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) can further develop to provide Distance Support to the United States Navy (USN). Distance Support is defined by the Chief of Naval Operations (CNO) as "a Navy Enterprise effort that combines people, processes, and technology into a collaborative infrastructure without regard to geographic location" (CNO 2007, 2). Specifically for NSWC PHD, Distance Support is the technical help provided remotely to USN ships in all areas of operation and maintenance for warfare systems.

The team developed the following problem statement to more completely capture the issue.

> In recent years, the Navy's decision to reduce manning and training with the increased complexity of combat systems as new programs emerge have led to a decline in Sailors' ability to operate, maintain, and sustain combat systems to the levels required to meet mission readiness requirements (Balisle 2011). Numerous Distance Support tools currently used to respond to USN fleet combat system issues are often slow and ineffective. The eventual technical solutions are often not captured for knowledge retention and reutilization, nor are they available as a self-help tool for the war-fighters. Knowledge data that is captured is difficult to access and utilize in a timely manner. In addition, current Distance Support tools used by Subject Matter Experts (SME) to obtain and analyze system performance metrics are manually intensive and limited in capability.

A systems engineering (SE) approach, adapted from the 2009 Department of Defense (DoD) SE Model, was developed and followed to ensure the recommended DAS satisfied stakeholders' needs. The first step of the SE process was to define stakeholder needs. Past NSWC PHD Distance Support studies and already completed surveys were analyzed to identify needs associated with DAS. It was determined that the stakeholders need a system that provides 1) easily accessible data, 2) high quality information, 3) current data, 4) well organized information, and 5) information displayed and reported when needed. An operational concept diagram was developed to show, at a very high level, the operational relationships amongst users and the new proposed DAS. This was an important first step to developing a conceptual design of the system that would provide the stakeholders with a preferred solution.

The second step in the SE process was to conduct requirements analysis to translate the needs of the stakeholders into DAS requirements. The team developed three categories of requirements, 1) characteristics, 2) design and construction, and 3) component level requirements. Functional analysis was then conducted to identify the system resources that would be required for DAS to achieve the operational concept that was developed from the requirements analysis. The high level functions that were determined necessary to aggregate data were 1) obtain data, 2) process data, 3) analyze data, 4) report data, and 5) display data.

The team conducted an Analysis of Alternatives (AoA) to determine the best alternative that would achieve DAS capabilities and meet the stakeholders' needs. Six alternatives were identified and analyzed to determine the two most effective alternatives, 1) build a brand new system or 2) modify and improve an existing system to meet the needs of the stakeholders. To determine the most feasible existing system, the team defined a number of evaluation measures and metrics, such as 1) the ability to access data, with a Threshold of 10 seconds and an Objective of 2 seconds, or 2) the Mean Time to Repair (MTTR), with a Threshold of 2 hours and an Objective of 1 hour. The team originally identified sixteen systems that could be modified to meet stakeholders' needs. After using the evaluation metrics to assess each existing system's performance based on their current capabilities, the team narrowed the list down to eight potential existing systems. Using swing weight matrices and the Quality Function Deployment (QFD) House of Quality (HOQ) model, the team further reduced the list to four potential existing systems, 1) ESDS, 2) Aegis Combat System Reliability Maintainability and Supportability Database (ACSRMS), 3) Maintenance Figure of Merit (MFOM), and 4) Material Readiness Database (MRDB). A gap analysis determined that the existing system with the least amount of functional gaps was ESDS. Cost Analysis was conducted using Constructive Systems Engineering Cost Model (COSYSMO) to compare the two alternatives, 1) modify ESDS (termed as ESDS+) or 2) build a new system. The results showed that ESDS+ would cost 60% less than building a new system, with the top cost drivers being system design and product evaluation. From Risk Analysis, Expert COSYSMO showed that ESDS+ had less risk issues than building a new system. The major risk area for both systems was attributed to two factors, documentation and the number and diversity of platforms. Thus, the results of the AoA lead the team to recommend modifying the existing ESDS, rather than develop a whole new system

The third and final step in the SE process was to develop the system architecture for DAS and ESDS+. After defining DAS requirements and tracing them to the system functions, the team identified all of the relationships between the functions and components and entered them into Vitech's CORE® software suite to document the functional architecture. The team used Integration Definition for Function Modeling (IDEF0) to model both the functional and physical architectures of DAS. The team also used a number of DoD Architecture Framework (DoDAF) products to identify the tasks, activities and operational elements required to complete the DAS' mission, and to depict the interconnections required for DAS to function. The architecture for ESDS+ was then developed based on the gap analysis and documented using DODAF products and IDEF0 models. By developing the system architecture, the team was able to apply a SE approach toward solving a real world problem for the Navy utilizing the knowledge and skills acquired from the NPS MSSE curriculum. The SE process proved to be effective at facilitating a thorough AoA that resulted in an architecture that satisfies the stakeholder needs.

# LIST OF REFERENCES

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Chief of Naval Operations. 2007. *Navy Distance Support Policy*. Washington, DC: Navy Pentagon. http://www.public.navy.mil/spawar/PEOEIS/NAVY311/Documents/CNO_Navy_DS_Support_Policy_22MAR2007.pdf.

# ACKNOWLEDGMENTS

The Distance Support team would like to extend their gratitude and acknowledgement for the help received from the following individuals that contributed to the success of this team and capstone project.

The team would like to thank first and foremost their families for their unwavering support, patience, and encouragement that have inspired the team to work diligently through each and every quarter of this 24 month long program.

The team would also like to thank their advisors, Ms. Brigitte Kwinn and Mr. Mark Rhoades, from the Naval Postgraduate School (NPS) for their support and guidance. In addition, the team would like to thank Dr. Paul Montgomery and Mr. Gregory Miller from NPS for their direction and recommendations during the progression of the project. Special thanks are extended to Ms. Mary Vizzini, NPS, for providing comments on many capstone report iterations and answering numerous grammar questions. The team would also like to extend their gratitude to Dr. Raymond Madachy (NPS) for his guidance and support of the team in the system engineering cost models.

The Distance Support team would also like to recognize the many contributions made by the stakeholders who have volunteered their time and expertise, specifically Mr. Dave Scheid and Mr. David Williams of the Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD).

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# I. INTRODUCTION AND PROJECT OVERVIEW

This capstone report has been developed by a team of students at the Naval Postgraduate School (NPS) in the Master's of Science in Systems Engineering (MSSE) Distance Learning Cohort 311–113O. The team, all employees of Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD), followed the classic "V" model of systems engineering (SE), developed by Kevin Forsberg and Hal Mooz (Forsberg, Mooz, and Cotterman 2005). The "V" model captured succinctly what the team saw as a logical path for developing a customer validated system based on the customer's needs. The problem was decomposed and analyzed so a solution could be designed that will be validated and verified by the customer. Past NSWC PHD Distance Support studies and already completed surveys were analyzed to develop stakeholder requirements, upon which functional analysis was performed using the Integration Definition for Function Modeling (IDEF0) method developed in CORE® software suite and applied the Department of Defense Architecture Framework (DoDAF) to develop the system architecture. An Analysis of Alternatives (AoA) was performed and development costs were estimated. Planning for solution implementation, integration and verification and validation were completed and are provided in a section listing recommendations. The conclusions made in this report are a direct result of the team's education and experiences supporting the United States Navy (USN) and its Sailors, the research and analysis of customers and their needs, and aligns with the Chief of Naval Operations (CNO) Navy Distance Support Policy, which states that Distance Support is to be the "Fleet's principal web-based readiness enabler, facilitating timely technical assistance, knowledge and education tools, and logistic support" (CNO 2007, 1).

The requirements of homeland defense, national security, and the war on terrorism, as outlined in the National Strategy for Homeland Security dated July 2002, have made a Navy ship's mission more critical than ever (U.S. Department of Homeland Security 2002). When equipment fails there is little time to wait for engineers or technicians to fly to the deployed ship to help resolve the problem, and in today's current fiscal climate, there is a strong pressure for In Service Engineering Agents (ISEA), which is one of NSWC PHD's main responsibilities, to reduce costs. As an ISEA, NSWC PHD provides support through installation, certification and training of Sailors to operate and maintain surface ship combat systems and weapon systems already installed aboard ships. In a memorandum from the Commander of Naval Sea Systems Command (NAVSEA) on promoting efficient spending, all agencies are directed to take more aggressive actions to perform mission critical functions in the most efficient and cost effective manner (Vice Admiral (VADM) McCoy 2012). Functional areas, such as the use of government funds for travel, are directly affected and as a result, to maintain current levels of support while complying with a reduction of travel, it is imperative that effective Distance Support tools are offered to augment the support of those engineers and to provide the best possible level of support to the USN. Distance Support is defined by the CNO as "a Navy Enterprise effort that combines people, processes, and technology into a collaborative infrastructure without regard to geographic location" (CNO 2007, 2–1). Specifically for NSWC PHD, Distance Support is the technical help provided remotely to USN ships in all areas of operation and maintenance for warfare systems.

Through the development, utilization, and delivery of leading-edge Distance Support technology to Sailors at sea, the engineers, logisticians, and technicians of NSWC PHD are working to help USN ships return to operational readiness twenty four hours a day, seven days a week without having to leave their positions. To NSWC PHD, Distance Support is important for the following reasons:

- Reduced-manned ships, such as the Littoral Combat Ship (LCS) can equate to a smaller skill set of maintenance expertise
- Increasing complexity of systems due to technological advancements, integration of emergent capabilities, and foreign combat system elements makes support more complicated
- Pressures to reduce Total Ownership Costs (TOC) affect the amount spent on supportability.

Current Distance Support solutions performed at NSWC PHD include remote monitoring, prognostics and knowledge management. Remote monitoring utilizes satellite links to evaluate system operation aboard ships. Prognostics is done when data from shipboard tests is sent to NSWC PHD and examined for warning indications and trends that can lead to the discovery of these failed parts. Knowledge management is when NSWC PHD releases advisories, workarounds and heuristics of trouble calls to be stored and accessed by others. Although these methods are sound, they are often slow and ineffective. Numerous Distance Support tools exist; however, they were independently developed by each naval system. These tools each have their own unique set of requirements and capabilities and therefore function independently. These tools can be consolidated and/or integrated to more effectively provide the USN with a more capable Distance Support infrastructure. In addition, Distance Support activities are often not retained for knowledge retention and reutilization. Knowledge that is captured is difficult to access and utilize in a timely manner. Better tools need to be developed to allow knowledge to be captured and made ready for use when needed to help improve Distance Support and ultimately fleet readiness. For this capstone project, the team focused on determining what methods and tools were needed to allow Distance Support knowledge and experience to be captured and accessed efficiently.

The team initially performed limited benchmarking, which is a process of investigating and discovering how others perform and/or provide particular functions and products of interest. For this project, the team researched how other organizations conduct Distance Support, whether or not they have experienced similar problems, and how they determine if Distance Support methods are successful. It was found that because of USN mission requirements, system failures cannot be tolerated for prolonged periods, which means the operators are more concerned about their present status, not in creating a holistic Distance Support system.

This need to provide immediate support has created an environment where the reaction of technical support responders is to focus on near term or real time solutions because their primary concern is for ships in harm’s way, needing fully operational systems to avoid compromising their mission and loss of life. The result is a need for a perpetually running system with the highest possible operational availability and lowest possible total downtime. While deployed, there are no spare ships to support a critical mission like there are spare tanks on the ground for the Army or aircraft in the hangar for the Air Force. During initial research and discussions, it was learned that the Navy already possesses numerous data collection and knowledge capturing tools and databases, such as modernization planning databases, casualty reporting databases, and specific system technical assist forms. Based on stakeholder feedback, the collective execution of Distance Support was unsatisfactory.

## A. PROBLEM STATEMENT

In a 2010 Aegis Weapon System (AWS)/SPY Radar Readiness Report, the Deputy Commander of Surface Warfare (SEA 21) Rear Admiral James McManamon noted that "A decline in Sailors ability to operate, maintain, and sustain (combat systems) necessitates the need to optimize Distance Support from fleet field support activities to meet current and future fleet readiness demands." As new surface ship programs emerge, the complexity of combat systems has increased. In recent years, the Navy has identified reducing manning levels as a key approach to reduce the fleet's operational costs. In a 2011 report detailing a review panel analysis of surface force readiness, it was noted that the Navy's decision to reduce manning dropped the fleet's availability levels to below the levels required to support material readiness requirements (Balisle 2011). With decreased manning, and the problem of inadequate Distance Support, problems with fleet readiness compound: reduced manning and inefficient Distance Support results in reduced fleet readiness, increases shore activity and Subject Matter Expert (SME) manpower requirements, decreases fleet independence, decreases efficiencies, and increases TOC.

As has been previously noted, current NSWC PHD Distance Support systems are often slow and ineffective, with each trouble call being handled on an ad hoc basis and relying heavily on the servicing engineer's personal experience. The solutions provided are not often captured for knowledge retention and reutilization and are not available as a self-help tool for the USN fleet as most responders and operators are more concerned with their present status rather than the health of the holistic Distance Support system.

Current tools used by the NSWC PHD SMEs to obtain and analyze system performance metrics are manually intensive, where operators must manually record and provide all performance metrics to the SMEs, and are thus limited in capability. As a result, engineering and supportability issues are not addressed in a timely manner and NSWC PHD SMEs are reacting to problems after they occur rather than being proactive to try and prevent problems. Furthermore, establishing relationships between similar problems continues to be a challenge as there is no systematic method to capture and maintain corporate knowledge of system issues found by the SMEs. A user-friendly efficient tool does not exist that captures knowledge through multiple available data sources for maintenance, performance and logistics that could be utilized in a timely manner to make Distance Support a more responsive and effective product.

The CNO defines Distance Support as "a Navy Enterprise effort that combines people, processes, and technology into a collaborative infrastructure without regard to geographic location… [and] Distance Support projects reactive, proactive, and predictive support to Sailors across functional areas in order to achieve the right readiness at the right time, at the right cost" (CNO 2007, 2). The CNSF categorizes Distance Support by the following four functional areas:

- Logistics
- Maintenance and Modernization
- Manpower, Personnel, Training and Education (MPT&E)
- War fighting.

In addition, each of these four categories has various sub-functions and unique processes. The magnitude and volume of fleet Distance Support activities that occur across these functional areas is enormous. The chart in Figure 1 describes some of the overall activities that are currently involved in providing Distance Support to the fleet.

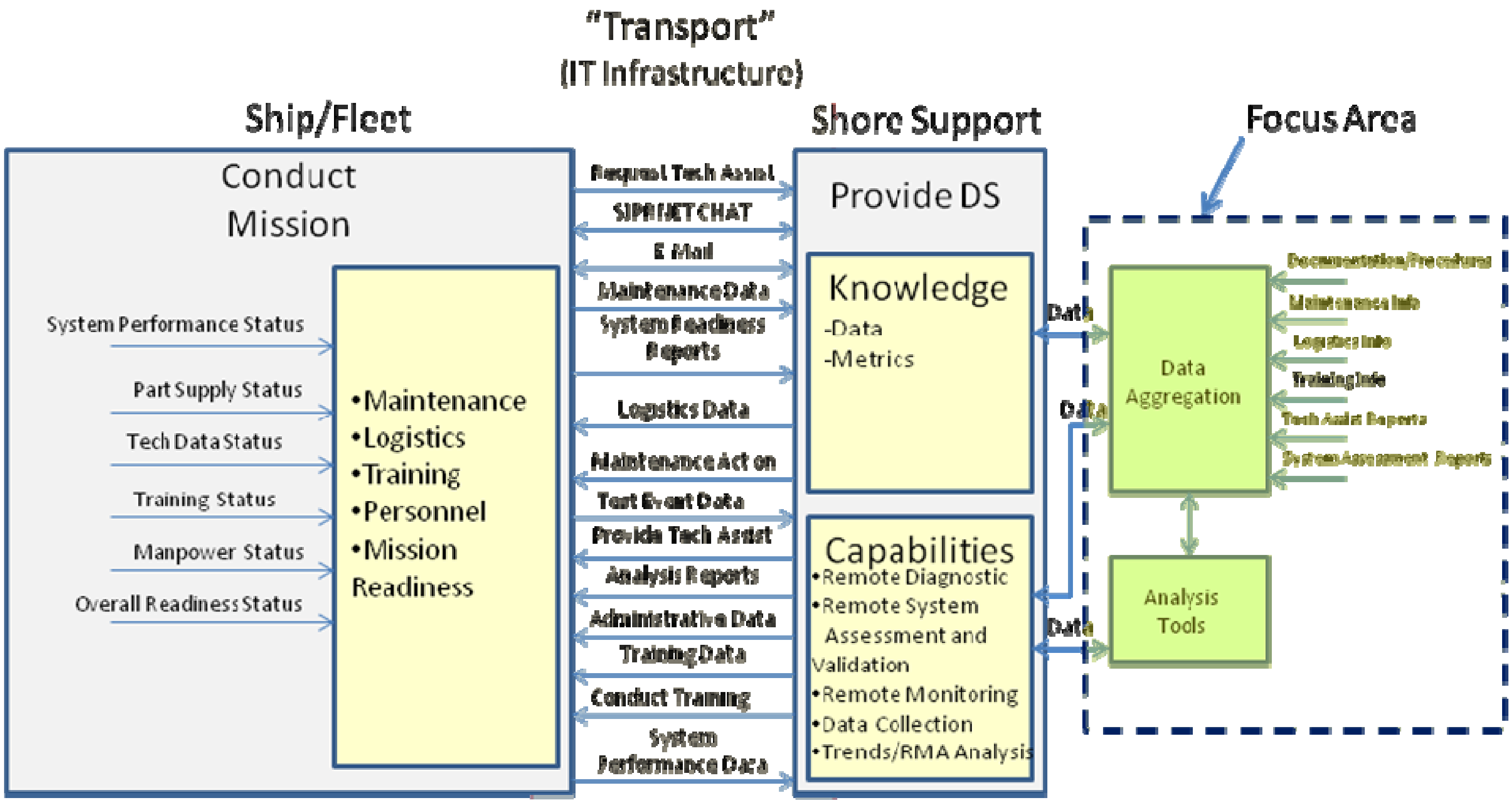



**Figure 1. Distance Support Process**

In the far left of Figure 1, the fleet customer's roles and needs are captured, in the list of requirements that are needed to conduct their mission. These requirements feed into the primary functions that ship's personnel perform, which include maintenance, logistics, training, personnel and mission readiness. "Shore Support," is the infrastructure that possesses the knowledge and capabilities that the fleet needs to support their mission. Between the fleet and shore support is the transport system that passes information and resources to and from the ship. As the diagram shows, Distance Support covers many functions and is quite complex.

The team soon realized that a capstone project that improves fleet Distance Support across all four functional areas was beyond their ability, given the limited resources and time constraints to complete the project. The team agreed that the project had to be scoped to a manageable level, so it was re-focused to the Distance Support areas that NSWC PHD currently supports. NSWC PHD is primarily involved in limited aspects of logistics, maintenance, and modernization of combat systems installed on surface ships. Since most of the team's work is related to maintenance, the team limited the scope of the research effort to maintenance functions. NSWC PHD's capabilities include both remote systems monitoring and technical assistance. Both services are provided in real time, near real time, and on a periodic basis. In 2011, NSWC PHD promulgated a Fleet Support Guidance document, where remote monitoring was defined as "the automated collection of the minimum required data provides the greatest opportunity to ensure the fleet is ready for war" and technical assistance was described as an act that "may take various forms of two way contact including telephone, e-mail, web 'chat', streaming video, etc."

In an effort to limit the scope of the project and increase chances for success, the team solicited input from NSWC PHD stakeholders. Stakeholders informed the team that they wanted the fleet's ability to help itself improved and to improve capturing technical responses to technical assistances. This guided the team's focus to developing a solution to aggregate data from numerous existing Distance Support sources and export data to the fleet to promote self-help and facilitate trend/failure analysis opportunities. Figure 2 shows how data will flow to and from the aggregation tool.

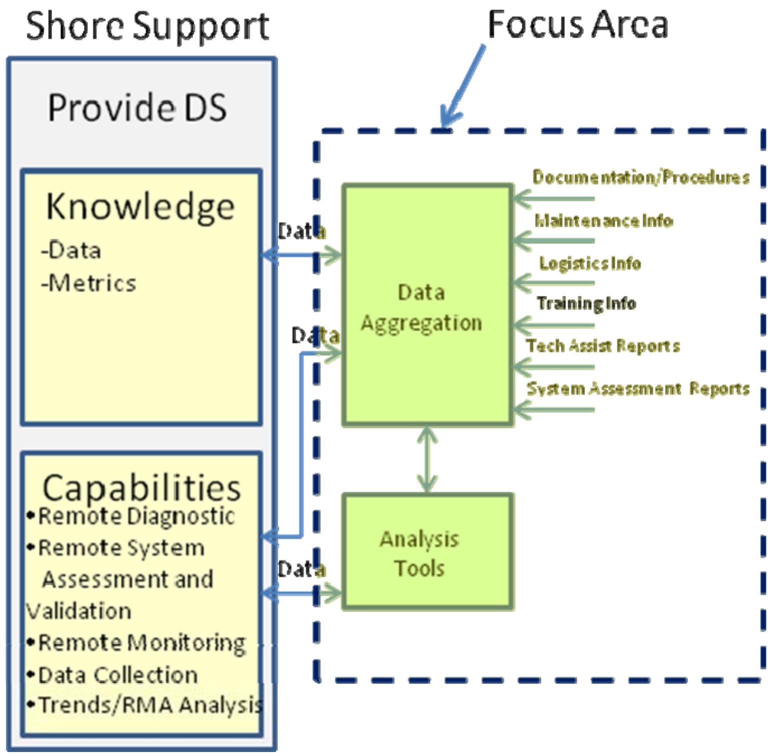



**Figure 2. Distance Support Process Focus Area**

After multiple iterations from discussions with advisors and stakeholders, the team developed the following problem statement to more completely capture the issue at hand.

> In recent years, the Navy's decision to reduce manning and training with the increased complexity of combat systems as new programs emerge have led to a decline in Sailors' ability to operate, maintain, and sustain combat systems to the levels required to meet mission readiness requirements (Balisle 2011). Numerous Distance Support tools currently used to respond to USN fleet combat system issues are often slow and ineffective. The eventual technical solutions are often not captured for knowledge retention and reutilization, nor are they available as a self-help tool for the war-fighters. Knowledge data that is captured is difficult to access and utilize in a timely manner. In addition, current Distance Support tools used by SMEs to obtain and analyze system performance metrics are manually intensive and limited in capability.

This problem statement was derived based on two previous Distance Support studies that concluded that Distance Support is often slow and ineffective. These studies are not releasable to the general public and were obtained from NSWC PHD sponsors. The first study was conducted by the AWS/SPY Radar Readiness Task Force in October of 2009. The Task Force performed an intensive review of all aspects regarding AWS/SPY to determine the factors that affect readiness for these two key warfare systems of the USN Fleet. The results and recommendations clearly pointed to these factors negatively affecting readiness. Some of the key issues identified are as follows:

- Manpower reductions and a lack of necessary experience in operators
- Inadequate shore-based training for the operators prior to deployment
- Electronic versions of system drawings are being supplied to ships to save expense, but they are difficult to use in troubleshooting
- Spare parts are not available on-board; requisitions have to be filled from other locations
- Uncertainty of who to contact for Distance Support and on-site technical support and inefficiencies when support is provided
- Auxiliary equipment support test and maintenance is frequently unavailable
- Preventative maintenance is not emphasized
- Fewer periodic ship assessments for the systems are performed than recommended
- Distance Support is not used as often as it should
- System performance monitoring and data collection is not being adequately done to determine readiness
- There is not a consistent method to document issues (2010 AWS/SPY Radar Readiness Report)

The second study used was the Distance Support Capability Based Assessment (CBA), which was conducted under the authority of Deputy Commander, United States Fleet Forces Command (USFFC) as part of a Distance Support Functional Analysis performed in 2010. The Distance Support CBA produced an integrated Distance Support capability proposal following the Joint Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel and Facilities (DOTMLPF) and policy solutions. The CBA fulfilled the analysis portion of the Joint Capabilities Integration and Development System (JCIDS). It defined Distance Support capability needs, capability gaps, capability excesses, and approaches to provide those capabilities within a specified functional or operational area. The Distance Support CBA has identified several areas that need to be improved. Those that directly apply to this capstone project are summarized as follows:

- Knowledge Management–Distance Support needs to be focused on enabling information sharing and providing remote support for maintenance and logistics. If effective, the burden on the shore-based infrastructure will be lessened.
- Collaborative Environment–Distance Support needs to utilize collaboration to provide timely technical responses, predict future material concerns and to enable the war fighter to employ proactive measures. This construct will improve Operational Availability (Ao), lower TOC and allow Sailors to gain more technical knowledge and skills.
- Optimized, Reduced, Minimal and Multi-Crew Shipboard Manning (Formerly identified as 'Minimal Shipboard Manning')–New ship programs, such as LCS, are delivering ships based on the assumption that the ships can be staffed minimally and leverage off of improved Distance Support. Efficiency of technical troubleshooting is the key to allow the ship's force to accomplish their diverse tasking.

The results from both the SPY/Aegis Task Force and the Distance Support CBA drove the team towards developing a solution that will improve Distance Support effectively and increase fleet self-sufficiency. From the initial problem statement, project sponsors believed that numerous Distance Support tools exist but need to be consolidated and/or integrated more effectively. The key problem, as previously stated, is that Distance Support activities are often not captured for knowledge retention and reutilization and the knowledge that is captured is difficult to access and utilize in a timely manner. It is this particular problem that this capstone research seeks to address.

## B. RESEARCH QUESTIONS

The following research questions were used by the team to guide their research:

- Why is improving the Navy's Distance Support system important or necessary?
- How do others conduct Distance Support and are they effective?
- How do the stakeholders define an effective and affordable Distance Support system?
- How can the existing Distance Support system be improved or modified to increase fleet readiness and reduce TOC?

## C. PROJECT ASSUMPTIONS AND CONSTRAINTS

The analyses conducted and discussed in this report were based on the following assumptions:

- Demand for Distance Support will increase or remain constant
- Regional Maintenance Center (RMCs), who are on the waterfront and the ship's first line of support on shore, and/or ISEA technical expertise, will be available for the foreseeable future
- RMCs/ISEAs are committed to Distance Support knowledge capturing and reutilization. For Distance Support to be a helpful and useful tool, buy-in from all stakeholders must occur
- The fleet and the shore support activities (to include the RMCs and ISEAs) will actively participate in improving Distance Support
- Access to existing Navy data capturing and knowledge retention databases will be permitted. (Reusing existing data is critical to avoid having to create duplicate infrastructure and resources for capturing Distance Support experiences and knowledge)
- Information contained within existing knowledge retention databases is sufficient for improving fleet self-help and performing data analysis.

Essentially, the assumptions made by the team were that the fleet would always need remote technical help and the USN Activities that are charged with technical support will continue to do so. Secure connection via the Web to the technical agents is also required.

## D. DESIGN TEAM STRUCTURE

The capstone team consisted of eight distance-learning students. The team was co-located at Port Hueneme, California, except for one satellite employee located in San Diego, California. The team was diverse and included a mix of senior and junior engineers from electrical, electronics and computer engineering backgrounds. Due to travel commitments and the fact that one employee worked at a different location, various tools were utilized to maintain communication including web-based meeting platforms Defense Connect Online (DCO) and Elluminate, and the web-based file sharing service Dropbox. In addition, weekly team meetings and class sessions were utilized for brainstorming sessions, discussing the status of projects and their progress, and preparing class materials and deliverables.

To execute the project, the team utilized a matrix organization as depicted in Figure 3 that applied project management and SE disciplines across the various products required for a solution. The chart summarizes the team’s roles and responsibilities.

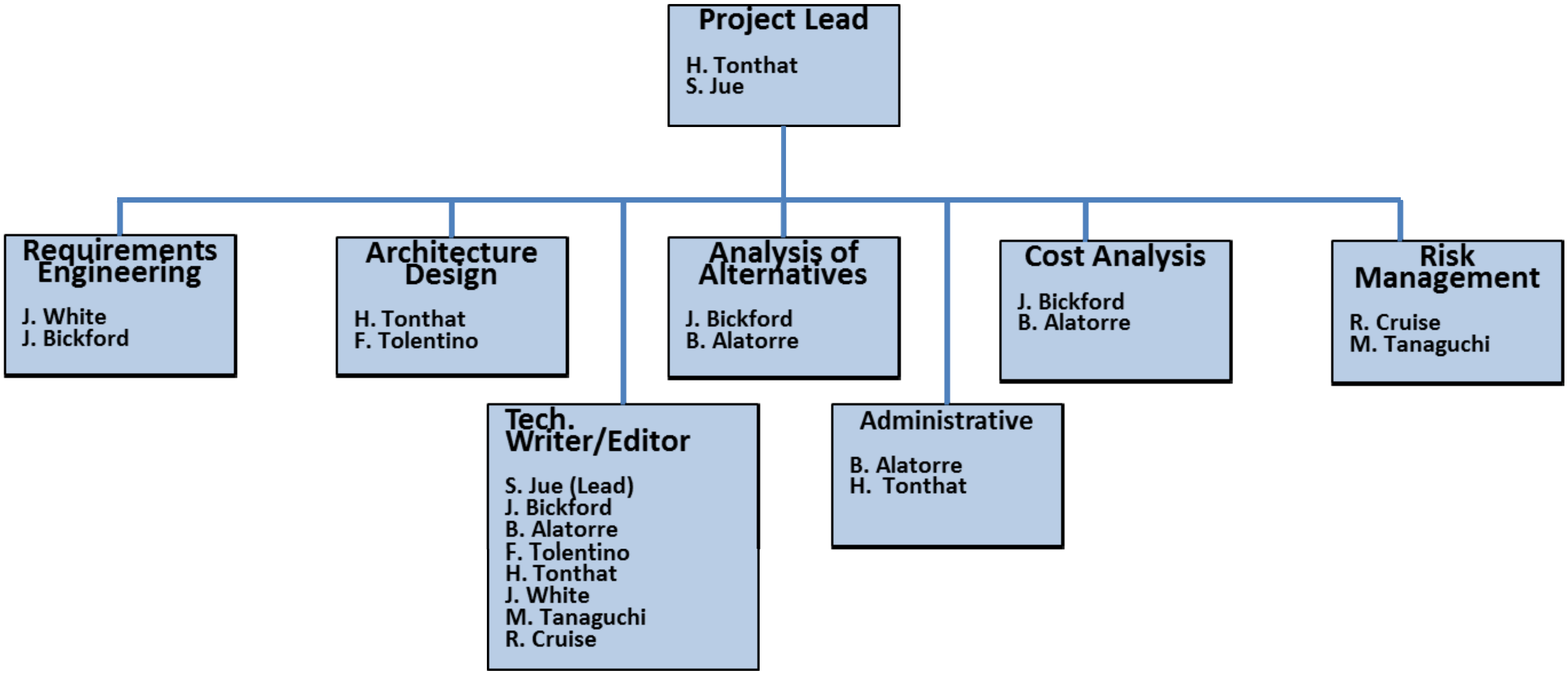



**Figure 3. Design Team**

The role of the Project Lead was to ensure the project was on schedule and meeting project objectives and requirements. Requirements engineering concerned the development, verification, and evaluation of all capstone project requirements. Cost Analysis included conducting the Business Cost Analysis (BCA) and Return on Investment (ROI). Architecture design included the development and design of the system architecture. This task translated stakeholder needs into system functional requirements and decomposed these requirements into functional architecture. Risk management covered the activities of conducting risk management, performing risk assessment, and providing risk mitigation. Personnel in charge of the AoA were tasked to lead the evaluation of alternative solutions. All team members were involved in the writing of the capstone report. The administrative members were responsible for taking notes during team meetings, keeping track of action items, and managing all other administrative needs that may develop during the life of the project.

## E. STAKEHOLDERS AND PROJECT SPONSORS

A list of stakeholders and their primary concerns in regard to this project is given in Table 1. Based upon the problem definition and research into the problem domain, the team selected seven primary stakeholders to focus on to ensure their needs were adequately addressed. The project was principally focused on improving fleet readiness; therefore the most important stakeholder was the fleet itself, as they are the ultimate users and beneficiaries.

| Stakeholder | Primary Concern |
|---|---|
| Fleet | Improve fleet readiness, reduce Total Ownership Costs (TOC) |
| Waterfront Activities | Lack of adequate Distance Support capabilities, capture knowledge |
| USN Type Commander (TYCOM) | Improve fleet readiness, Distance Support effectiveness. system performance metrics |
| Naval Sea Systems Command (NAVSEA) | Lack of adequate Distance Support capabilities, reduce Life Cycle Cost (LCC) , system performance metrics, failure trends |
| Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) | Improve fleet readiness, lack of adequate Distance Support capabilities, capture knowledge, and reduce LCC/TOC |
| Program Executive Office (PEO) | Improve Distance Support and reduce TOC, failure trends, acquisition impacts |
| Office of the Chief of Naval Operations (OPNAV) | Improve fleet readiness and reduce TOC |

**Table 1. Stakeholders**

While effective Distance Support can improve the work of many different stakeholders, there are many priorities shared by all. The primary concern of the fleet was to minimize equipment down time, which was also a concern shared by all stakeholders. An additional concern important to the fleet (and all stakeholders) was the improvement of equipment reliability and the reduction of TOC. In a budget constrained environment, reducing TOC was extremely important for ensuring an affordable Navy for the future.

All of the project sponsors are from NSWC PHD and are listed in Table 2. NSWC PHD, as the ISEA for most of the Navy's surface weapon systems, has the unique ability to influence and address stakeholder concerns. Knowledge capturing and knowledge reutilization are key components to enabling NSWC PHD to improve component/system reliability and to provide faster, more thorough Distance Support to the fleet, all of which improves fleet readiness and while reducing TOC.

| Sponsor | Title |
|---|---|
| Mr. Timothy Troske | Technical Director |
| CAPT Theodore Olson, USN | Office of Logistics (OOL), Deputy Commander |
| Mr. Fabio Vitale | OOL, Director |
| CAPT Scott Davis, USN | Chief Engineer (CHENG), Office of Engineering Technology (OET) |
| Mr. Dave Scheid | OET, Chief Innovations Officer |
| Mr. David Williams | OET, Distance Support Advocate |
| Ms. Coralyn Akers | Fleet Liaison |
| Mr. John Lester | Systems Engineering (SE)–Air Dominance Department Lead |
| Mr. Noel Camanag | SE–Land Attack Department Lead |
| Mr. James Childs | SE–Ship Defense and Expeditionary Warfare Department Lead |

**Table 2. NSWC PHD Project Sponsors**

## F. SYSTEMS ENGINEERING PROCESS

A tailored SE process was used to reflect the uniqueness of the project. The team adopted the new 2009 DoD SE Model as shown in Figure 4, as a framework for the project SE process due to its standard applicability to SE projects (Defense Acquisition University (DAU) 2011). The 2009 DoD SE Model consists of two major processes: 1) the technical management process, which steers system development to meet project or phase objectives, and 2) the technical processes, which are depicted in a V-shaped pattern to portray the "top-down" design that occurs as requirements are allocated from the system to lower-level elements. The V-shaped model also shows the "bottom–up" realization, from the lowest level components to higher assemblies to achieve the complete system. The technical processes are applied across the life cycle of a system and at different levels in the system hierarchy to develop the system (DAU 2011).

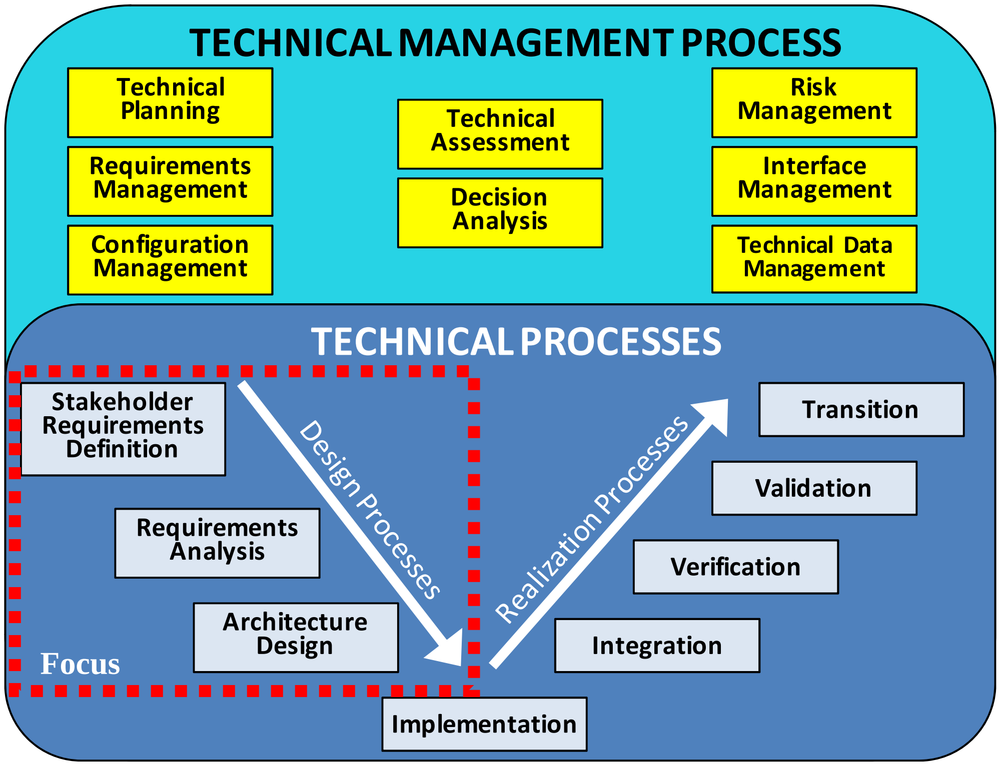



**Figure 4. 2009 DoD System Engineering Model (From DAU 2011)**

The team used the tailored SE process as illustrated in Figure 5 for activities in the development of the capstone project. This figure reflects the project activity hierarchy that was pursued as the team progressed through the SE process. The first step was to define the stakeholder needs. This step was accomplished by reviewing past studies and already completed surveys provided by NSWC PHD project sponsors, categorizing the results, and conducting a needs analysis. The results of the needs analysis were then used for the requirements analysis. After completing the requirements analysis, the system architecture was designed and modeled. A preferred solution that adequately satisfies stakeholder requirements was then recommended for system implementation.

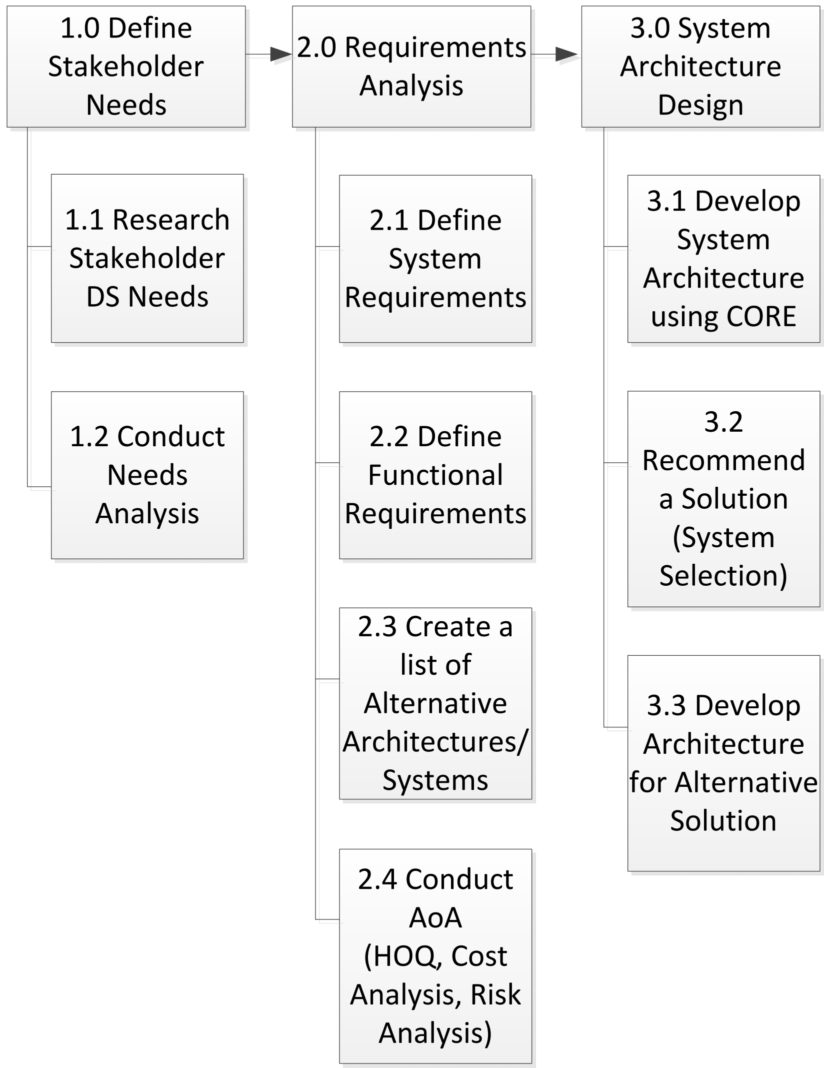



**Figure 5. SE Process to Project Activities (After DAU 2011)**

Figure 6 shows the SE process used for mapping stakeholder needs to alternative solutions. The first step was to map needs to requirements, followed secondly by requirements to functions, and thirdly functions to components. The mapping process not only allowed alternative solutions to be compared, it also provided traceability back to the requirements. The Vitech CORE® modeling tool was used to capture, track, and produce the SE architecture artifacts which will be discussed in more detail later in the report. Through CORE®, the requirements were mapped into a hierarchy and then allocated to system functions. These functions were then tied to forms or components for the architecture.

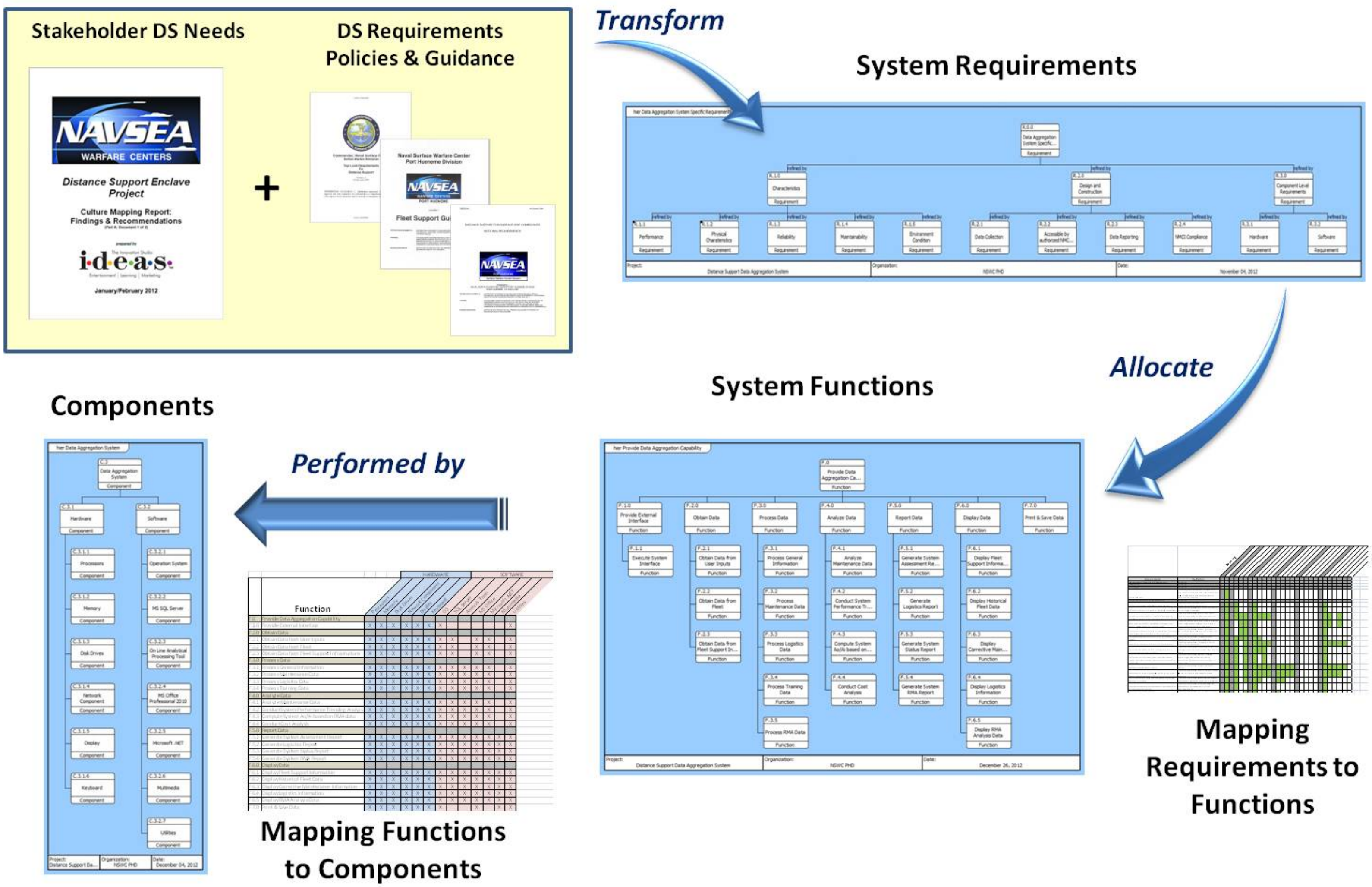



**Figure 6. Requirements to Components Mapping Process**

## G. SUMMARY

The project development methodology was to: 1) apply SE techniques to clearly define the problem, 2) prioritize stakeholder requirements, 3) perform a functional analysis, 4) research and compare possible solutions, and 5) develop a conclusion and recommendation. In addition, the project focused on finding a solution to determine what methods and tools were needed to allow Distance Support knowledge and experience to be captured and utilized to help improve Distance Support and ultimately fleet readiness. The stakeholder needs focused on developing a solution that would aggregate data from numerous existing Distance Support sources, export data to the fleet to promote self-help, and export data to help facilitate trend and failure analysis opportunities. Finally, the project scope focused on improving Distance Support knowledge capturing and reutilization as it applies to NSWC PHD. Subsequent chapters of this report will discuss in detail these SE techniques in turn and outline how the team came to their conclusion.

# II. DEFINING STAKEHOLDER NEEDS

The first step of the SE process was to define stakeholder needs. This was an important first step to developing a conceptual design of the system that would provide the stakeholders with a preferred solution. "Having defined the problem completely and thoroughly, a needs analysis should be performed with the objective of translating a broadly defined 'want' into a more specific system-level requirement" (Blanchard and Fabrycky 2011, 58).

## A. DERIVING STAKEHOLDER NEEDS

The first step taken after developing the initial problem statement was to determine the stakeholder needs. To help with this, the team met with key NSWC PHD sponsors, Dave Scheid and David Williams, and solicited their guidance on how best to approach this task. In addition to providing guidance, the sponsors also provided past Distance Support studies that were previously conducted.

Two of the studies utilized by the team were summarized in Chapter I. In addition, the team was also provided survey results that were originally used to develop the LCS Distance Support philosophy. The survey results are not releasable to the general public. In summary, this report details the methodology, findings, and recommendations following three days of Culture Mapping Sessions held in Naval Base San Diego and at NSWC PHD in January of 2012. Culture mapping methodology included several small group sessions which encouraged anecdotes on the current state of Distance Support and then were "mapped" to determine a more complete understanding of its nature. These sessions were also conducted to understand the Distance Support processes and functions across the fleet and discern the challenges to Distance Support that LCS may present as a unique mission platform. To NSWC PHD sponsors, these results were very important because the LCS shipboard manning is expected to be significantly lower than traditional war ships, which means that LCS ships will be more dependent on Distance Support than ever before. One of the most important findings from the culture mapping reports was learning that to be useful, a tool must be simple to operate and be quick to provide help.

The stakeholder needs were derived from the LCS Culture Mapping Sessions and the past Distance Support studies. The stakeholder needs were then organized and re-written in terms of requirements. Requirements are discussed in more detail later in the report.

## B. NEEDS ANALYSIS

By performing a thorough stakeholder needs analysis, the team determined that NSWC PHD needed to improve Distance Support data aggregation and knowledge reutilization in order to provide more effective Distance Support capability to the fleet. In addition, improved data aggregation enables NSWC PHD to perform more effective trend analysis to improve equipment reliability, utilizing existing shore support resources and processes.

When a failure occurs with a shipboard system, Sailors normally engage in troubleshooting efforts to isolate the failed component based on their own experience. Sailors are usually motivated to correct the failure as quickly as possible and if this effort is prolonged, the Sailor will look for assistance from others. The first priority is to exhaust the resources available on the ship and once that occurs, the Sailor will pursue assistance from ashore. The typical process is to contact the local RMC and if those resources are not readily available then they often contact the ISEA. The last resort is usually to contact the Original Equipment Manufacturer (OEM). To summarize, the current process is usually time consuming and significantly prolongs system down time.

In today's environment where ships are a limited resource, Sailors have more collateral duties and have very little time for combat system maintenance. To avoid lengthy troubleshooting sessions, Sailors often prefer someone telling them what component to replace and how to replace it. An analogy would be that the "check engine" light in a car goes on so the owner takes the car to the dealer for a diagnosis. The dealer quickly determines which parts have failed. The owner can then buy the parts and install them or have the dealer install them. In that scenario, the problem gets fixed with the least amount of the car owner's time consumed. Thus, the requirements for help can be colloquially summarized as follows:

- Determine what's broken with the system (i.e., what failed or what's not working right)
- Determine what parts need to be ordered and from where (in the most expeditious way)
- Determine how to replace the parts
- Determine what to do with the old parts.

Using the analogy above and feedback from stakeholders, the following general statements seem to capture some of the most important self-help requirements for the Navy. Operators need:

- Help with operation and maintenance
- Quick access to the right information or resources (including people)
- Useful and effective information or assistance
- Information that is easy to understand and follow information
- Help that is immediate or information regarding who to contact for more help.

According to the stakeholders, the most effective Distance Support system would include the ability to conduct prognostics to predict failures in advance and replace defective components before they fail; this would mean that equipment would be replaced at a more convenient time than would be the case if equipment was replaced because of failure or at an unanticipated time. In the absence of prognostic capability, which has not yet fully matured, the most effective Distance Support system would emulate having fully knowledgeable technical experts and complete parts support on board a ship so that when a combat system experiences a failure, the root cause can be determined without delay and the failure corrected immediately. In regards to maintenance, minimizing down time is the key element of achieving high Ao and the highest state of fleet readiness. Any delays in replacing failed components results in longer down times. As discussed previously, in today's Navy not all parts are available on board and the availability of technical experts is limited. The most knowledgeable technical experts are not shipboard and reside on shore at various organizations. These organizations include the RMCs, the ISEAs, and the OEMs. If it were possible to place a SME on every ship, the need for Distance Support would be eliminated. Since these resources are mostly civil servants and private parties, it is not possible to position these resources on a Navy war ship, especially in combat. Technical experts consist of trained professionals with the most knowledge, skills, and abilities; the expertise of such a technical expert is difficult to have shipboard. The turnover frequency of active duty military personnel alone prevents sufficient retention of fully trained individuals. Therefore, the goal of an effective Distance Support system are to provide immediate access to the SMEs, share as much system fault information with that SME, and provide the ship with immediate access to the knowledge that the technical experts possess without having to contact or position the technical expert on site.

From the stakeholder needs analysis, the ideal solution would meet the following criteria for knowledge and technical information:

- Easily accessible
- High Quality information (accurate, useful, reliable, and complete)
- Data sorted by its age (i.e., providing most recent information)
- Well organized data
- Information displayed and/or reported when needed.

Past Distance Support surveys and studies showed that Sailors usually avoid using any process or tool that does not meet the above criteria. Thus, providing Sailors immediate access to technical information that meets the above criteria should improve self-help. This change would reduce the need to contact SMEs ashore.

Ship-to-shore access to technical information currently exists but is often slow or difficult to access and utilize. The primary vehicles for accessing technical information include websites, electronic media like Compact Disks (CD), and e-mail. E-mail is currently the most convenient method, but Sailors often experience delays because of not knowing who to contact, different time zones, and SME availability. Although e-mail is often slow, it is usually effective at getting help to the ships, eventually. Ships have bandwidth limitations that often prevent Sailors from accessing and searching the numerous websites that are available, especially while deployed. In addition, many Sailors are often not aware of the websites that are available, including the NSWC PHD Sailor to Engineer (S2E) website. Numerous websites exist, but contain limited information and are usually only updated as a need arises.  websites are convenient but rarely meet the required attributes for Distance Support, which are easily accessible, high quality information, most recent data, and well organized. Thus, Sailors rarely prefer to utilize websites because they fail to meet the minimum Distance Support criteria provided above.

Technical and recorded information that resides on unique databases and servers is also difficult for Sailors to access. Typically, to have access, a user is required to obtain permission to use the information contained in the database. Once permission is provided, finding useful information can be extremely difficult and time consuming. On the other hand, many databases are routinely updated by the host organization and usually contain the most recent historical information. In addition to technical information, information related to maintenance performed by others and past Distance Support experiences is often captured in these databases. SMEs also rely on this technical and historical information for conducting technical assistance. The ability to extract and display information, automatically when needed, could significantly increase self-help capabilities.

## C. OPERATIONAL CONCEPT DEFINITION

The team defined a system that would answer all the needs described by the stakeholders and referred to it as the Data Aggregation System (DAS). The operational concept of the DAS was to aggregate, and integrate engineering and supportability information from internal and external sources and to capture SMEs knowledge to improve today’s and tomorrow’s fleet readiness through Distance Support capabilities.

The system will enhance the effectiveness and efficiency of near real-time data management and utilization by providing benefits in the following ways:

- Providing maintenance information to enable fleet self help
- Providing insight to help predict potential problems before they occur by utilizing Key Performance Indicator (KPI) "triggers" to help focus SMEs on the pertinent issues for their systems
- Addressing engineering and supportability issues quickly by automating data collection/aggregation from a variety of available sources
- Assisting sponsors and/or customers in prioritizing requirements within the budget cycle
- Managing engineering expertise and knowledge effectively
- Providing accurate and repeatable results through standardization of fault diagnostics and repair
- Providing the ability to efficiently display baseline or combat system cumulative reporting across the enterprise in support of organizational, programmatic, or individual needs
- Providing timely and accurate information to the SME for fleet technical assistance via Distance Support
- Providing the ability to produce special reports quickly and more cost effectively
- Capturing corporate knowledge from the SMEs, situations, and processes continuously and make available for training and future reference/analysis
- Maintaining historical records and related corporate knowledge that is easily retrieved by any user.

The diagram shown in Figure 7 describes the concept operation of the DAS where multiple data sources are collected either from the ships or from various fleet support agencies. After the data is collected through a network interface, the system will then process and analyze the data to generate multiple products that are categorized as follows:

- Performance Health Trigger, which is a key parameter with a threshold associated to it directly related to the performance of a system
- Corrective Maintenance Solutions are considered as equipment troubleshooting tips provided by the SMEs, list of common equipment failure items and common corrective actions, updated troubleshooting procedures and maintenance work packages, part list, and many more products that can be used for self-help corrective maintenance
- Predictive Analysis and Modeling, or forecasting future states and issues of the system based on historical data
- Operational Data Analysis; analysis of ship's system performance based on different mission area
- Statistic Modeling, results from system testing and Reliability, Maintainability, and Availability (RMA) data collected over time can be used to create statistic model for future trending and predictive analysis
- Data Validation; ship's system performance and system configuration data will be collected, measured and validated with specification requirements for accuracy and effectiveness.

The arrows in the center of Figure 7 that are pointing to the top of the diagram reflect information and knowledge being reused and shared with both the fleet and shore support organizations. The data aggregation occurring in the middle is the primary focus of this capstone project.

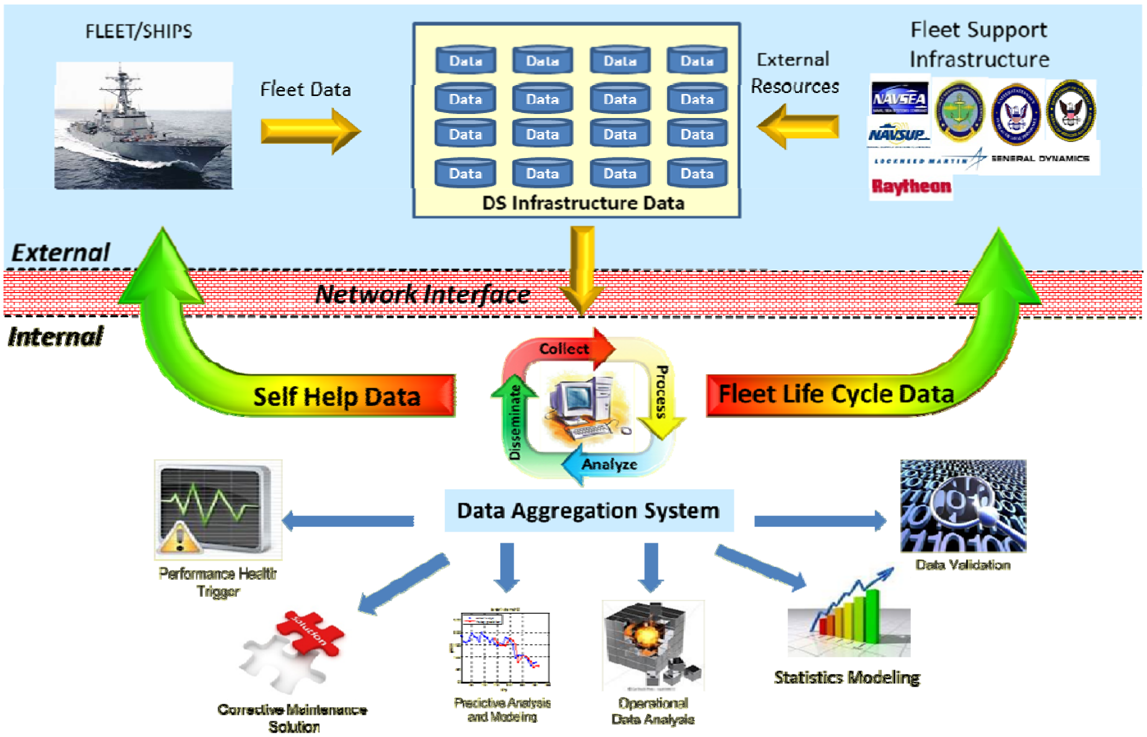



**Figure 7. Data Aggregation System Operational Concept**

### 1. DAS Users

In the context of operation, the "user" is defined as anyone who utilizes the DAS to analyze data or obtain information. A user can be a SME of a particular system, fleet customer, or sponsor who has the need to see the system life cycle data. Additional details on how each of these users will utilize the Data Aggregation are described in the following paragraphs.

#### *a. SME*

Equipment, software, and systems engineers, as well as supportability and financial personnel will use the DAS as a resource to conduct engineering and supportability investigations. The DAS will allow the SME to review multiple data sources, such as technical assistance data generated by the Command Issues Management (CIM), remote system diagnostic and assessment reports resulted from Operational Readiness Test System Tech Assist Remote Support (ORTSTARS), testing Maintenance and Material Management (3M) data which contains RMA data imported from the

Material Readiness Database (MRDB), supply data collected from the Naval Supply Systems Command (NAVSUP) database, and so forth. These users would utilize the data to conduct root cause analysis and develop a possible solution to issues.

#### *b. Fleet Customer*

The USN fleet, RMC personnel, USFFC, Type Commanders (TYCOMs), and Class Squadrons (CLASSRON) will use the DAS as a data source which will provide pertinent data needed to assist with fleet responses to system and equipment maintenance and performance issues. These issues may include common questions and answers pertaining to equipment corrective maintenance, troubleshooting procedures, metrics, information on issues that the SME has analyzed, fleet issues addressed previously, or other concerns investigated by the ISEA.

#### *c. Program Sponsors*

Sponsors such as NAVSEA, Program Executive Office, Integrated Warfare Systems (PEO IWS), Program Executive Office, Ships (PEO SHIPS), Program Manager, Sea Navy Theater Wide Program Office (PMS 452), USN Missile Defense Agency (MDA) and NSWC PHD will use the DAS information and results of engineering and supportability investigations to assist them in making high-level decisions based on historical data, trends, fleet usage, and emergent issues.

### 2. DAS Data

The DAS will access the data from multiple sources through a network interface connected through the Navy’s existing network infrastructure. Based on the team’s research, the databases discussed in the following subsections were identified as prominent data sources that will be accessed and processed by the DAS. These databases contain a significant amount of information and most are routinely updated with new information as it becomes available. Most of this information is currently used by ISEAs, shore support maintenance personnel and the supply system to track system configurations, system performance, maintenance actions, and to improve system reliability. Shipboard Sailors rarely possess or attempt to access the information contained within these databases, primarily due to a lack of awareness of the databases' existence or utility, difficultly accessing information, or the need to obtain permission. The information contained within these databases is extremely useful for sharing past Distance Support experiences and for identifying reliability improvement opportunities. In addition, much of the knowledge that SMEs possess is captured within these databases. The DAS will be a tool that will process this information in a way that satisfies the Distance Support criteria, improving the self-help capability. To satisfy the Distance Support criteria developed in this report, the data will have to be aggregated such that the information is readily accessible, high quality, and well organized.

#### *a. NAVSEA Logistics Center (NSLC) Maintenance and Material Management (3M)*

The 3M repository contains shipboard created deferred and non-deferred jobs, shore facility jobs created in support of ships, and information related to the planning of deferred maintenance. The repository also contains Intermediate Maintenance Activity job completion information and some public/private depot level completion data for off-ship maintenance. Supply transactions that associate supply demands to shipboard and non-shipboard issues are available within the new repository. Preventive Maintenance (PMS) completion information is also available. The database has been enhanced to include, metrics at the job level and a breakout of Selective Level Reporting information from in-stream narrative to fielded table information.

DAS will obtain 3M data for two main reasons, which are to obtain ship and equipment configuration information and ship and equipment field maintenance information. This information is used to provide System Operational Effectiveness (SOE) metrics, which are Mean Time Between Failures (MTBF), cost, number of failures due to human factors, and so forth.

#### *b. Command Issues Management (CIM)*

CIM is an application which is being used to track all NSWC PHD fleet technical assistances, and other types of work, for instance program action items, trend analysis, system anomalies, engineering investigations, and so forth. DAS will obtain

CIM data to report the effectiveness of NSWC PHD's support to the Fleet. Some examples of CIM metrics are: 1) Technical Assistances (TA) open greater than or equal to 90 days at the end of the month, 2) TA costs due to closed TAs open less than 90 days, and 3) TA productivity metrics for TAs closed less than 90 days.

#### *c. Test Observation Reports (TORs)*

The TORs database contains Test Observation Reports from Combat System Ship Qualification Trial (CSSQT) and other test events in which NSWC-PHD participates. DAS will obtain TOR data to report system Probability of No Human Error (Pp) metrics and Human System Integration (HSI) information as part of NSWC PHD's Safety Effective and Affordable Review (SEAR) process. TOR HSI elements are as follows: 1) human factors, 2) personnel, 3) habitability, 4) manpower, 5) training, 6) survivability, and 7) environment, safety and occupational health.

#### *d. Engineering Information System (EIS) Problem Description Database (PDDB)*

The EIS PDDB contains engineering problem description reports for investigations in which NSWC-PHD participates. DAS will obtain EIS PDDB data to report open and closed engineering investigations on equipment.

#### *e. General Distribution Allowance Parts List (GDAPL)*

The Navy's General Distribution Allowance Parts List (GDAPL) cross-references part numbers, National Stock Numbers (NSNs) and Commercial and Government Entity (CAGE) Codes to Allowance Part Lists (APLs). Obtained from the Navy Ships Parts Control Center (SPCC), this database shows top-down, bottom-up relationships between all parts in the system. GDAPL is a Microsoft® Windows based application; it contains a current drawdown of the Weapon Systems File for APLs and Allowance Equipment Lists (AELs) as of the date of extraction. The GDAPL is a quarterly issued item, and is distributed in October, January, April, and July. DAS will obtain GDAPL information to develop equipment configuration management tables that, in turn, support SOE metrics. For more information on GDAPL, visit the website: http://www.navicp.navy.mil/05/caprod.htm.

#### *f. Material Readiness Database-Next Generation (MRDB-NG)*

MRDB-NG data is a consolidation of validated 3M, Casualty Report (CASREP), employment, cost, equipment identification code, and other information which is then used to generate overall equipment Ao, MTBF, Mean Time To Repair (MTTR), support indices, and other logistics and sparing indices at the system level. Equivalent indices and cost of replacement parts are also generated at the block and part level. DAS will obtain MRDB-NG information for equipment Ao metrics that, in turn, supports SOE metrics.

#### *g. Navy Data Environment -Afloat Master Planning System (NDE-AMPS)*

The Afloat Master Planning System (AMPS) provides data on major shipboard systems (Configurations) with a focus toward Battle Force interoperability. It also carries planning information about scheduled Installations, Alterations and Configuration Changes. DAS will obtain AMPS data for Strike Group configuration information that, in turn, supports SOE metrics grouping at the strike group level. For more information on NDE-AMPS, visit the website: https://www.nde.navy.mil/.

#### *h. Global Distance Support Center (GDSC) Remedy*

The GDSC Remedy is a virtual call center connecting Fleet and Industrial Supply Center (FISC) Norfolk and San Diego to process customer requests for information, products and services from the logistics system. DAS will obtain GDSC Remedy data to report to NSWC PHD the effectiveness of NSWC PHD's support to the Fleet. Some examples of GDSC Remedy metrics are: 1) TAs open greater than or equal to 90 days at the end of the month, 2) TA costs due to TAs closed in less than 90 days, and 3) TA productivity metrics for TAs closed in less than 90 days. For more information on GDSC Remedy, visit the website: http://www.anchordesk.navy.mil/.

#### i. *Diminishing Manufacturing Sources and Material Shortages (DMSMS)*

The Government-Industry Data Exchange Program (GIDEP) is a cooperative effort to exchange research, development, design, testing, acquisition, and logistics information among government and industry participants. DMSMS notices originate when a part manufacturer announces that a part or a production line will be discontinued. The majority of GIDEP DMSMS notices have been issued on piece parts, especially in the electronics area (primary microcircuits); however, DMSMS also occurs at the module, component, equipment, or other system indenture level. GIDEP is designated as the Department of Defense centralized database for managing and disseminating DMSMS information. The database contains data for not only parts manufactured in accordance with military or government specification but also commercial parts. DAS will obtain DMSMS data to identify Lowest Replaceable Units (LRUs) that are of concern to the ISEA because they are or will be obsolete. For more information on DMSMS, visit the website: http://www.gidep.org/.

#### j. *Federal Logistics Data (FEDLOG) Information Center*

FEDLOG can be used by engineering, technical research, provisioning, procurement/contracting, supply, cataloging, maintenance, distribution, storage, transportation, quality assurance and disposal personnel to retrieve management, part/reference number, supplier, commercial and government entity, freight, Interchangeability and Substitutability (I&S) and characteristics information recorded against NSNs. FEDLOG also provides service unique data for additional search capabilities. FEDLOG is published monthly on Compact Disk-Read Only Memory (CD-ROM) and Digital Video Disc (DVD) by the Defense Logistics Information Service (DLIS). DAS will obtain FEDLOG information to develop a National Item Identification Number (NIIN) to CAGE and part number cross-reference table because LRUs may be referred to by part number by engineers and by NIIN by logisticians. For more information on FEDLOG, visit the website: http://www.nslc.navsea.navy.mil/.

#### *k. Program Information System Mission Services (PRISMS)*

The PRISMS database contains the configuration data used by the Board of Inspection and Survey (INSURV) to conduct their inspections. DAS will use PRISMS information to support INSURV information-based products.

#### *l. Navy Data Environment (NDE) - Configuration Data Managers Database Open Architecture (CDMD-OA)*

The CDMD-OA tracks the status and maintenance of naval equipment and their related logistics items, such as drawings and manuals, on ships and naval activities around the world. The term "open architecture" is used to denote the fact that CDMD-OA is a client/server-based system, not dependent upon any vendor's proprietary hardware or software; data may flow to and from CDMD-OA provided that open protocols are used. The status of a given piece of equipment on a ship determines what and how many spare parts will be stored on that ship for it, making this tracking extremely important in terms of cost, shipboard space and weight, and the operational availability of the ship. DAS will obtain CDMD-OA information for ship / equipment configuration information. For more information on NDE CDMD-OA, visit the website: https://www.nde.navy.mil/.

#### *m. Trouble Feedback Reports (TFBRs)*

The TFBRs database contains records of equipment malfunction events that occurred at the Aegis production test center and shipyard. TFBR information will be used for production and/or integration performance metrics that, in turn, support SOE metrics.

#### *n. Safety Hazard Alert Reports (SHARs)*

The SHARs database contains Safety Working Group investigation summaries for Aegis ships. SHAR data will be used to support safety metrics that, in turn, supports NSWC PHD's SEAR process.

#### *o. NDE-Navy Modernization (NDE-NM)*

NDE-NM is a database that tracks and maintains logistical data for modernizing ships in the Navy. NDE-NM stores engineering information, alteration information, automated tracking of materials usage and requirements, alteration scheduling and completion status and detailed shipyard scheduling. DAS will obtain NDE-NM information to identify ship availabilities, their duration, and when they occurred. This information is used to derive operating times that, in turn, supports SOE metrics. For more information on NDE-NM, visit the website: https://www.nde.navy.mil/.

#### *p. Visibility and Management of Operating and Support Costs (VAMOSC)*

The Navy VAMOSC management information system collects and reports USN and U.S. Marine Corps (USMC) historical weapon system Operating and Support (O&S) costs. VAMOSC provides the direct O&S costs of weapon systems, some linked indirect costs (e.g., ship depot overhead), and related non-cost information such as flying hour metrics, steaming hours, age of aircraft, and so forth. VAMOSC has recently added the military personnel database, which contains all active duty USN and USMC personnel costs and attributes data. DAS will obtain VAMOSC data to support affordability metrics that, in turn, supports NSWC PHD's SEAR process. For more information on VAMOSC, visit the website: http://www.oscamtools.com/Vamosc.htm.

#### *q. Aegis Configuration Control and Engineering Status System (ACCESS)*

The ACCESS database contains data for ship / baseline configuration information and for alteration information. DAS will use ACCESS data to group ships by baseline and to determine if and when an alteration has been installed on a particular ship.

#### *r. Board of Inspection and Survey (INSURV)*

The INSURV is tasked with conducting material inspections and surveys of ships and service craft and providing an assessment of the material readiness of these vessels to Congress and Navy leadership. DAS will use INSURV material readiness information to support NSWC PHD's SEAR process and INSURV results data analysis.

#### *s. Aegis Weapon System (AWS) Part-to-Block*

AWS Part-to-Block is data from the OEM that lists AWS LRUs, the block in the reliability block diagram they belong to, the quantity of each in each block, the criticality of the part to the block and to AWS, and the minimum quantity of parts required to be operational within the block.

#### *t. Sailor To Engineer (S2E)*

S2E is a web-based portal hosted by NSWC PHD that provides Sailors the instant access to engineering and logistics experts at NSWC PHD and other NSWC commands. The S2E page is a source of information for solving problems and answering questions regarding combat/weapon systems, hull, mechanical, and electrical systems, or underway replenishment performance and maintenance.

#### *u. Aegis Combat System Reliability Maintainability Supportability (ACSRMS)*

The ACSRMS database is comprised mostly of database objects germane to the Aegis Combat System (ACS). ACSRMA includes data from the following databases: ACCESS, GDAPL, PDDB, SHARs, and TFBRs. Depending on the completeness of the data contained in ACSRMS, DAS may just obtain the data directly from ACSRMS instead of query the data from original sources.

## D. SUMMARY

From the needs analysis, it was determined that the stakeholders needed a system that provides easily accessible data, high quality information, current data, well organized information, and information displayed and reported when needed. An operational concept diagram was developed to show, at a very high level, the operational relationships amongst users and the new proposed DAS. Chapter III discusses how these needs were mapped to system requirements, then to functions, as well as the AoA that was conducted to determine the best alternative that answers the stakeholder's needs.

# III. REQUIREMENTS ANALYSIS

The second step in the SE process, after defining stakeholders' needs, was to conduct the requirements analysis that identified the operational, functional, physical, and performance requirements (Blanchard and Fabrycky 2011). The requirements analysis process was necessary to translate the needs of the stakeholders into an operational scenario. This assisted with the development of the set of system operational requirements, the maintenance and support concepts, and the identification of Measures of Effectiveness (MOE) and Measures of Performance (MOP). These requirements and measures were then used to compare the operational suitability of alternatives so that the most effective solution was chosen based on a sound scientific process.

## A. DEFINING STAKEHOLDER REQUIREMENTS

Requirements were used to determine the functional and physical characteristics for the integration and design considerations of the DAS. Figure 8 shows a simplified view of the requirements generation process as it relates to the other major SE tasks within this project. As the figure depicts, requirements drive system functions that in turn drive physical components considerations. An architecture framework is used to construct a solution that will bound and clarify requirements, functions, and physical components. As constraints or limitations are reached or discovered within each process, a feedback loop exists to initiate re-evaluation of that particular element.

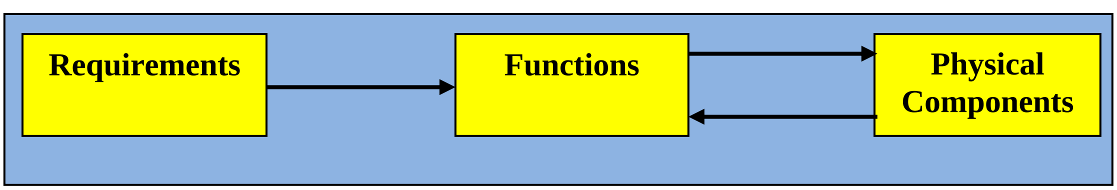



**Figure 8. Requirements Mapping in SE Process**

To identify requirements, the Distance Support capstone team analyzed a combination of inputs from the stakeholders, including past studies and already completed surveys conducted by NSWC PHD personnel in relation to Distance Support, which was discussed in detail in Chapters I and II. The team then compared the system requirements with the Distance Support policy and guidance published by SEA 21 to ensure all requirements met current Distance Support standards. From these inputs, the requirements for DAS were identified. A complete listing of these requirements can be found in Appendix A.

## B. REQUIREMENTS PARTITION

Figure 9 shows the DAS requirements. The team used their past experiences with Navy standard formats for developing combat system requirement specifications to group the requirements into three different categories. The categories are defined as: 1) Characteristics, 2) Design and Construction, and 3) Component Level Requirements. The first category, Characteristics, is where the requirements are related to system capability and performance. The second category, Design and Construction, calls out the requirements associated with data accessibility: data collection, data formatting, the interface encountered by the user, and the aspects dealing with Information Assurance (IA) compliance. The third category, Component Level Requirements, identifies the requirements for the hardware and software.

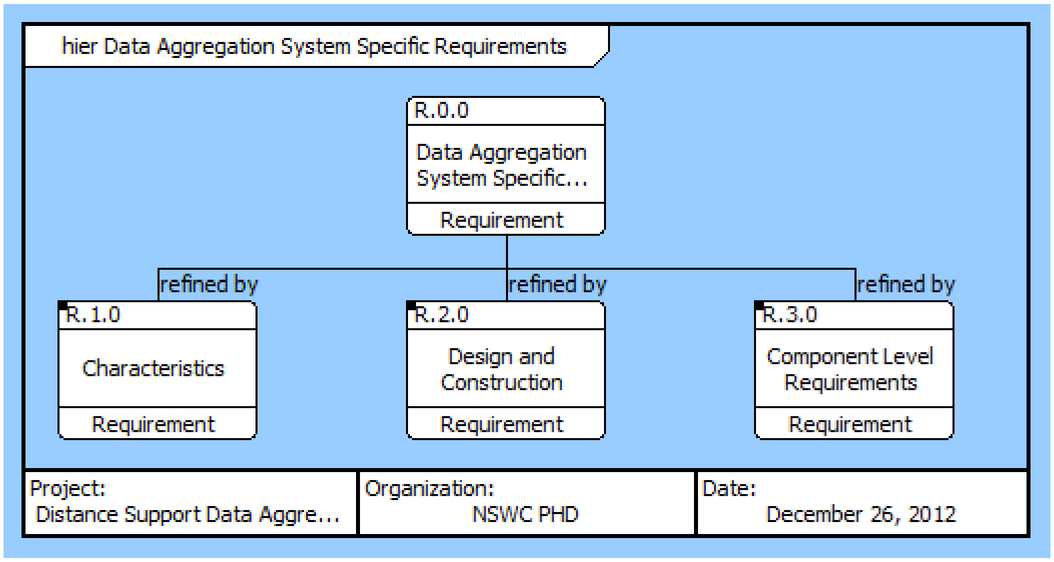



**Figure 9. Top Level Requirements**

### 1. Characteristic Requirements (R.1.0)

The characteristic requirements as shown in Figure 10 define the requirements of the system based on its performance, physical characteristics, reliability, maintainability, as well as the environment conditions where the system will be operated.

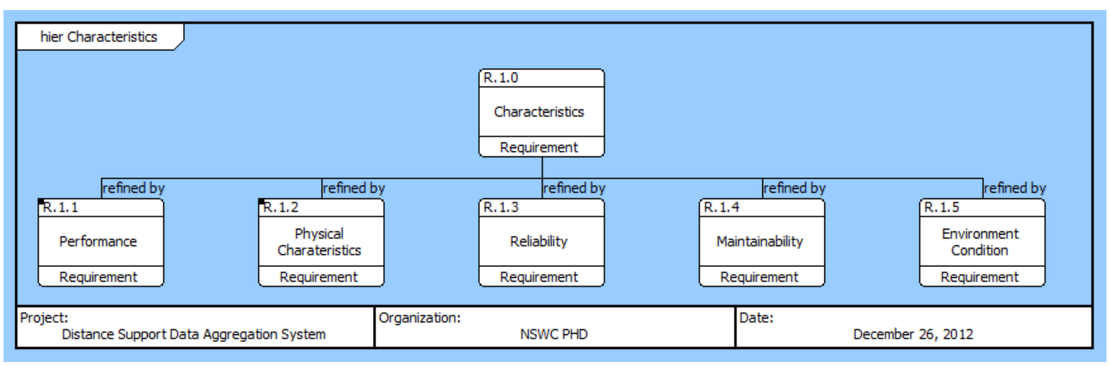



**Figure 10. Characteristics Requirements**

#### *a. Performance Requirements (R.1.1)*

The performance requirements shown in Figure 11 address the requirements of the DAS based on the primary functions that must be executed in support of DAS' mission. The requirements are measured in terms of accuracy, accessibility, quality, and timeliness. The performance requirements of the DAS are categorized and described as follows:

(1) External Interface: The system shall be capable of interfacing with various other systems, databases, and data systems to collect and provide necessary data to perform all the functions.

(2) Fleet Maintenance Support Data and Metrics: The system shall process, analyze, and provide data and metrics that will be used to support fleet maintenance.

(3) Logistics Data: The system shall process, analyze, and provide logistics data in support of fleet maintenance and life cycle support.

(4) Training Data: The system shall provide data that reflects fleet training discrepancies.

(5) RMA Analysis Data: The system shall be able to process, analyze and provide RMA data with respect to combat system performance.

(6) Reports: The system shall be designed to allow the user to generate, save, and print the reports to a file with the standard format such as Acrobat Portable Document Format (PDF) or Microsoft® Office products (i.e., Word or Excel) from the web pages where the data can be selected and filtered by user defined characteristics.

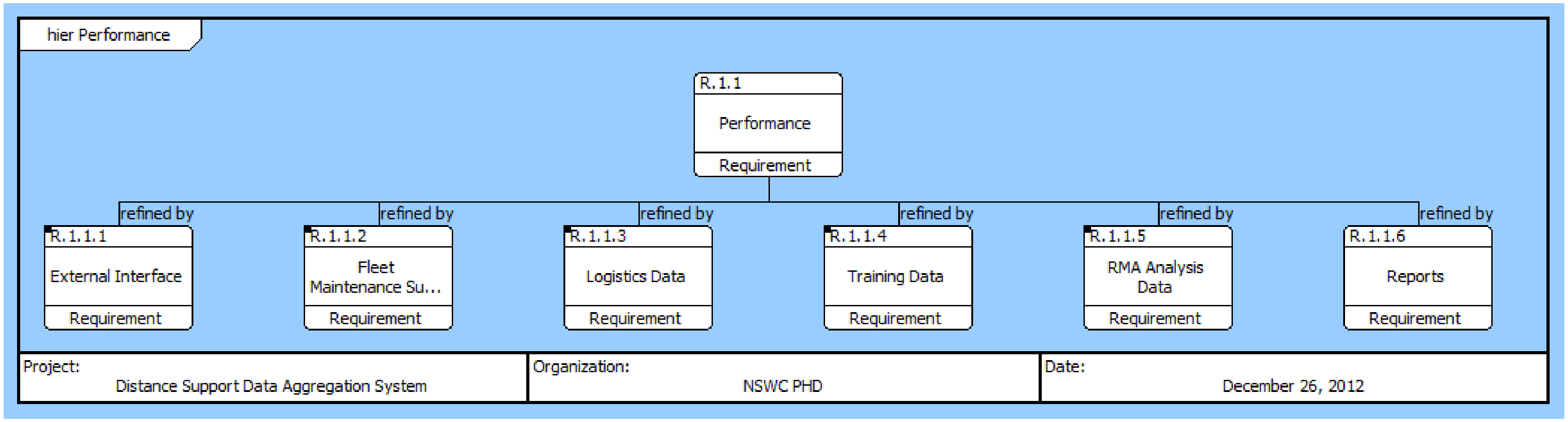



**Figure 11. Performance Requirements**

#### *b. Physical Characteristics (R.1.2)*

This group of requirements was established to ensure the DAS will not exceed the physical capabilities of the host platform. Among these characteristics, the following are deemed most critical to a successful integration: human system integration, and physical size (dimensions).

The physical characteristics requirements, as shown in Figure 12, were decomposed to the following listed requirements:

(1) Human System Integration: The system shall be designed and tested to satisfy human engineering design requirements and standards included in but not limited to the latest version of DoD Design Criteria Standard Human Engineering, U.S. Army Aviation and Missile Command, MIL-STD-1472F, 1999.

(2) Size: The physical size of the DAS shall conform to the lab space available at NSWC PHD. The major components that are selected for the system shall support rack mount installation.

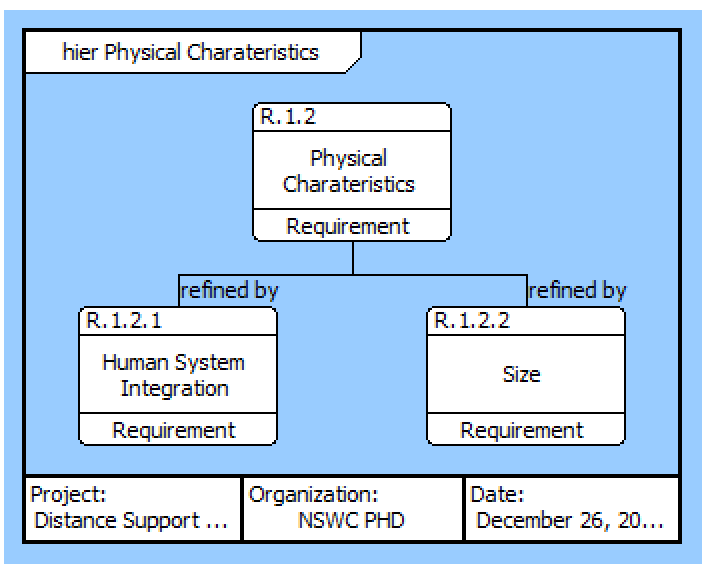



**Figure 12. Physical Characteristics**

### *c. Reliability (R.1.3)*

The reliability requirement establishes the minimum mean time between failures that the system must achieve in response to internal system failures (i.e., faults, component failures). The Key Performance Parameters (KPP) subsection, discussed later in this report, provides additional information, including the threshold value that must be achieved.

### *d. Maintainability (R.1.4)*

This requirement calls out the mean time to restore the system, including hardware and software, from a system reload and from routine maintenance.

### *e. Environment Condition (R.1.5)*

This requirement refers to the location and space with respect to temperature where the system will be operated under specific environment conditions.

## 2. Design and Construction Requirements (R.2.0)

The design and construction requirements depicted in Figure 13 comprise the requirements for data collection, data reporting, Navy Marine Corps Intranet (NMCI) compliance, and print and save.

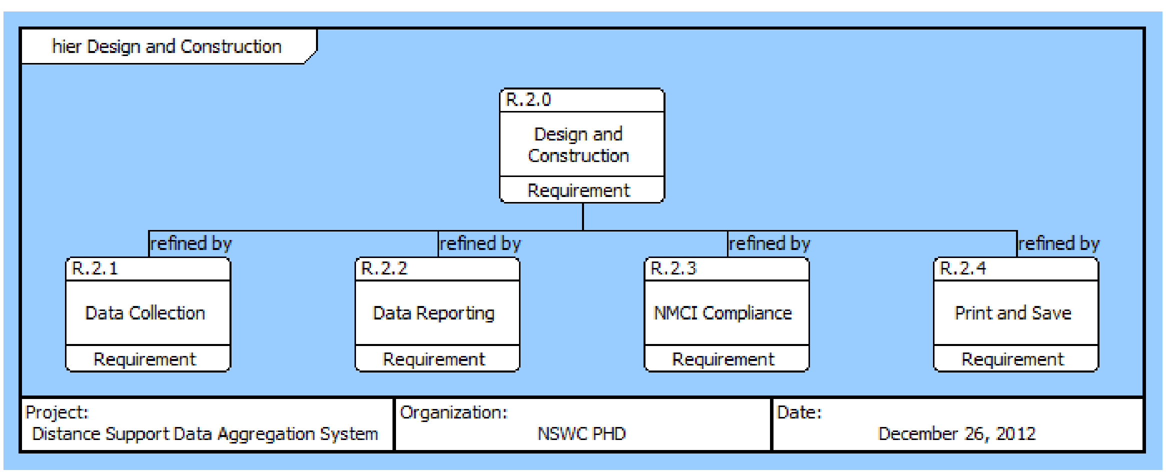



**Figure 13. Design and Construction Requirements**

***a. Data Collection (R.2.1)***

The system shall be designed to collect data either by manually entered data from the user interface or automatically from an external file or database.

***b. Data Reporting (R.2.2)***

The system shall be designed to generate and display data as specified in the performance section (R.1.1).

***c. NMCI Compliance (R.2.3)***

The system shall be designed to comply with NMCI.

***d. Print and Save (R.2.4)***

The system shall have the capability to Print and Save the data.

**3. Components Level Requirements (R.3.0)**

The component level requirements identified the system design requirements with respect to the hardware and software. Since the primary sources of information for the DAS reside on existing computer network devices and servers, the DAS must also contain components that can interface with these servers and retrieve necessary information. Therefore, at a minimum, the two primary components of the DAS include both hardware and software as depicted in Figure 14. Figure 14 shows the hierarchy of Component Level Requirements that were refined into two different categories, hardware components and software components.

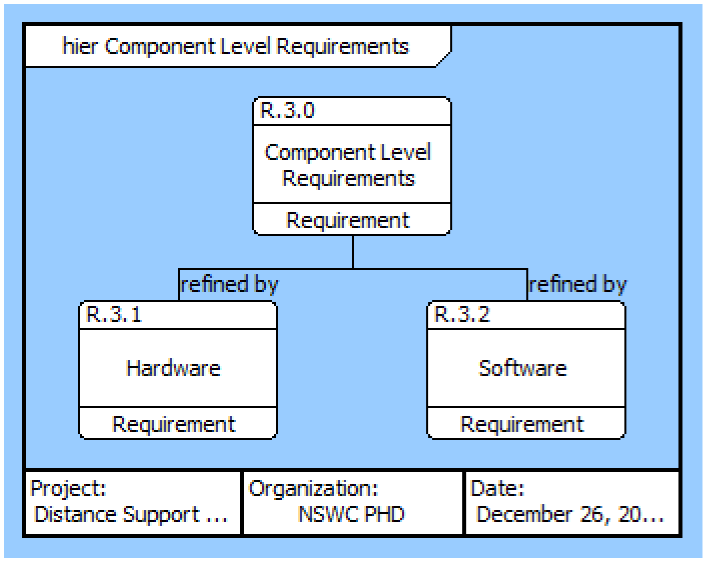



**Figure 14. Components Level Requirements**

#### *a. Hardware (R.3.1)*

The system shall use Commercial Off-the-Shelf (COTS) hardware that is capable of supporting the design characteristics defined in the characteristics section (R.1.0).

#### *b. Software (R.3.2)*

The system shall use COTS software that is capable of supporting the design characteristics defined in the characteristics section (R.1.0)

## C. FUNCTIONAL REQUIREMENTS

The team elected to utilize Vitech's CORE® software suite to analyze requirements. CORE® is a tool specifically designed for SE, facilitating simple steps from requirement analysis to architecture design and then to testing. After defining the stakeholder requirements and inputting them into CORE®, the team moved on to define the system functions necessary to satisfy the requirements. Most functions were defined using past studies, surveys, benchmarking, and team member's personal experience with the available tools for data aggregation. The team drafted a list of needs, which was reviewed and updated through several revisions by stakeholders in order to develop the final list of functions, which can be found in Appendix B. This final list was entered into CORE® and defined in a hierarchal format that allowed top functions to be decomposed into more detailed lower level functions. A total of four levels of decomposition were created in CORE®.

Figure 15 provides a high level view of the functions required to aggregate data and how the flow of data is passed from one function to the other. After the data is received by DAS, it is processed, analyzed, and reported. The output data is displayed to the end user in the format requested. The end user can save, print or generate a report to support the issue they are tracking.

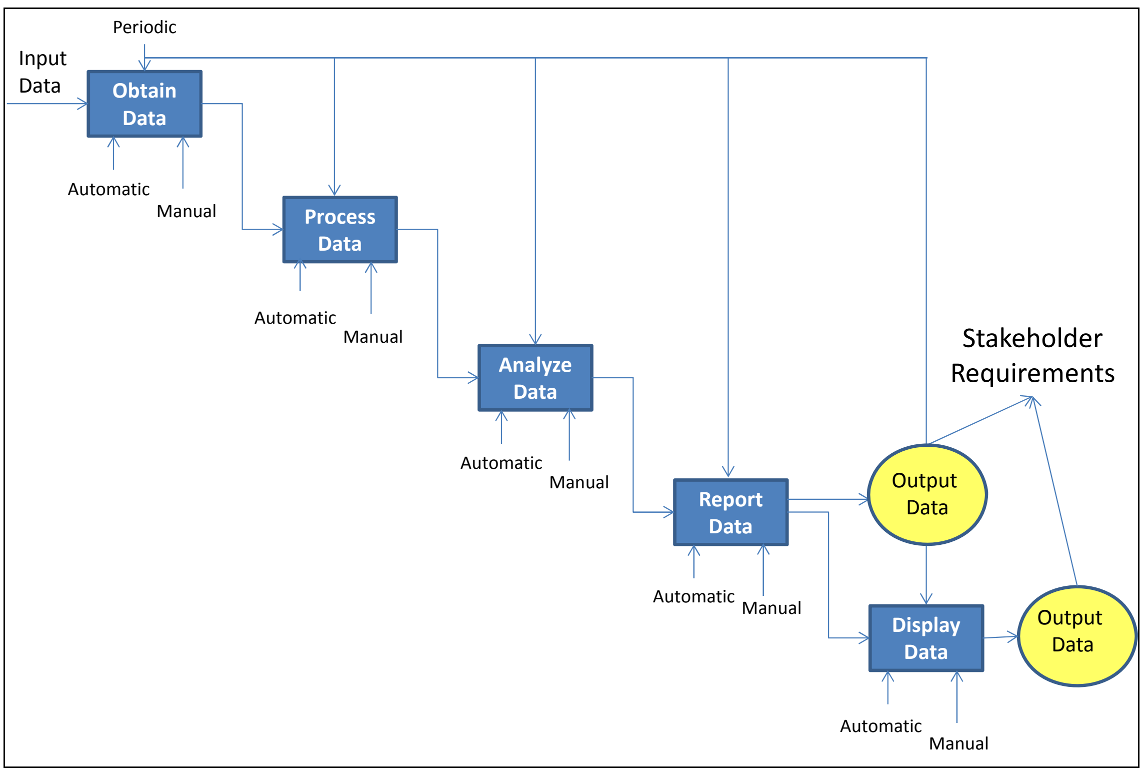



**Figure 15. System Function Flow Diagram**

## D. INPUT-OUTPUT REQUIREMENTS

The input requirements of DAS include the user and/or fleet input data and the fleet maintenance data infrastructure. This process is illustrated in Figure 16. The output requirements include numerous displays and reports. Reports include: 1) system status reports, 2) system RMA reports, 3) system assessment reports, 4) logistics reports, 5) historical system performance reports, and 6) historical maintenance reports. In addition to reports, the output requirements also include: 1) training data, 2) system, ship, and Point of Contact (POC) information, 3) system performance trend data, 4) RMA data, 5) maintenance cost data, 6) logistic data, 7) logistics cost data, and 8) Question and Answer (Q&A) data. At the user interface, the system will display troubleshooting procedures for the following: 1) common equipment failures, 2) corrective maintenance data, 3) technical support information, 4) logistics data, 5) RMA and trend data, 6) fleet training deficiency data, 7) fleet readiness data, and 8) fleet costs.

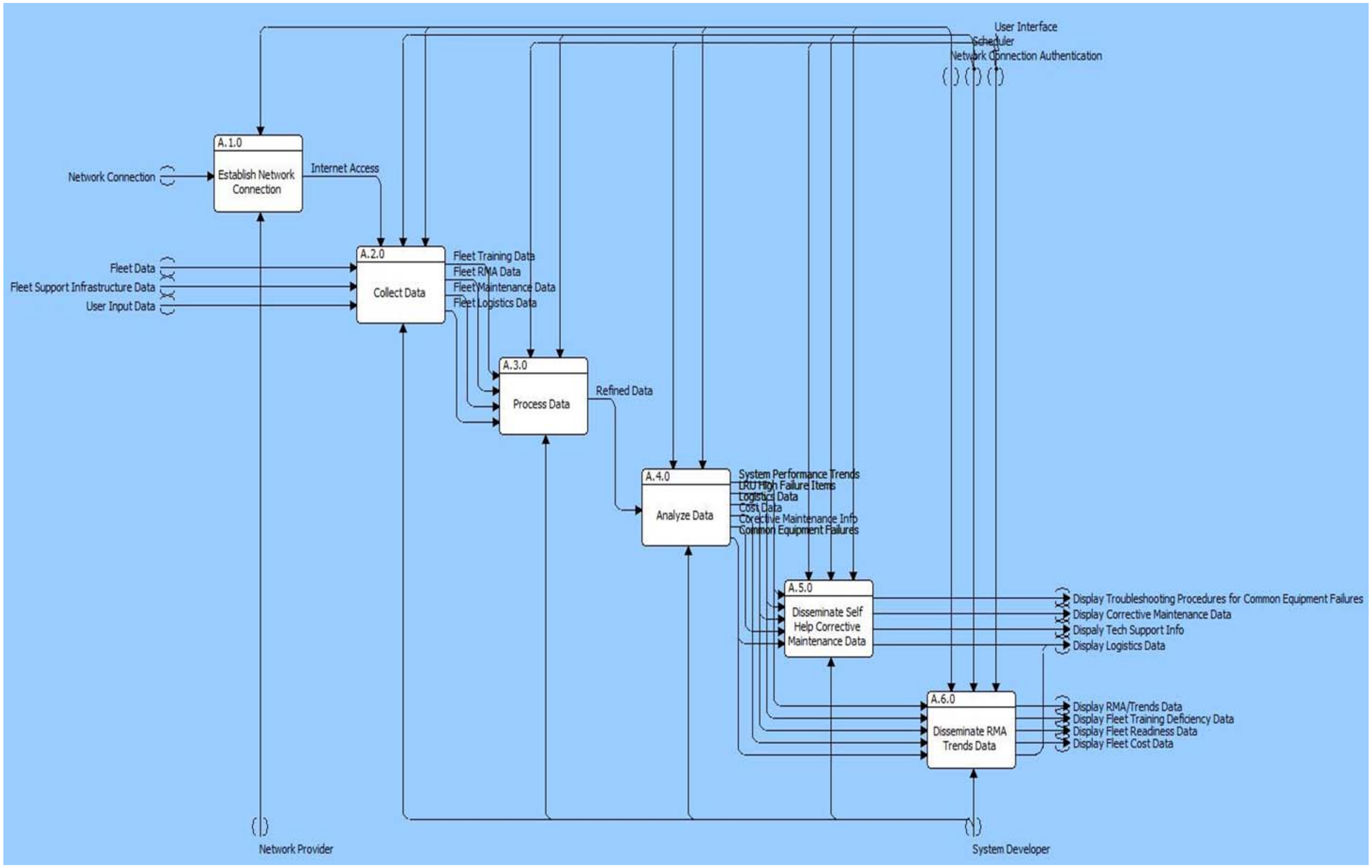



**Figure 16. Provide Data Aggregation Capability (IDEF0)**

Figure 17 provides an enlarged excerpt taken from Figure 16. It shows a focused graphic of the Obtain Data and Process Data blocks in the DAS' IDEF0.

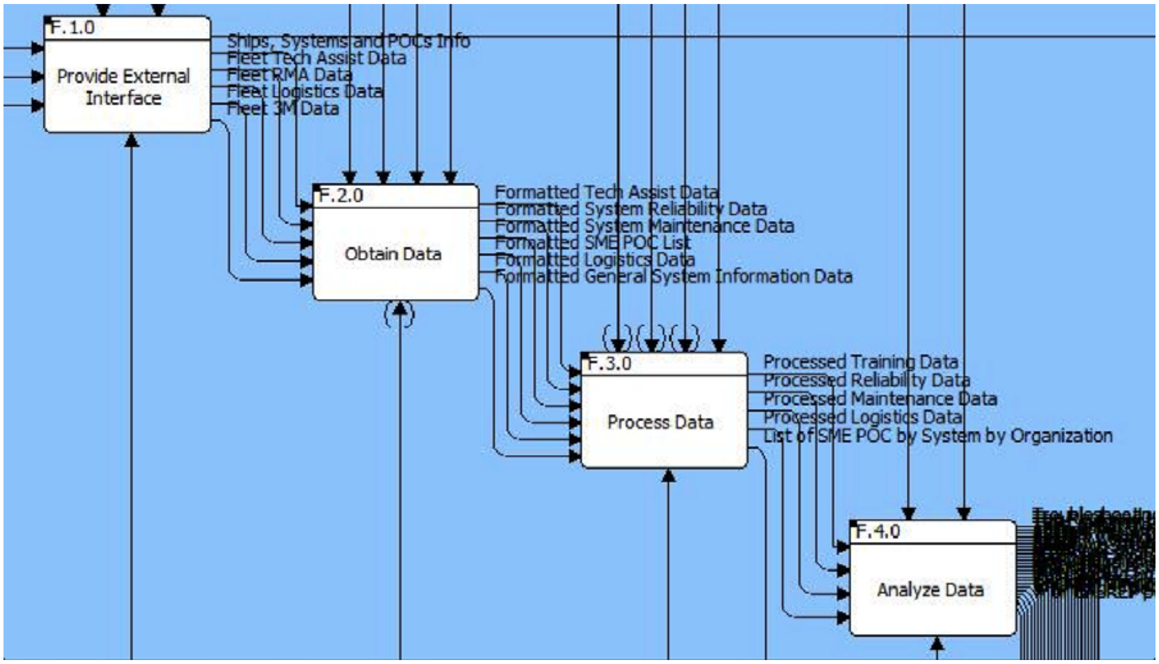



**Figure 17.** **Enlarged Excerpt Taken From DAS IDEF0**

## E. FUNCTIONAL ANALYSIS AND ALLOCATION

As defined in *System Engineering and Analysis*,

> The functional analysis is an iterative process of translating system requirements into detailed design criteria and the subsequent identification of the resources required for system operation and support. It includes breaking requirements at the system level down to subsystem, and as far down the hierarchical structure as necessary to identify input design criteria and/or constraint for the various elements of the system. The purpose is to develop the top level system architecture, which deals with both 'requirements' and structure (Blanchard and Fabrycky 2011, 86).

DAS development began with a physical context diagram of the initial system concept as shown in Figure 18. The DAS is highlighted by the dotted box. The input and output interfaces to and from DAS are covered later in this section. This context diagram created a system boundary which helped to scope and bound the project. The context diagram also describes the external interfaces and the relationships between the developed system and the external systems. Once finalized, the context diagram provided the foundation for the DAS architecture.

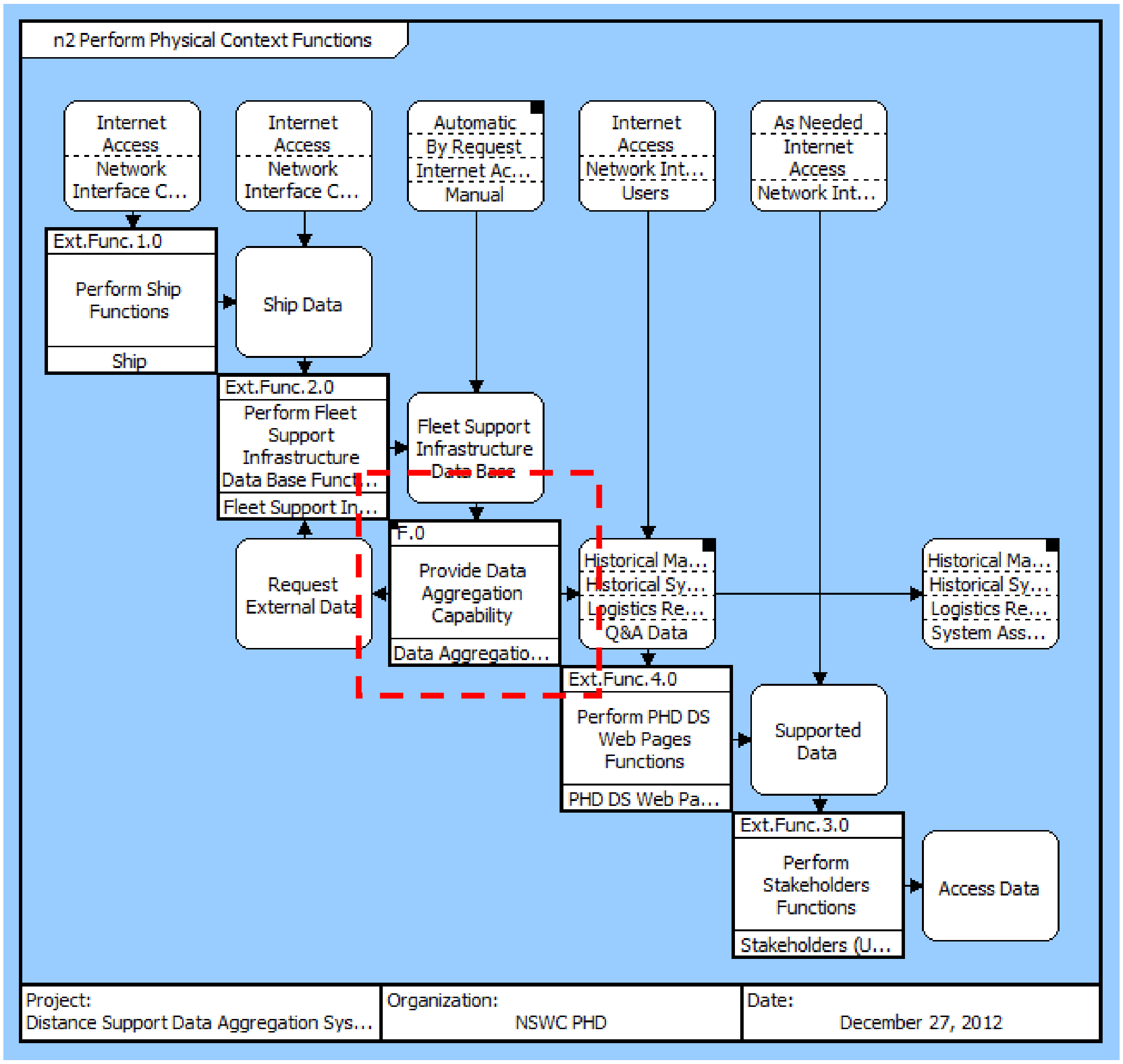



**Figure 18. Physical Context Diagram**

## 1. Functional Decomposition and Hierarchy

The functional hierarchy describes the high level functions needed to meet the system requirements. These high level functions were then further decomposed in an iterative process to determine lower level functions to a level that was sufficient to define the system architecture. The functional hierarchy that was determined after completing the requirements analysis is shown in Figure 19. The second level system functions are: 1) provide external interface, 2) obtain data, 3) process data, 4) analyze data, 5) report data, 6) display data, and 7) print and save data. More detailed functions are further defined at the third level as indicated in Figure 19.

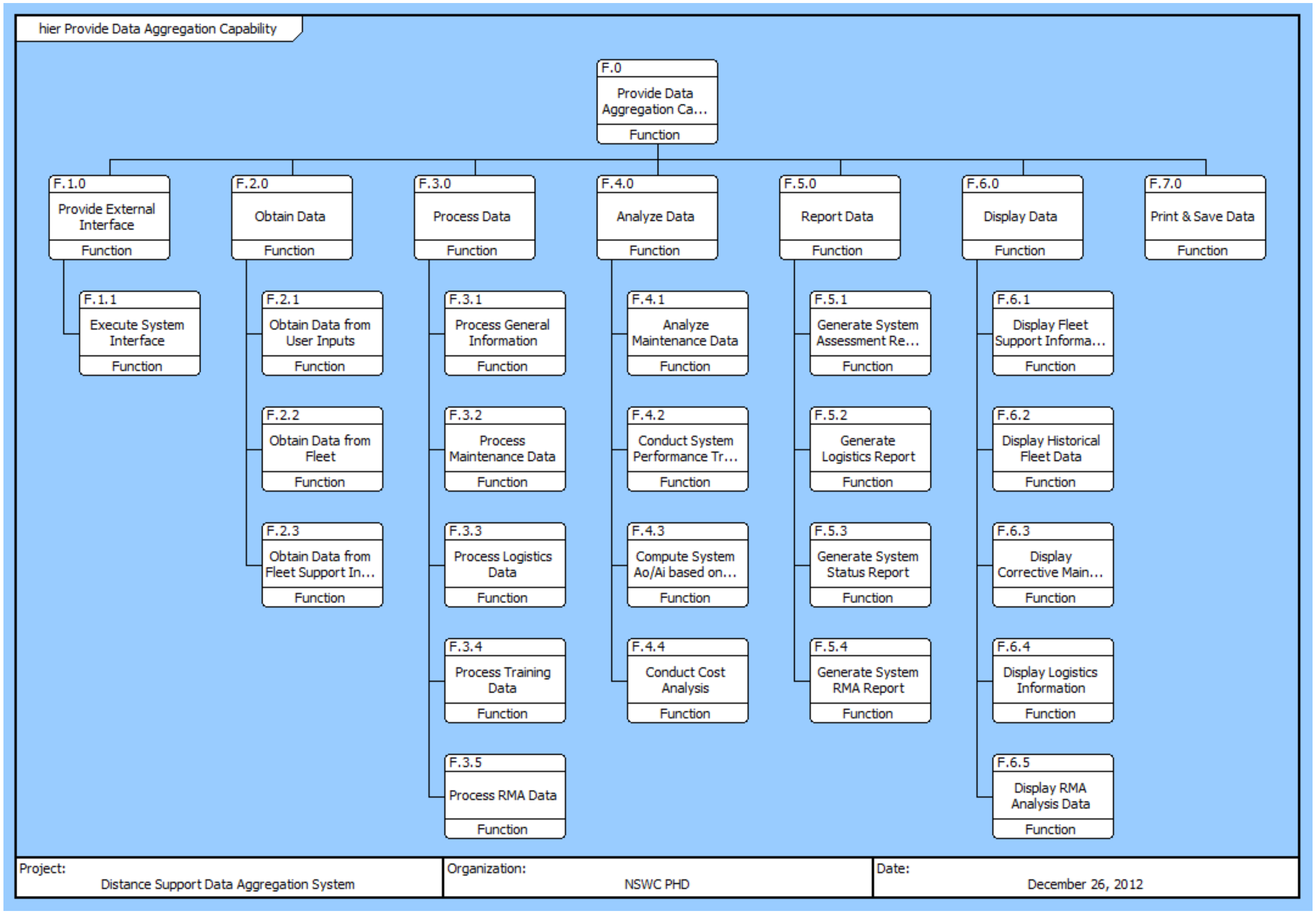



**Figure 19. Functional Hierarchy**

### 2. System Functions Description

The high level system function descriptions are provided in Appendix B. These high level system functions are contained within the first, second, and third levels of decomposition as described in Figure 19. The team recognized that additional levels beyond the third level are necessary to adequately describe the system architecture however, due to time constraints the project was limited to only decomposing down to four levels. Functional descriptions beyond the third level are contained within the CORE® model that was used to develop this project.

### 3. Functional Allocation Matrix

#### *a. Mapping requirements to system functions*

The next step in the architectural development phase was to create an allocation matrix that mapped requirements to system functions and system functions to physical components. The allocation matrix was an effective tool because it provided traceability between the requirements to functions and then functions to physical components of the DAS. Traceability was an important consideration for system integration to ensure each requirement was allocated to at least one function and all the functions included in the architecture were allocated to the physical components. It is an important corollary that the aforementioned logic applies in reverse and all physical components directly map to functions required by the stakeholders.

The complete functional allocation matrix can be found in Appendix B. Figure 20 provides an excerpt from the matrix due to size constraints. A dot (•) is placed in the column and row intersection where a desired function is filled by its corresponding requirements and physical components.

SAMPLE

| | Requirements | Provide Data Aggregation Capability | Provide External Interface | Execute System Interface | Obtain Data | Obtain Data from User Inputs | Obtain Data from Fleet | Obtain Data from Fleet Support Infrastructure | Process Data | Process General Information | Process Maintenance Data | Process Logistics Data | Process Training Data | Analyze Data | Analyze Maintenance Data | Conduct System Performance Trending Analysis | Compute System Ao/Ai based on RMA data | Conduct Cost Analysis | Report Data | Generate System Assessment Report | Generate Logistics Report | Generate System Status Report | Generate System RMA Report | Display Data | Display Fleet Support Information | Display Historical Fleet Data | Display Corrective Maintenance Information | Display Logistics Information | Display RMA Analysis Data | Print & Save Data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.0.0 | Data Aggregation System Specific Requirements | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.0 | Characteristics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1 | Performance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.1 | External Interface | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.2 | Fleet Maintenance Support Data and Metrics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.2.1 | Display a list of system/subsystem on each platform | | ● | ● | | ● | | | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.2 | Display SME contact information for each system/subsystem | | ● | ● | | ● | | | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.3 | Display a list of Open CASREP, Trouble Tickets, and Help Desk items open for a speciific ship or an entire Strike Group | | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | | | | | | | | | | | | ● | ● | | ● | | |

**Figure 20. Mapping Requirements to System Functions**

### *b. Mapping system functions to system components*

The functional allocation matrix was created using the functions and the physical components designed to perform those functions of DAS. The team did not use specific physical components to avoid limiting the type of technology that could be integrated. The complete matrix shows that each function was mapped to a physical component. In this manner, the allocation matrix provides traceability between system functions and physical components.

## 4. System Enhanced Functional Flow Block Diagrams

Accomplishment of the functional analysis is facilitated through the use of Enhanced Functional Flow Block Diagrams (EFFBDs). The EFFBD in Figure 21 provides a flow block diagram of high level system functions derived from the system requirements. The main functions of DAS are defined as: 1) provide external interface, 2) obtain data, 3) process data, 4) analyze data, 5) report data, 6) display data, and 7) print and save data.

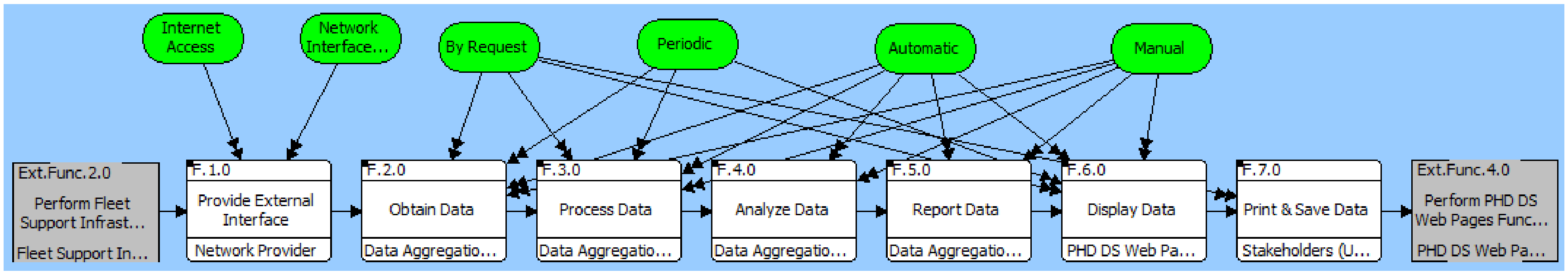



**Figure 21. Enhanced Functional Flow Block Diagram**

### *a. External Enhanced Function Flow Block Diagram*

The external function flow block diagram, shown in Figure 22, was designed using CORE® was used by the team to help identify the external system interfaces. The DAS will need to interface with multiple sources and therefore it is critical to identify and understand the external functions necessary to ensure the quality of the data targeted for aggregation and reporting. The high level external functions identified by the stakeholders include: 1) perform fleet support infrastructure database functions, 2) perform NSWC PHD Distance Support web page functions, 3) perform stakeholder functions, and 4) ultimately perform ship functions. Figure 22 depicts the flow of information and functional relationship from one source to the next. The high level controls for each function are shown at the top. These controls include: 1) by request, 2) periodic, 3) manual, 4) Internet access, 5) network interface, 6) automatic, and 7) as needed. Identifying the controls was necessary to identify the access points required to execute functions and sub functions. More specifically, to ensure the flow of data to and from the DAS was accurate and complete, and to ensure the system interfaces were designed accordingly.

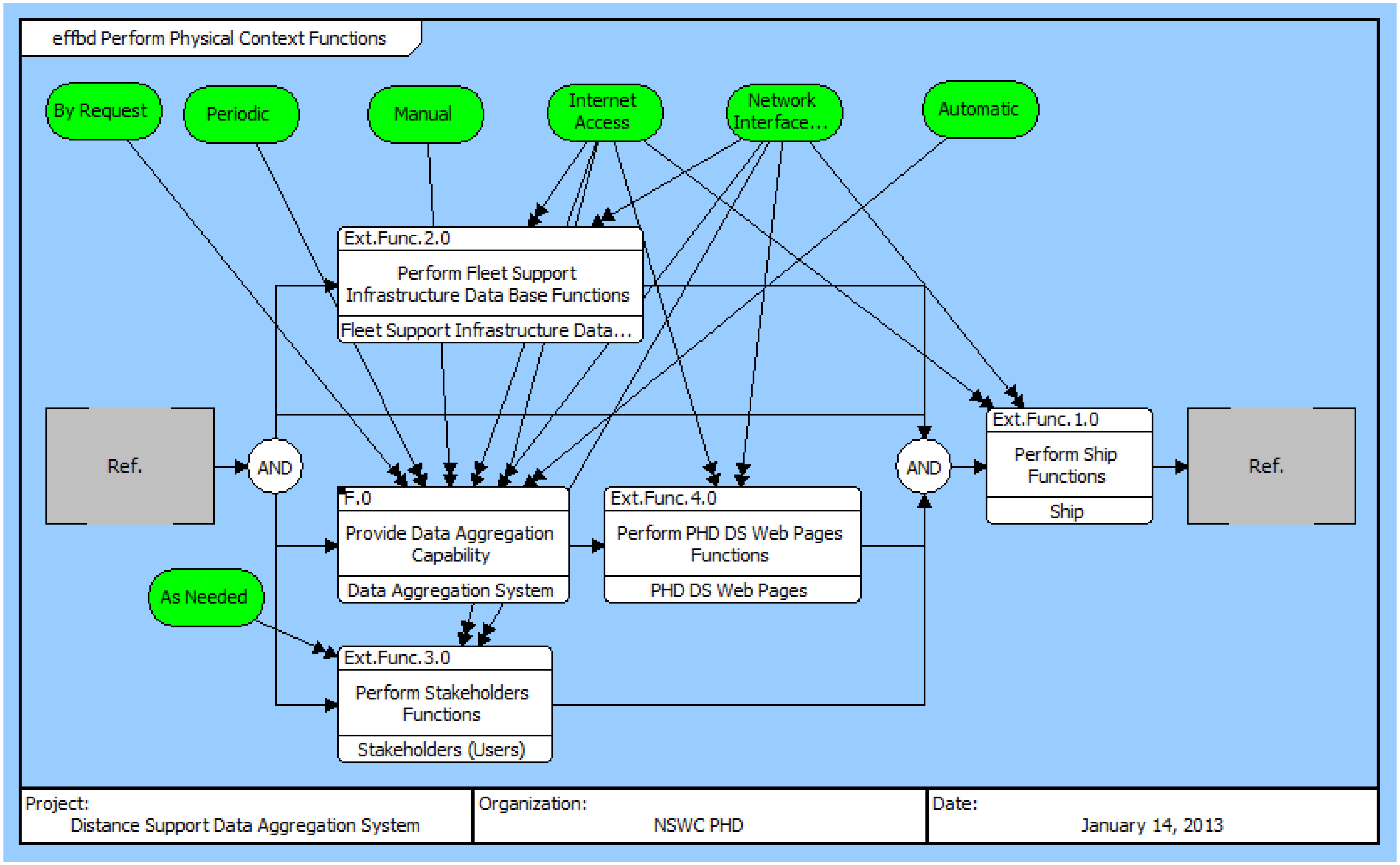



**Figure 22. External Enhanced Function Flow Block Diagram**

### *b. Provide External Interface Functions Enhanced Flow Block Diagram (F.1.0)*

Figure 23 provides more detail in regards to the first DAS function, execute system interface (F.1.0). The diagram in Figure 23 shows the controls and the specific data processed by this function. To execute the system interface function, system users and the fleet support infrastructure database will process data via the network interface and Internet access which are highlighted in green color in Figure 23. The network interface and Internet access are considered the controls for the external interface function. The data processed during this function will include: 1) fleet logistics data, 2) fleet technical assist data, 3) ships, system, and point of contact information, 4) fleet RMA data, and 5) fleet 3M data. A network provider is also necessary to perform this function. The network provider will be responsible for establishing the physical connection between the DAS and the external systems.

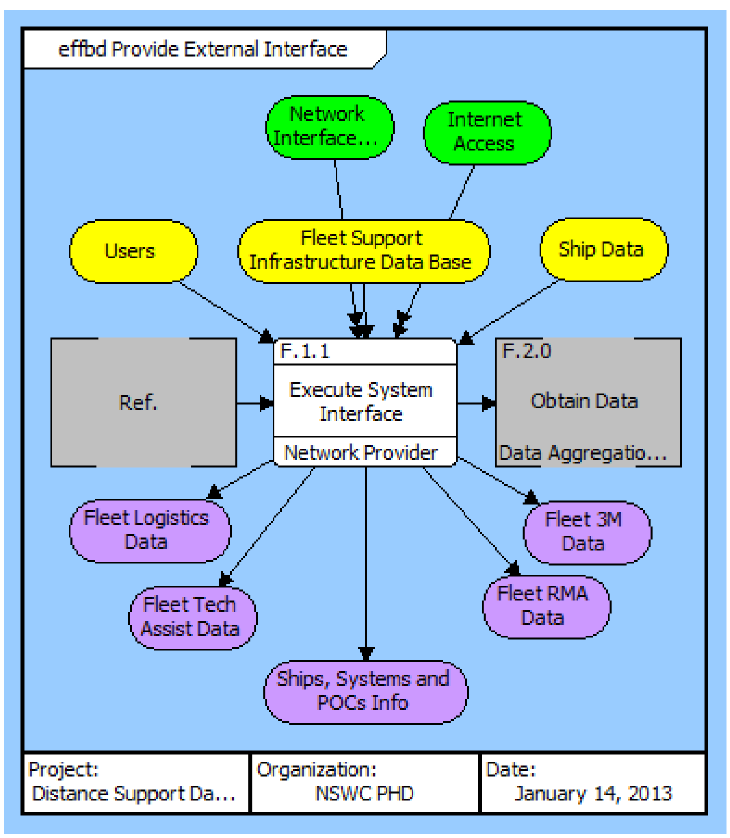



**Figure 23. Provide External Interface Function (F.1.0)**

### c. *Obtain Data Functions Enhanced Flow Block Diagram (F.2.0)*

Figure 24 is also from the CORE® model and provides details in regards to the second DAS function, obtain data function (F.2.0). This function is further decomposed in Figure 24 to the next lower level to further describe the controls and information processed by this function. Data will need to be obtained from multiple sources which include: 1) data from user inputs, 2) data from the fleet, and 3) data from the fleet support infrastructure. The controls for these functions include: 1) manual, 2) by request, 3) periodic, and 4) automatic. In addition to capturing data from multiple sources, the obtain data function will also be required to convert multiple data formats to a common format so that the data can be processed without loss of data. This is a critical component of DAS, to ensure the quality of the data satisfies stakeholder needs.

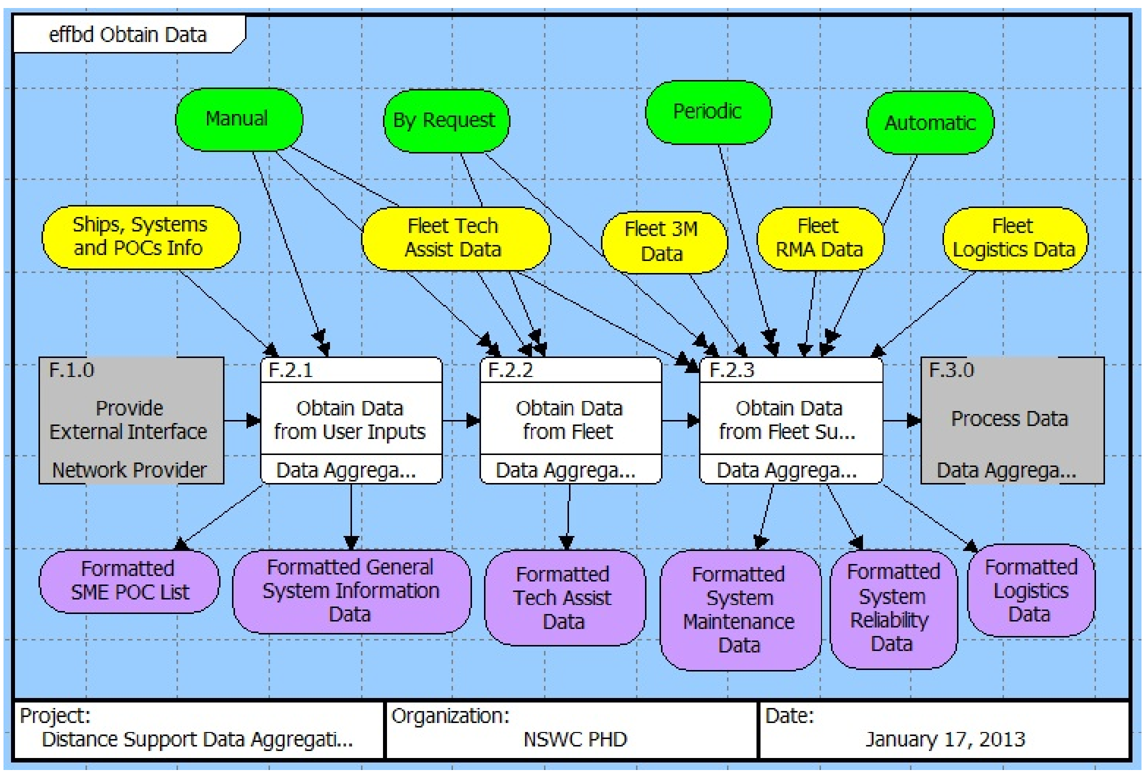



**Figure 24. Obtain Data Function (F.2.0)**

#### *d. Process Data Enhanced Function Flow Block Diagram (F.3.0)*

Figure 25 is another CORE® model that describes the process data function (F.3.0). Figure 25 further decomposes this function to five sub functions: 1) process general information, 2) process maintenance data, 3) process logistics data, 4) process training data, and 5) process RMA data. These sub functions were determined to be necessary for DAS to produce the desired products and information. These sub functions were further decomposed in CORE® and can be found in Appendix B. The controls for this function include: 1) by request, 2) automatic, 3) manual, and 4) periodic. The inputs to these sub functions come directly from the obtain data function. In general, the process data function involves data filtering, data consolidation, data organizing, data comparing, and data categorizing all of which are necessary for effective analyzing and reporting which are additional functions to be performed in DAS.

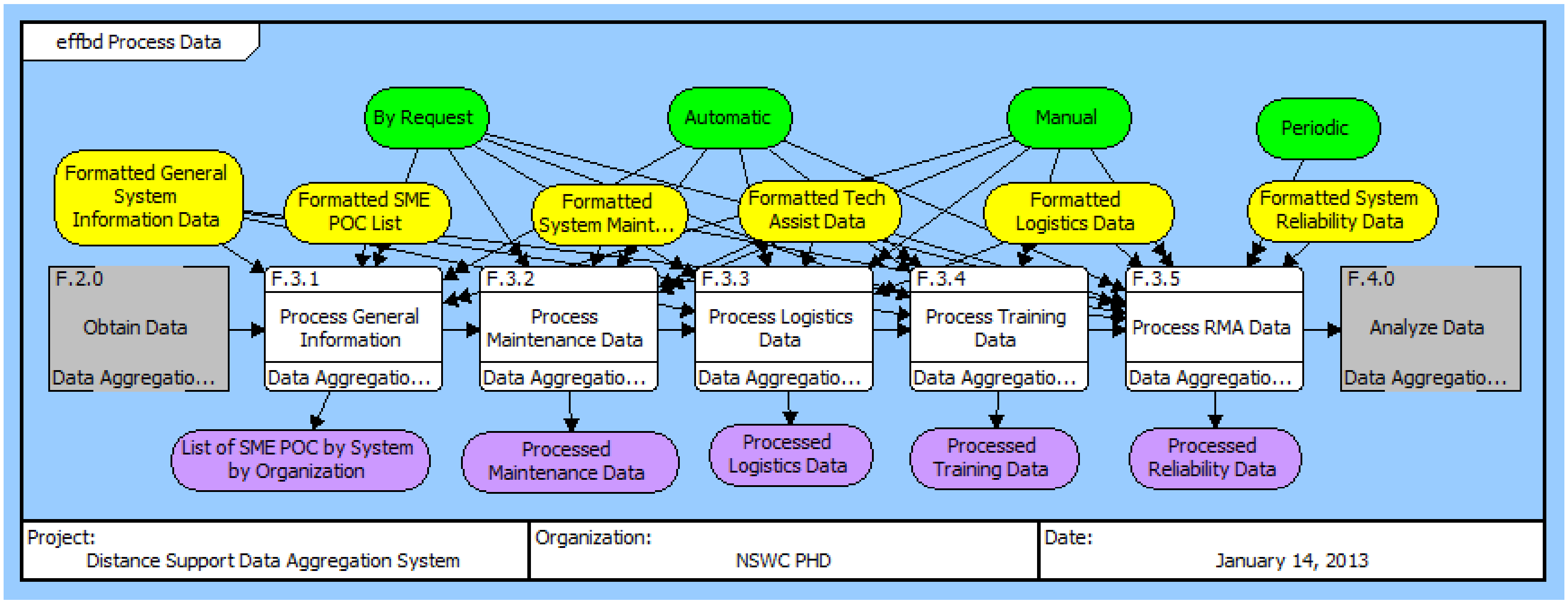



**Figure 25. Process Data Function (F.3.0)**

#### *e. Analyze Data Enhanced Function Flow Block Diagram (F.4.0)*

The analyze data function (F.4.0), which is necessary for the ISEAs to monitor the effectiveness of system maintenance, logistics support, training, and reliability in order to enable continuous system improvements, as well as to facilitate self-help capabilities for the fleet, is decomposed in CORE® to four sub functions as shown in Figure 26. These sub functions include: 1) analyze maintenance data, 2) conduct system performance trends, 3) compute system Ao and Inherent Availability (Ai), and 4) conduct cost analysis. These sub functions are further decomposed in CORE® and included in Appendix B. The four sub functions are necessary for DAS to fully analyze the formatted data and produce useful information for the stakeholders. The inputs from the process data function include: 1) maintenance data, 2) reliability data, 3) logistics data, and 4) training data. The information that is produced by the analyze data function includes: 1) technical assistance metrics, 2) CASREP metrics, and 3) system and component failure metrics.

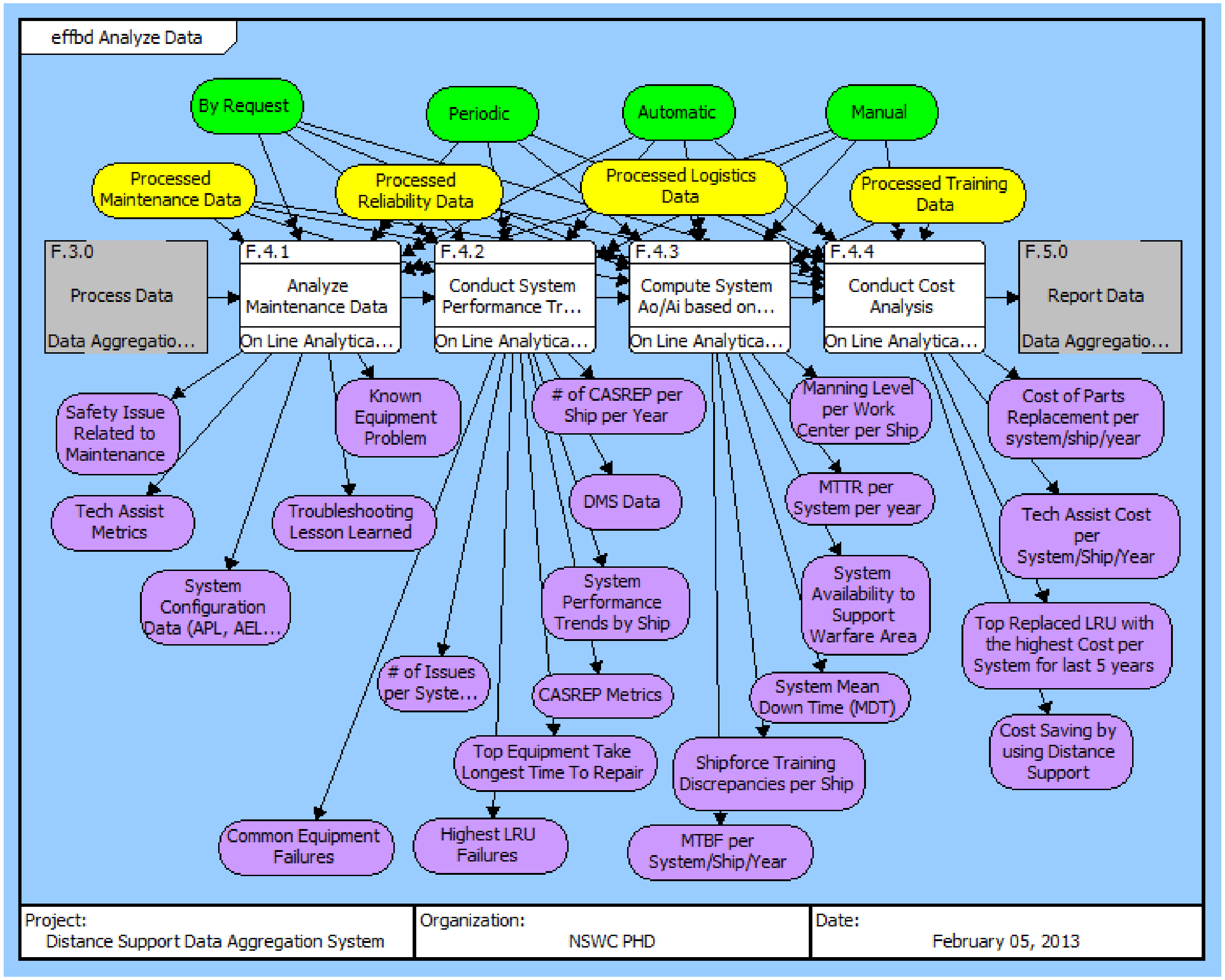



**Figure 26. Analyze Data Function (F.4.0)**

#### *f. Report Data Function Flow Block Diagram (F.5.0)*

The outputs of the analyze data function (F.4.0) are fed directly into the report data function (F.5.0) as shown in the CORE® model in Figure 27. The report data function was decomposed to four sub functions that include: 1) generate system assessment reports, 2) generate logistics reports, 3) generate system status reports, and 4) generate system RMA reports. These sub functions are further decomposed in CORE® and included in Appendix B. As with the previous functions, the controls for this function include: 1) by request, 2) automatic, and 3) manual. The reporting data function (F.5.0) prepares the data for the display data function (F.6.0) and satisfies the need to provide stakeholders with a tool to review and share results from the data analysis process.

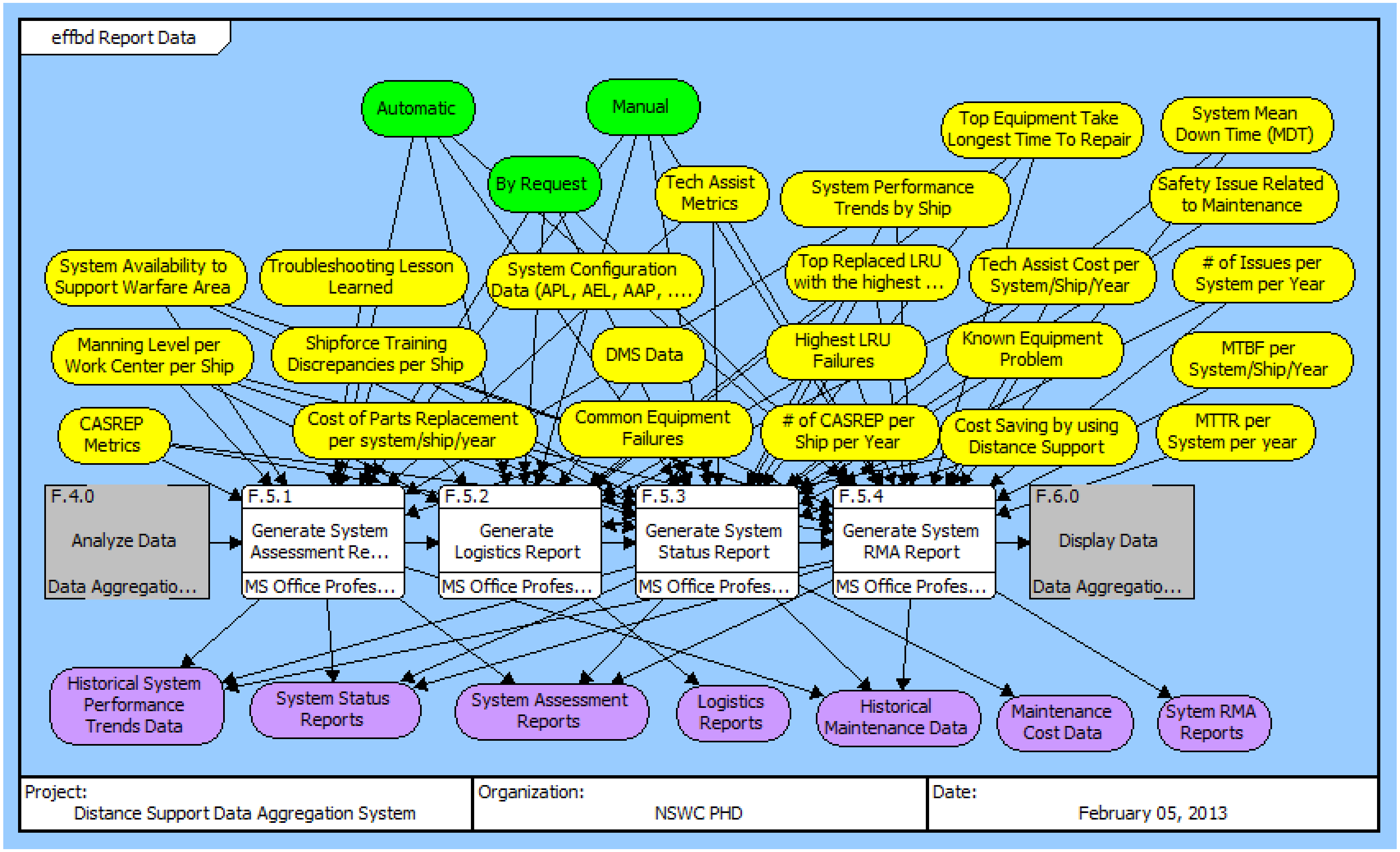



**Figure 27. Report Data Function (F.5.0)**

#### *g. Display Data Enhanced Function Flow Block Diagram (F.6.0)*

Figure 28 is another CORE® model depicting the display data function (F.6.0) at a high level. This function was decomposed into five sub functions including: 1) display fleet support information, 2) display historical fleet data, 3) display corrective maintenance, 4) display logistics data, and 5) display RMA analysis data. Further decomposition into lower functions was performed in CORE® and included in Appendix B. The controls for this function include: 1) automatic, 2) by request, 3) manual, and 4) periodic. As previously mentioned, controls were necessary to identify access for executing sub functions. Figure 28 also shows examples of some of the information that is aggregated to produce the various displays. The aggregated data as inputs to the sub functions includes items such as: 1) system configuration, 2) SME POCs, 3) highest LRU failures, 4) CASREP metrics, and 5) technical assistance metrics. The various displays needed from the report data function include such things as logistics data, RMA data, training data, and cost data. The display data function and related sub functions are necessary to visually produce useful self-help and trend analysis information for the stakeholders.

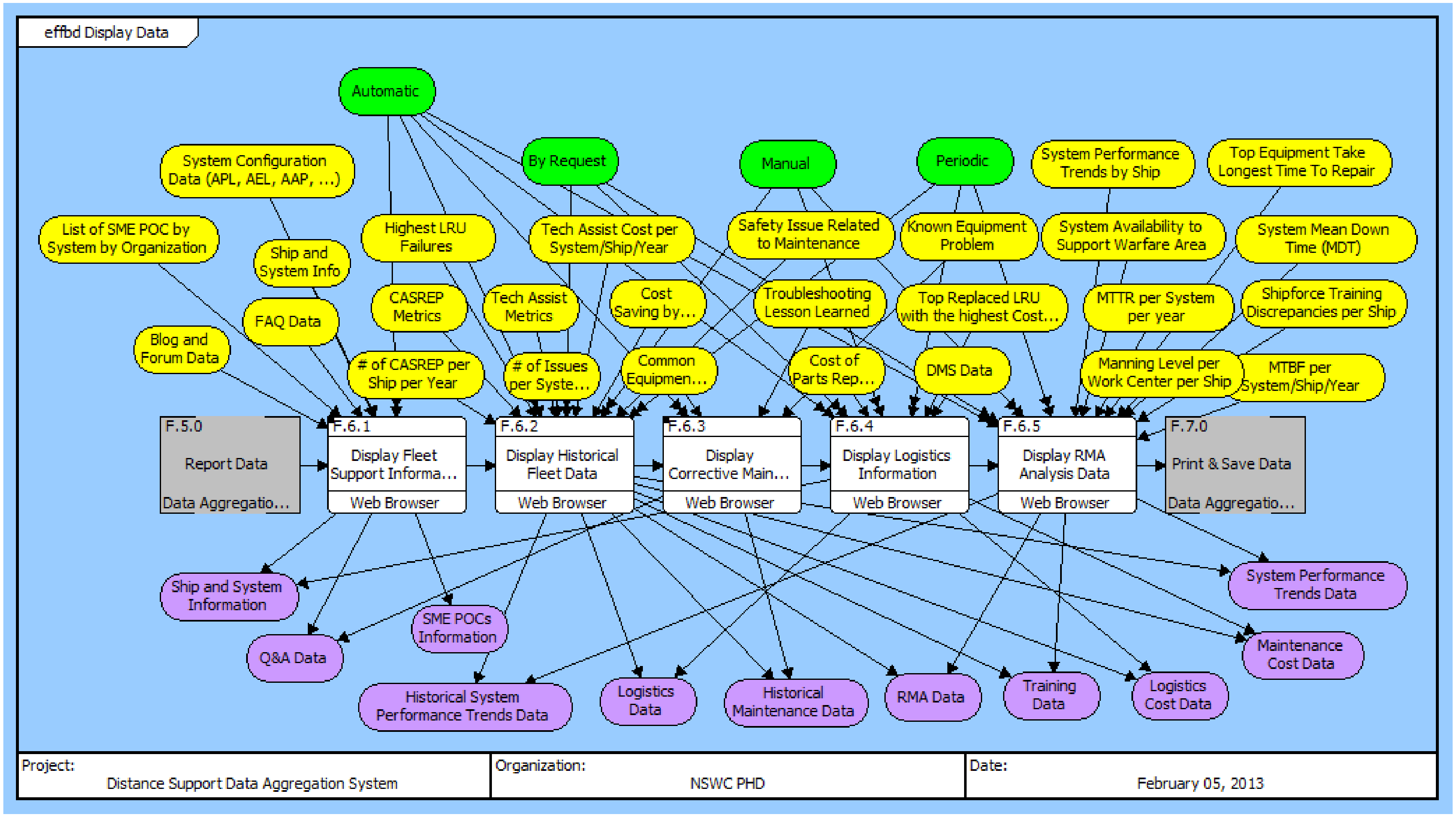



**Figure 28. Display Data Function (F6.0)**

### *h. Print and Save Function Flow Block Diagram (F.7.0)*

Figure 29 shows the CORE® model that describes the print and save function (F.7.0). Further decomposition into lower sub functions was performed in CORE® and included in Appendix B. The control for this function is limited to "by request." The "by request" control was selected to ensure that unnecessary print and save actions would be avoided. Figure 29 also shows examples of some of the information that would typically be saved and printed. The aggregated data that stakeholders indicated would typically be printed and saved includes 1) historical maintenance data, 2) logistics reports, 3) system RMA reports, 4) system assessment reports, and 5) historical system performance trend data.

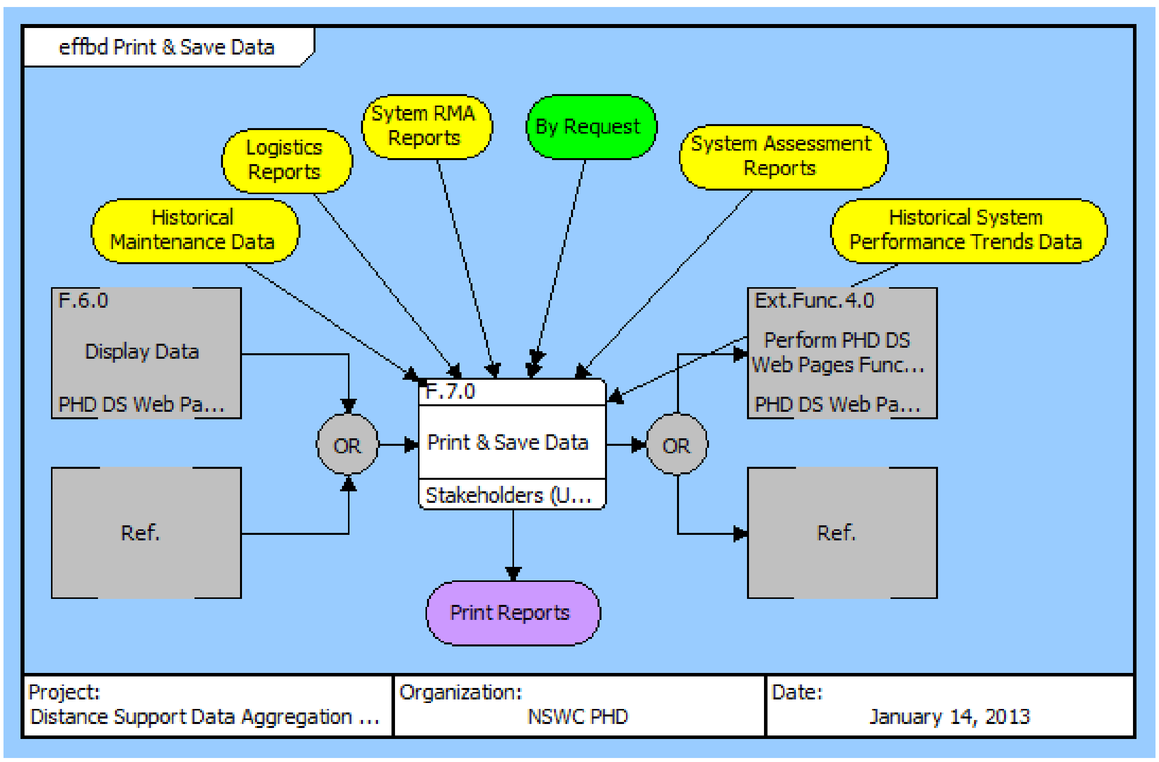



**Figure 29. Print & Save Data Function (F.7.0)**

### 5. External Functions

Figure 30 shows the interface between the external functions and DAS. In this diagram, the DAS receives input data from both the fleet support infrastructure database and ship functions, and it outputs data that is sent to NSWC PHD Distance Support web page functions for report and display. The data will be requested and accessed by the stakeholder via stakeholder functions.

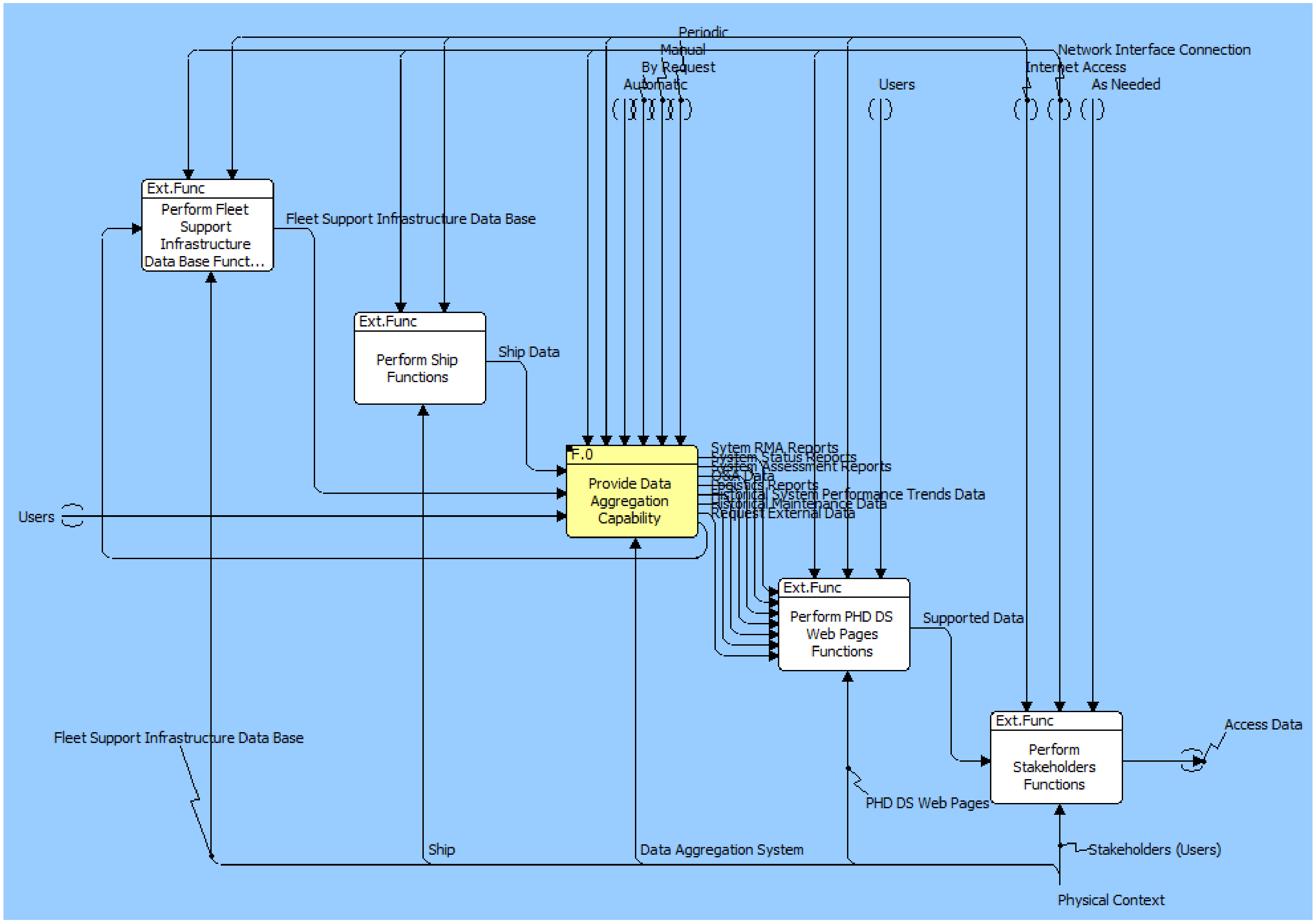



**Figure 30. Perform Physical Context Functions (IDEF0)**

The diagram in Figure 31 provides a high level view of the functions required to aggregate data and how the data is passed from one function to the other. In short, after the data is received, it is processed, analyzed, reported, and then displayed to the users.

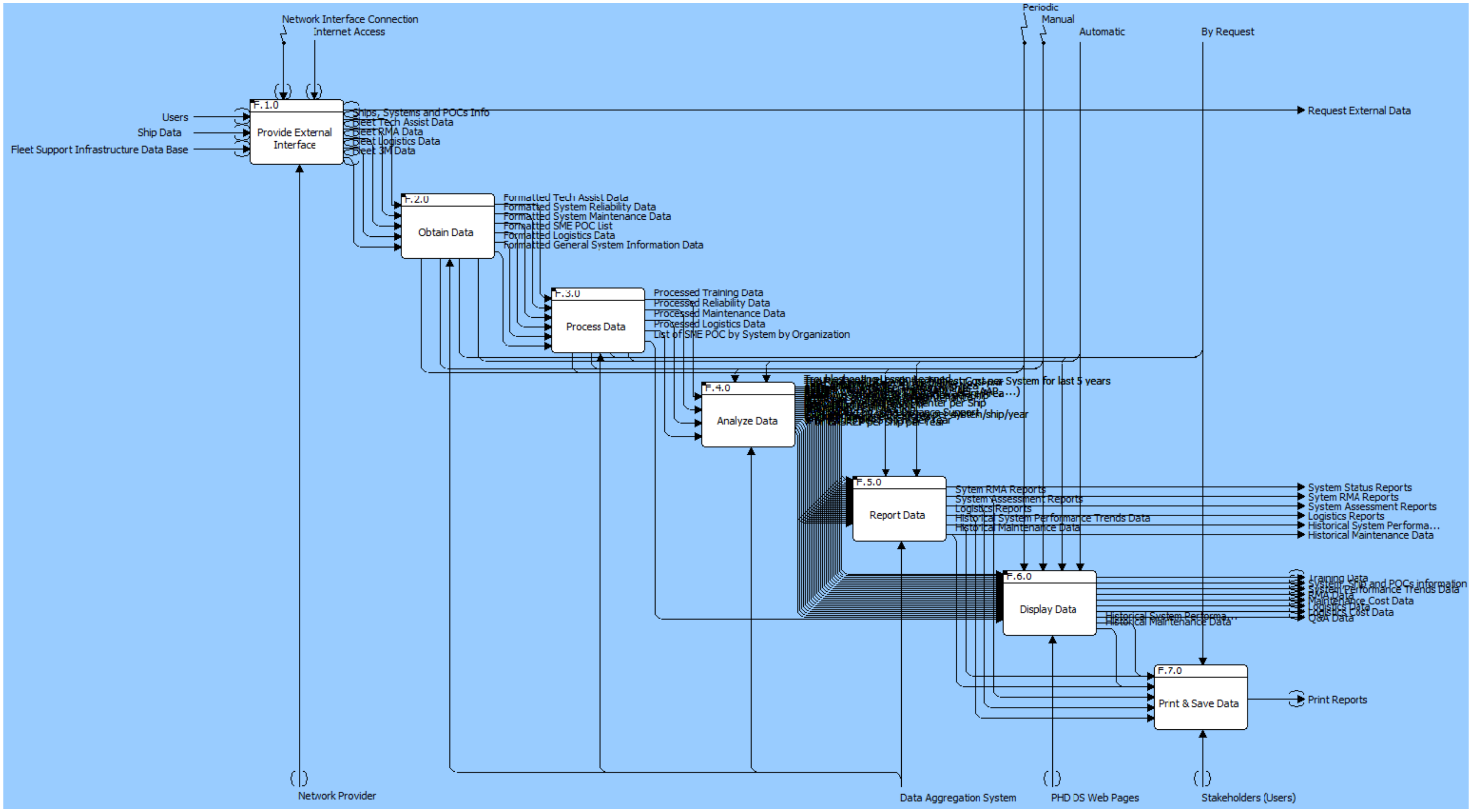



**Figure 31. High Level System Functions IDEF0 Diagram**

## F. EVALUATION MEASURES AND METRICS

Based on stakeholder requirements, the DAS would need to meet the following performance requirements:

- Data Collection Process - the ability to connect and capture available information from multiple sources, including the ability to overcome incompatibility of sources (i.e., interoperability)
- Data Quality - the ability to display accurate, useful, reliable, and complete data, including historical troubleshooting experience data, repair procedures data, and historical technical assist experience data
- Accessibility - the ability to display information when needed including the accessibility of ship-to-shore connectivity and access time of the initial request to receipt of information
- Data Organizing and Processing - the ability to organize data for effective analysis.

Based upon the above performance measures and assistance from stakeholders, the team defined the following metrics for the system:

- Metrics related to data quality
- Accuracy, usefulness, reliability, and completeness
- Age of data (how often updated)
- Metrics related to DAS
- Availability of data (accessibility)
- Data processing (how effective at combining)
- Time of report generation.

Since the requirements discussed in Chapter II are very general, the team further defined them in order to derive metrics that contained measurable attributes. Table 3 summarizes the metrics that were defined by the stakeholders as the key metrics to be used in development of the system architecture. As discussed previously, the stakeholders indicated that the DAS must be effective at aggregating available information so metrics related to the quality of the information are important for ensuring that the information will be beneficial.

| Requirement | Metrics | |
|---|---|---|
| | Objective | Threshold |
| Accuracy (Ability to provide correct and consistent results) | Probability of accuracy = 99.5% (5 discrepancies per 1000 data requests) | Probability of accuracy = 99% (10 discrepancies per 1000 data requests) |
| Accessibility (Ability to access data via Port Hueneme Division (PHD) web page) | 2 seconds (*) | 10 seconds |
| Adaptability (Ability to interface with multiple application/database) | All databases that can be accessed defined in the requirements | All databases that can be accessed defined in the requirements |
| Flexibility (Easily to learn and use) | Non-Proprietary Software & Compliant with Department of Defense (DoD) Standard | Compliant with DoD Standard |
| Human Factors (Easily to learn and use) | Time for new user to obtain data t = 3 minutes, return user t = 2 minutes | Time for new user to obtain data t = 5 minutes, return user t = 3 minutes |
| Maintainability (Ability to fault detect and fault isolate) | Mean Time To Repair (MTTR) $\leq$ 1 hour | MTTR $\leq$ 2 hours |
| Reliability (Reliable to sustain operation) | 1 failure per 12 months | 1 failure per 9 months |
| Availability (Operational Availability ($A_O$)) | $A_O \geq 99.9\%$ | $A_O \geq 99\%$ |
| Time to Generate Report (System) | Data rate t = 15 seconds per 1 megabyte (MB) | Data rate t = 20 seconds per 1 MB |
| Completeness | Display all available data that the system can generate from existing database | Display all available data that the system can generate from existing database |
| Timeliness (Frequency of data update) | Upon request | Daily |

**Table 3. Requirement Metrics**

These metrics were used as evaluation measures in the AoA to help determine which alternative would best meet DAS requirements. In order to do so, the team split the metrics listed in Table 3 into two groups. The first group is the metrics related to data quality, which include accuracy, usefulness, reliability, completeness, and so forth, as well as the age of data (how often updated). The second group is the metrics related to

DAS, which include availability of data (accessibility), data processing (how effective at combining) and time of report generation.

The team decided that it was necessary to determine to what extent each alternative in the AoA met these metrics. Thus, a scale from zero (0) to ten (10) was implemented to rate each alternative on how well it performed with respect to the metric, where a score of zero implied the alternative did not satisfy the metric at all and a score of ten meant the alternative satisfied the threshold. Table 4 summarizes the metrics related to data quality and Table 5 summarizes the metrics related to DAS.

| Quality Type | Question | Metric |
|---|---|---|
| Accuracy | Does the data reflect a verifiable source in a precise way? (Is the data correct?) | Scale 0–10, 10 = best |
| Completeness | Is all necessary data present? | Scale 0–10, 10 = best |
| Consistency | Are there any contradictions between data sets? | Number of contradictions between data sets / Number of Data sets |
| Data processing | How effective is system at combining data? | Scale 0–10, 10 = best |
| Relevancy | Is the data applicable and helpful for the task at hand? | Scale 0–10, 10 = best |
| Reliability | Does the obtained answers conform the expected answers? | Number of answers that conform the expected answers / Total number of answers |
| Timeliness | How often is the data updated? | Number of updates per day |
| Usefulness | Is there any difference in having or not having the data for the user? | Scale 0–10, 10 = best |

**Table 4. Metrics Related to Data Quality**

| Characteristic | Definition | Metric |
|---|---|---|
| Accessibility | The time it takes to access the system (availability of data). | Access Time (t = seconds) |
| Adaptability | Complexity scale to interface with other systems. | Scale 0–10, 10 = least complex |
| Flexibility | Ease of modification. | Scale 0–10, 10 = best |
| Data Processing | System effectiveness of combining the data. | Scale 0–10, 10 = best |
| Human Factors | User friendliness, degree of automation, displays, controls, feedback, and so forth. | Scale 0–10, 10 = best |
| Maintainability | The ease with which the system can be maintained. | MTTR (t = minutes)<br>Mean Maintenance Downtime (MMD) (t =minutes) |
| Reliability | The ability of the system to perform and maintain its function in routine and unexpected circumstances. | Operational Availability (Ao), Mean Time Between Failures (MTBF) (t = hours) |
| Time of Report Generation | The time it takes from the request of a new report to the point it is available for use. | t = seconds |

**Table 5. Metrics Related to DAS**

## G. ANALYSIS OF ALTERNATIVES (AOA)

To find an effective solution for aggregating data, a structured approach, shown in Figure 32, was utilized. First, the details of DAS functions were clearly defined and entered into CORE®. Once the functions were defined, alternative solutions that consisted of new, experimental, and existing systems were identified. The team worked with stakeholders to compare, prioritize, and organize the stakeholder requirements using a swing weight model. The stakeholder preferences obtained by the normalized weights produced by the swing weight model were then used to compare, or map, technical characteristics to requirements, functions to technical characteristics, and alternatives to functions using a Quality Function Deployment (QFD) House of Quality (HOQ) model. A gap analysis was then conducted to identify the functional gaps of each of the existing systems. Finally, a cost benefit analysis was performed to compare alternatives and select the most affordable alternative that provided the best solution. Details of each step in this approach are discussed in the paragraphs that follow.

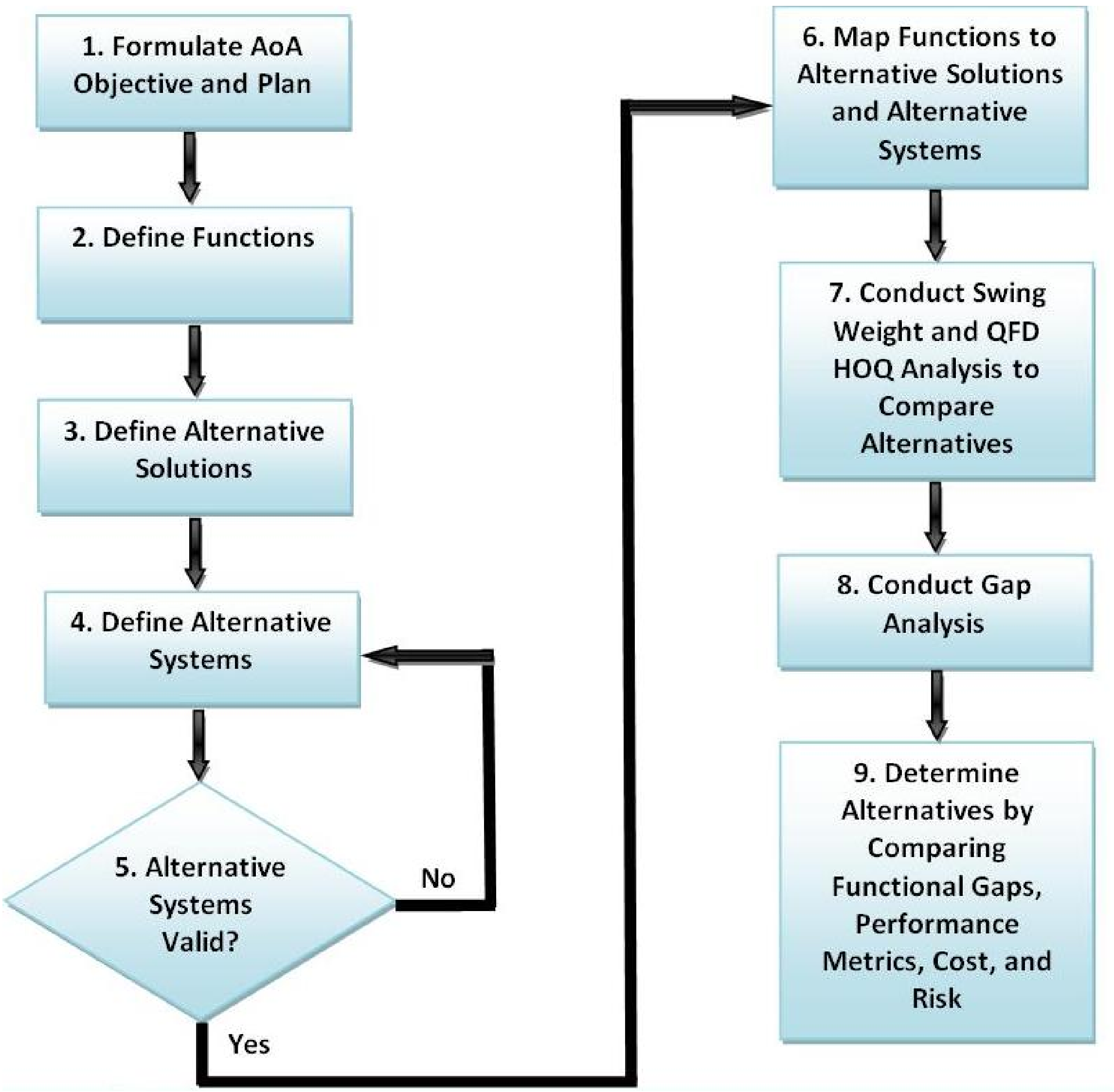



Figure 32. AoA Approach

### 1. Determining Alternative Solutions

To identify alternative solutions, the team performed a number of online searches and brain storming sessions. The team also utilized the information gathered to eliminate infeasible solutions. Thus, the team generated the following alternatives to satisfy DAS and provide reasoning to why certain alternatives were eliminated:

- Alternative 1. Do nothing (maintain the status quo). Alternative 1, to do nothing, was eliminated because stakeholders indicated that to do nothing is unacceptable since the need for improved Distance Support is growing every day. The development of DAS has significant interest at the highest levels within the NAVSEA command.
- Alternative 2. Modify Sailor training curriculum and teach Sailors how to access data from available sources. Alternative 2, to modify Sailor training curriculum, was also eliminated due to feedback from stakeholders that showed that the increasing burden on Sailors to perform their own research is not effective. Sailors just do not have the time to conduct their own research. Plus with this alternative, there was the possibility of the system having a poor response time, limited response quality control, limited automated data collection and reporting capability, and thus would not meet many of the system requirements.
- Alternative 3. Perform manual data aggregation by increasing the number of shore support personnel. Alternative 3, to perform manual data aggregation, was also eliminated because increasing the shore based work force is not possible in a fiscally constrained environment. Additionally, this alternative would require insurmountable life cycle costs due to high labor costs, large time delays between data requests and deliveries since everything would

be done manually, and not meet all system requirements. Thus, this option is simply not feasible at this time and not cost effective.

- Alternative 4. Develop a "self-help" styled forum in which fleet activities can ask the combat systems community for solutions to their issues. Experts or other combat system personnel can search and answer questions. Alternative 4 was eliminated because although it offers limited life cycle costs, after initial development costs, it presents a high possibility of poor response time and limited data collection and reporting capability. Furthermore, this alternative does not offer the required data display capability, making it un-useful for shore based activities, and overall does not meet all system requirements.
- Alternative 5. Develop a new database and/or website that would collect, combine, and display data.
- Alternative 6. Modify an existing database and/or website.

Alternatives 5 and 6 were determined to be feasible based on numerous discussions with stakeholders and were thus selected for further analysis. Alternative 5, developing a brand new system, and Alternative 6, modifying an existing system, could meet every requirement and customer need if cost and time were not factors. Thus, it was determined that a cost and risk analysis should be conducted to compare these alternatives and are discussed later in this chapter. These analyses would determine the cost, schedule, and risk drivers that would impact the development of the system. Before these analyses could be conducted, an existing system for Alternative 6 had to be chosen.

### 2. Identifying Alternative Existing Systems (Alternative 6)

The team researched existing systems within the Navy and outside the Navy, including commercial systems that could be used as a model for DAS. Numerous systems were identified to possess some or most of the functions required for the system. In order to ensure that a solution was selected that met the requirements and executed the important system functions; the alternative existing systems were evaluated. Table 6 lists the acceptable systems that were identified for further analysis.

| Acronym | Name | Host Organization |
|---|---|---|
| **ACSRMS** | Aegis Combat System Reliability Maintainability and Supportability Database | Naval Surface Warfare Center , Port Hueneme Division (NSWC PHD) |
| **ADA** | Albridge Data Aggregation (Financial) | Commercial |
| **AIDA** | Adaptive Independent Data Application | University of Virginia |
| **CIM** | Command Issue Management | NSWC PHD |
| **DTIC** | Defense Technology Information Center | Assistant Secretary of Defense for Research and Engineering (ASD (R&E)) |
| **ESDS** | Engineering and Supportability Decision System | NSWC PHD |
| **GDSC Remedy** | Global Distance Support Center Remedy | Fleet and Industrial Supply Center Norfolk/San Diego (FISC NF/SD) |
| **MFOM** | Maintenance Figure of Merit | Commander, U.S. Fleet Forces Command (CFFC) |
| **MRDB** | Material Readiness Database | Naval Surface Warfare Center (NSWC) Corona |
| **NDE-NM** | Navy Data Environment-Navy Modernization | CFFC |
| **NSLC 3M** | NAVSEA Logistics Center - Maintenance and Material Management | Naval Supply Systems Command (NAVSUP) |

| Acronym | Name | Host Organization |
|---|---|---|
| **NANOOS VS** | Northwest Associate of Network Ocean Observing System Visualization System | State of Washington |
| **ORTSTARS** | Operational Readiness Test System Tech Assist Remote Support | NSWC PHD |
| **RDAM** | Regional Data Archiving and Management | State of Illinois |
| **S2E** | Sailor To Engineer | NSWC PHD |
| **VAMOSC** | Visibility and Management of Operating and Support Costs | CFFC |

**Table 6. Alternative Existing Systems**

#### *a. Mapping Alternatives to Functions*

The team was able to put together a rather extensive list of existing systems that could potentially be modified to meet the DAS requirements, so the systems were further analyzed in order to gain a better understanding of their functionality. The capabilities and functions of each of the identified existing systems were researched and defined. Then the functions of each system were mapped to the required system functions, which can be seen in Figure 33.

| | Function | ACSRMS | ADA | AIDA | CIM | DTIC | ESDS | GDSC - REMEDY | MFOM | MRDB | NANOOS VS | NDE | NSLC-3M | ORTSTARS | RDAM | S2E | VAMOSC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F.0 | Provide Data Aggregation Capability | | | | | | | | | | | | | | | | |
| F.1.0 | Provide External Interface | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 |
| F.1.1 | Execute System Interface | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 |
| F.2.0 | Obtain Data | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F.2.1 | Obtain Data from User Inputs | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 | 1 | 1 |
| F.2.2 | Obtain Data from Fleet | | | | | | | | | | | | 1 | 1 | | | |
| F.2.3 | Obtain Data from Fleet Support Infrastructure | 1 | | | 1 | | 1 | 1 | 1 | 1 | | 1 | | | | 1 | 1 |
| F.3.0 | Process Data | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| F.3.1 | Process General Information | | 1 | 1 | 1 | 1 | | 1 | | | 1 | 1 | 1 | | | 1 | 1 |
| F.3.2 | Process Maintenance Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | | | 1 | |
| F.3.3 | Process Logistics Data | 1 | | | | | 1 | | 1 | 1 | | | 1 | | | | 1 |
| F.3.4 | Process Training Data | | | | | | | | | 1 | | | 1 | | | | |
| F.4.0 | Analyze Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 |
| F.4.1 | Analyze Maintenance Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | |
| F.4.2 | Conduct System Performance Trending Analyis | 1 | | | | | 1 | | 1 | 1 | | | | 1 | | | |
| F.4.3 | Compute System Ao/Ai based on RMA data | 1 | | | | | 1 | | 1 | 1 | | | | | | | |
| F.4.4 | Conduct Cost Analysis | 1 | | | | 1 | 1 | | | 1 | | | | | | | 1 |
| F.5.0 | Report Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | | 1 | 1 |
| F.5.1 | Generate System Assessment Report | | | | 1 | | 1 | | | | | | | 1 | | | |
| F.5.2 | Generate Logistics Report | 1 | | | | | 1 | | 1 | 1 | | | 1 | | | | 1 |
| F.5.3 | Generate System Status Report | 1 | | | | | 1 | | 1 | | | | | 1 | | | |
| F.5.4 | Generate System RMA Report | 1 | | | | | 1 | | 1 | 1 | | | | | | | |
| F.6.0 | Display Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | 1 | 1 | | | 1 | 1 |
| F.6.1 | Display Fleet Support Information | | | | | | | 1 | | | | 1 | 1 | | | 1 | |
| F.6.2 | Display Historical Fleet Data | 1 | | | 1 | | 1 | 1 | 1 | 1 | | 1 | | | | 1 | |
| F.6.3 | Display Corrective Maintenance Information | | | | 1 | | | 1 | | | | | | | | 1 | |
| F.6.4 | Display Logistics Information | 1 | | | | | 1 | | | 1 | | 1 | 1 | | | 1 | 1 |
| F.6.5 | Display RMA Analysis Data | 1 | | | | | 1 | | 1 | 1 | | | | | | | |
| F.7.0 | Print & Save Data | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Total | 22 | 5 | 5 | 16 | 6 | 23 | 16 | 20 | 22 | 5 | 10 | 18 | 12 | 4 | 17 | 15 |

Selected

Group

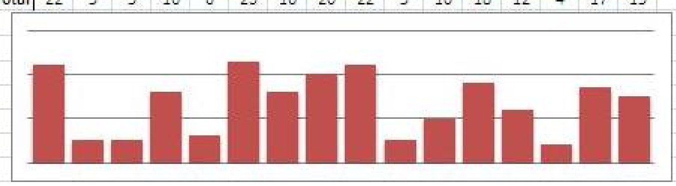


**Figure 33. AoA Mapping Existing Systems against Functions**

By mapping each of the existing system's functions to the required DAS functions, the team was able to compare and identify the functional gaps for each of the existing systems. The systems that had the most functional gaps were then eliminated from further consideration one by one until half the number of systems that were originally analyzed remained, leaving the top eight systems with the least gaps. The top eight systems that were selected for further consideration were ACSRMS, CIM, GDSC Remedy, MRDB, NSLC-3M, S2E, Engineering and Supportability Decision System (ESDS), and Maintenance Figure of Merit (MFOM).

#### b. *Conducting Swing Weights and QFD HOQs to Compare Existing Systems*

After down selecting to eight existing systems, the team worked with the stakeholders to evaluate and prioritize requirements using a swing weight model. Swingwise comparison was used vice pairwise or other simple weighting systems because the swingwise comparison considers not only importance but range of variance (Parnell and Trainor 2009). One requirement may be the most important to a stakeholder, but the range of solutions to meet that requirement may be so small that the overall product success is not impacted. A list of top-level requirements was developed by meeting with stakeholders and then swing weight methodology was used to create the stakeholder attribute rankings. Instead of ranking the requirements against each other in a pairwise comparison, the stakeholders were asked to evaluate the full range of the specific attribute when comparing. The stakeholders were asked to determine the requirement that offers the best improvement from known ranges and to assign a value of 100 to it. The remaining requirements were then analyzed to determine their range of bad to good against the range of the top requirement. For example, if the swing from worst case to best case on a specific requirement was 60% as good as the swing for the top requirement, it received a score of 60. This formed a utility function based on stakeholder's preferences. Figure 34 shows the net result of this process.

| Top Level Requirements | Swing Weight Utility | Swing Weights normalized | Rank |
|---|---|---|---|
| External Interface | 20 | 0.021 | 14 |
| Fleet Maintenance Support Data and Metrics | 75 | 0.080 | 5 |
| Logistics Data | 50 | 0.053 | 8 |
| Training Data | 50 | 0.053 | 8 |
| RMA Analysis Data | 50 | 0.053 | 8 |
| Reports | 75 | 0.080 | 5 |
| Human System Integration | 90 | 0.096 | 3 |
| Reliability | 100 | 0.107 | 1 |
| Maintainability | 33 | 0.035 | 13 |
| Environment Condition | 20 | 0.021 | 14 |
| Data Collection | 50 | 0.053 | 8 |
| Accessible by authorized NMCI Users | 70 | 0.075 | 7 |
| Data Reporting | 50 | 0.053 | 8 |
| NMCI Compliance | 90 | 0.096 | 3 |
| Hardware Requirements | 10 | 0.011 | 16 |
| Software Requirements | 10 | 0.011 | 16 |
| Fleet Access | 95 | 0.101 | 2 |

**Figure 34. Swing Weight Utility Function for Top Level Requirements**

A QFD HOQ model was then used to prioritize technical characteristics against top-level requirements. QFD HOQ was chosen based on the focus of the stakeholder requirements. As the main task for this project was to design a real system for supporting the USN fleet, there needed to be a logical path from needs to a solution. "HOQ constitutes a team approach to help ensure that the 'voice of the customer' is reflected in the ultimate design" (Blanchard and Fabrycky 2011, 82). The normalized weights obtained from the top-level requirements swing weight matrix, shown in Figure 34, were used as inputs into the HOQ shown in Figure 35. This method for analysis provides traceability from stakeholder requirement evaluations to technical characteristics to system functions to alternative solutions, allowing the team to select an alternative solution based on stakeholder preferences (Blanchard and Fabrycky 2011).

On the HOQ, the top-level requirements were the "What's" and the key technical characteristics were the "How's" of the DAS. The technical characteristics include aspects that affect the design and operation that can be measured with respect to the current requirements. The HOQ was also provided to the stakeholders to obtain an indication of the stakeholders' judgment of the impact of the technical characteristics on the requirements. The following non-linear scale was used by stakeholders to indicate the weight of impact of technical characteristics on requirements:

| | |
|---|---|
| Not related or low importance | left blank |
| Necessary | 1 |
| Important | 3 |
| Critical | 9 |

| Top Level Requirements (Whats) | Weight | Accuracy | Accessibility | Adaptability | Completeness | Flexibility | Human Factors | Maintainability | Reliability | Timeliness | Time of Report Generation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Technical Characteristics (Hows) | | | | | | | | | |
| External Interface | 0.021 | | 9 | 9 | | 9 | | | | 3 | |
| Fleet Maintenance Support Data and Metrics | 0.080 | 9 | | | 9 | | 3 | | | 3 | 9 |
| Logistics Data | 0.053 | 9 | | | 9 | | 3 | | | 3 | 9 |
| Training Data | 0.053 | 9 | | | 9 | | 3 | | | 3 | 9 |
| RMA Analysis Data | 0.053 | 9 | | | 9 | | 3 | | | 3 | 9 |
| Reports | 0.080 | 9 | | | 9 | | 3 | | | 3 | 9 |
| Human System Integration | 0.096 | | | 3 | | 3 | 9 | | | | |
| Reliability | 0.107 | | 3 | | | 1 | | 9 | 9 | | 3 |
| Maintainability | 0.035 | | 3 | | | 1 | | 9 | 9 | | 3 |
| Environment Condition | 0.021 | | | 1 | | 1 | 9 | | | | |
| Data Collection | 0.053 | 9 | 3 | 3 | 9 | 3 | | 1 | 1 | 9 | 9 |
| Accessible by authorized NMCI Users | 0.075 | | 9 | 1 | | 1 | | | | | |
| Data Reporting | 0.053 | 9 | 3 | 3 | 9 | 3 | | 1 | 1 | 9 | 9 |
| NMCI Compliance | 0.096 | | 9 | 1 | | 1 | | | | | |
| Hardware Requirements | 0.011 | | 3 | 9 | | 3 | 1 | 1 | 1 | 3 | 9 |
| Software Requirements | 0.011 | | 3 | 9 | | 3 | 9 | 1 | 1 | 3 | 3 |
| Fleet Access | 0.101 | 3 | 9 | | 3 | | 9 | 3 | 9 | 9 | 9 |
| Total | 1.00 | | | | | | | | | | |
| Weighted Performance | | 4.142 | 3.448 | 1.183 | 4.142 | 1.197 | 3.033 | 1.708 | 2.316 | 2.958 | 5.303 |
| Percent Performance | | 0.141 | 0.117 | 0.040 | 0.141 | 0.041 | 0.103 | 0.058 | 0.079 | 0.101 | 0.180 |

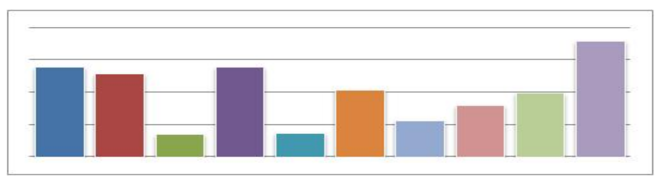


**Figure 35. HOQ1 Requirements to Technical Characteristics**

From Figure 35, using the normalized weights produced by the HOQ, it can be concluded that Time of Report Generation, Accuracy, and Completeness were the most critical technical characteristics for the DAS. The HOQ results suggested that the most critical characteristics were related to the overall goal of providing a fast, easy to use, useful, and effective system to the user. Furthermore, it is important to note that the HOQ results aligned with the feedback obtained from the stakeholders' needs analysis, further demonstrating that the results of the process followed by the team accurately reflects the preferences of the stakeholders.

A second QFD HOQ, shown in Figure 36, was used to map technical characteristics to functions. The normalized weights obtained from the previous QFD HOQ were used as inputs into the second HOQ, continuing with the traceability from requirements to technical characteristics to functions. The HOQ was also given to the stakeholders to obtain an indication of the stakeholders' opinion of the impact of the functions on the technical characteristics and the same non-linear scale was used.

| | | Functions (Hows) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Technical Characteristics (Whats) | Weight | Provide External Interface | Provide User Interface | Obtain Data | Obtain Data from User Inputs | Obtain Data from Fleet | Obtain Data from Fleet Support Infrastructure | Process Data | Process General Information | Process Maintenance Data | Process Logistics Data | Process Training Data | Analyze Data | Analyze Maintenance Data | Conduct System Performance Trending Analysis | Compute System Ao/Ai based on RMA data | Conduct Cost Analysis | Report Data | Generate System Assessment Report | Generate Logistics Report | Generate System Status Report | Generate System RMA Report | Display Data | Display Fleet Support Information | Display Historical Fleet Data | Display Corrective Maintenance Information | Display Logistics Information | Display RMA Analysis Data | Print Data |
| Accuracy | 0.141 | | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 9 | 9 | 9 | 9 | 3 | 9 | 9 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 1 |
| Accessibility | 0.117 | 9 | 9 | 3 | 3 | 3 | 3 | | | | | | | | | | | | | | | | | | | | | | |
| Adaptability | 0.040 | 9 | 1 | 9 | 9 | 9 | 9 | | | | | | | | | | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 9 |
| Completeness | 0.141 | | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 9 | 9 | 9 | 9 | 3 | 9 | 9 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 9 | 1 |
| Flexibility | 0.041 | 9 | | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Human Factors | 0.103 | | 9 | | | | | | | | | | | | | | | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Maintainability | 0.058 | 3 | 3 | 3 | 3 | 3 | 3 | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Reliability | 0.079 | 3 | 9 | 3 | 3 | 3 | 3 | | | | | | | | | | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Timeliness | 0.101 | 1 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 3 | 3 | | | | | | | | | | | | | | | | | |
| Time of Report Generation | 0.180 | 3 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Total | 1.00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Weighted Performance | | 2.8 | 6.3 | 6.5 | 6.5 | 6.5 | 6.5 | 4.6 | 4.6 | 4.6 | 2.9 | 2.9 | 4.2 | 4.2 | 4.2 | 4.2 | 2.5 | 5.5 | 5.5 | 3.8 | 5.5 | 5.5 | 4.6 | 4.6 | 4.6 | 4.6 | 2.9 | 4.6 | 2.6 |
| Percent Performance | | 0.022 | 0.049 | 0.051 | 0.051 | 0.051 | 0.051 | 0.036 | 0.036 | 0.036 | 0.023 | 0.023 | 0.033 | 0.033 | 0.033 | 0.033 | 0.020 | 0.043 | 0.043 | 0.029 | 0.043 | 0.043 | 0.036 | 0.036 | 0.036 | 0.036 | 0.023 | 0.036 | 0.020 |

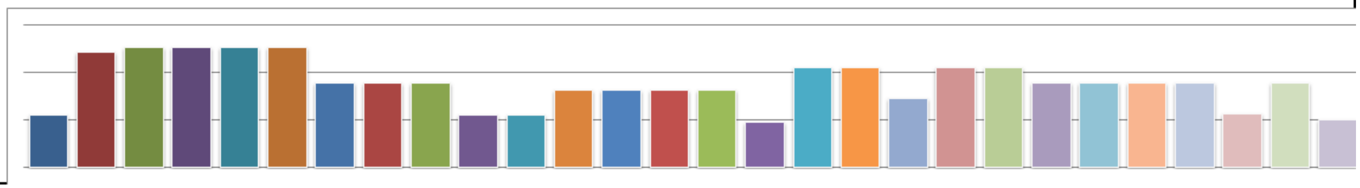


**Figure 36. HOQ2 Technical Characteristics to Function**

From Figure 36, using the normalized weights produced by the second HOQ, the key functions identified include: 1) provide user interface, 2) obtain data, 3) obtain data from user inputs, 4) obtain data from fleet, and 5) obtain data from fleet support infrastructure.

Finally, the third QFD HOQ, as shown in Figure 37, mapped functions to existing systems. As was the case with the previous HOQs, the normalized weights from the second HOQ were entered as inputs for this HOQ. Furthermore, as with the previous HOQs, the HOQ was provided to the stakeholders to obtain an indication of the stakeholders' opinion of the impact of the existing systems on the functions and the same non-linear scale was used. The team used the third HOQ in order to rank the previously identified top eight existing systems and come up with the performance weight for each system.

| Functions | Weight | Existing Systems: ESDS | ACSMRS | S2E | NSLC-3M | MFOM | GDSC - REMEDY | CIM | MRDB |
|---|---|---|---|---|---|---|---|---|---|
| Provide External Interface | 0.022 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 9 |
| Provide User Interface | 0.049 | 1 | 3 | 9 | 9 | 3 | 3 | 3 | 9 |
| Obtain Data | 0.051 | 9 | 9 | 3 | 9 | 9 | 9 | 9 | 9 |
| Obtain Data from User Inputs | 0.051 | 3 | 3 | 9 | 1 | 3 | 3 | 9 | 3 |
| Obtain Data from Fleet | 0.051 | | | | 3 | | | | |
| Obtain Data from Fleet Support Infrastructure | 0.051 | 9 | 9 | 3 | | 1 | 9 | 9 | 1 |
| Process Data | 0.036 | 9 | 9 | 3 | 3 | 9 | 3 | 3 | 9 |
| Process General Information | 0.036 | | | 3 | 1 | | 9 | 1 | |
| Process Maintenance Data | 0.036 | 9 | 9 | 3 | 1 | 9 | 3 | 1 | 9 |
| Process Logistics Data | 0.023 | 9 | 9 | | 3 | 9 | | | 9 |
| Process Training Data | 0.023 | | | | 1 | | | | 3 |
| Analyze Data | 0.033 | 9 | 9 | 1 | 3 | 9 | 1 | 3 | 9 |
| Analyze Maintenance Data | 0.033 | 9 | 9 | 3 | 9 | 9 | 1 | 3 | 9 |
| Conduct System Performance Trending Analysis | 0.033 | 9 | 9 | | | 9 | | | 9 |
| Compute System Ao/Ai based on RMA data | 0.033 | 3 | 9 | | | 9 | | | 9 |
| Conduct Cost Analysis | 0.020 | 9 | 9 | | | | | | 9 |
| Report Data | 0.043 | 9 | 9 | 9 | 3 | 9 | 3 | 3 | 9 |
| Generate System Assessment Report | 0.043 | 9 | | | | | | 1 | |
| Generate Logistics Report | 0.029 | 9 | 3 | | 9 | 9 | | | 3 |
| Generate System Status Report | 0.043 | 3 | 1 | | | 3 | | | |
| Generate System RMA Report | 0.043 | 9 | 1 | | | 3 | | | 1 |
| Display Data | 0.036 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Display Fleet Support Information | 0.036 | | | 9 | 3 | | 3 | | |
| Display Historical Fleet Data | 0.036 | 9 | 9 | 3 | | 9 | 9 | 1 | 9 |
| Display Corrective Maintenance Information | 0.036 | | | 9 | | | 3 | 9 | |
| Display Logistics Information | 0.023 | 3 | 9 | 1 | 3 | | | | 9 |
| Display RMA Analysis Data | 0.036 | 9 | 9 | | | 9 | | | 9 |
| Print Data | 0.020 | 9 | 9 | 9 | 9 | 9 | 3 | 3 | 9 |
| Total | 1.00 | | | | | | | | |
| Weighted Performance | | 6.084 | 5.530 | 3.525 | 3.038 | 5.087 | 2.937 | 2.880 | 5.440 |
| Percent Performance | | 0.176 | 0.160 | 0.102 | 0.088 | 0.147 | 0.085 | 0.083 | 0.158 |

**Figure 37. HOQ3 Functions to Existing Systems**

From Figure 37, by comparing the performance weights produced by the HOQ, the top four existing systems were identified, which were ESDS, ACSRMS, MFOM, and MRDB.

#### *c. Gap Analysis*

In order to identify the best Alternative 6, an existing system that could be modified for DAS, from the top four systems identified by using Swing Weights and QFD HOQs, the team used the third QFD HOQ, which mapped existing systems to functions, to conduct a functional gap analysis. All of the functions that were missing by each of the top four existing systems were listed. The results can be seen in Table 7.

| Existing Systems | Gaps (Functions) |
|---|---|
| Engineering and Supportability Decision System (ESDS) | Obtain Data from Fleet<br>Process General Information<br>Process Training Data<br>Display Fleet Support Information<br>Display Corrective Maintenance Information |
| Aegis Combat System Reliability Maintainability and Supportability Database (ACSRMS) | Obtain Data from Fleet<br>Process General Information<br>Process Training Data<br>Generate System Assessment Report<br>Display Fleet Support Information<br>Display Corrective Maintenance Information |
| Maintenance Figure of Merit (MFOM) | Obtain Data from Fleet<br>Process General Information<br>Process Training Data<br>Conduct Cost Analysis<br>Generate System Assessment Report<br>Display Fleet Support Information<br>Display Corrective Maintenance Information<br>Display Logistics Information |
| Material Readiness Database (MRDB) | Obtain Data from Fleet<br>Process General Information<br>Process Training Data<br>Generate System Assessment Report<br>Display Fleet Support Information<br>Display Corrective Maintenance Information |

**Table 7. Gap Analysis Chart**

The number of gaps for each system was then used as a metric to evaluate the remaining systems. Table 7 shows that ESDS has only five functional gaps while ACSRMS and MRDB have six and MFOM has eight. Furthermore, it can be noted that all of ESDS' functional gaps are also functional gaps for the other three systems. In other words, the other three systems had at least the same functional gaps as ESDS. As a result, the best solution based on the least amount of functional gaps was ESDS.

After identifying ESDS to be the existing system with the least functional gaps, the team continued the AoA process by examining system documentation for each of the four systems. The following findings resulted from that process: 1) ACSRMS was no longer supported by the contractor, thus it was eliminated as a potential solution, 2) the results of MFOM and MRDB analyses showed that ESDS already aggregates data from both systems and 3) MFOM and MRDB have limited data aggregation capability, significantly increasing the amount of effort that would be required to make modifications. Since ESDS already aggregates data from MFOM and MRDB, and both systems have limited data aggregation capability, the team determined that modifying ESDS was the most suitable existing system option for Alternative 6 that would meet the needs of the stakeholders and solve the problem. To distinguish between the existing ESDS and the modified ESDS, the team has acquired the term "ESDS Plus" (ESDS+) and has utilized it for the rest of this report.

## H. COST ANALYSIS

In today's budget constrained environment, all government spending is subject to scrutiny. Fleet and shore based activities are under extreme pressure to minimize costs, but weapon system availability requirements are higher than ever. While many efforts to increase fleet readiness have been extremely costly, Distance Support can reduce costs for shore-based activities and the ships they support. Although initial development costs can be high, by reducing travel requirements, supporting system operability, and lowering MTTR, Distance Support is an extremely valuable tool that can provide a ROI in a very short period of time.

### 1. Costs Overview

The costs for a Distance Support system can be broken down into four categories: 1) development costs, 2) life cycle costs, 3) disposal costs and 4) savings. Distinguishing between these costs will help to estimate initial costs, and extrapolate over time to determine life cycle costs at specific future dates. Disposal costs will be incurred when the system is replaced and disposed of in the future, and with these costs accounted for, overall total life cycle cost can be determined.

#### *a. Development Cost*

Development costs include all costs associated with the development of a new system. Major costs associated with development costs are 1) stakeholders' needs analysis, 2) requirements analysis, 3) programming costs, and 4) early beta testing debugging efforts. These costs are non-recurring, as they take place only during the development of the system. In the case of systems with hardware, this may include installation and the testing of the hardware systems when it is installed or fielded.

For the purpose of this project, the team assumed that the DAS will utilize basic processing requirements, and therefore will not require extensive hardware development or installation. This will both reduce the installation costs, as well as disposal costs.

#### *b. Life cycle Cost*

Life cycle costs include all costs required to support the fielded active system. These costs include 1) technical support, 2) training, 3) monitoring and troubleshooting costs, 4) debugging efforts, 5) information assurance updates, and 6) incremental updates to keep the system running effectively.

For DAS, the majority of life cycle costs will be incurred through debugging and troubleshooting, information assurance, and incremental updates. An automated DAS will require minimal oversight, so full time support employees are not likely to be necessary to the support of the system. Periodic maintenance contracts to a contractor may suffice, which will help maintain low life cycle costs.

Current NSWC PHD funding given to ESDS for life cycle support is approximately $245,000 per year. In addition to traditional life cycle support efforts, this includes contractor support to help train NSWC PHD engineers to use the system. This allocation of monies also funds full time contractors to support data acquisition support for NSWC PHD command-sponsored studies and briefings such as SEAR briefings for combat system elements.

#### *c. Disposal Costs*

Disposal costs include all costs associated with disposing the final system at the end of its life, including 1) system hardware removal costs, 2) destruction or demilitarization costs, and 3) physical disposal costs. In some cases, parts of the systems can be demilitarized and reutilized as a cost avoidance technique.

For a software focused DAS, with minimal hardware installation, disposal costs will be negligible in comparison to development costs, life cycle costs, and savings, and therefore can be ignored for this project.

#### *d. Savings*

Distance Support has the ability to save costs in several important areas. Effective Distance Support applications can reduce repair time, reduce the number of onsite CASREP SME technical assists, and most importantly stop system issues from preventing a ship to complete a mission.

For the stakeholders at NSWC PHD, DAS could result in major travel cost reductions. Navy Sailors primarily submit CASREPs to notify shore based activities of major system failures. NSWC PHD, as the ISEA for many of these Navy systems, is called upon to fix CASREPs. These engineering efforts supported by shore-based activities such as NSWC PHD often require an on-site technical subject matter to visit the ship in need. These trips are costly due to travel expenses and labor, so an overall reduction in travel can have major cost savings for shore based activities.

(1) Time Savings - The effective utilization of Distance Support will save both fleet end users and shore based support activities valuable time when working to correct system issues. This means Sailors have to spend less time troubleshooting their systems, and they can spend more time on other tasks and auxiliary functions.

(2) Value of Reduced Downtime - The most valuable aspect of effective Distance Support is the improvements to Ao and reduction in system downtime. Determining the value of reduced system downtime can be a difficult and subjective determination.

If a system failure is critical, the impacts could greatly increase costs. There is usually not a second ship that can immediately fill the mission requirements if a deployed ship has a major system failure. This means in time of national crisis or international tensions and a USN ship is required to be deployed it is imperative that ship remains at maximum operational readiness levels.

### 2. Development Cost Analysis through Constructive Systems Engineering Cost Model (COSYSMO)

Through the AoA, the team determined two options to meet the DAS requirements: 1) modify ESDS and 2) build a new Distance Support system. The team determined the development costs associated with both options by using the COSYSMO Version 2.0. COSYSMO 2.0 is a systems engineering cost estimation tool that was a development effort between NPS and University of Sothern California (USC), built on a framework developed by COSYSMO model developer Dr. Ricardo Valerdi of Massachusetts Institute of Technology (MIT). COSYSMO can be effectively used by systems engineers to estimate cost for developing software systems.

COSYSMO can be found at http://cosysmo.mit.edu/wp-content/uploads/2010/11/academicCOSYSMO_2.0.xls and instructions on it use can be found at several sites, including: http://powershow.com/view1/1d7deb-NDFiY/Towards_COSYSMO_20_Future_Directions_and_Priorities_CSSE_Annual_Research_Review_Los_Angeles_CA_powerpoint_ppt_presentation. COSYSMO is a model used to compute an estimated number of person-months of a project will require. COSYSMO has been calibrated with the data sets from multiple DoD organizations and companies to enhance the accuracy of the model.

The application of COSYSMO has been used to determine which of the two options would require less engineering effort to develop. The specific version of the tool that the team used was COSYSMO 2.0 because it allows users to account for redesign efforts. This was necessary to compare the new system to the estimated costs of redesigning ESDS to meet the requirements.

COSYSMO takes in a specific set of pre-defined user-inputs. The COSYSMO 2.0 Software Documentation, titled *Systems Engineering Cost Estimation with COSYSMO*, which was written by Ricardo Valerdi from the Massachusetts Institute of Technology in 2008, provides extremely specific definitions for each degree of complexity for factors that will drive software size, and software cost. By making the definitions of each degree of complexity, there is less ambiguity when predicting input parameters. As a result, COSYSMO more accurately estimates costs across a variety of platforms and a wide range of users. The following section covering COSYSMO inputs describes the pre-defined inputs that a COSYSMO user needs to determine for their system and select when using the cost estimation tool.

#### *a. COSYSMO Inputs:*

Size Drivers: The numbers of requirements, algorithms, interfaces, and operational scenarios to be entered into COSYSMO as inputs are broken down into several categories. The size drivers are differentiated and entered into COSYSMO based on degree of complexity (easy, nominal, and difficult).

(1) COSYSMO Size Drivers–Size drivers are factors that influence the final developed system's software size and complexity. Each input directly increases the number of source lines of code (SLOC) of the final system. Size driver inputs for COSYSMO are as follows for a New System:

- Number of Requirements
- Number of Interfaces
- Number of System Specific Algorithms
- Number of Operational Scenarios.

For a redesigned system, the inputs are the same, but each driver is broken down further into these categories: 1) reused, 2) modified, 3) deleted, 4) adopted and 5) managed. These inputs are then fed through a ruse algorithm to convert these inputs to an equivalent number of new input parameters.

(2) COSYSMO Cost Drivers–cost drivers are input parameters that impact the overall development cost of the system based on factors that do not necessarily impact the actual software size. Cost drivers are broken down into two different categories: application factors and team factors. Application factors impact the complexity of the system due to the installed platforms, documentation requirements, and other general factors that complicate the operational scenario of the final system. Team factors are the various factors that impact the development team's ability to develop and build the system.

COSYSMO Cost Drivers are all also broken down by complexity: 1) very low, 2) low, 3) nominal, 4) high, 5) very high, and 6) extra high.

Application Factors:

- Requirements Understanding
- Architecture Understanding
- Level of Service Requirements
- Migration Complexity
- Technology Maturity
- Documentation Match to Life Cycle Needs
- Number and Diversity of Installations/Platforms
- Number of Recursive Levels of the Design

Team Factors:

- Stakeholder team cohesion
- Personnel/team capability

- Personnel experience/ continuity
- Process capability
- Multisite coordination
- Tool Support

Figures 38 and 39 show the input variables that were used to run the COSYSMO analysis. Figure 38 depicts the inputs for ESDS+ while Figure 39 depicts the inputs used for a New System.

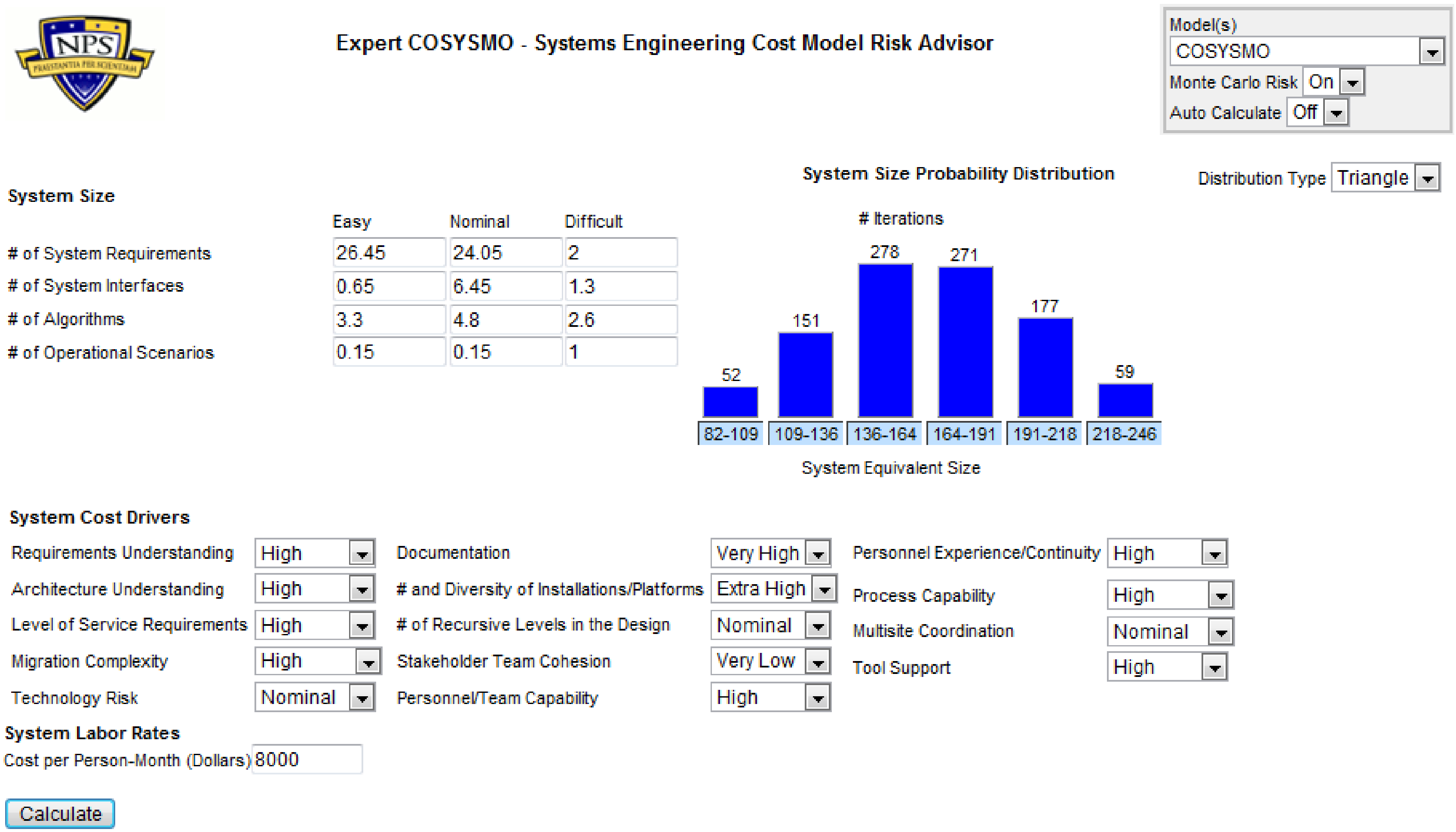



**Figure 38. Expert COSYSMO Inputs - ESDS+**

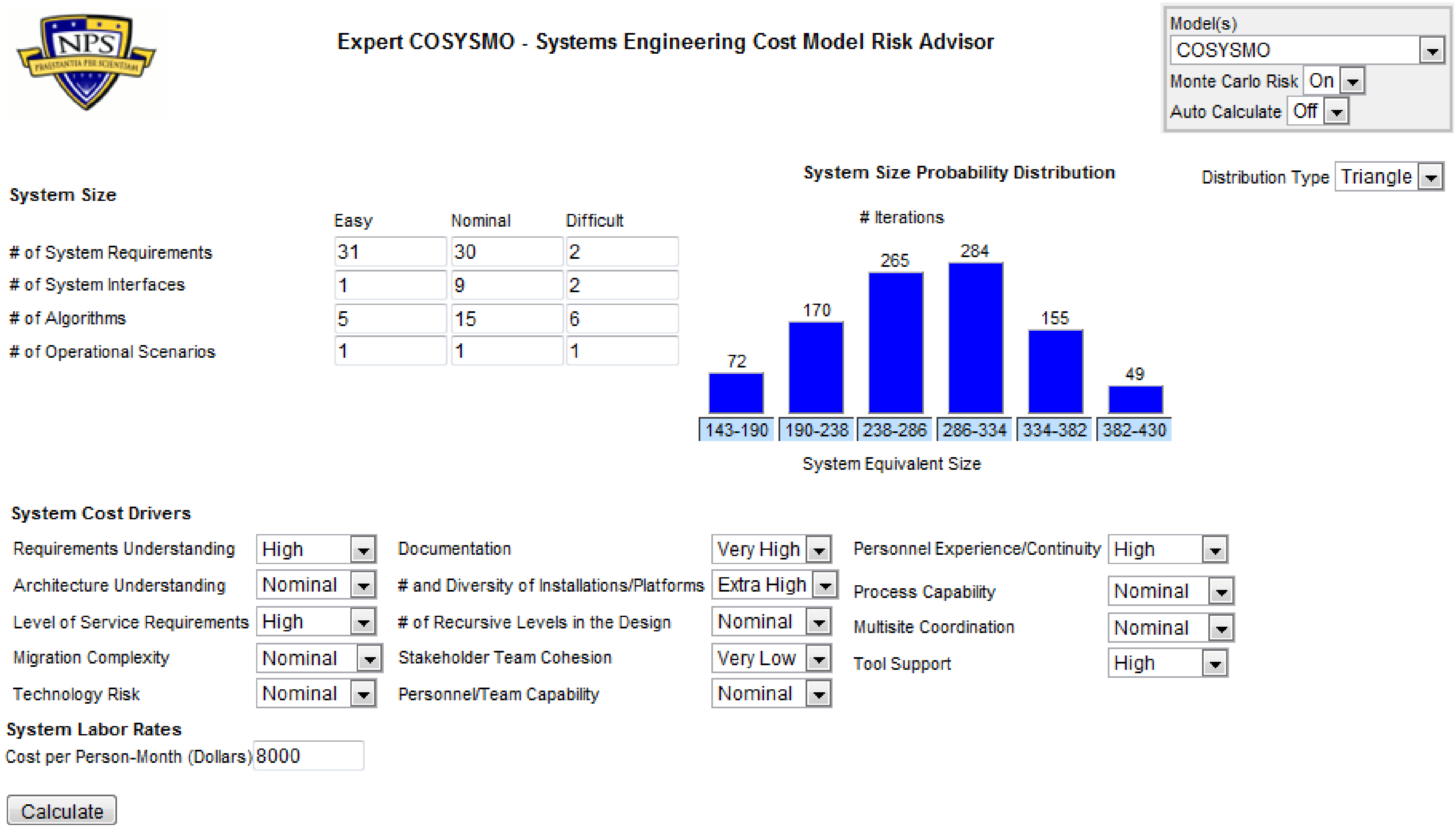



**Figure 39. Expert COSYSMO Inputs - New System**

### *b. COSYSMO Analysis:*

To determine COSYSMO input values, the system requirements from the requirements analysis was used. The complexity of each requirement was used to determine the complexity of each, to determine the approximate number of system-specific algorithms that would be needed, and to identify the number of system interfaces and the complexity of each of those interfaces. Next, each function was mapped to the two systems to be compared to determine which of the functions would lead to a new requirement for development or an existing requirement already completed that can be modified and reutilized.

For the new system, each of these requirements was entered into COSYSMO as new requirements. For the improved ESDS system (ESDS+), each function had to be determined as a new, reused, modified, adopted, or managed requirement. All of these values and their rankings were then entered into COSYSMO.

In 2012, NSWC PHD conducted a funding profile analysis and created a report titled *ESDS Cost Breakdown.* In this analysis, NSWC PHD estimated costs of future ESDS overhauls to include additional functionality desired by NSWC PHD management. This report was used to compare the COSYSMO outputs to verify the cost estimates.

## 3. Development Cost Estimates from COSYSMO

The outputs from the COSYSMO Analysis are as shown in Table 8.

| Option | Estimated Effort (Person-Months) | Estimated Effort Less Tech. Management |
|---|---|---|
| **ESDS+** | 102 | 85 |
| **New System** | 258 | 214 |

**Table 8. COSYSMO Analysis Outputs**

The team's assessments indicate that the estimated development effort to modify ESDS to meet the new requirements will cost 40% of the total development cost required to build a new system.

COSYSMO computed approximately 17% of the total cost of the project as "Technical Management Costs." This expense was eliminated because NSWC PHD contractors will be conducting the work, with government oversight covering the majority of technical management efforts. It was estimated that one person month was 160 hours of labor, and a software engineer contractor's cost ranged between $50.00/hour to $100.00/hour. Taking these factors into account, the resulting estimates are shown in Table 9.

| Option | Software Engineer Hourly Cost ($50/hour) | Software Engineer Hourly Cost ($100/hour) |
|---|---|---|
| **ESDS+** | $680,000 | $1,360,000 |
| **New System** | $2,064,000 | $4,128,000 |

**Table 9. COSYSMO Analysis Outputs**

In the study, *ESDS Cost Breakdown*, cost estimates to upgrade the functionality of ESDS was in the range of $818,000 per major overhaul. Thus the team felt confident that their AoA cost analysis results were realistic.

### 4. Cost Analysis - Monte Carlo Simulation

Expert COSYSMO also has the ability to run a simple Monte Carlo Simulation based on the user inputs. The Monte Carlo Simulation allows the user to determine how uncertainty in the variables affects the projected outcome based on hundreds or even thousands of simulation runs. For this analysis, the Monte Carlo Simulation outputs a range of system development effort costs. Figure 40 shows the Monte Carlo Simulation outputs for ESDS+ while Figure 41 shows the Monte Carlo Simulation outputs for a new system.

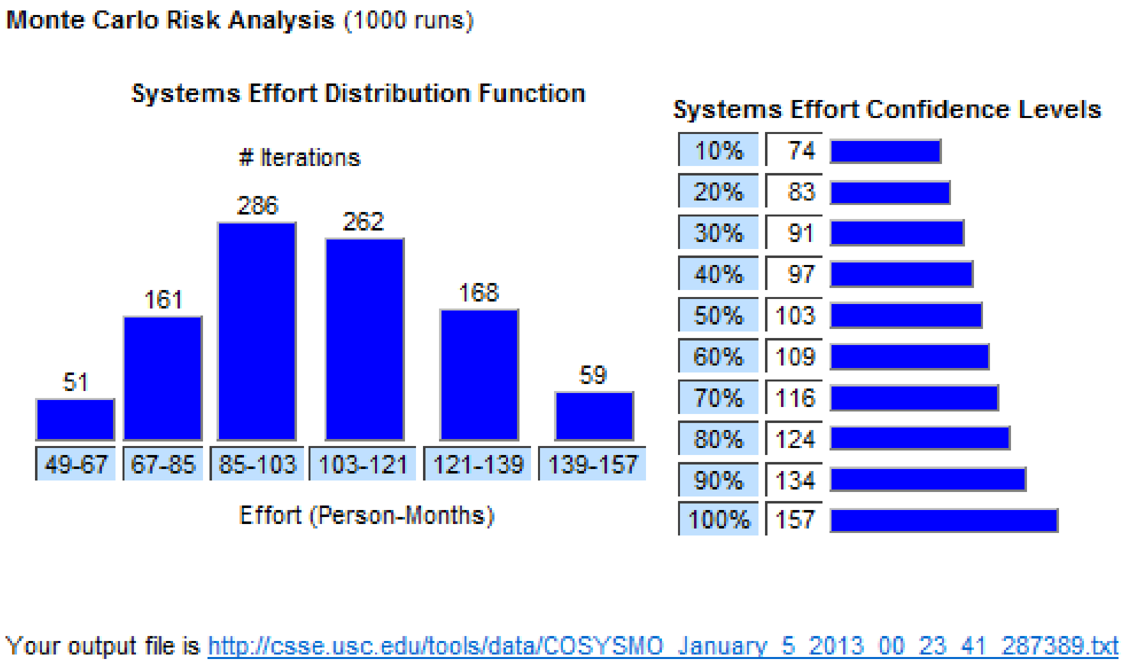



**Figure 40. Expert COSYSMO Output Monte Carlo Simulation - ESDS+**

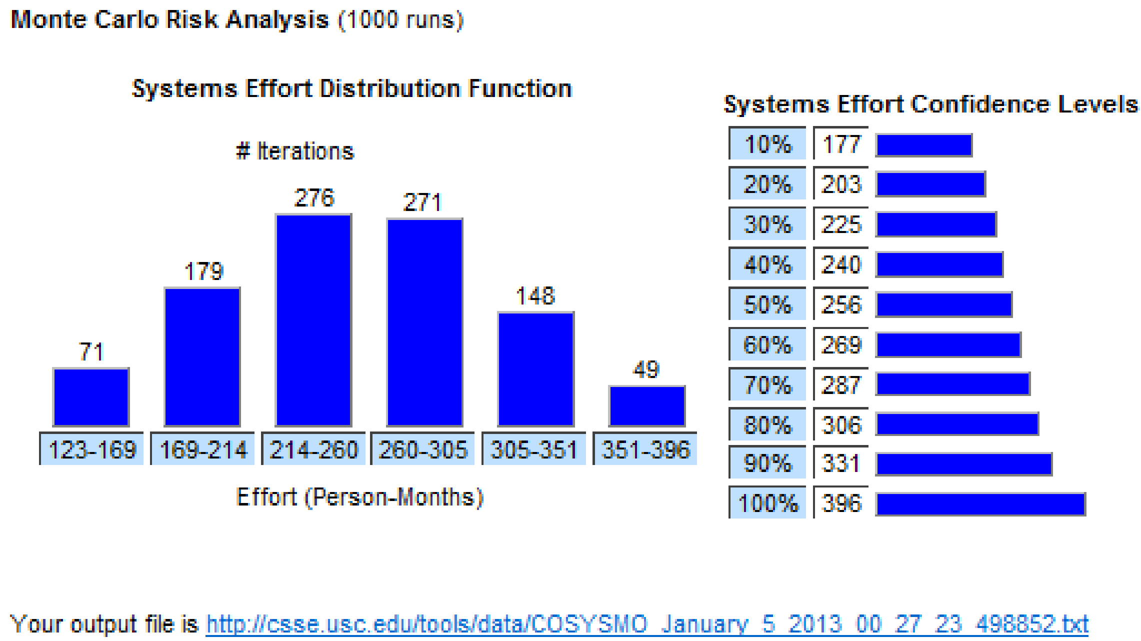



**Figure 41. Expert COSYSMO Output Monte Carlo Simulation - New System**

As seen in Figures 40 and 41, the range of effort in person-months can vary substantially. As a result, there is some noticeable uncertainty in the actual effort required to build the DAS solution. This will have to be factored in when drafting the contract for the DAS.

## I. RISK ANALYSIS

Risk analysis began at the commencement of this research effort, following the Risk Management Guide for DoD Acquisition written in 2006. Risk factors were included in the cost estimates previously discussed in this report to see if mitigating risk factors would affect system development costs. The risk analysis process was to: 1) identify risks, 2) analyze the risks identified to determine their severity and probability of occurrence and 3) determine how the risks could be mitigated or controlled. Table 10 shows the adapted severity table to assess risks.

| Level | Schedule |
|---|---|
| **1** | Minimal or no impact |
| **2** | Able to meet key dates<br>Slip < 1 week |
| **3** | Minor schedule slip. Able to meet key milestones with no schedule float<br>Slip < 2.5 weeks |
| **4** | Program critical path affected<br>Slip < 1 month |
| **5** | Cannot meet key program milestones<br>Slip > 1 month |

**Table 10. Risk Consequence Classification (After Office of the Under Secretary of Acquisition, Technology and Logistics 2006)**

The probability of occurrence is as important as the severity and it is categorized by the criteria in Table 11.

| Level | Likelihood | Probability of Occurrence |
|---|---|---|
| **1** | Not Likely | ≤10% |
| **2** | Low likelihood | ≤30% |
| **3** | Likely | ≤50% |
| **4** | Highly likely | ≤90% |
| **5** | Near Certain | ≤100% |

**Table 11. Risk Likelihood Classification (From Office of the Under Secretary of Acquisition, Technology and Logistics 2006)**

Upon judging the severity and probability of a negative event, the specific risk identified can be classified by utilizing the chart in Figure 42. "Stop light" colors of red, yellow and green are used to categorize the risk. The goal for this effort was to move any identified risks from the red and yellow regions to the green region via mitigation.

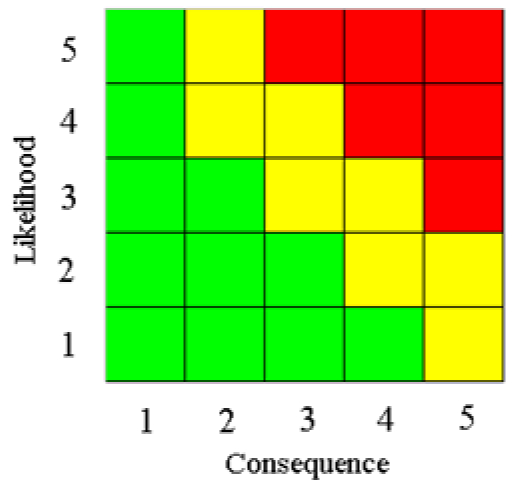



**Figure 42. Risk Assessment Matrix (From DoD 2006)**

The team identified and tracked programmatic and technical risks for the project. The following details the analysis of the highest risks of both categories:

### 1. Technical Risks:

For technical risk, there is already a precedent that has been set by the existing database and the tool set programmers that exist at NSWC PHD. This existing information and the knowledge of NSWC PHD personnel can be leveraged in the development of the DAS. Although the other products may not provide a complete Distance Support process, they are stable and do perform tasks with data as designed. Following the DoD risk management guide, these risks will need to be monitored on regular basis and newly identified risks will be added. Figure 43 shows these Technical Risks.

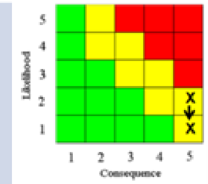
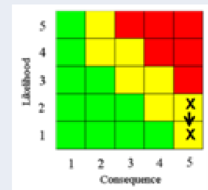
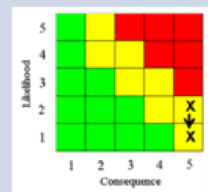
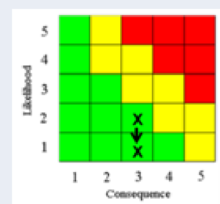
| Risk # | Description | Likelihood | Consequence | Response | Risk Assignment |
|---|---|---|---|---|---|
| 100 | Data cannot be formatted to a standard form for consolidation | Low Likelihood | Cannot meet key program milestones | Mitigate risk by using NSWC PHD ISEA Stakeholders to ensure data format viable |  |
| 101 | Data cannot be "pulled" correctly to a standard form for consolidation | Low Likelihood | Cannot meet key program milestones | Control risk by utilizing NSWC PHD database experts' heuristics to reduce likelihood of occurring' |  |
| 102 | Data being consolidated is resident in non-classified and classified sources; Getting data from unclassified to secret enclaves is arduous and could cause classified spillage if not performed properly | Low Likelihood | Program critical path affected | Ensure all programmers are up to date in "low to high" training and utilize established protocol for transfer |  |
| 103 | HSI and Reliability Deficient in Testing | Low Likelihood | Minor schedule slip | Mitigate/Control by using the "build a little, test a little" technique, not waiting for the end of the project to get feedback |  |

**Figure 43. Technical Risks**

### 2. Programmatic Risks:

A data aggregation tool is only as good as the data being entered. With this in mind, a review of the solutions for issues will be necessary by SMEs for accuracy. Also, a review is necessary for ensuring that the tool's methodology is sound, safe, and consistent with the documentation being used and agrees with known best practices. In some cases, efficiencies in reporting will be necessary, since many SMEs are obligated to track personal highlights (weekly accomplishments for personnel reasons) and complete trip reports. The intent is to improve the existing reporting without adding workload to the experts who need to be spending their time on providing active support. Figure 44 shows these programmatic risks.

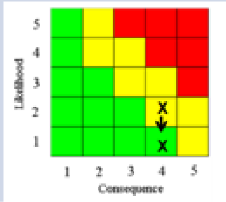
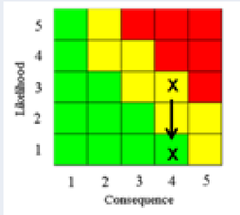
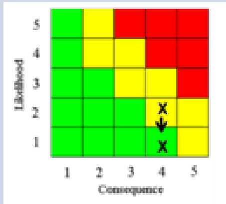
| Risk # | Description | Likelihood | Consequence | Response | Risk Assignment |
|---|---|---|---|---|---|
| 200 | Human-In-Loop element is not available to ensure consolidated data makes sense and is accurate | Low Likelihood | At least one requirement not met | Control risk by utilizing NSWC PHD branch heads to ensure SMEs are available |  |
| 201 | Informative narrative useful data not entered in fields | Likely | At least one requirement not met | Control risk by requiring review of department chief systems engineers of the SME input to ensure a quality product |  |
| 202 | DS data from at least one NSWC PHD System is not available for consolidation | Low Likelihood | At least one requirement not met | Mitigate risk by utilizing NSWC PHD Department Systems Engineers to ensure data is available |  |

**Figure 44. Programmatic Risks**

### 3. Cost Risks:

The cost estimation tool utilized was the Expert Constructive Systems Engineering Cost Model (Expert COSYSMO). It provided the team with the ability to estimate the overall system cost risk by analyzing the cost driver input parameters. This estimate was done by using an input comparison table with calibrated risk analysis comparing each input against all others and looking for potentially high risk areas.

Whenever a risk area is identified, Expert COSYSMO provides a risk value and attempts to provide a risk mitigation strategy. Expert COSYSMO identified several high, medium and low risk areas for both modifying ESDS and building a new Distance Support tool.

Once all risk areas were identified and risk values estimated, an overall risk value was calculated by summing all of these values. The final overall risk value will be in the range of zero to 702. The risks associated with each option are summarized in Table 12. The input and output parameters that went into Expert COSYSMO can be found in Appendix C–Risk Analysis Through COSYSMO.

| Option | Number of Low Risk Areas | Number of Medium Risk Areas | Number of High Risk Areas | Total Risk: |
|---|---|---|---|---|
| **ESDS+** | 8 | 4 | 1 | **44.7** |
| **New System** | 11 | 4 | 1 | **45.7** |

**Table 12. Risks Associated with Each Option**

The outputs of Expert COSYSMO require review because it does not have insight to the systems it compares. The team found that Expert COSYSMO gave a medium risk for "ESDS+" because Migration Complexity was rated as high. This assessment was determined to be inaccurate because there will be no actual migration of existing ESDS infrastructure, rather the existing system will simply be built upon in a next major system revision. Therefore, the team removed this from the Medium risk areas and moved it to Low risk.

For both systems, the Documentation input is very high due to rigorous DoD standards and requirements, and the Number and Diversity of Platforms is Extra high due to the wide range of potential users the database will be accessed by. These two factors combined may cause major issues for system programmers, builders and integrators. As a result this is a major risk area for both systems.

Tables 13 and 14 summarize the medium and low risks for each system, as well as the risk mitigation suggestions from Expert COSYSMO.

| **Risk Level** | **Input 1** | **Input 2** | **Risk Mitigation Strategy from Constructive Systems Engineering Cost Model (COSYSMO)** |
|---|---|---|---|
| **Medium Risk** | Documentation = Very High | Diversity of Platforms = Extra High | Not applicable |
| | Service Requirements = High | Diversity of Platforms = Extra High | Understand baseline functionality better and how it changes across installations/platforms |
| | Level of Service Requirements = High | Stakeholder Team Cohesion = Very Low | Put people with experience working together to meet the high ‘illities |
| | Level of Service Requirements = High | Documentation = Very High | Extensive documentation to support traceability for high interoperability |
| **Low Risk** | Migration Complexity = High | Diversity of Platforms = Extra High | Limit legacy system involvement, reduce the number of interfaces by defining a common interface |

| **Risk Level** | **Input 1** | **Input 2** | **Risk Mitigation Strategy from Constructive Systems Engineering Cost Model (COSYSMO)** |
|---|---|---|---|
| | Technology Risk = Nominal | Diversity of Platforms = Extra High | Early identification of potential installations, upfront effort including prototyping to cover each installation |
| | Migration Complexity = High | Stakeholder Team Cohesion = Very Low | Enable legacy system communication among team |
| | Migration Complexity = High | Documentation = Very High | Find old documents and people to translate them, seek analogous documentation and learn from it, reverse-engineer old system |
| | Technology Risk = Nominal | Stakeholder Team Cohesion = Very Low | Rigorous enforcement of gate criteria early, increased coordination and frequency of communication |
| | Technology Risk = Nominal | Documentation = Very High | Prototype, modeling and simulation, trade studies |
| | Documentation = Very High | Multisite Coordination = Nominal | Not applicable |
| | Documentation = Very High | # of Recursive Levels in Design = Nominal | Not applicable |

**Table 13. Risk Associated with Improving ESDS**

| Risk Level | Input 1 | Input 2 | Risk Mitigation Strategy from Constructive Systems Engineering Cost Model (COSYSMO) |
|---|---|---|---|
| Medium Risk | Documentation = Very High | Stakeholder Team Cohesion = Very Low | Not applicable |
| | Level of Service Requirements = High | Diversity of Platforms = Extra High | Understand baseline functionality better and how it changes across installations/platforms |
| | Level of Service Requirements = High | Stakeholder Team Cohesion = Very Low | Put people with experience working together to meet the high 'illities |
| | Level of Service Requirements = High | Documentation = Very High | Extensive documentation to support traceability for high interoperability |
| Low Risk | Technology Risk = Nominal | Diversity of Platforms = Extra High | Early identification of potential installations, upfront effort including prototyping to cover each installation |
| | Migration Complexity = Nominal | Diversity of Platforms = Extra High | Limit legacy system involvement, reduce the number of interfaces by defining a common interface |
| | Architecture Understanding = Nominal | Diversity of Platforms = Extra High | Prototyping, much testing |
| | Technology Risk = Nominal | Stakeholder Team Cohesion = Very Low | Rigorous enforcement of gate criteria early, increased coordination and frequency of communication |
| | Architecture Understanding = Nominal | Stakeholder Team Cohesion = Very Low | Setup system level IPT's with customers, involve customers early, prioritize requirements |

| Risk Level | Input 1 | Input 2 | Risk Mitigation Strategy from Constructive Systems Engineering Cost Model (COSYSMO) |
|---|---|---|---|
| | Technology Risk = Nominal | Documentation = Very High | Prototype, modeling and simulation, trade studies |
| | Documentation = Very High | Multisite Coordination = Nominal | To Be Determined (TBD) |
| | Documentation = Very High | # of Recursive Levels in the Design = Nominal | TBD |
| | Documentation = Very High | Process Capability = Nominal | Subcontract, hire or partner with high process domain expertise |
| | Documentation = Very High | Personnel/Team Capability = Nominal | TBD |
| | Architecture Understanding = Nominal | Documentation = Very High | Do more documentation |

**Table 14. Risk Associated with Building a New System**

## J. SUMMARY

The purpose of the requirements analysis was to translate stakeholder needs into a set of system operational requirements and maintenance and support concepts. Functional analysis was then conducted to identify the system resources that would be required for DAS to achieve the operational concept that was developed from the requirements analysis. Using the results of the requirements analysis and functional analysis, the team conducted an AoA to find the best alternative that would achieve DAS capabilities the stakeholders need. To do this, a number of alternatives were identified. The team determined that the most effective alternatives were to either build a brand new system, or to modify and improve an existing system to meet the needs of the stakeholders. Due to the number of existing Distance Support systems that currently exist, the team had to reduce the number of possible systems. The team defined a number of evaluation measures and metrics so each system's performance could be assessed based on their current capabilities. Stakeholders were asked to complete a swing weight matrix to determine their preference weight for each requirement. Then three QFD HOQs were used to reduce the number of possible existing systems to four. A gap analysis was performed to determine that the existing system with the least amount of functional gaps was ESDS. Cost Analysis was conducted using COSYSMO to compare the two alternatives, either 1) modify ESDS (ESDS+) or 2) build a new system. The results showed that ESDS+ would cost 60% less than building a new system. Thus, if the SE hourly cost was estimated to be $50 per hour, ESDS+ would cost $680,000 and the new system would cost $2,064,000 to develop. From Risk Analysis, Expert COSYSMO showed that ESDS+ had less risk issues. Expert COSYSMO evaluated the total risk exposure points of ESDS+ as 44.7 and the new system as 45.7.

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# IV. SYSTEM ARCHITECTURE DESIGN

The third step in the SE process was to develop the system architecture of DAS. To do this, first the team defined the requirements which translated from the stakeholder's needs then traced the requirements to the system functions, allocated the functions to the components and established all the relationships between the functions and components. The team utilized Vitech's CORE® software suite to document the functional architecture and the analysis as discussed in Chapter III. Then, DoDAF products were created to describe the DAS architecture in the graphical and tabular presentation. The team used the DAS architecture to instantiate the ESDS+ architecture, which would be based on augmenting the current ESDS architecture.

## A. ARCHITECTURAL DEVELOPMENT APPROACH

The system architecture was developed using a top-down functional decomposition and allocation approach. According to Buede,

> The functional architecture of a system contains a hierarchical model of the functions performed by the system, the system's components, and the system configuration items; the flow of informational and physical items from outside the system through the transformational processes of the system's functions and on to the waiting external systems being serviced by the system; a data model of the system's items; and a tracing of input/output requirements to both the system's functions and items (Buede 2009, 211).

IDEF0 was used as the graphical process modeling technique to represent the functional architecture of the DAS. IDEF0 modeling was chosen because IDEF0 has well-defined, standardized syntax and semantics that distinguish between the inputs to be transformed into outputs and the control information that guides the transformation process. In addition, the IDEF0 is capable of representing the physical architecture, namely the mechanism within IDEF0 (Buede 2009). Specific IDEF0 modeling details can be found in the 2009 National Institute of Standards and Technology, *Integration Definition for Function Modeling (IDEF0)*. An example of IDEF0 syntax is shown in Figure 45.

The primary elements of IDEF0 diagrams captured within this document are summarized as follows:

- Function–a transformation of *inputs* to *outputs*, by means of some *mechanis*m, and subject to certain *controls*, that is identified by a function name and modeled by a *box*
- Box–a rectangle containing a verb or verb phase and representing a function in a diagram
- Input–represents what is transformed or consumed by the function to produce the function's output
- Control–represents conditions that must be met before the function can produce correct output; used as the stimulus for the response (e.g. tasking, orders, requests)
- Output–represents what is produced by the function
- Mechanism–represents the mechanism for the function or in other words, the means to carry out the function.

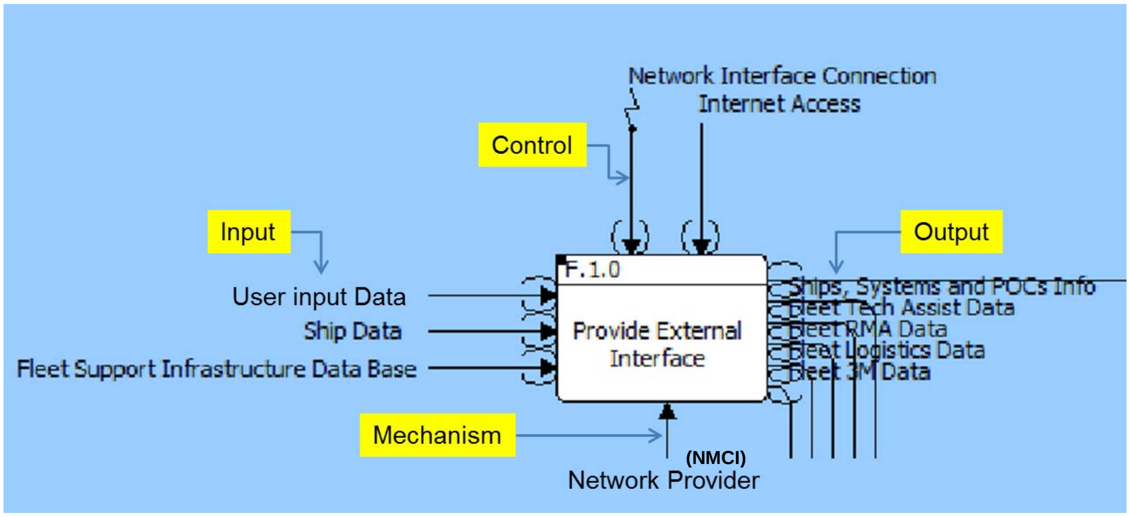


**Figure 45. IDEF0 Syntax Example**

The methodology for developing the architecture followed a hierarchal approach. DoDAF products were used extensively throughout the development of the DAS architecture. DoDAF is widely used by organizations developing system solutions for the DoD. From the *Architecture Framework Version 2.0, Volume 1: Introduction, Overview, and Concepts, Managers Guide*, DoDAF V2.0 is defined as the "overarching, comprehensive framework and conceptual model enabling the development of architectures to facilitate the ability of DoD managers at all levels make key decisions more effectively" (DoD 2009, 2). Since this project's SE process would not follow the entire V-shaped pattern of the 2009 DoD SE Model, not every DoDAF product was created for this project. The DoDAF products created were limited to the Operational and System Views and only the products that were applicable to the DAS architecture and within the scope of the capstone project. All other DoDAF products were deferred to future work. As illustrated in Figure 46, all of the Operational Views (OV), including: 1) Operational View (OV-1), 2) Operational Node Connectivity View (OV-2), 3) Operational Activity View (OV-5), and 4) Operational Event Trace Description (OV-6c), were developed during the stakeholder requirement definition phase. The System Views (SV) shown in Figure 46, including: 1) System Interface Description (SV-1), 2) System Resource Flow Description (SV-2), 3) System Functionality Description (SV-4), and 4) Operational Activity to System Function Traceability Matrix (SV-5a), were generated to facilitate the requirements analysis and architecture design.

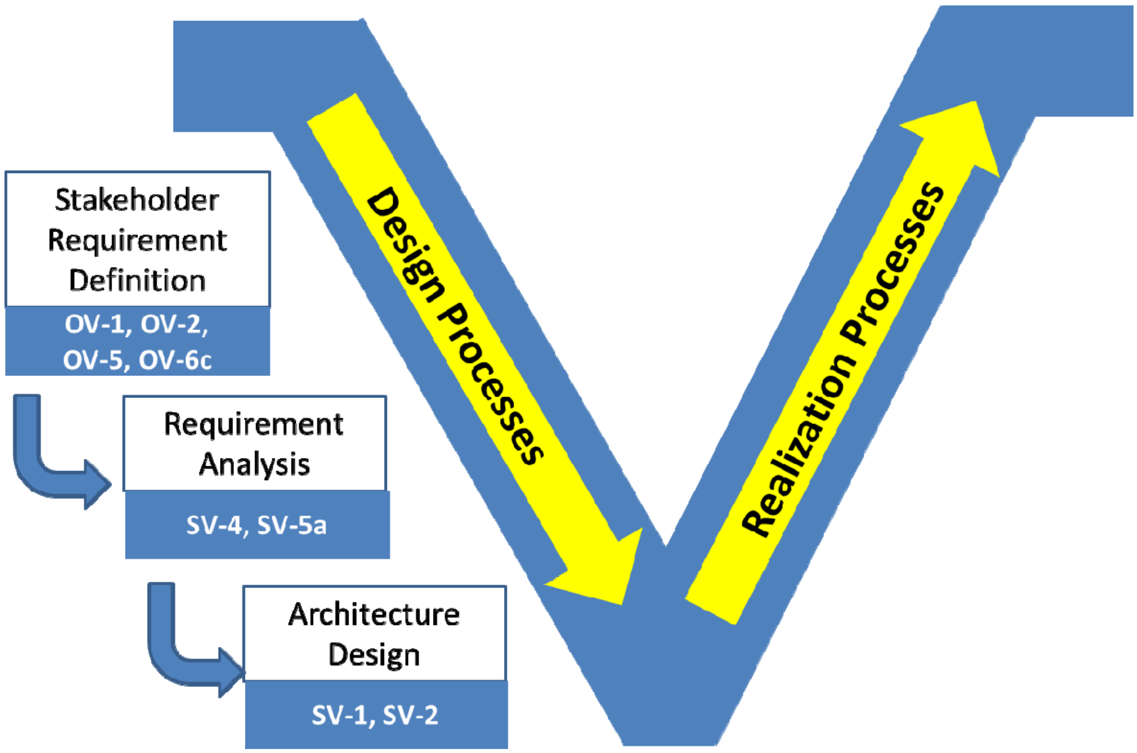


**Figure 46. DoDAF Products Development Mapped to SE Process**

The DoDAF products were built based on the sequence depicted in Figure 47. The build sequence was derived from "DoDAF Architecture Framework, Example Build Process" by Don Muehlbach, Ph.D. Each view builds on previous views and can result in the refinement of prior views as the architecture matures. The OV-1 illustrates the high level operational view of USN surface fleet conducting Distance Support in which the DAS is considered a subsystem of the overall Distance Support System of Systems (SoS). The OV-5 depicts and decomposes the DAS operational activities necessary to support that mission. The OV-2 shows the connections and information flows among various entities (nodes) needed to execute those activities. The OV-6c reveals the time sequence of the decomposed activities. The SV-5a maps the decomposed operational activities to system functions (and, by extension, to systems). The SV-4 shows the connections and information flows among the system functions. The SV-1 describes interfaces required among systems to perform assigned functions. The SV-2 specifies the system resource flows between the systems.

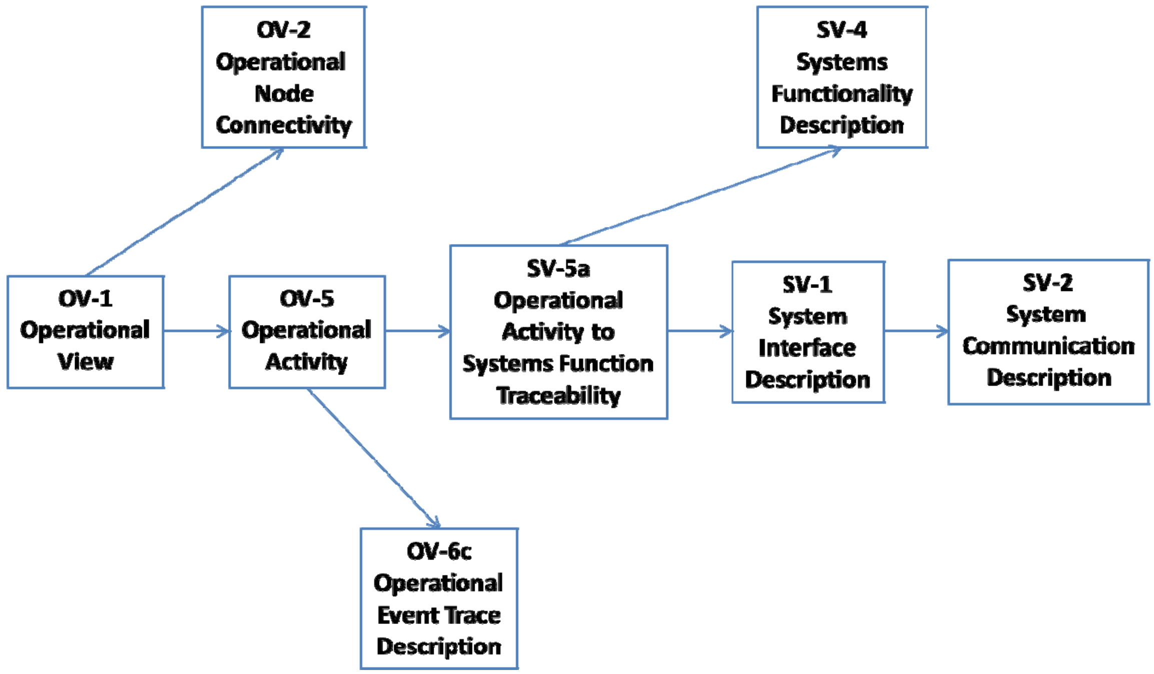


**Figure 47. DoDAF Products Build Sequence**

Table 15 provides the product name and a brief definition of all the DoDAF views that were developed and documented as the architecture artifacts for this project.

| Department of Defense Architecture Framework (DoDAF) Product | DoDAF Product Name | General Description |
|---|---|---|
| OV-1 | High Level Operational Concept Graphic | High level graphical/textual description of operational concept |
| OV-2 | Operational Node Connectivity Description | Operational nodes, connectivity, and information exchange need lines between nodes |
| OV-5 | Operational Activity Model | Capabilities, operational activities, relationships among activities, inputs, and outputs, overlays can show cost, performing nodes, or other pertinent information |
| OV-6c | Operational Event Trace Description | One of the three products used to describe operational activity - identifies business rules that constrain operation |
| SV-1 | Systems Interface Description | Identification of system nodes, systems, and system items and their connections, within and between nodes |
| SV-2 | Systems Communications Description | System nodes, systems, and system items, and their related communication lay-down |
| SV-4 | Systems Functionality Description | Functions performed by systems and the system data flows among system functions |
| SV-5a | Operational Activity to Systems Function Traceability Matrix | Mapping of systems back to capabilities or of system functions back to operational activities |

**Table 15. DoDAF Products Description**

## B. OPERATIONAL ARCHITECTURE

### 1. Operational View (OV-1)

The DAS will be used as a Distance Support tool in a collaborative secured environment where the data will be accessed and shared by multiple entities including ships at sea and shore based support infrastructure. Figure 48 illustrates the high level concept of operation of the DAS hosted by NSWC PHD where ships communicate with shore based infrastructure via satellite communication (SATCOM) in real time or near real time as parts of Distance Support with respect to six different functions of Distance Support as indicated at the bottom of the diagram.

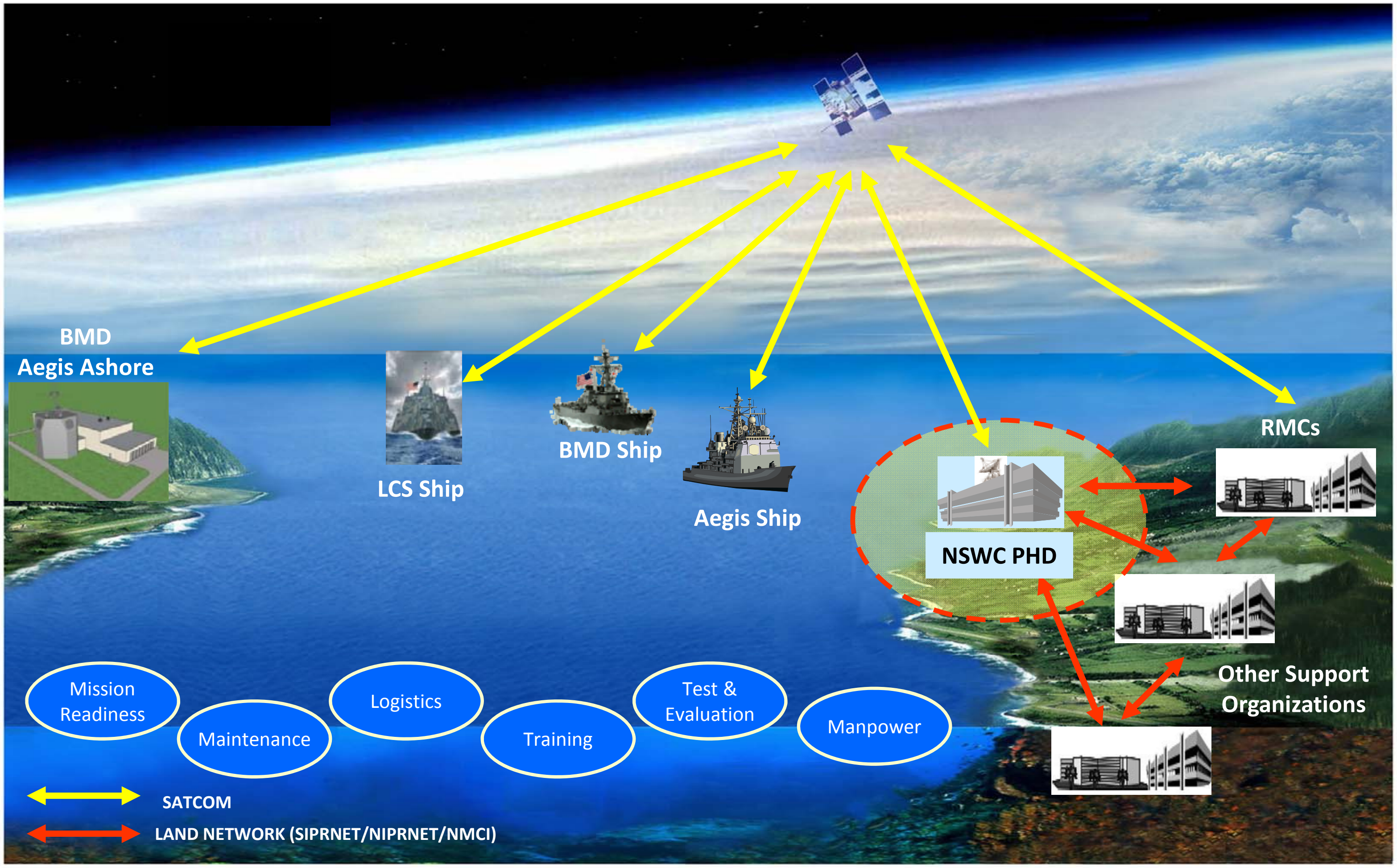


**Figure 48. Distance Support Operational View (OV-1)**

### 2. Operational Nodes Connectivity (OV-2)

The Operational Nodes Connectivity as shown in Figure 49 illustrates the data required for aggregation in support of Distance Support are exchanged between the DAS located at NSWC PHD to the external nodes through a series of existing unclassified and classified networks, a level of interconnectivity currently employed by the Navy today.

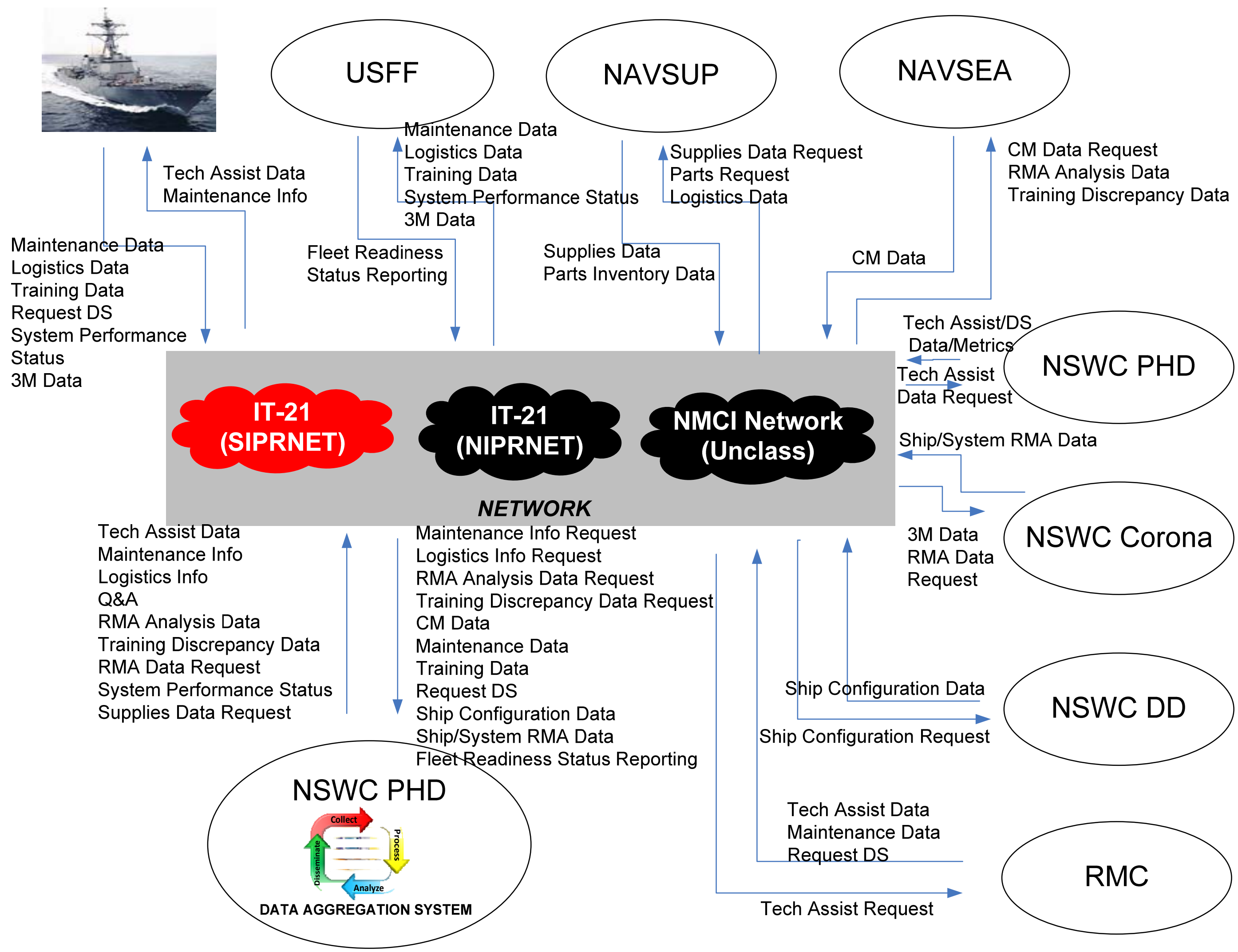


**Figure 49. Operational Nodes Connectivity (OV-2)**

### 3. External Interface

The external interface between the DAS and other systems and/or databases, where the maintenance and logistics data is generated by the ship, will be collected by DAS through multiple data sources residing in different organizations. The new data exchange is illustrated in dotted arrows in Figure 50 while the solid arrows indicated the current process that is executed in the Navy support infrastructure today.

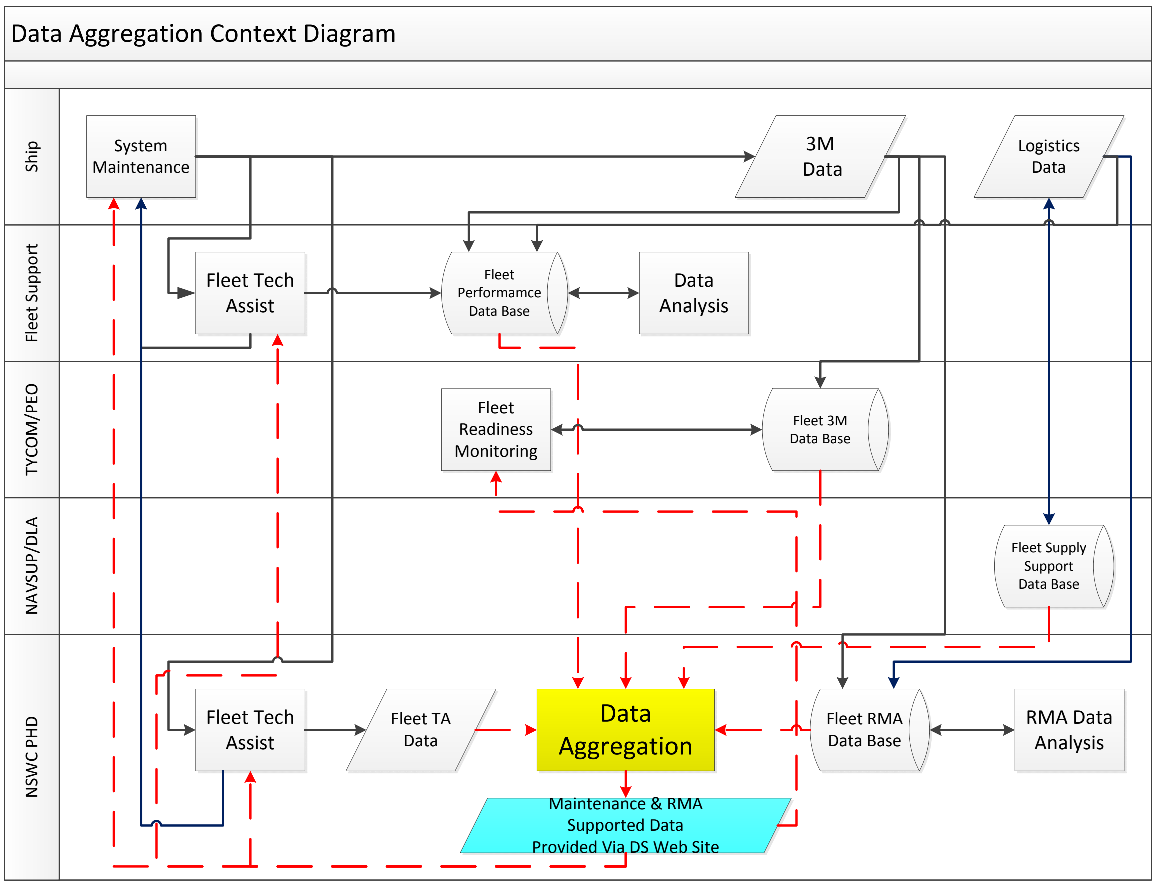


**Figure 50. DAS External Interface Diagram**

### 4. Operational Activities (OV-5)

The next step in the architectural development phase was the creation of the Operational Activity Model (OV-5) shown in Figures 51 and 52. Due to the size of Figure 51, Figure 52 was provided to show an enlarged figure focused on the Analyze Data, Disseminate Self Help Corrective Maintenance Data, and Disseminate RMA

Trends Data blocks. This approach decomposed all of the functions into their component operations. The OV-5 system was modeled using the IDEF0 format to better illustrate the flow of key elements necessary for the system to accomplish its mission. The main activities are: 1) Establish Network Connection, 2) Collect Data, 3) Process Data, 4) Analyze Data, 5) Disseminate Self Help Corrective Maintenance Data and 6) Disseminate RMA Trends Data. Each activity consists of nodes that have input, output, control, and mechanism flows going into and out of each node.

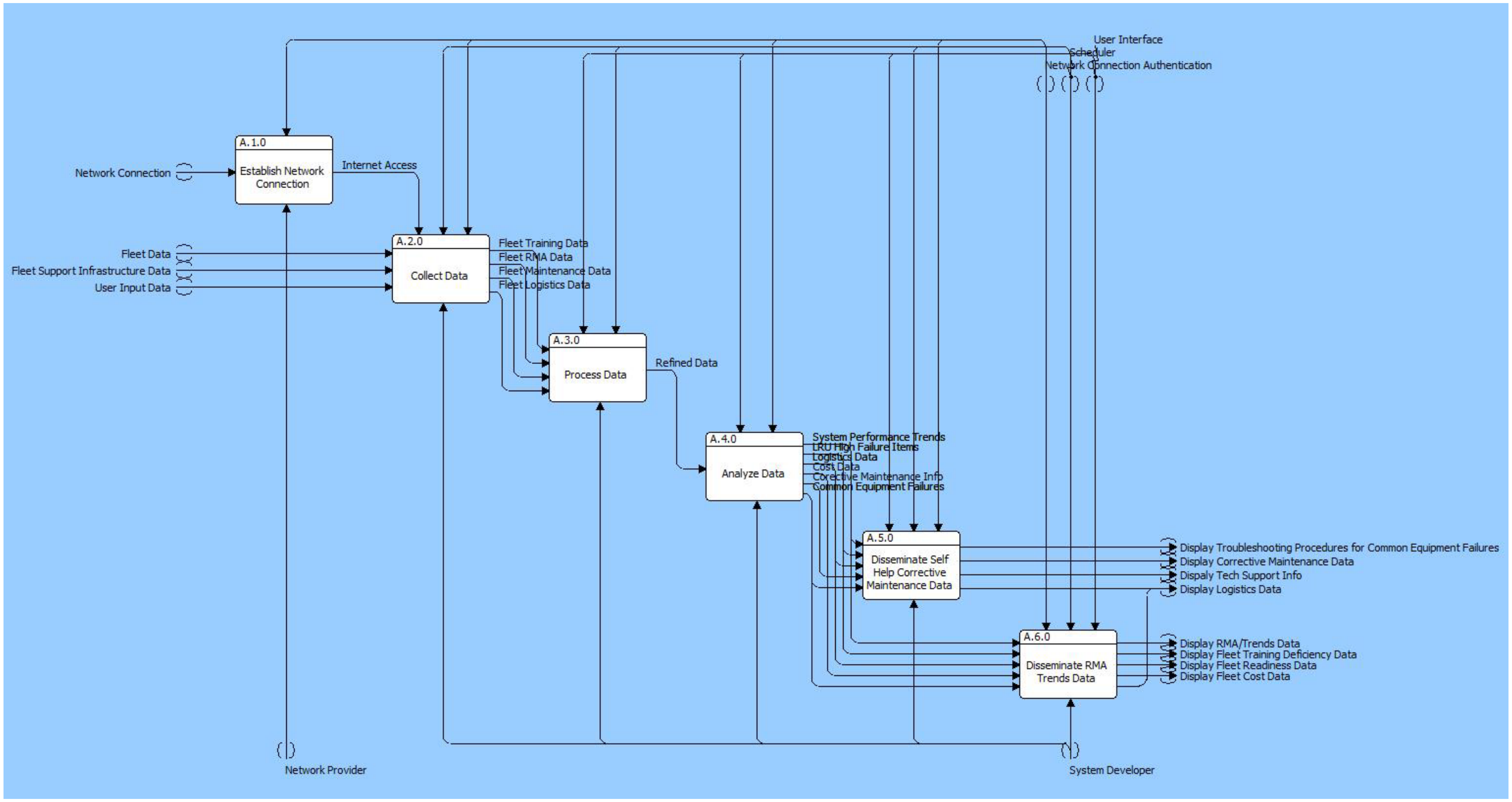


**Figure 51. Operational Activities (OV-5)**

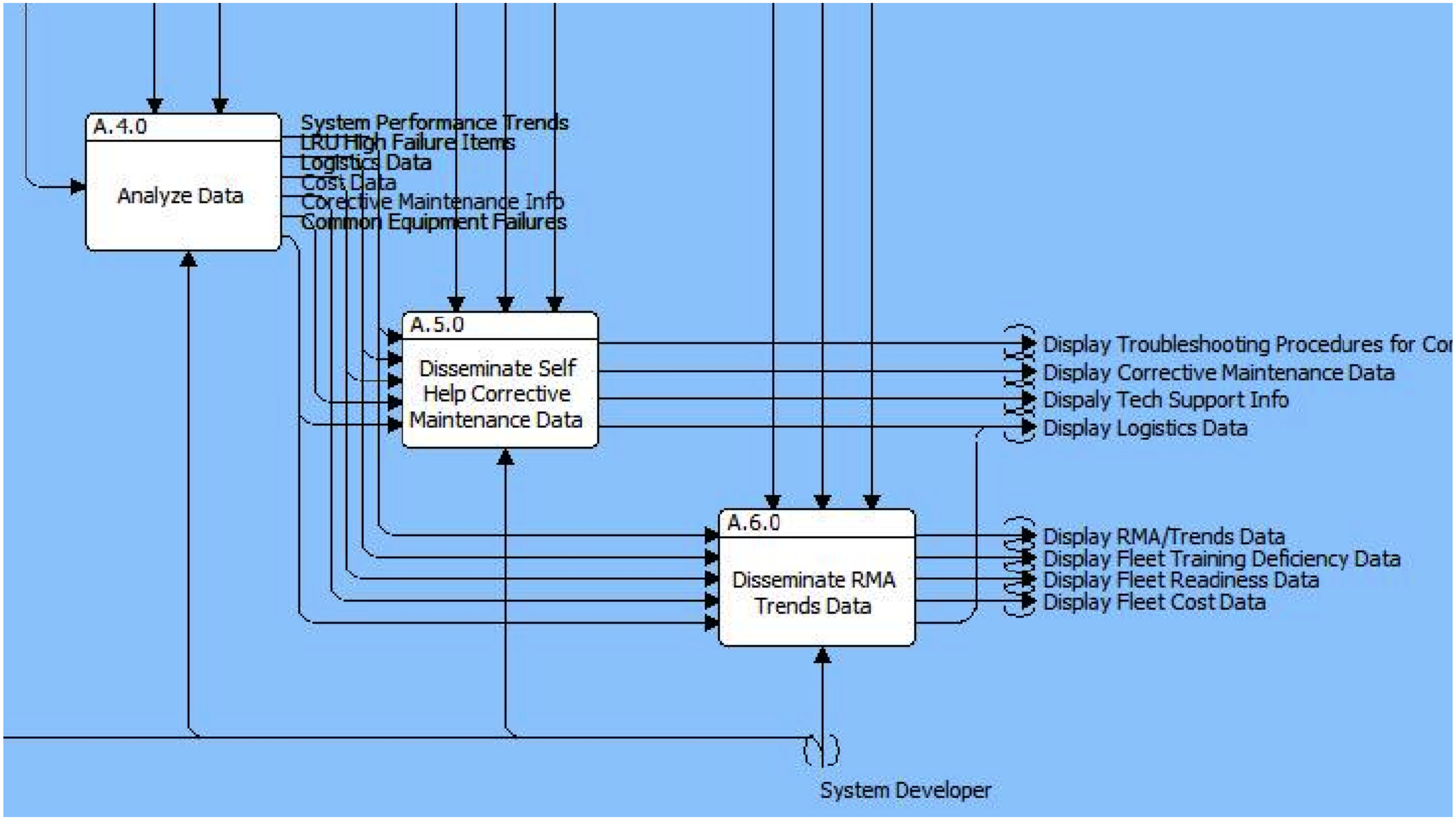


**Figure 52. Enlarged Operational Activities (OV-5)**

The first node is to "Establish Network Connection" (A.1.0). This allows the DAS to connect and aggregate data from other fleet support infrastructure systems and/or databases by an Internet connection provided by network providers such as NMCI or Navy Information Technology for the 21st Century (IT-21). After the network connection is established, the data (fleet data, fleet support infrastructure data, and user input data) will be collected via the "Collect Data" node (A.2.0) either automatically (scheduled) or manually (from the user interface). The "Collect Data" node will filter the data into different categories such as 1) fleet training data, 2) fleet RMA data, 3) fleet maintenance data, and 4) fleet logistics data. The collected data is then sent to the "Process Data" (A.3.0) node for refinement. The fourth node is "Analyze Data" (A.4.0). At this node, all the data will be analyzed to generate multiple end products such as 1) System Performance Metrics, 2) Corrective Maintenance Solution, 3) Predictive Trends Analysis, and 4) Life Cycle Cost Metrics that will be sent to the "Disseminate Self Help Corrective Maintenance Data" (A.5.0) node and the "Disseminate RMA Trends Data" (A.6.0) node to make the data available for the stakeholder access either in the form of a report or a display on NSWC PHD web pages.

### 5. Operational Event Trace Description (OV-6c)

The Operational Event Trace Description (OV-6c) is a graphical method of describing the operational activities or functions that are performed by the operational nodes through a scenario or a sequence of events with respect to time. As depicted in Figure 53, the event starts with the "Establish Network Interface" function, which is performed automatically by all the nodes through a series of Navy enterprise network connections including Navy IT-21 and NMCI. After the connections are established, the data from the fleet and fleet support infrastructure databases are sent to DAS though the external functions "Distribute Ship Data" and "Distribute Fleet Support Data" (the analysis of these functions are not within scope of this project). The next events are executed by the functions within DAS that include: 1) "Obtain Data," 2) "Process Data," 3) "Analyze Data," 4) "Report Data," 5) "Display Data," and 6) "Print and Save Data." After the data is aggregated, processed, and analyzed, the output data will be made available through the NSWC PHD Portal for the ships and stakeholders to get access via the "Access Data" function. (The "Access Data" function is not covered in this report due to the limited scope of this project).

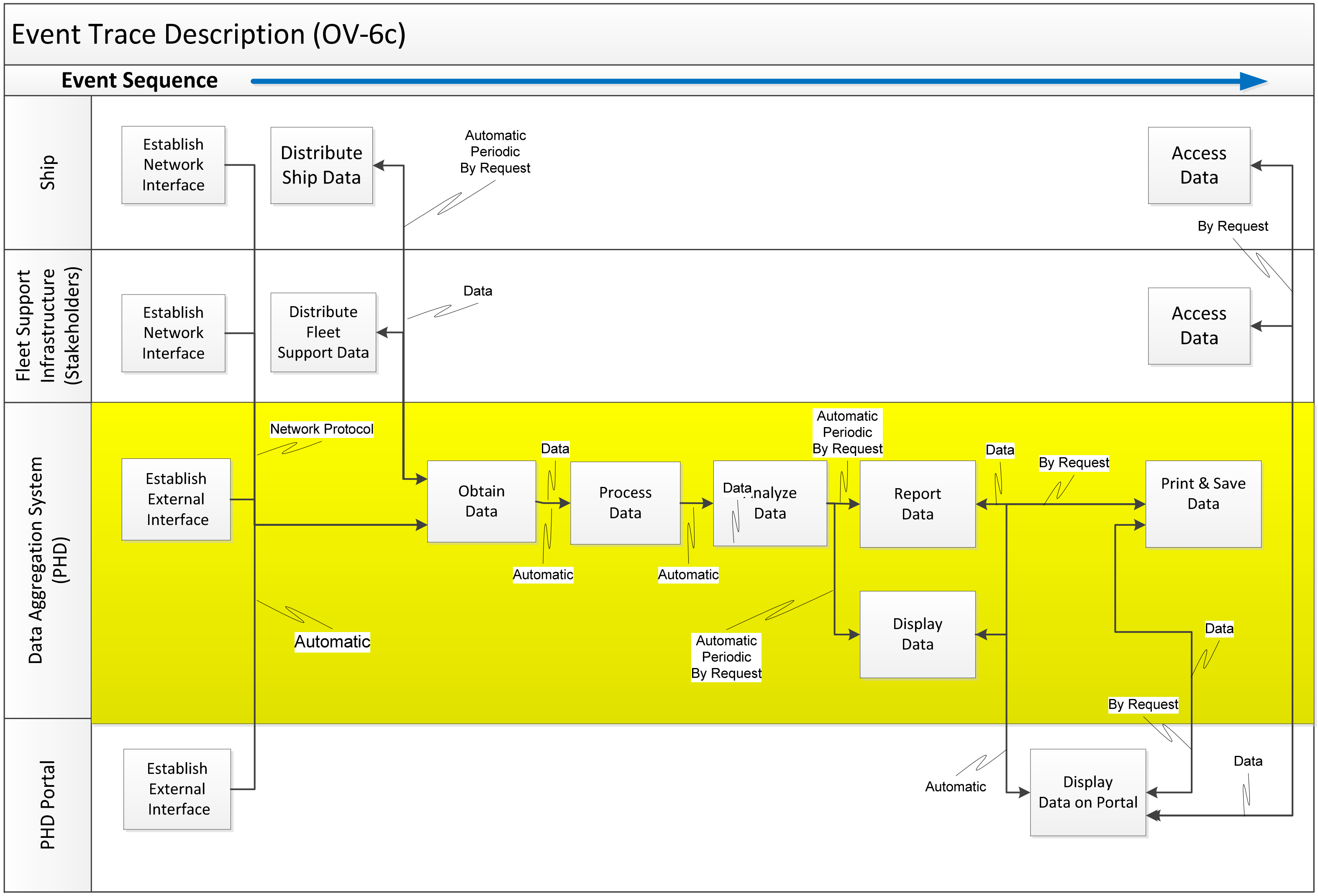


**Figure 53. Operational Event Trace Description (OV-6c)**

## C. FUNCTIONAL ARCHITECTURE

### 1. System Functionality Description (SV-4)

In continuation of the architectural development phase, the DAS Functionality Description (SV-4) was created as shown in Figure 54. The goal of the SV-4 was to specify the functional decomposition the data flows among the functions that the DAS must perform. As defined in DoDAF V2.0 Volume 2, *Architecture Data and Model, Architect's Guide*, which is dated 28 May 2009, the purposes of the SV-4 are to "develop a clear description of the necessary data flows that are input (consumed) by and output (produced) by each resource, to ensure that the functional connectivity is complete, and to ensure that the functional decomposition reaches and appropriate level of detail" (DoD 2009, 206). The focus of the SV-4 was on the functions themselves and the order in which they occur. It was necessary to create a SV-4 since a system's functions drive its architecture, or in other words, form follows function. In addition to providing a deeper understanding of what functions DAS must perform, the SV-4 fed input data into other architectural products such as the functional allocation matrices and the SV-5a. DoDAF does not specify what functional modeling language must be used for the SV-4. A top down approach was used to create the SV-4 diagram which each "swim lane" lies across horizontally in the diagram representing the high level system functions. The SV-4 was created within the context of the OV-1, OV-5, and system boundary diagram. The functions included in the SV-4 needed to allow the DAS to meet the mission described by the OV-1. They also needed to be aligned to some operational activity within the OV-5.

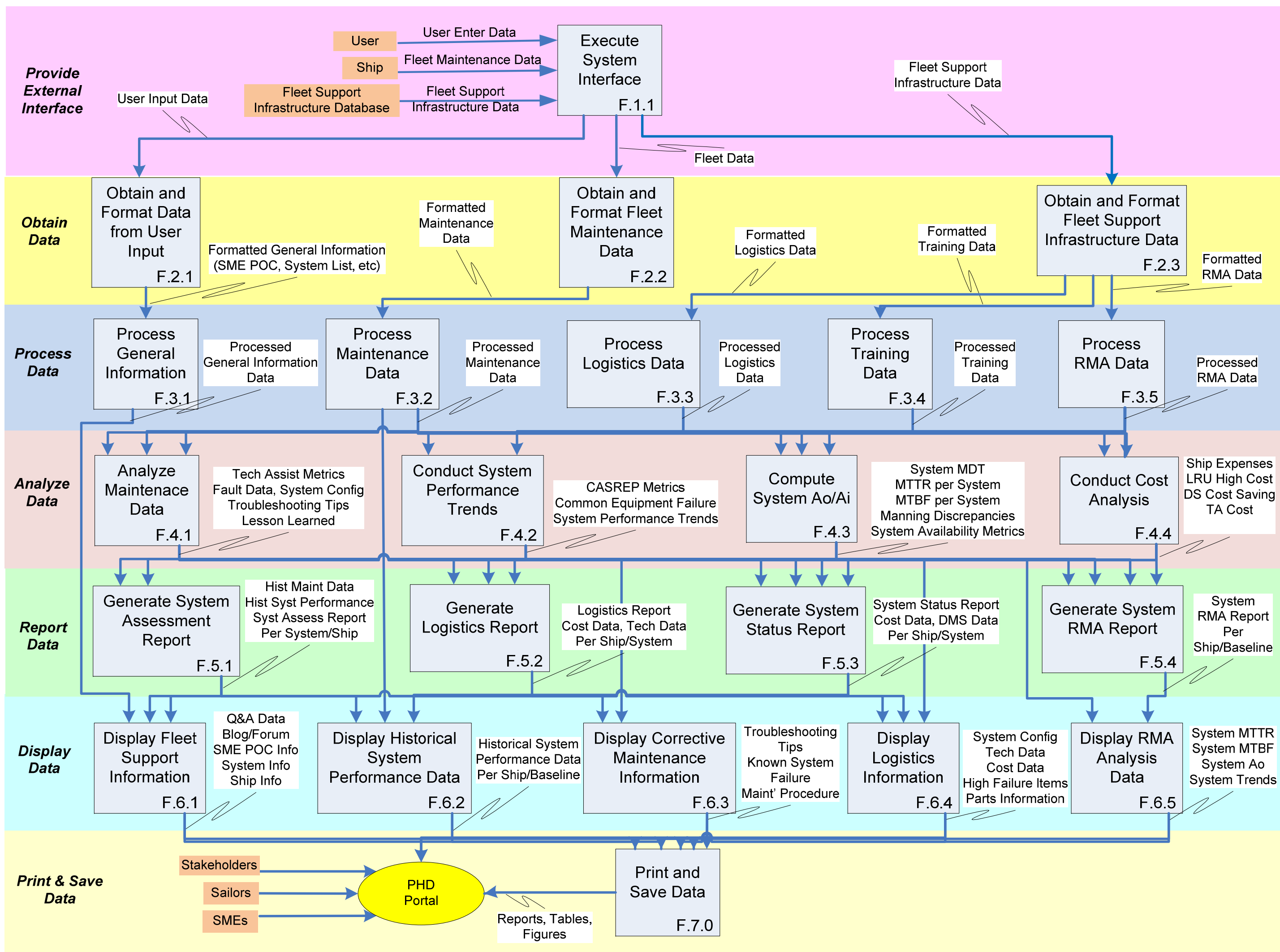


**Figure 54. System Functionality Description (SV-4)**

### 2. System View of Operational Activity to Systems Function Traceability Matrix (SV-5a)

The Operational Activity to System Function Traceability Matrix (SV-5a) identifies activities and the associated system functions required by DAS to perform the activities successful. The SV-5a relates system functions from the SV-4 to the operational activities from the OV-5. The SV-5a illustrates how the system functions support DAS capability, thus identifying the transformation of an operational need into a purposeful action performed by DAS. Figure 55 shows the mapping between an operational activity and a system function denoted by a dot to assess the status of the system function.

| | Function | Operational Activity: A1.0 Establish Network Connection | A.2.0 Collect Data | A.3.0 Process Data | A.4.0 Analyze Data | A.5.0 Disseminate Self Help Corrective Maintenance Data | A.6.0 Disseminate RMA Trends Data |
|---|---|---|---|---|---|---|---|
| F.0 | Provide Data Aggregation Capability | | | | | | |
| F.1.0 | Provide External Interface | • | | | | | |
| F.1.1 | Execute System Interface | • | | | | | |
| F.2.0 | Obtain Data | | | | | | |
| F.2.1 | Obtain Data from User Inputs | | • | | | | |
| F.2.2 | Obtain Data from Fleet | | • | | | | |
| F.2.3 | Obtain Data from Fleet Support Infrastructure | | • | | | | |
| F.3.0 | Process Data | | | | | | |
| F.3.1 | Process General Information | | | • | | | |
| F.3.2 | Process Maintenance Data | | | • | | | • |
| F.3.3 | Process Logistics Data | | | • | | | • |
| F.3.4 | Process Training Data | | | • | | | • |
| F.3.5 | Process RMA Data | | | • | | | • |
| F.4.0 | Analyze Data | | | | | | |
| F.4.1 | Analyze Maintenance Data | | | | • | • | • |
| F.4.2 | Conduct System Performance Trending Analyis | | | | • | | • |
| F.4.3 | Compute System Ao/Ai based on RMA data | | | | • | | • |
| F.4.4 | Conduct Cost Analysis | | | | • | | • |
| F.5.0 | Report Data | | | | | | |
| F.5.1 | Generate System Assessment Report | | | | | • | • |
| F.5.2 | Generate Logistics Report | | | | | | • |
| F.5.3 | Generate System Status Report | | | | | • | • |
| F.5.4 | Generate System RMA Report | | | | | | • |
| F.6.0 | Display Data | | | | | | |
| F.6.1 | Display Fleet Support Information | | | | | • | |
| F.6.2 | Display Historical Fleet Data | | | | | • | • |
| F.6.3 | Display Corrective Maintenance Information | | | | | • | • |
| F.6.4 | Display Logistics Information | | | | | • | • |
| F.6.5 | Display RMA Analysis Data | | | | | • | • |
| F.7.0 | Print & Save Data | | | | | • | • |

**Figure 55. System View of Operational Activity to System Function (SV-5a)**

## D. PHYSICAL ARCHITECTURE

### 1. System Interface Description (SV-1)

As defined in DoDAF V.2.0, the system interface description (SV-1) addressed the composition and interaction of systems. The SV-1 links together the operational and systems architecture models by depicting how resources are structure and interact to realize the logical architecture specified in an OV-2. Figure 56 depicts the composition and interactions of the DAS with other systems as previously defined in OV-1 and OV-2. DAS will connect to other systems via a Transmission Control Protocol/Internet Protocol (TCP/IP).

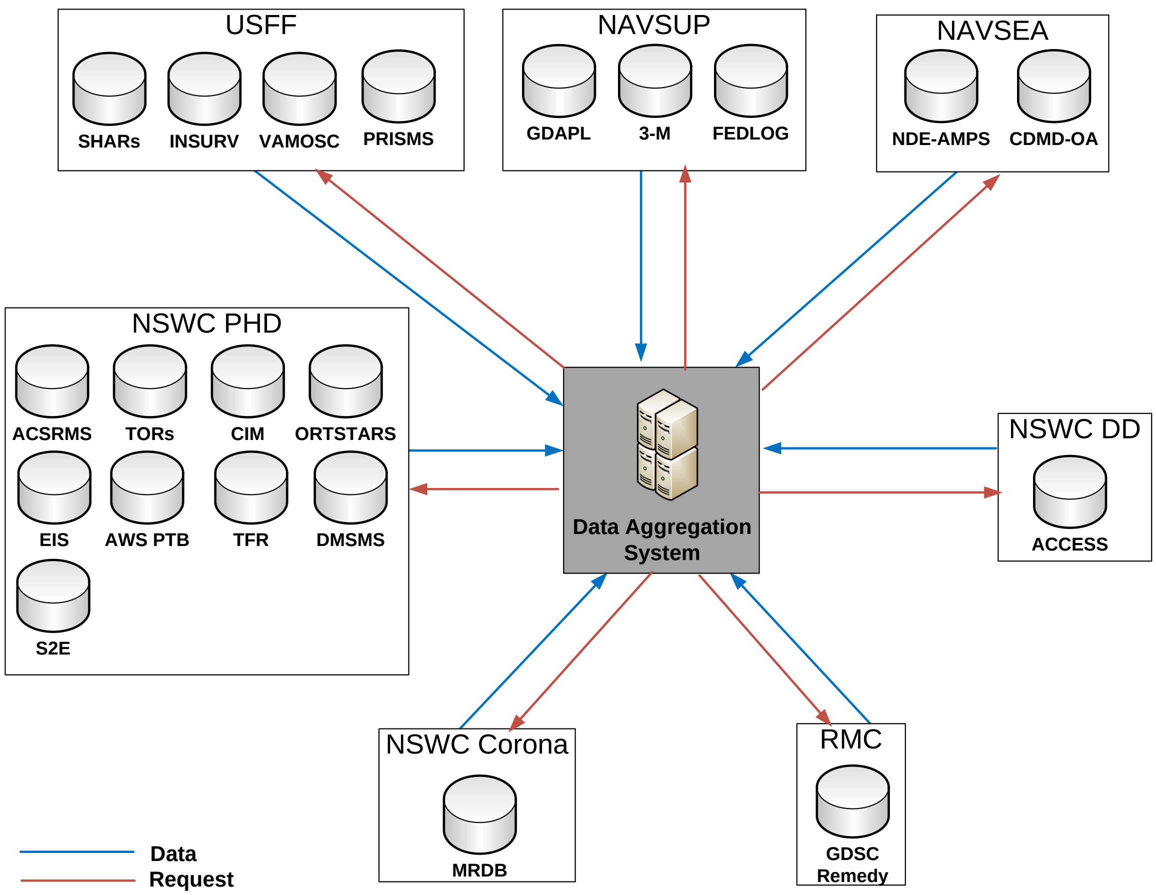


Figure 56. System Interface Description (SV-1)

### 2. System Resource Flow Description (SV-2)

The system resource flow description identifies the systems flow between systems as shown in Figure 57. The interfaces between DAS and other systems are comprised of internal and external interfaces. The internal interface is defined the interactions of the systems within NSWC PHD physical boundary. DAS interfaces with other NSWC PHD systems for display and data storage through and an unclassified NMCI network. Even though the scope of the project was only focus on unclassified data, it is considered that the classified network topology and system interface are considered very similar to unclassified environment.

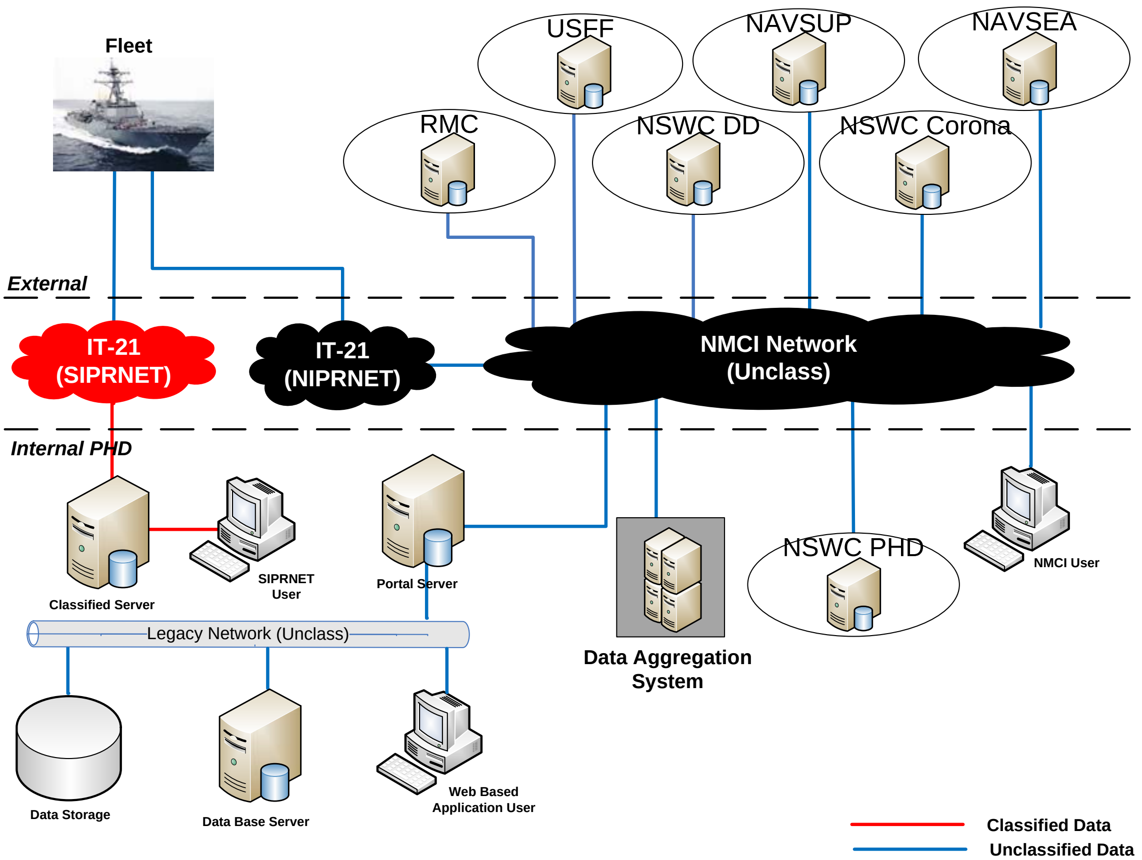


Figure 57. System Resource Flow Description (SV-2)

## E. ESDS+ ARCHITECTURE

Based on the results from the AoA previously addressed in Chapter III Section J, it is recommended that modifying ESDS will be a better solution than developing a new system based on the gap analysis, cost analysis and risk analysis that was performed. This section defines the augmented architecture of ESDS+, or the extent of the system architecture modifications that must occur to the existing ESDS, in order to meet all the functional architecture of DAS. In this report, the functions that require modifications and/or additions will be referred to as augmented functions. The approach of defining the ESDS+ architecture was based on the gap analysis between the existing ESDS and DAS functional requirements. As previously defined, the five high level functions, as shown in Figure 58, that are required additions for ESDS+ are: 1) obtain data from fleet, 2) process general information, 3) process training data, 4) display fleet support data and 5) display corrective maintenance data.

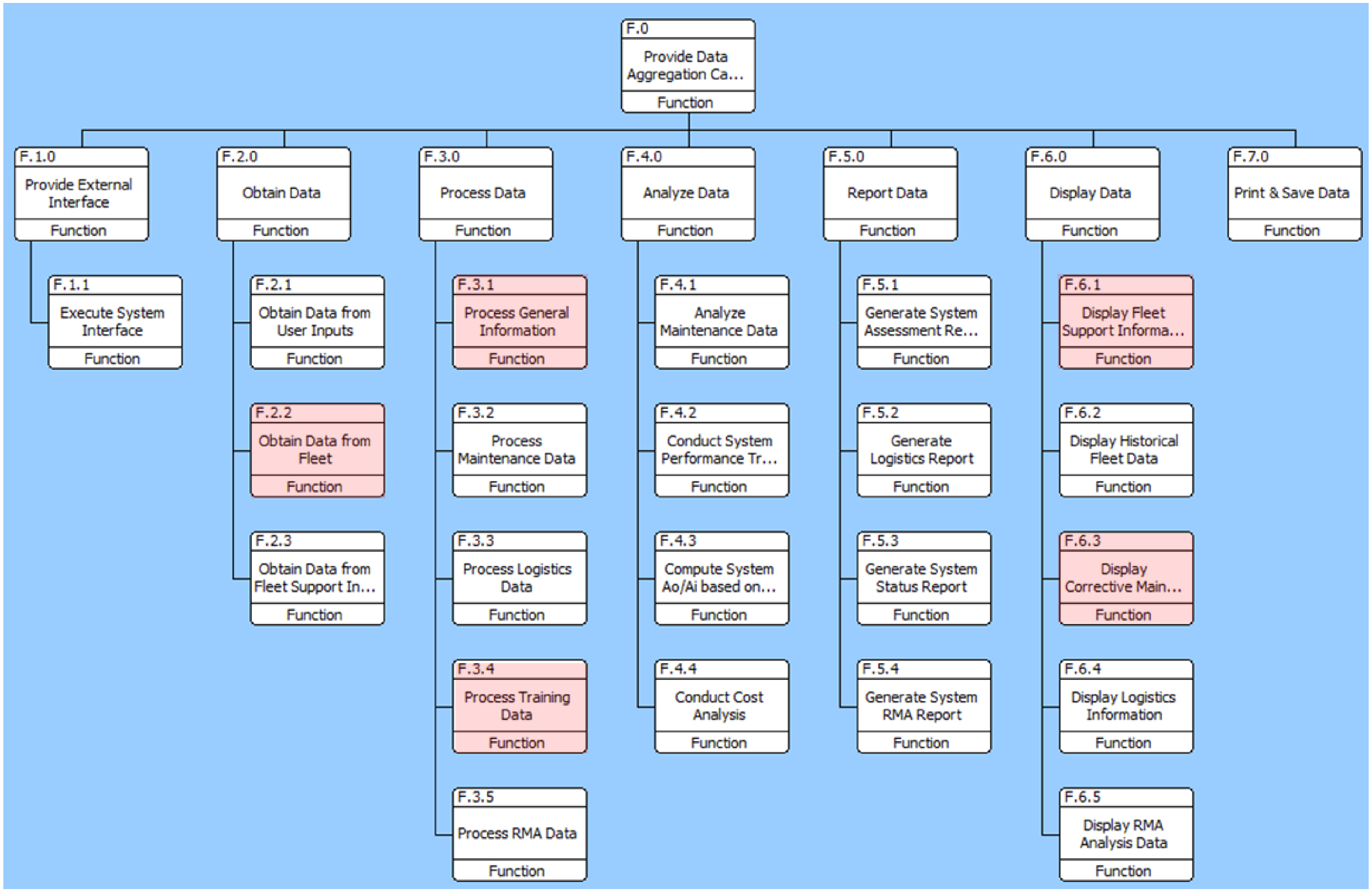


**Figure 58. Modified ESDS Augmented Functions**

In order to expand the ESDS+ architecture in further detail, each defined augmented function was decomposed to the lower level function. An IDEF0 diagram was created to show how the inputs are converted to outputs among the functions. The following paragraphs and figures will address ESDS+'s functional decomposition with its respective IDEF0 diagram. It is important to note that ESDS was designed and developed as an engineering and supportability analysis tool rather than a Distance Support tool (NSWC PHD 2009); therefore all functional gaps are mainly associated with fleet support.

### 1. Obtain Data (F.2.0)

ESDS currently does not collect data directly from the fleet. Stakeholders have expressed the need for DAS to collect remote assessment reports, ships' system performance data, and technical assistance reports. Figure 59 shows the functional decomposition of the "Obtain Data from Fleet" function while Figure 60 shows the "Obtain Data from Fleet" functional interface diagram.

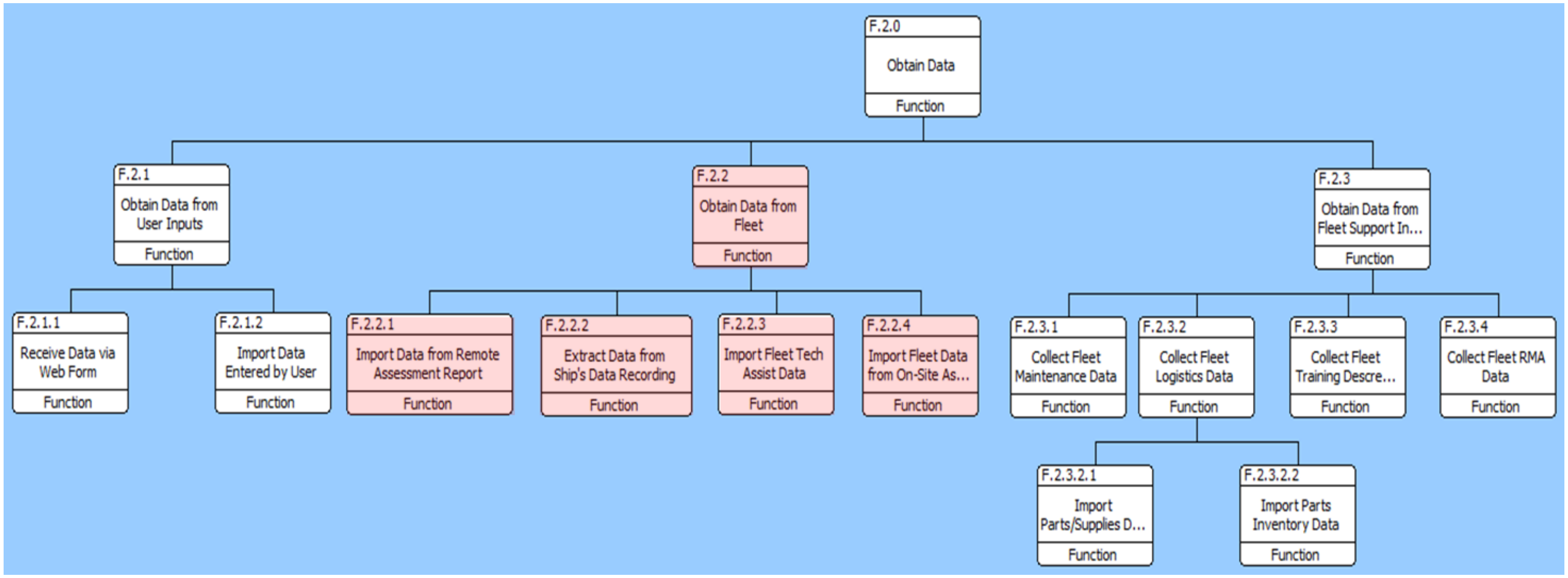


**Figure 59. Augmented Functions Obtain Data (F.2.0)**

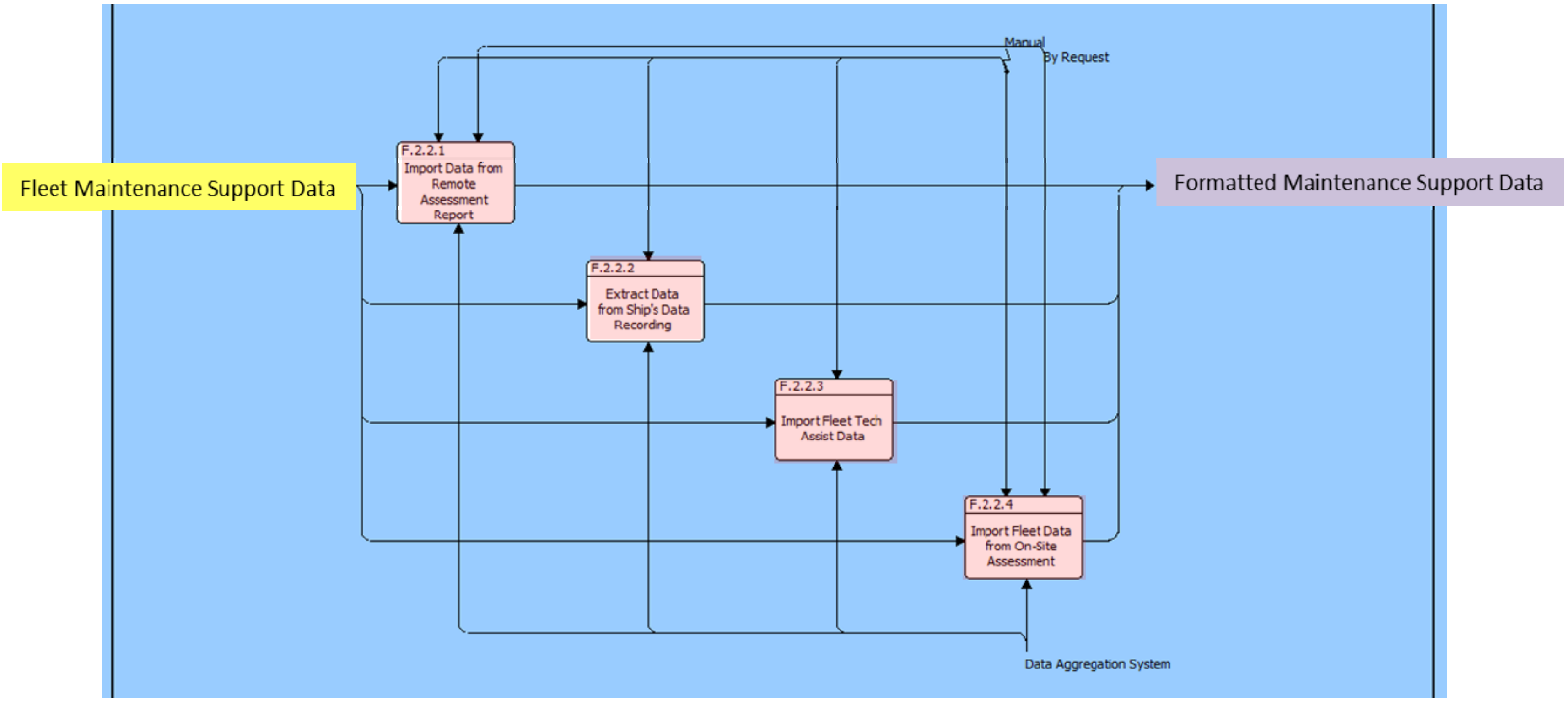


**Figure 60. Obtain Data From Fleet IDEF0 (F.2.2)**

### 2. Process Data (F.3.0)

Another ESDS functional gap was processing general information. ESDS does not collect and process general information pertaining to SMEs point of contact, ship and system description, and system configuration for instance. Figure 61 shows the decomposed "Process General Information" function. The functions that would need to be added for ESDS+ are: 1) "Provide SME POC Information by Organization and System," 2) "Provide System Information Based on a Hierarchy Structure," 3) "Provide Frequently Asked Question Data" and 4) "Provide Blog and Forum Data." The interface diagram is illustrated in Figure 62. Figure 63 shows the decomposed "Process Training Data" function. The augmented function is "Process Training Discrepancy Data."

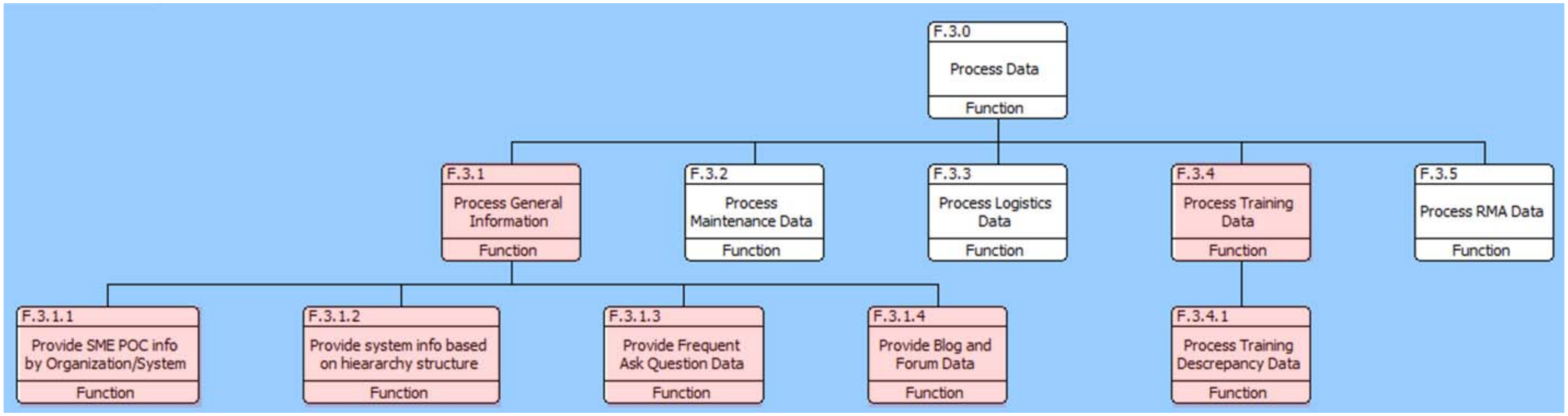


**Figure 61. Augmented Functions Process Data (F.3.0)**

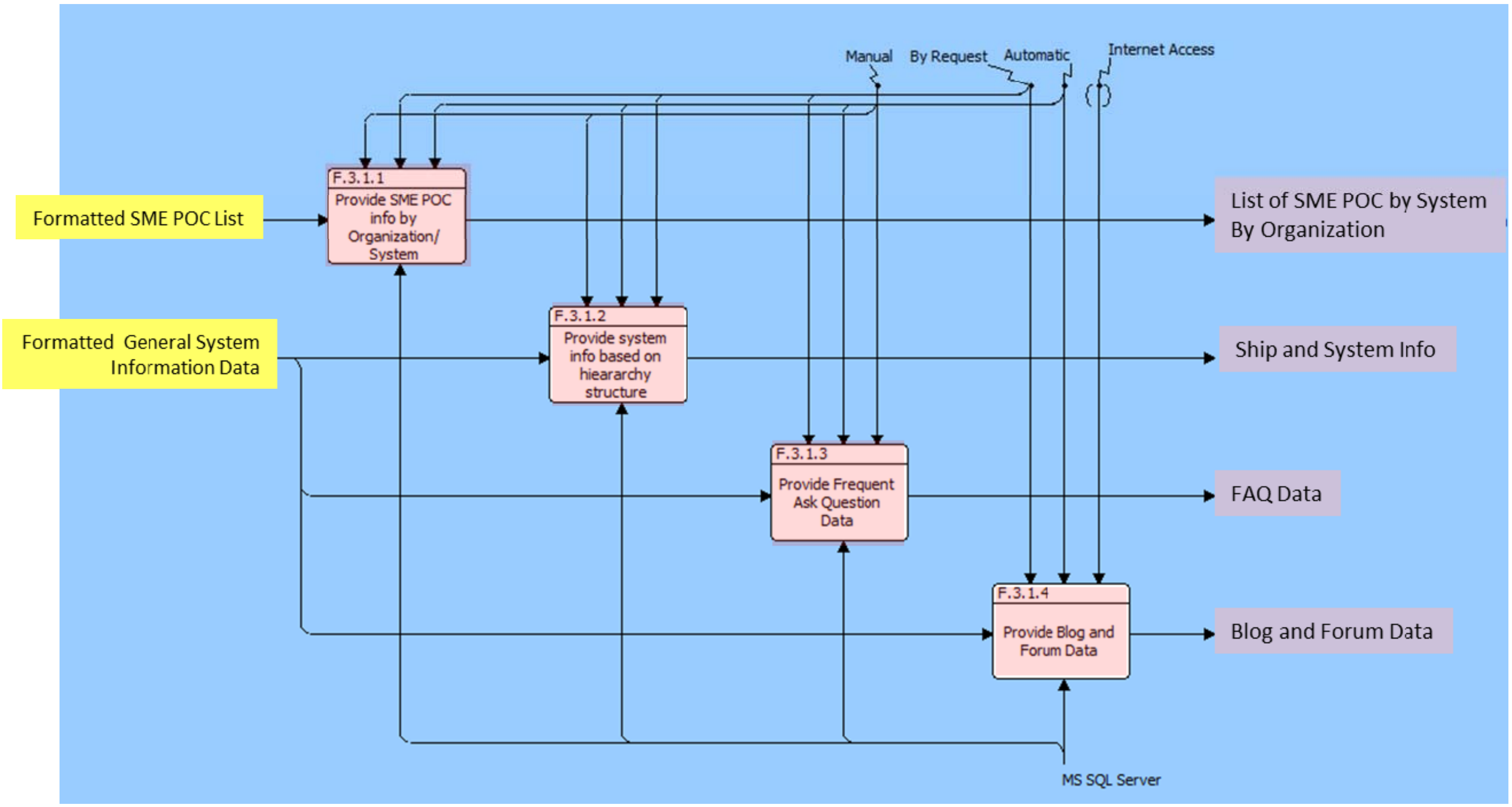


**Figure 62. Process General Information IDEF0 (F.3.1)**

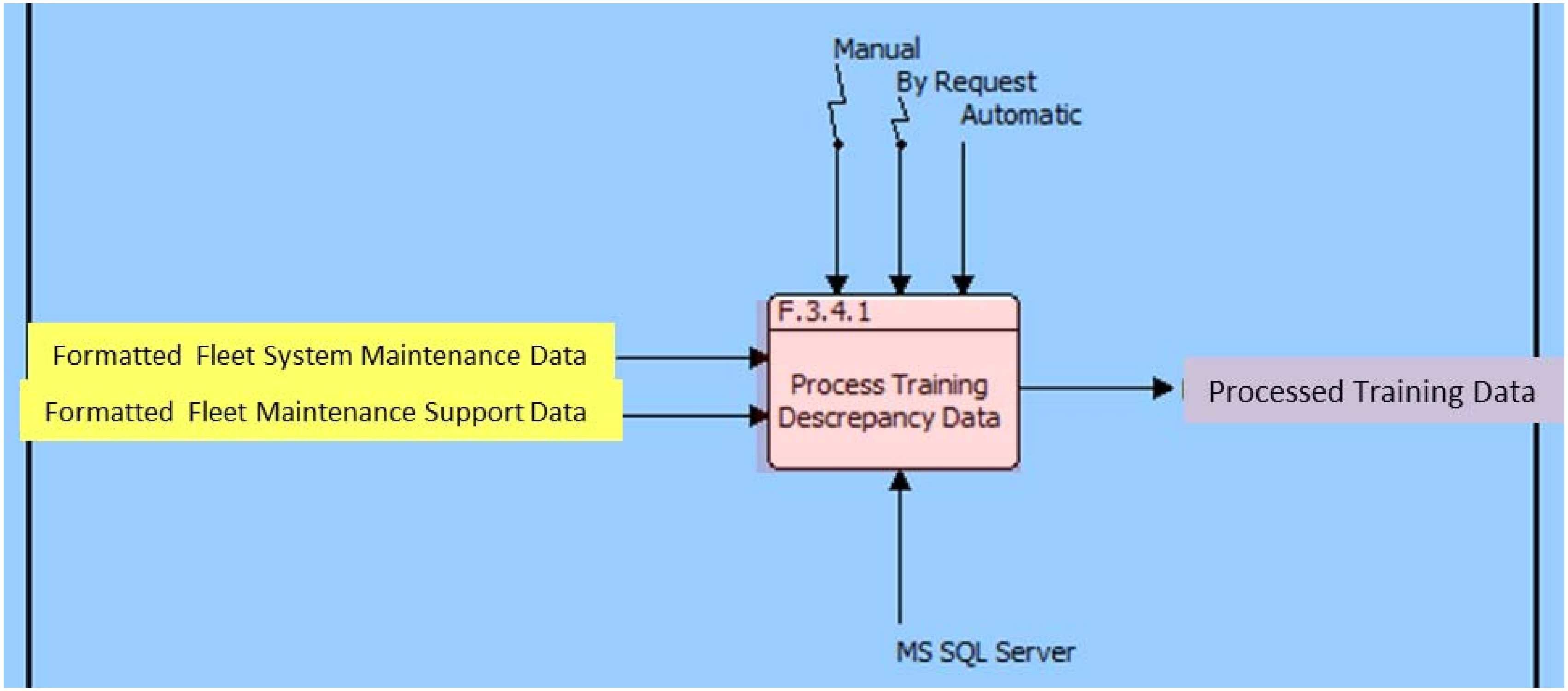


**Figure 63. Process Training Data IDEF0 (F.3.4)**

### 3. Display Data (F.6.0)

ESDS provides some information related to fleet historical data concerning logistics and RMA data that can be accessed via the NSWC PHD Portal. ESDS does not provide any information that can be used for self-help maintenance support, such as 1) a listing of SME point of contacts, 2) ship and system information, 3) troubleshooting tips, 4) frequently asked questions, 5) equipment common failure items, nor 6) forums where Sailors and SMEs can share information related to equipment maintenance. Figures 64, 65, and 66 illustrate the augmented functions for displaying data that are required for ESDS+.

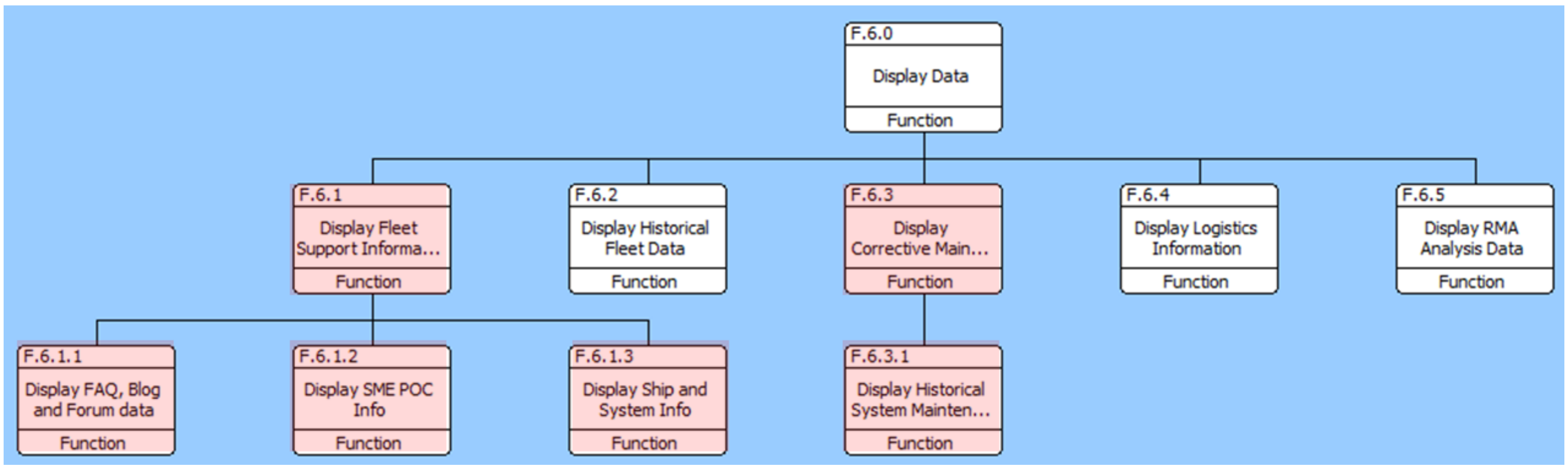


**Figure 64. Augmented Functions Display Data (F.6.0)**

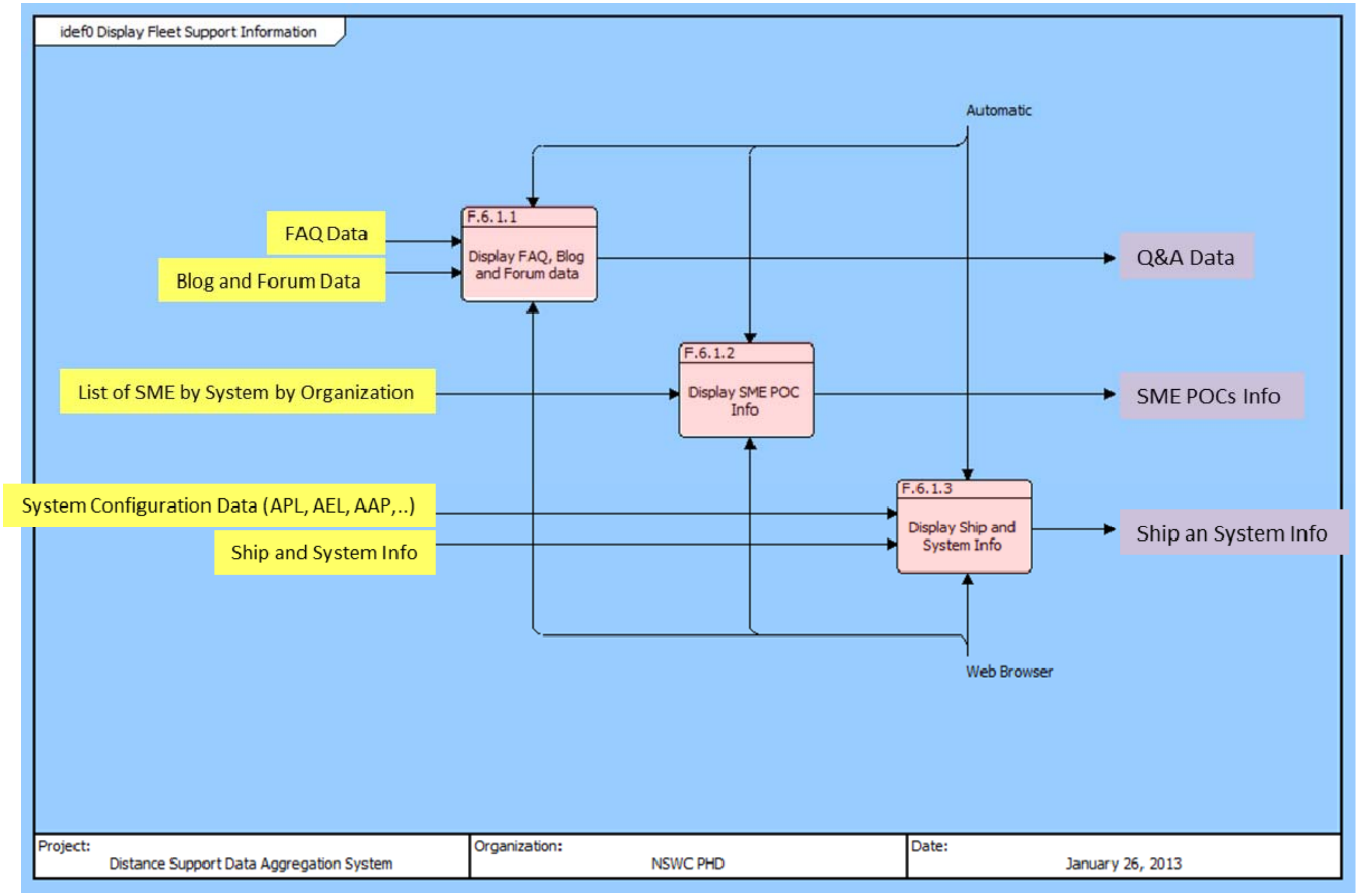


**Figure 65. Display Fleet Support Information IDEF0 (F.6.1)**

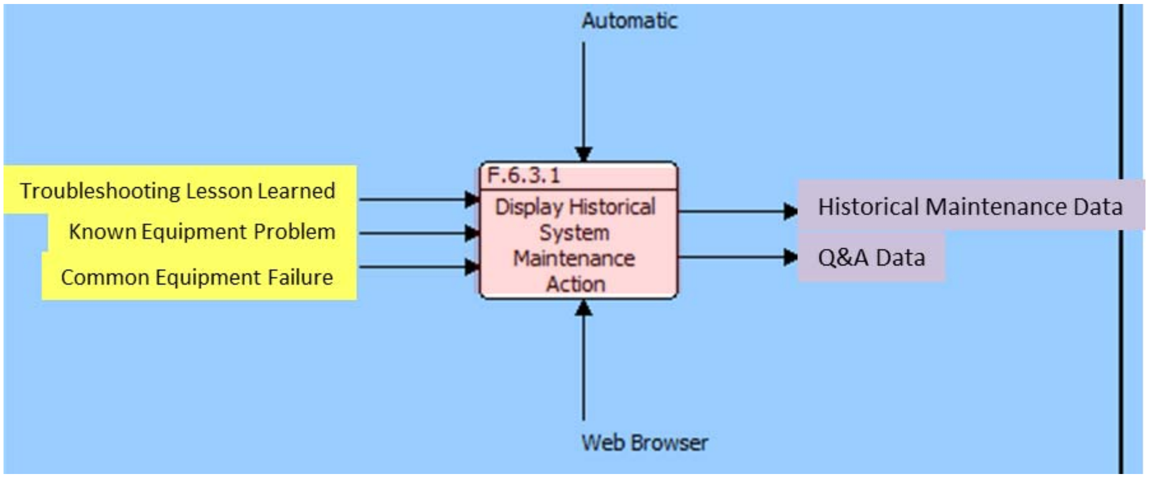


**Figure 66. Display Corrective Maintenance Information IDEF0 (F.6.3)**

## F. SUMMARY

The last step of the SE process that the team completed was to develop the architecture for DAS and ESDS+. "The ultimate goal [of a system architecture] is the generation of information for decision makers to determine what the proposed systems are likely to do, to compare these systems with related current and proposed technology, and to acquire appropriate new technologies compatible or complementary with current capabilities" (Dam 2006, 1). The team used IDEF0 to map how inputs are transformed into outputs and the controls that make it happen. The IDEF0 was used to model both the functional and physical architectures of DAS. As a means of describing the DAS architecture, a number of DoDAF products were developed. The DoDAF products were tailored to this project and thus only a limited number of Operational Views and Systems Views were produced. The DoDAF Operational Views identify the tasks and activities that need to be accomplished as well as the operational elements required to complete the DAS' mission. The DoDAF System Views depict the interconnections between software and hardware required for DAS to function. The architecture for ESDS+ was then developed based on the gap analysis that was discussed in Chapter III, the DoDAF products, and the IDEF0 model developed for DAS.

# V. CONCLUSION

## A. SUMMARY

This capstone project addressed the need for a solution to improve the Navy's current Distance Support capability, as the Navy and related stakeholders have determined that an improved Distance Support capability is necessary and will greatly benefit fleet readiness. In order to address the need for improved Distance Support, the team recommends the use of a DAS to aggregate and capture knowledge. Furthermore, the team recommends implementing the DAS by improving ESDS to provide additional functionality and significantly enhance self-help and otherwise improve Distance Support capabilities. The term "ESDS Plus" (ESDS+) has been adopted to distinguish between the current system and the preferred system.

To guide the project, the team answered the following research questions, which were developed to frame the team's research effort:

- Why is improving the Navy's Distance Support system important or necessary?
- How do others conduct Distance Support and are they effective?
- How do the stakeholders define an effective and affordable Distance Support system?
- How can the existing Distance Support system be improved or modified to increase fleet readiness and reduce TOC?

### 1. Why is improving the Navy's Distance Support system important or necessary?

This research question was important because the answers were used to develop the following problem statement:

> In recent years, the Navy's decision to reduce manning and training with the increased complexity of combat systems as new programs emerge

> have led to a decline in Sailors' ability to operate, maintain, and sustain combat systems to the levels required to meet mission readiness requirements (Balisle 2011). Numerous Distance Support tools currently used to respond to USN fleet combat system issues are often slow and ineffective. The eventual technical solutions are often not captured for knowledge retention and reutilization, nor are they available as a self-help tool for the war-fighters. Knowledge data that is captured is difficult to access and utilize in a timely manner. In addition, current Distance Support tools used by Subject Matter Experts (SME) to obtain and analyze system performance metrics are manually intensive and limited in capability.

This problem statement can be broken down into the following four sub-problems.

#### *a. Current Distance Support Tools are often Slow and Ineffective*

The stakeholders indicated that increasing the Distance Support capability has become even more important as budgets are constrained. The combat system personnel aboard USN ships are tasked to have their equipment in a mission-ready state at all times when deployed. Diagnostics on these complex systems can be lengthy, as can the typical trouble call for help from the shore-based technical support infrastructure. To improve the Distance Support process and to avoid unnecessary system down time from waiting for technical assistance from shore support, Sailors can quickly and easily search and obtain maintenance information via ESDS+ without having to contact the SME.

#### *b. Technical Solutions are often not Captured nor Available to the Fleet*

Previous NSWC PHD Distance Support studies and already completed surveys revealed that most technical issues are being responded to on a case by case basis in manner that is dependent upon the assigned SME's knowledge of the system. Any solutions discovered may not be recorded for a technical community forum to be used by other end users. ESDS+ will address this problem by collecting data directly from the fleet and displaying the data in clear and concise reports. The ability to extract and display information automatically could significantly increase Sailors' ability conduct maintenance using a self-help tool. Some examples of the topics that would be available are 1) a listing of SME points of contact, 2) ship and system information, 3) troubleshooting tips, 4) frequently asked questions, 5) equipment common failure items, or 6) forums where Sailors and SMEs can share information related to equipment maintenance.

#### c. *Captured Data is Difficult to Access and Utilize*

Presently, NSWC PHD is providing Distance Support utilizing tools such as prognostics and remote monitoring, but the methodology used is based on what was developed for individual systems, meaning the content and tools are hosted on system-exclusive servers. For Sailors to gain access to the data, special permission is typically required. As a data aggregator, ESDS+ would interface with all of the existing Distance Support tools so data could be readily available and accessed efficiently by all Sailors and SMEs. Also, by augmenting the five ESDS functions, the users would be able to obtain more informative reports that are user-friendly.

#### d. *Current Distance Support Tools are Manually Intensive and* **Limited in Capability**

When SMEs assist Sailors in troubleshooting efforts, the primary vehicle of communication is usually e-mail. Thus, Sailors are required to manually provide all metrics to the SMEs. This leads to limits in capability, as well as creates room for errors and miscommunication. ESDS+ would automatically obtain data such as ships' system performance and trending analysis data directly from the fleet, which would eliminate the need to manually enter data to obtain help.

### 2. How do others conduct Distance Support and are they effective?

This capstone project examined other organizations to learn if they experience the same problems NSWC PHD does with respect to Distance Support, and how they judge success. With regards to USN Distance Support, the focus is fixing a deployed asset. If a ship cannot perform a particular mission, the ship itself most likely cannot be replaced quickly. It is because of this paradigm that knowledge is not captured from events and the Distance Support system does not currently meet the goals of the stakeholders.

### 3. How do the stakeholders define an effective and affordable Distance Support system?

The team applied an SE approach to clearly define the architecture that would be an effective and affordable Distance Support system. The team started by consulting past NSWC PHD Distance Support surveys and studies to clearly define needs. The result of the analysis showed that NSWC PHD needed to improve Distance Support data aggregation and knowledge reutilization capabilities in order to provide more effective Distance Support to the fleet. To do this, the needs analysis suggested that the solution needed to be easily accessible, provide high quality information that was current, relevant, accurate, reliable and complete, the data should be well organized and displayed and/or reported as needed. These needs were used to develop a CONOP (at a very high level), to identify the stakeholders, and to determine how the stakeholders would communicate with their system provided as a solution. After completion of the initial research, the team scoped the project to the data aggregation process, which was named DAS, to ensure the project could be completed within the time allowed since the data aggregation process itself is quite complex and software intensive.

Once the needs were defined, a requirements analysis was conducted to identify the operational, functional, physical and performance requirements of the DAS. The requirements fell into three major categories: 1) Characteristics, 2) Design and Construction, and 3) Component Level requirements. Together, these requirements could be used to translate the stakeholders' needs into a set of system operational, maintenance and support concepts. The team used Vitech's CORE® software suite to input the DAS requirements, beginning the development of the DAS architecture. DAS functions were then identified. The functions were: Provide External Interface, Obtain Data, Process Data, Analyze Data, Report Data, Display Data, and Print and Save Data. The functions were traced to the DAS requirements and design criteria. This tracing helped identify the necessary resources required for DAS support and operation.

The team solicited preferences from stakeholders in order to prioritize and further define the system requirements and system functions. By focusing on higher level data integration system requirements and functions, the team conducted an AoA to identify alternatives and this included modifying existing systems that could satisfy all system requirements. Unfortunately, the team was unable to identify an existing system that could meet all requirements, which meant that some development would be required. To minimize development, the team conducted a gap analysis of the existing systems, and determined that among the possible alternatives, ESDS contained the least number of functional gaps.

Since cost was a critical determining factor, the team compared the cost of ESDS+ to building an entirely new system. The team focused the cost analysis on development costs of the two alternatives, as it was determined that life cycle costs, disposal costs, and savings would be relatively similar between both options. COSYSMO 2.0 software was used to estimate and compare the engineering effort that would be required to develop ESDS+ or a brand new system. The cost analysis revealed that ESDS+ was the less expensive solution, estimating that the development effort of ESDS+ would cost approximately 40% of the total development cost required to build a new system. To further analyze the two alternatives, Expert COSYSMO was used to conduct a cost risk analysis. On a scale of zero to 702, the results showed that ESDS+ had a risk level of 44.7 and the new system had a risk level of 45.7, which shows that both alternatives are equally risky.

#### 4. How can the existing Distance Support system(s) be improved or modified to increase fleet readiness and reduce total ownership costs?

Based on the team's analysis, ESDS+ was therefore recommended as the preferred alternative. This turned out to be good news, because a significant amount of resources have already been invested in developing ESDS. ESDS is currently in use at the NSWC PHD Command, but only on a limited basis. By adding self-help and other missing functionality to ESDS, Distance Support capabilities will be significantly enhanced.

ESDS+ is the recommended solution because it also answers the team's problem statement, which was used to structure this study. ESDS+ seeks to be a user-friendly efficient tool that will capture knowledge through multiple available data sources for maintenance, performance and logistics that could be utilized in a timely manner to make Distance Support a more responsive and effective product.

## B. AREAS FOR FUTURE RESEARCH

There are many more opportunities to continue improving the USN Distance Support capability, further the development and implementation of the DAS, and examine the other many components of the overall function of providing Distance Support. For future work, the team recommends that the user interface function of the DAS be expanded to increase the usability of the aggregated data. In addition, the following list provides examples of areas that need further research and development, and could be conducted in other capstone projects at NPS:

- Complete development, testing, and evaluation of the ESDS+
- Expand on the user interface function
- Improve the content and quality of the data sources
- Improve knowledge capturing systems, methods, and techniques
- Measure and improve data access times
- Improve connectivity to the DAS, especially while deployed
- Expand the DAS beyond maintenance to include areas such as training, logistics, personnel, and mission readiness
- Expand the DAS to included classified information sharing

- Conduct unlimited analysis of the data produced by the DAS to increase effectiveness and efficiencies related to producing, operating, and maintaining Navy weapons systems and related functions, i.e., improve equipment reliability and increase operational availability
- Refine the DAS architecture.

Finally, the team strongly encourages the stakeholders to go forward with the planning and budgeting to develop ESDS+ as the recommended solution for improving Distance Support and enabling the fleet to maintain the highest state of mission readiness while minimizing TOC.

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# APPENDIX A. SYSTEM REQUIREMENTS

The Table 16 lists all requirements the Distance Support team derived from past Distance Support studies.

| Number | Name | Description |
|---|---|---|
| R.0.0 | Data Aggregation System (DAS) Specific Requirements | The system shall display status on installed engineering alterations and engineering alterations under development or planned for development |
| R.1.0 | Characteristics | The system shall display status on installed engineering alterations and engineering alterations under development or planned for development |
| R.1.1 | Performance | The system shall display status on installed engineering alterations and engineering alterations under development or planned for development |
| R.1.1.1 | External Interface | This system shall be capable of interface with other systems including human interface and databases to collect and provide necessary data to perform all the functions. |
| R.1.1.1.1 | System Interface | The system shall have the capability to interface with other systems and databases within fleet support infrastructure to aggregate the data |

| Number | Name | Description |
| --- | --- | --- |
| R.1.1.1.2 | User Interface | The system shall be accessible via Port Hueneme Division (PHD) Portal |
| R.1.1.2 | Fleet Maintenance Support Data and Metrics | Group Title |
| R.1.1.2.1 | Display a list of system/subsystem on each platform | The system shall provide a list of system/subsystem on each platform |
| R.1.1.2.2 | Display Subject Matter Expert (SME) contact information for each system/subsystem | The system shall display SME contact information for each system/subsystem |
| R.1.1.2.3 | Display a list of Open Casualty Reports (CASREP), Trouble Tickets, and Help Desk items open for a specific ship or an entire Strike Group | The system shall display a list of Open CASREP, Trouble Tickets, and Help Desk items open for a specific ship or an entire Strike Group |
| R.1.1.2.3.1 | Search and Display CASREP data based on category, ship, element, system subsystem, symptom, status | The system shall be able to search and display the CASREP data based on category, ship, element, system subsystem, symptom, and status |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.4 | Display Area of Responsibility (AOR) requirements/Standing Orders (Classified) for all platform in a Strike Group | The system shall display AOR requirements/Standing Orders (Classified) for all platform in a Strike Group |
| R.1.1.2.5 | Display outstanding/open CASREP, 2-Kilo, and Technical Assist Visit Request | The system shall display outstanding/open CASREP, 2-Kilo, and Technical Assist Visit Request |
| R.1.1.2.6 | Display Technical Assist Visit Reports (TAVRs) by system | The system shall display TAVRs by system |
| R.1.1.2.7 | Display the past and current In-Service Engineering Agent (ISEA) investigations at the systems, equipment, and Lowest Replaceable Unit (LRU) levels | The system shall display the past and current ISEA investigations at the systems, equipment, and LRU levels |
| R.1.1.2.8 | Display status on installed engineering alterations and engineering alterations under development or planned for development | The system shall display status on installed engineering alterations and engineering alterations under development or planned for development |
| R.1.1.2.9 | Display unclassified CASREP metrics | The system shall display unclassified CASREP metrics |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.10 | Display known problems (issues seen by other Ships) and frequently asked questions | The system shall display known problems (issues seen by other Ships) and frequently asked questions |
| R.1.1.2.11 | Display lessons learned and past troubleshooting/problem resolution information | The system shall display lessons learned and past troubleshooting/problem resolution information |
| R.1.1.2.12 | Display authorized detailed troubleshooting procedures for common equipment failures | The system shall display authorized detailed troubleshooting procedures for common equipment failures |
| R.1.1.2.13 | Display Command Issues Management (CIM) information (status) | The system shall display CIM information (status) |
| R.1.1.2.14 | Display a ship's combat system software configuration (including the software version of each sub-system) | The system shall display a ship's combat system software configuration (including the software version of each sub-system) |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.15 | Display Board of Inspection and Survey (INSURV) and Availability schedules and type, for instance Selected Restricted Availability (SRA), Docking or Dry-docking Selected Restricted Availability (DSRA), or Regular Overhaul (ROH), for ships and provide a graphical representation of the INSURV and Availability schedules of an entire Strike Group | The system shall display INSURV and Availability schedules and type like SRA, DSRA, and ROH for ships and provide a graphical representation of the INSURV and Availability schedules of an entire Strike Group |
| R.1.1.2.16 | Display common equipment failures and corrective action taken per element/system/subsystem/components | The system shall display common equipment failures and corrective action taken per element/system/subsystem/components |
| R.1.1.2.17 | Display a user-selectable range of the top equipment taking the longest time to repair | The system shall display a user-selectable range of the top equipment taking the longest time to repair |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.18 | Display a user-selectable range of the top LRUs with the highest failure rates for equipment in a Pareto diagram for specific systems | The system shall display a user-selectable range of the top LRUs with the highest failure rates for equipment in a Pareto diagram for specific systems |
| R.1.1.2.19 | Display (using a Pareto diagram) a user-selectable range of the top high-usage rate LRUs for specific systems | The system shall display (using a Pareto diagram) a user-selectable range of the top high-usage rate LRUs for specific systems |
| R.1.1.2.20 | Display manning level per work center per ship | The system shall display manning level per work center per ship |
| R.1.1.2.21 | Display manning qualification to conduct mission per work center per ship per mission | The system shall display manning qualification to conduct mission per work center per ship per mission |
| R.1.1.2.22 | Display performance trends per element/system/subsystem | The system shall display performance trends per element/system/subsystem |
| R.1.1.2.23 | Display maintenance work hours at the ship/system/cabinet/LRU level | The system shall display maintenance work hours at the ship/system/cabinet/LRU level |
| R.1.1.2.24 | Display past and current technical assistance efforts requested by the fleet | The system shall display past and current technical assistance efforts requested by the fleet |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.25 | Correlate Preventive Maintenance (PMS) history with material readiness or equipment failures and display the results | The system shall correlate PMS history with material readiness or equipment failures and display the results |
| R.1.1.2.26 | Display the composition (unclassified) and planned deployment dates (Classified) for current and future Strike Groups and others deployed as identified by the Fleet Commanders | The system shall display the composition (unclassified) and planned deployment dates (Classified) for current and future Strike Groups and others deployed as identified by the Fleet Commanders |
| R.1.1.2.27 | Display Combat System (CS) Safety Issues per Ship and historical/trends data | The system shall display CS Safety Issues per Ship and historical/trends data |
| R.1.1.2.28 | Display current configuration and past configurations up to 5 years by ship by system | The system shall display current configuration and past configurations up to 5 years by ship by system |
| R.1.1.2.29 | Display an average time-open bar chart for 2-Kilo | The system shall display an average time-open bar chart for 2-Kilo |

| Number | Name | Description |
|---|---|---|
| R.1.1.2.30 | Display Mean Time To Repair (MTTR) metrics using data from 2-Kilo Maintenance Man Hours (MMH) and repair time information | The system shall display MTTR metrics using data from 2-Kilo MMH and repair time information |
| R.1.1.2.31 | Display MTTR Data from Material Readiness Database (MRDB) | The system shall display MTTR Data from MRDB |
| R.1.1.2.32 | Display Mean Time Between Equipment Mission Critical Events (MTB(EMCE)) and Mean Time Between Equipment Malfunction Events (MTB(EME)) or obtain and display data from MRDB | The system shall display MTB (EMCE) and MTB(EME) or obtain and display data from MRDB |
| R.1.1.3 | Logistics Data | Group Title |
| R.1.1.3.1 | Display Allowance Part List (APL) of all systems | The system shall display APL of all systems |
| R.1.1.3.2 | Display a user-selectable range of the normalized top LRU with the highest cost by system-year or cabinet-year | The system shall display a user-selectable range of the normalized top LRU with the highest cost by system-year or cabinet-year |

| Number | Name | Description |
|---|---|---|
| R.1.1.3.3 | Provide high demand and high cost parts per element/system/subsystem /LRU | The system shall generate and display high demand and high cost parts per element/system |
| R.1.1.3.4 | Provide ship class and ship baseline Cost Report | The system shall generate and display cost reports based on ship class, ship baseline, and individual ship |
| R.1.1.3.5 | Provide Cost Reports based on system/subsystem | The system shall generate and display Cost Reports for each system/subsystem |
| R.1.1.3.6 | Compare and display Mean Logistics Delay Time (MLDT) for any LRU at ship/system level | The system shall display the comparison chart of MLDT for any LRU at ship/system level where data is available |
| R.1.1.3.7 | Display parts that have failed in the past quarter above a specified threshold in three categories | The system shall display parts that have failed in the past quarter above a specified threshold in three categories |
| R.1.1.3.8 | Display technical publications (bulletins) developed by shore support activities, such as ISEA and Regional Maintenance Center (RMC) | The system shall display technical publications (bulletins) developed by shore support activities, such as ISEA and RMC |

| Number | Name | Description |
|---|---|---|
| R.1.1.3.9 | Display the number of failures of LRUs at the ship baselines, and class levels | The system shall display the number of failures of LRUs at the ship baselines, and class levels |
| R.1.1.3.10 | Display supply inventory, sparing info, for any user-specified part by National Item Identification Number (NIIN) | The system shall display supply inventory, sparing info, for any user-specified part by NIIN |
| R.1.1.3.11 | Display Diminishing Manufacturing Sources (DMS) data by system/equipment/LRU | The system shall display DMS data by system/equipment/LRU |
| R.1.1.3.12 | Display part numbers and part's usage based on historical data | The system shall display part numbers and its usage based on historical data for the last 5 years |
| R.1.1.4 | Training Data | Group Title. |
| R.1.1.4.1 | Display Training Discrepancies from Ship Reports, Technical Assist Visit Report, On-Site Training Report, trip report, and Availability report | The system shall display Training Discrepancies from Ship Reports, Technical Assist Visit Report, On-Site Training Report, trip report, and Availability report |
| R.1.1.4.2 | Display training deficiencies CASREP, and 2-Kilo reports | The system shall display training deficiencies from CASREP and 2-Kilo reports |

| Number | Name | Description |
|---|---|---|
| R.1.1.5 | Reliability, Maintainability, and Availability (RMA) Analysis Data | Group Title |
| R.1.1.5.1 | Display RMA drivers from individual ship, ship baseline, Strike Group, and Warfare-Area levels | The system shall display RMA drivers from individual ship, ship baseline, Strike Group, and Warfare-Area levels |
| R.1.1.5.2 | Display an assessment of system/subsystem performance | The system shall collect data from ship readiness reporting such as Maintenance Figure of Merit (MFOM) and Operational Readiness Test System Tech Assist Remote Support (ORTSTARS) to assess and display the status of system/subsystem with Red/Yellow/Green indicators based on system/subsystem specifications or user-defined threshold |
| R.1.1.5.3 | Display Operational Availability (Ao), Mean Time Between Failure (MTBF), and Mean Down Time (MDT) data per ship baseline | The system shall display Ao, MTBF, and MDT data per ship baseline |
| R.1.1.5.4 | Display unclassified and classified MFOM indicators | The system shall display unclassified and classified MFOM indicators |

| Number | Name | Description |
|---|---|---|
| R.1.1.6 | Reports | The system shall be designed to allow the user to generate, save, and print the reports to a file with the standard format such as Acrobat Portable Document Format (PDF) or Microsoft® Office (Word, Excel) from the web pages where the data can be selected and filtered by user defined |
| R.1.2 | Physical Characteristics | Group Title |
| R.1.2.1 | Human System Integration | The system shall be designed and tested to satisfy human engineering design requirements and standards included in but not limited to the latest version of MIL-STD-1472F. |
| R.1.2.2 | Size | The major components that are selected for the system shall support rack mount installation |
| R.1.3 | Reliability | The system shall be designed with redundancy capability which is capable of supporting the $A_O$ of 90% |
| R.1.4 | Maintainability | The system shall be designed to support hardware and software maintenance where MTTR is less than 1 hour and the completed reload will take no more than 20 minutes. |
| R.1.5 | Environment Condition | The system shall be designed to operate in a normal laboratory environment conditions. |
| R.2.0 | Design and Construction | Group Title |

| Number | Name | Description |
|---|---|---|
| R.2.1 | Data Collection | The system shall be designed to collect data either by manually enter data from user interface or data push/pull from external file or database |
| R.2.2 | Data Reporting | The system shall be designed to generate and display data as specified in section 1.1 |
| R.2.3 | Navy Marine Corps Intranet (NMCI) Compliance | The system shall be designed to comply with NMCI |
| R.2.4 | Print and Save | The system shall have the capability to Print and Save the data |
| R.3.0 | Component Level Requirements | Group Title |
| R.3.1 | Hardware | The system shall use Commercial Off-the-Shelf (COTS) hardware that capable to support the design characteristics defined in section 1.0 |
| R.3.2 | Software | The system shall use COTS software that capable to support the design characteristics defined in section 1.0 |

**Table 16. System Requirements**

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# APPENDIX B. SYSTEM FUNCTIONS

This section documents the system functions artifacts that were developed and generated from CORE®. Table 17 provides a list of all system functions that were derived from the requirements analysis. Figures 67, 68, 69, 70, 71, and 72 show DAS functional hierarchy in greater detail. Figures 73, 74, 75, 76, 77, and 78 illustrate DAS functional IDEF0 diagrams. Figure 79 shows the mapping requirements to system functions analysis results, and Table 18 lists all of the data exchanges that occur between all of the DAS functions.

| Number | Name | Description |
|---|---|---|
| F.0 | Provide Data Aggregation Capability | Group Title. The capability of aggregating data from numerous existing Distance Support sources, exporting data to the fleet to promote self-help, and exporting data to help facilitate trend/failure analysis opportunities. |
| F.1.0 | Provide External Interface | Group Title. Provide communication with the external systems. |
| F.1.1 | Execute System Interface | Establish network connection |
| F.2.0 | Obtain Data | Group Title. Obtain data from the external systems. |
| F.2.1 | Obtain Data from User Inputs | Users input data into system database and web pages |
| F.2.1.1 | Receive Data via Web Form | Data is entered by user via a Web Form |
| F.2.1.2 | Import and Format Data Entered by User | User enter data directly into the system either by using a form or a spreadsheet |
| F.2.2 | Obtain Data from Fleet | Recorded System Performance Data is downloaded from ship either manually or automatic. |

| | | |
|---|---|---|
| F.2.2.1 | Import Data from Remote Assessment Report | Import data from Assessment Report |
| F.2.2.2 | Extract Data from Ship's Data Recording | Extract data from data recording transferred from ship to shore via SIPRNET |
| F.2.2.3 | Import Fleet Tech Assist Data | Obtain Tech Assist Data from the following database: Command Issues Management (CIM), Global Distance Support Center (GDSC) Remedy, Trip Report, and SIPRNET CHAT |
| F.2.2.4 | Import Fleet Data from On-Site Assessment | Import Data from the Board of Inspection and Survey (INSURV) or Chief of Naval Operations (CNO) Availability |
| F.2.3 | Obtain Data from Fleet Support Infrastructure | Data is collected through the Fleet Support Infrastructure database: Sailor To Engineer (S2E) , GDSC Remedy, CIM, Aegis Combat System Reliability Maintainability and Supportability Database (ACSRMS), Aegis Configuration Control and Engineering Status System (ACCESS), Maintenance Figure of Merit (MFOM), Material Readiness Database (MRDB), NAVSEA Logistics Center (NSLC) Maintenance and Material Management (3M), Federal Logistics Data (FEDLOG), Configuration Data Managers Database–Open Architecture (CDMD-OA), and so on |
| F.2.3.1 | Collect Fleet Maintenance Data | Collect Ship's Report Maintenance Data |
| F.2.3.1.1 | Import Fleet Maintenance Action Data | Collect data from 3M database |
| F.2.3.2 | Collect Fleet Logistics Data | Collect fleet logistics data such as part usages, part inventory, and requisition information. |
| F.2.3.2.1 | Import Parts/Supplies Data | Import parts/supplies data from NSLC and Naval Supply Systems Command (NAVSUP) |
| F.2.3.2.2 | Import Parts Inventory Data | Import parts inventory data |

| | | |
|---|---|---|
| F.2.3.3 | Collect Fleet Training Discrepancy Data | Collect fleet personnel training discrepancy data |
| F.2.3.4 | Collect Fleet Reliability, Maintainability, and Availability (RMA) Data | Collect fleet RMA data |
| F.3.0 | Process Data | Group Title. Process collected data. |
| F.3.1 | Process General Information | Process and Filter the data into different categories. |
| F.3.1.1 | Provide Subject Matter Expert (SME) Point of Contact (POC) info by Organization/System | Provide a list of the SME POCs filtered by systems that they support and by organization (i.e., John Smith, NSWC PHD, SPY-1A RADAR, john.smith@navy.mil, (805) 228–1234) |
| F.3.1.2 | Provide system info based on hierarchy structure | Listing the system information based on hierarchy structure below:<br>-Platform (i.e., CG/DDG or DDG1000)<br>-Segment (i.e., Combat System, Hull, Mechanical and Electrical (HM&E), Command, Control, or Communications, Computers & Intelligence (C4I))<br>-Element (i.e., SPY, Command and Decision (C&D), Weapon Control System (WCS), Engine, or Navigation)<br>-System (i.e., Transmitter, Power Generator, or Display)<br>-Subsystem<br>-Component |
| F.3.1.3 | Provide Frequent Ask Question (FAQ) Data | Provide FAQ Data |
| F.3.1.4 | Provide Blog and Forum Data | Provide Blog and Forum Data shared by fleet personnel and fleet support agents |
| F.3.2 | Process Maintenance Data | Process, filter, and categorize the maintenance data |
| F.3.3 | Process Logistics Data | Process, filter, and categorize the logistics data |

| | | |
|---|---|---|
| F.3.4 | Process Training Data | Process, filter, and categorize the training data |
| F.3.5 | Process RMA Data | Process, filter, and categorize the RMA data |
| F.4.0 | Analyze Data | Group Title. Analyzing and updating the data |
| F.4.1 | Analyze Maintenance Data | Analyze the maintenance data |
| F.4.2 | Conduct System Performance Trending Analysis | Analyze and conduct the system performance trending Analysis |
| F.4.3 | Compute System Operational Availability ($A_O$)/Inherent Availability ($A_i$) based on RMA Data | Analyze and compute the system $A_O$/$A_i$ based on the RMA data |
| F.4.4 | Conduct Cost Analysis | Conduct Cost Analysis |
| F.5.0 | Report Data | Group Title. Generate Reports |
| F.5.1 | Generate System Assessment Report | Generate reports based on the data collected from Tech Assists, remote monitoring, or system assessment. The system will have the ability to generate the assessment reports either by automatically or manually |
| F.5.2 | Generate Logistics Report | Generate reports that associated with logistics such as supplies inventories, Part Usages, and high cost failure items |
| F.5.3 | Generate System Status Report | Generate reports based on the ship's reported system status |
| F.5.4 | Generate System RMA Report | Generate reports based on RMA analysis, such as $A_O$, Mean Time Between Failures (MTBF), and Mean Time To Repair ( MTTR) |
| F.6.0 | Display Data | Group Title. Display data via NSWC PHD WebPages |

| | | |
|---|---|---|
| F.6.1 | Display Fleet Support Information | Display in website the following general information: In-Service Engineering Agent (ISEA) POCs (names, phone number, e-mail) - Hierarchical structure system information based on ship class, element (Combat System (CS), C4I, HM&E) |
| F.6.1.1 | Display FAQ, Blog and Forum data | Display consolidated data relative to FAQ, Blog, and Forum posted by fleet personnel and fleet support agents |
| F.6.1.2 | Display SME POC Info | Display SME POCs |
| F.6.1.3 | Display Ship and System Info | Display ship and system information |
| F.6.2 | Display Historical Fleet Data | Display historical Fleet data including the information below:<br>-Number of Casualty Report (CASREP) per ship per year<br>-Current Open and Closed CASREP |
| F.6.3 | Display Corrective Maintenance Information | Display information to assist ship force to conduct corrective maintenance based on system/equipment hierarchy. Data include Questions and Answers (Q&A), Troubleshooting tips, and Common equipment failure symptom |
| F.6.3.1 | Display Historical System Maintenance Action | Display information pertaining historical system maintenance actions |
| F.6.4 | Display Logistics Information | Display information related to Logistics based on system hierarchy. Data include Tech Manual Bibliography, Maintenance Index Page (MIP)/Preventive Maintenance (PMS) listing, Allowance Part List (APL), Allowance Equipment List (AEL) Listing, On-Board Spares list, and Links to download Tech Manual. |
| F.6.5 | Display RMA Analysis Data | Display information related to Reliability, Maintainability, and Availability of each system on each ship. Data include System $A_O$. |

| | | |
|---|---|---|
| F.7.0 | Print & Save | Print and Save Data performed by Stakeholders. |

**Table 17. System Functions**

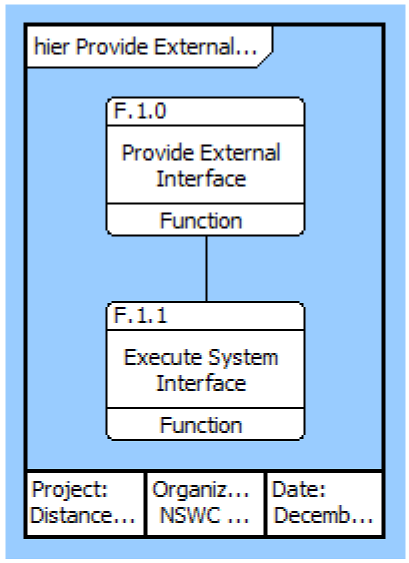


**Figure 67. Provide External Function (F.1.0)**

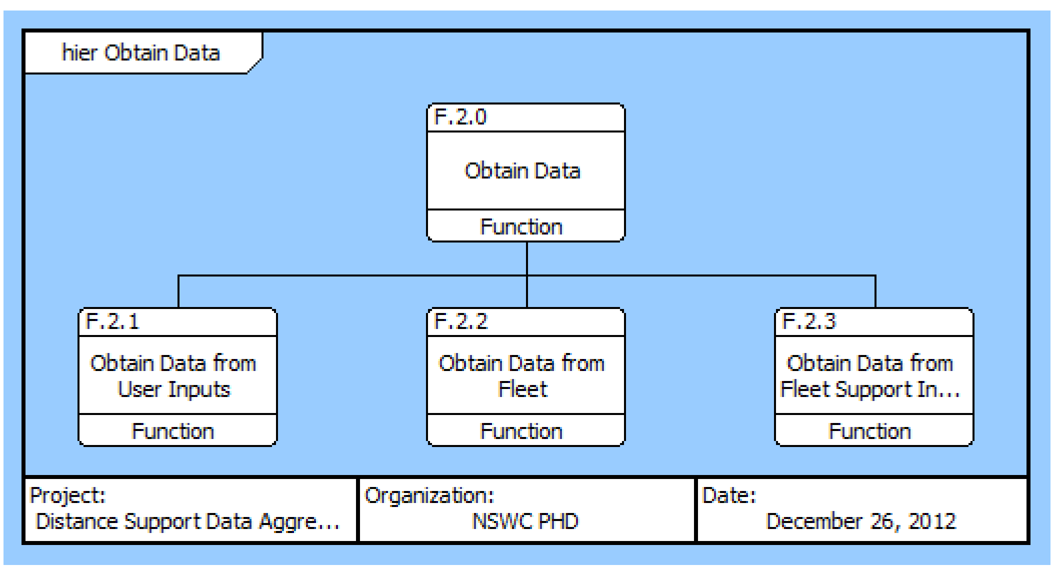


**Figure 68. Obtain Data Functions (F.2.0)**

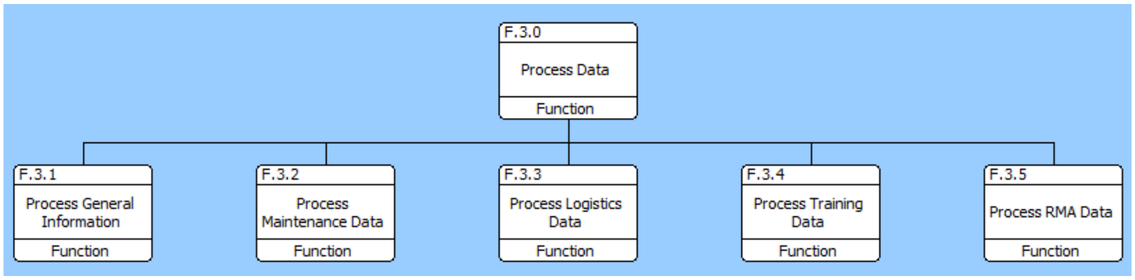


**Figure 69. Process Data Functions (F.3.0)**

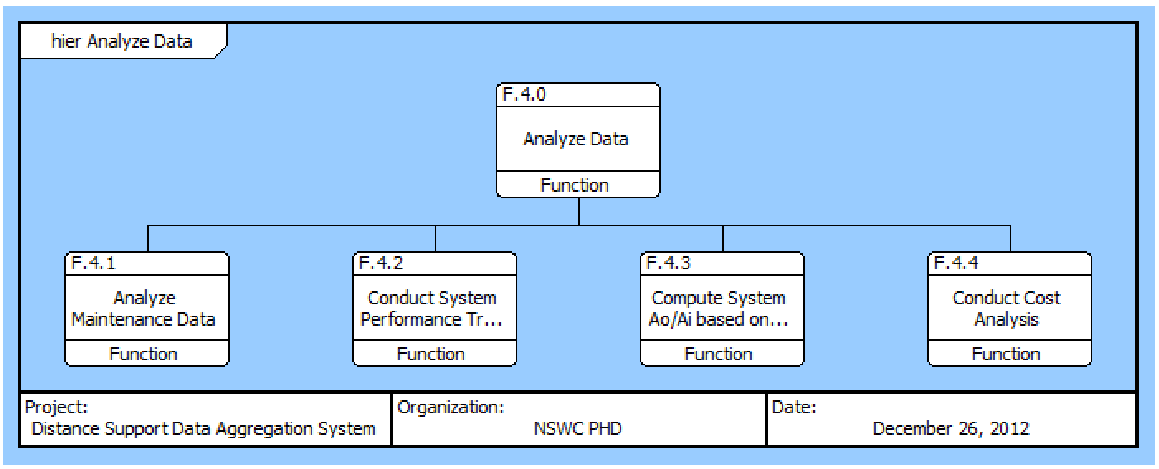


**Figure 70. Analyze Data Functions (F.4.0)**

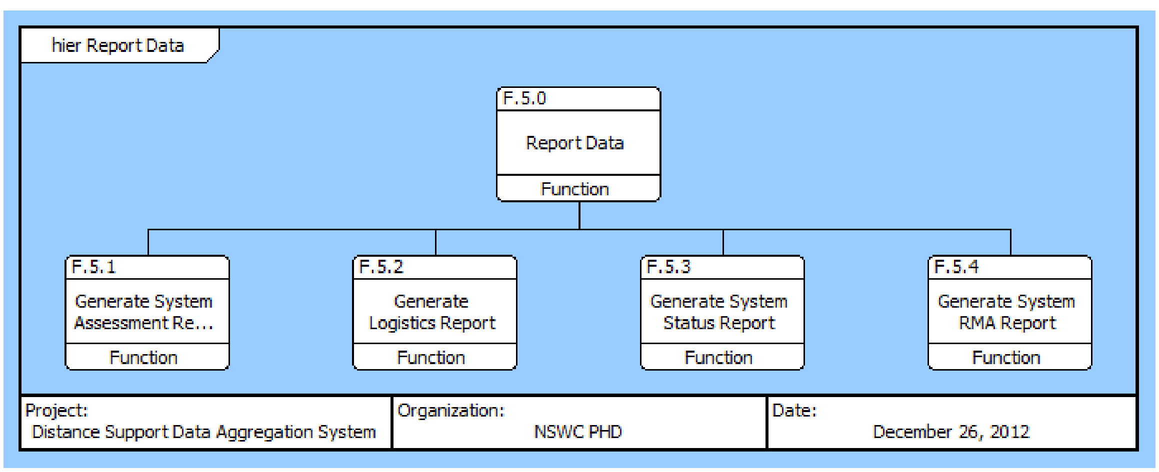


**Figure 71. Report Data Functions (F.5.0)**

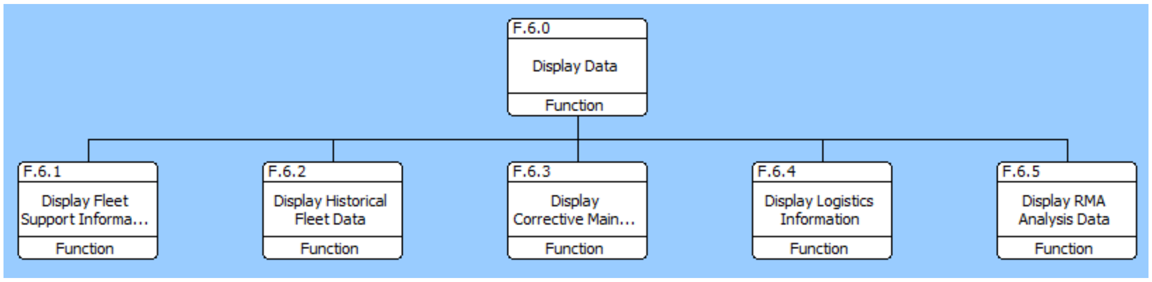


**Figure 72. Display Data Functions (F.6.0)**

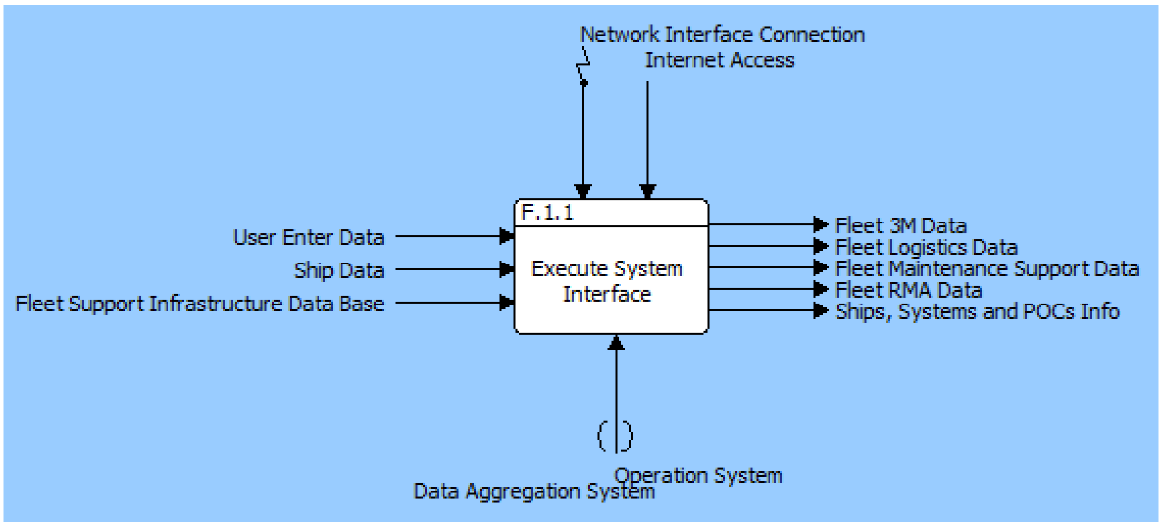


**Figure 73. Provide External Interface IDEF0 (F.1.0)**

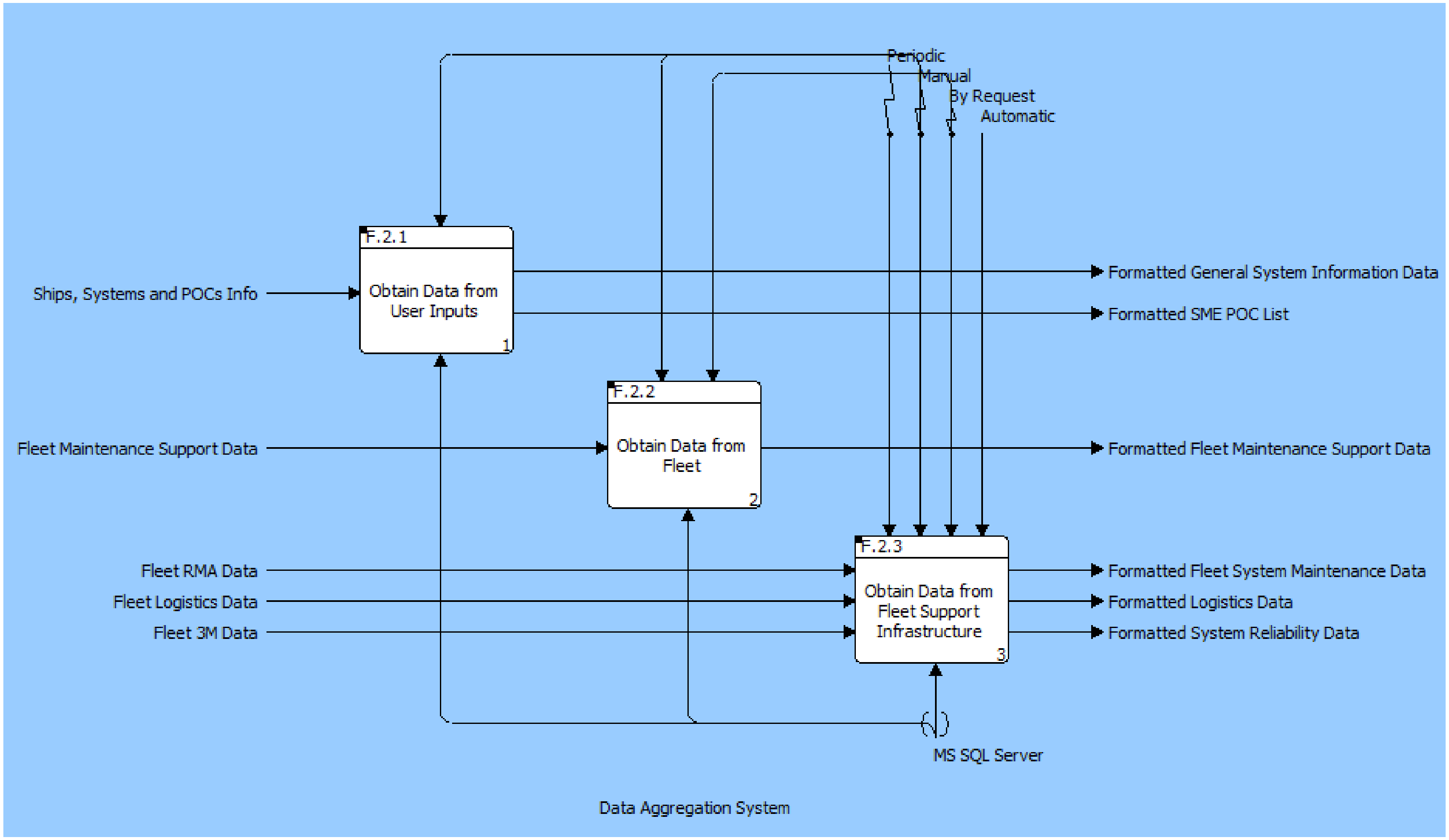


**Figure 74. Obtain Data IDEF0 (F.2.0)**

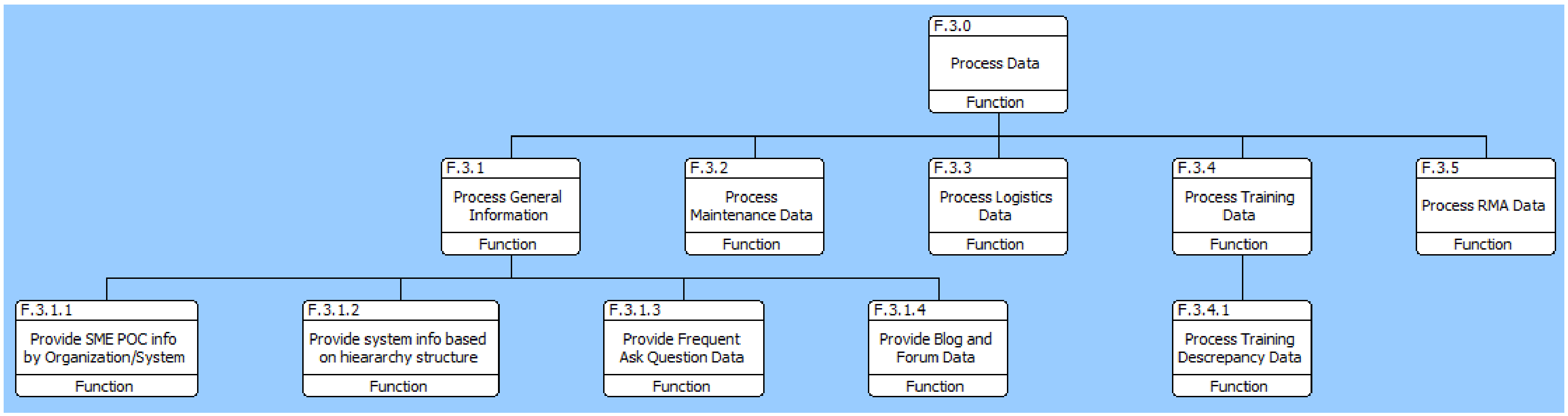


**Figure 75. Process Data IDEF0 (F.3.0)**

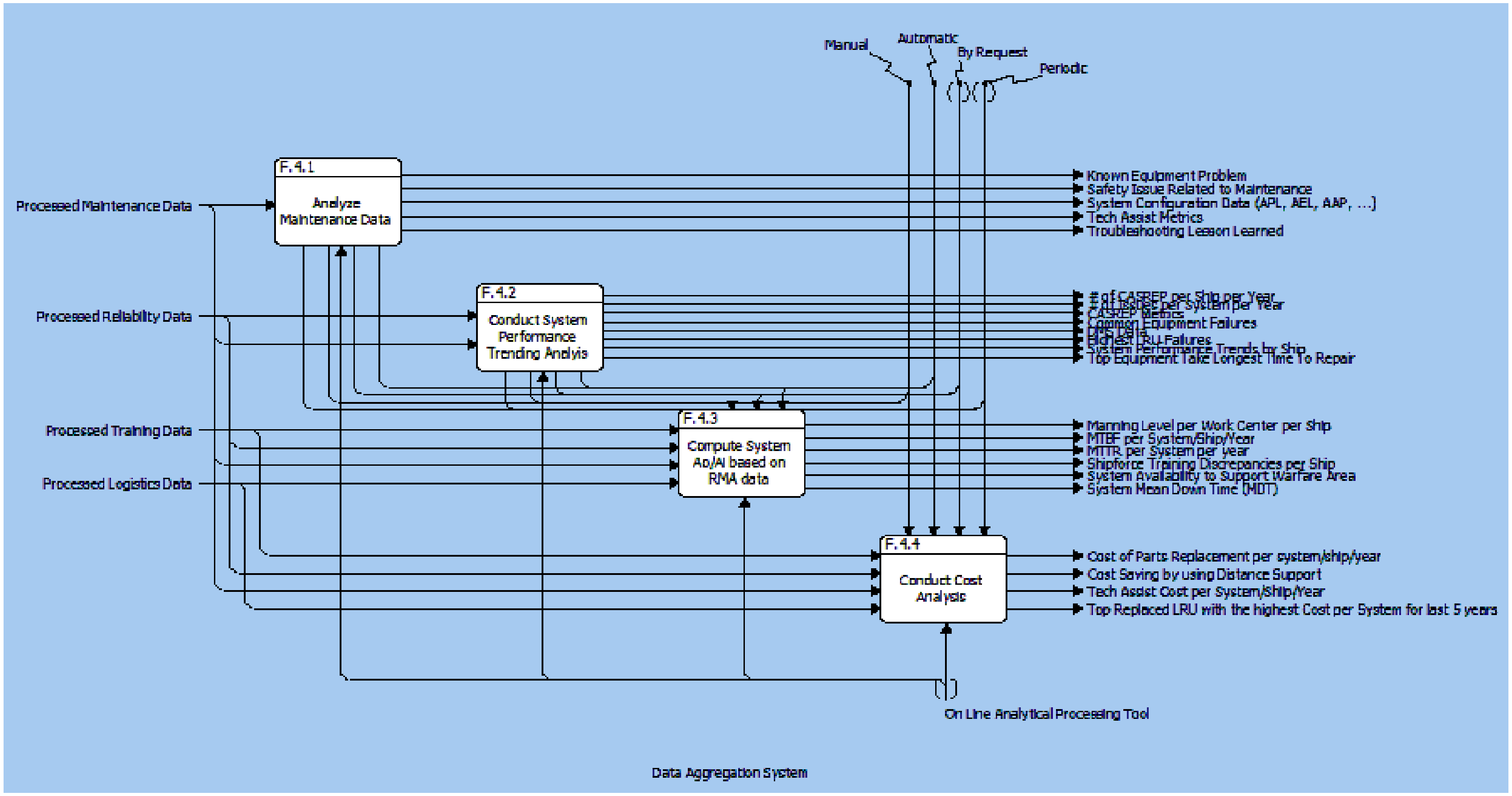


**Figure 76. Analyze Data IDEF0 (F.4.0)**

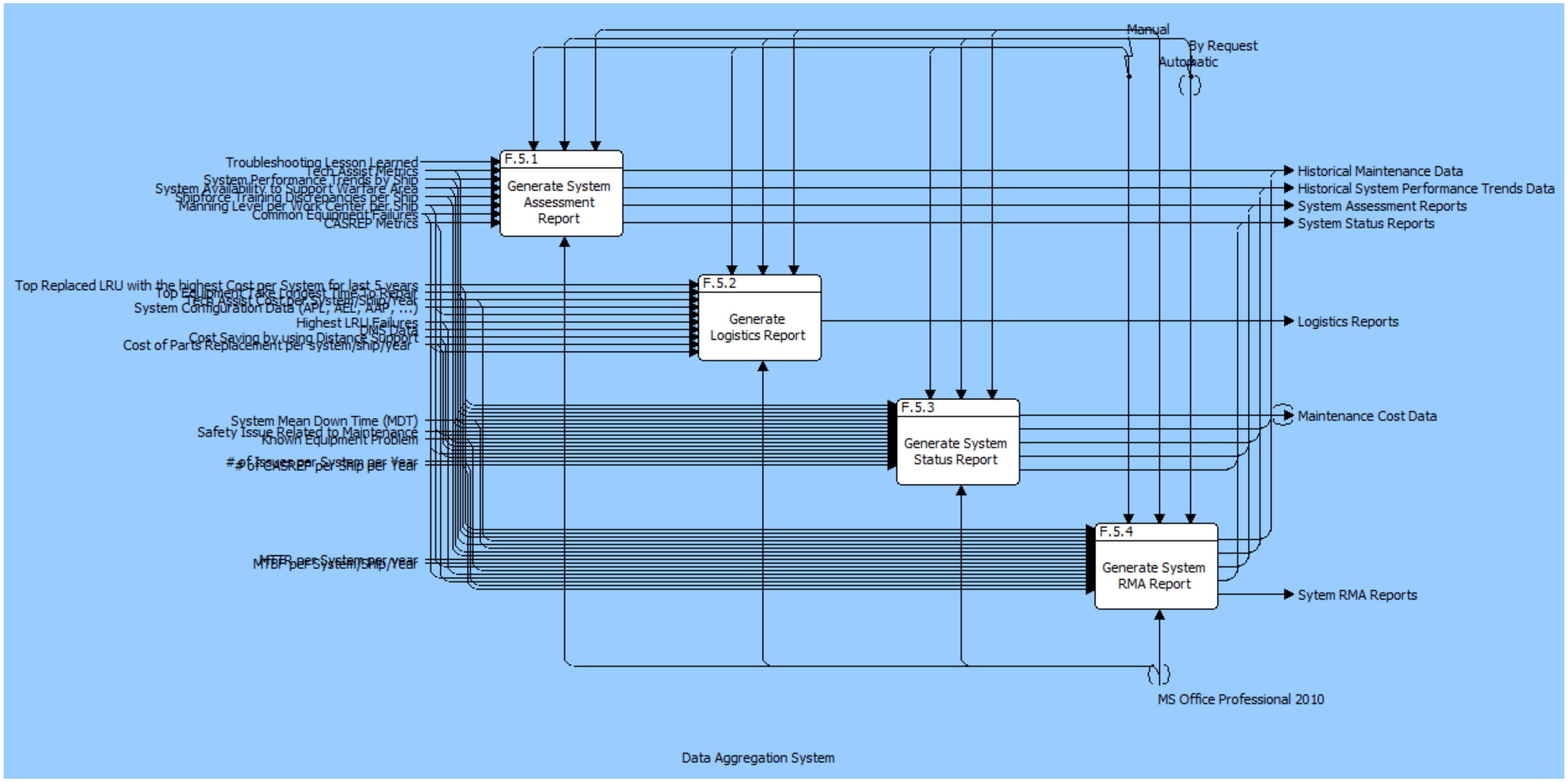


**Figure 77. Report Data IDEF0 (F.5.0)**

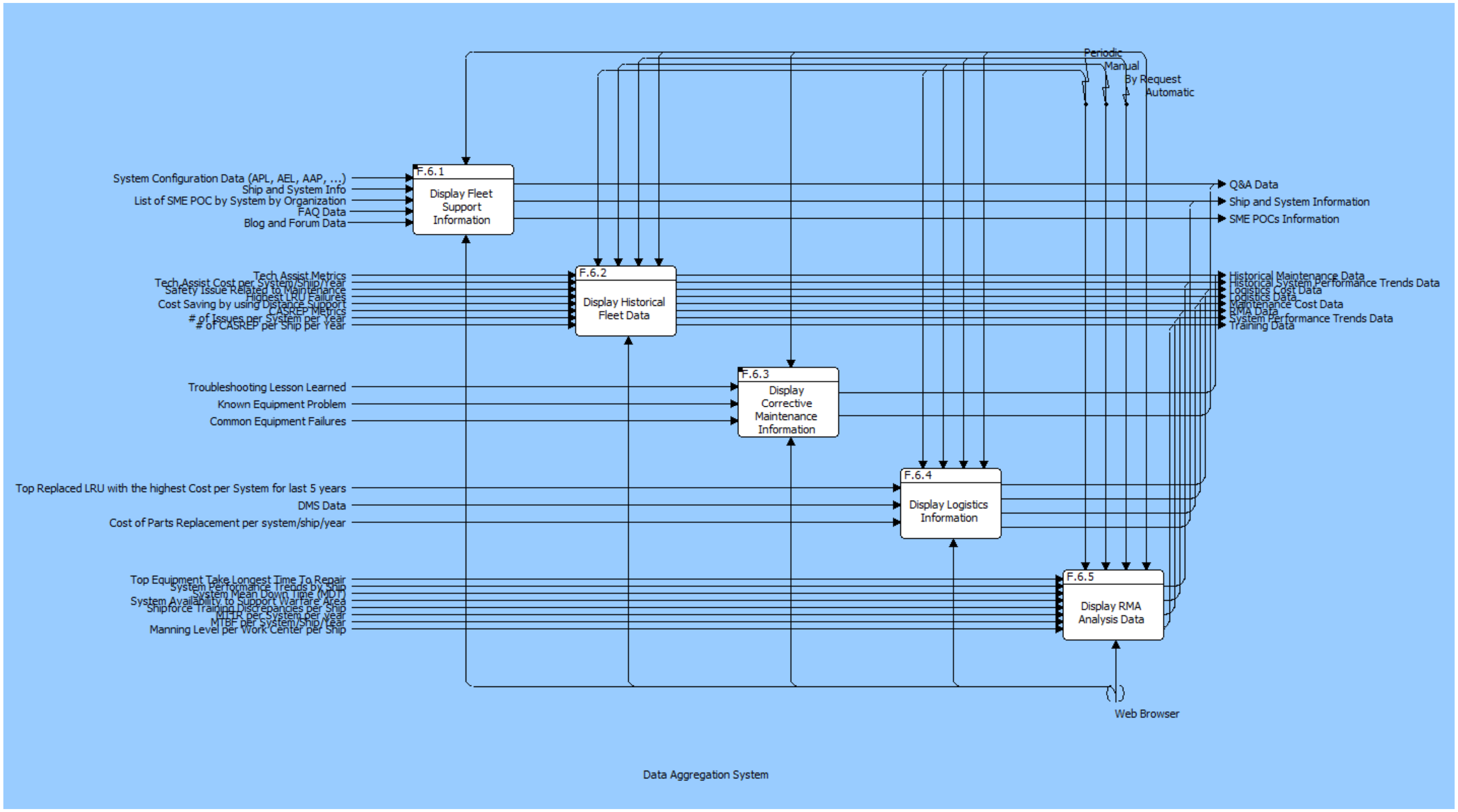


**Figure 78. Display Data IDEF0 (F.6.0)**

## Functions

| | Requirements | Provide Data Aggregation Capability | Provide External Interface | Execute System Interface | Obtain Data | Obtain Data from User Inputs | Obtain Data from Fleet | Obtain Data from Fleet Support Infrastructure | Process Data | Process General Information | Process Maintenance Data | Process Logistics Data | Process Training Data | Analyze Data | Analyze Maintenance Data | Conduct System Performance Trending | Analyze/Compute System Ao/Ai based on RMA data | Conduct Cost Analysis | Report Data | Generate System Assessment Report | Generate Logistics Report | Generate System Status Report | Generate System RMA Report | Display Data | Display Fleet Support Information | Display Historical Fleet Data | Display Corrective Maintenance Information | Display Logistics Information | Display RMA Analysis Data | Print & Save Data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.0.0 | Data Aggregation System Specific Requirements | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.0 | Characteristics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1 | Performance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.1 | External Interface | | ● | ● | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.2 | Fleet Maintenance Support Data and Metrics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.2.1 | Display a list of system/subsystem on each platform | | ● | ● | | ● | | | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.2 | Display SME contact information for each system/subsystem | | ● | ● | | ● | | | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.3 | Display a list of Open CASREP, Trouble Tickets, and Help Desk items open for a speciific ship or an entire Strike Group | | ● | ● | | ● | ● | ● | | ● | ● | ● | ● | | | | | | | | | | | | ● | ● | | ● | | |
| R.1.1.2.3.1 | Search and Display CASREP data based on category, ship, element, system subsystem, sympton, status | | ● | ● | | | ● | ● | | ● | | | | | | | | | | | | | | | ● | ● | | ● | | |
| R.1.1.2.4 | Display Area of Responsibility (AOR) requirements/Standing Orders (Classified) for all platform in a Strike Group | | ● | ● | | | ● | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.5 | Display outstanding/open CASREP, 2 Kilo, Tech Assist Visit Request | | ● | ● | | ● | ● | ● | | ● | ● | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.6 | Display Technical Assist Visit Reports (TAVRs) by system | | ● | ● | | ● | | ● | | ● | ● | ● | ● | | | | | | | | | | | | ● | ● | ● | ● | ● | |
| R.1.1.2.7 | Display the past and current ISEA investigations at the systems, equipment, and LRU levels | | ● | ● | | ● | | ● | | ● | ● | ● | | | | | | | | | | | | | ● | | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.1.1.2.8 | Display status on installed engineering alterations and engineering alterations under development or planned for development | | ● | ● | | ● | | ● | | ● | | ● | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.9 | Display unclassified CASREP metrics | | ● | ● | | ● | | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | | | | | | | ● | ● | ● | ● | ● | |
| R.1.1.2.10 | Display known problems (issues seen by other Ships) and frequently asked questions | | ● | ● | | ● | | ● | | ● | ● | ● | ● | | ● | ● | ● | ● | | | | | | | ● | ● | ● | ● | | |
| R.1.1.2.11 | Display lessons learned and past troubleshooting/problem resolution information | | ● | ● | | ● | | ● | | ● | ● | | | | ● | ● | | | | | | | | | ● | | | | | |
| R.1.1.2.12 | Display authorized detailed troubleshooting procedures for common equipment failures | | ● | ● | | ● | | | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.13 | Display CIM information (status) | | ● | ● | | | | ● | | ● | | | | | ● | | | | | | | | | | ● | | | | | |
| R.1.1.2.14 | Display a ship's combat system software configuration (including the software version of each sub-system) | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.15 | Display INSURV and Availability schedules and type (SRA, DSRA, RCOH, etc.) for ships and provide a graphical representation of the INSURV and Availability schedules of an entire Strike Group | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.16 | Display common equipment failures and corrective action taken per element/system/subsystem/components | | ● | ● | | ● | | ● | | ● | ● | | | | ● | | | | | | | | | | ● | ● | ● | ● | | |
| R.1.1.2.17 | Display a user-selectable range of the top equipment taking the longest time to repair | | ● | ● | | ● | | ● | | ● | ● | | | | ● | ● | | | | | | | | | ● | ● | ● | ● | | |
| R.1.1.2.18 | Display a user-selectable range of the top LRUs with the highest failure rates for equipment in a Pareto diagram for specific systems | | ● | ● | | ● | | ● | | ● | ● | | | | | ● | ● | | | | | | | | ● | ● | ● | ● | ● | |
| R.1.1.2.19 | Display (using a Pareto diagram) a user-selectable range of the top high-usage rate LRUs for specific systems | | ● | ● | | ● | | ● | | ● | ● | ● | | | | | | | | | | | | | ● | ● | ● | ● | ● | |
| R.1.1.2.20 | Display manning level per work center per ship | | ● | ● | | | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.1.1.2.21 | Display manning qualification to conduct mission per work center per ship per mission | | ● | ● | | | | ● | | ● | | | ● | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.22 | Display performance trends per element/system/subsystem | | ● | ● | | | | ● | | ● | ● | | | | | ● | ● | | | | | | | | ● | ● | ● | | ● | |
| R.1.1.2.23 | Display maintenance work hours at the ship/system/cabinet/LRU level | | ● | ● | | | | ● | | ● | ● | | | | ● | | | | | | | | | | ● | ● | ● | | | |
| R.1.1.2.24 | Display past and current technical assistance efforts requested by the Fleet | | ● | ● | | ● | | ● | | ● | ● | | | | ● | | | | | | | | | | ● | ● | ● | | | |
| R.1.1.2.25 | Correlate PMS history with material readiness or equipment failures and display the results | | ● | ● | | | | ● | | ● | | | | | ● | ● | | | | | | | | | ● | ● | | | | |
| R.1.1.2.26 | Display the composition (unclassified) and planned deployment dates (Classified) for current and future Strike Groups and other deployers identified by Fleet Commanders | | ● | ● | | | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.27 | Display CS Safety Issues per Ship and historical/trends data | | ● | ● | | | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.2.28 | Display current configuration and past configurations up to 5 years by ship by system | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | ● | ● | | | | |
| R.1.1.2.29 | Display an average time-open bar chart for 2-Kilos | | ● | ● | | | | ● | | ● | | | | | | | | | | | | | | | ● | ● | | | ● | |
| R.1.1.2.30 | Display Mean Time To Repair (MTTR) metrics using data from 2-Kilo Maintenance Man Hours (MMH) and repair time information | | ● | ● | | | | ● | | ● | ● | | | | ● | | | | | | | | | | ● | | | | ● | |
| R.1.1.2.31 | Display Mean Time To Repair (MTTR) Data from MRDB | | ● | ● | | | | ● | | ● | ● | | | | ● | | | | | | | | | | ● | ● | | | ● | |
| R.1.1.2.32 | Display Mean Time Between Equipment Mission Critical Events (MTB(EMCE)) and Mean Time Between Equipment Malfunction Events (MTB(EME)) or obtain and display data from MRDB | | ● | ● | | | | ● | | ● | ● | | | | ● | ● | ● | | | | | | | | | | | | | |
| R.1.1.3 | Logistics Data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.3.1 | Display Allowance Part List (APL) of all systems | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.3.2 | Display a user-selectable range of the normalized top Lowest Replaceable Unit (LRU) with the highest cost by system-year or cabinet-year | | ● | ● | | | | ● | | ● | ● | ● | | | ● | | | ● | | | ● | | | | ● | ● | | ● | | |

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| R.1.1.3.3 | Provide high demand and high cost parts per element/system/subsystem/LRU | | ● | ● | | | | ● | | ● | ● | ● | | | | | | ● | | | | | | | | | | | | |
| R.1.1.3.4 | Provide ship class and ship baseline Cost Report | | ● | ● | | | | ● | | ● | | ● | | | | | | ● | | | ● | | | | ● | | | ● | | |
| R.1.1.3.5 | Provide Cost Reports based on system/subsystem | | ● | ● | | | | ● | | ● | | ● | | | | | | ● | | | ● | | | | ● | | | ● | | |
| R.1.1.3.6 | Compare and display Mean Logistics Delay Time (MLDT) for any LRU at ship/system level | | ● | ● | | | | ● | | ● | | ● | | | | | | | | | | | | | ● | | | ● | | |
| R.1.1.3.7 | Display parts that have failed in the past quarter above a specified threshold in three categories | | ● | ● | | ● | | ● | | ● | | ● | | | | ● | | | | | | | | | ● | ● | | ● | | |
| R.1.1.3.8 | Display technical publications (bulletins) developed by shore support activities, such as ISEA and RMC | | ● | ● | | ● | | ● | | ● | | | | | | | | | | | | | | | ● | | | | | |
| R.1.1.3.9 | Display the number of failures of LRUs at the ship baselines, and class levels | | ● | ● | | | | ● | | ● | | ● | | | | | | | | | ● | | | | ● | ● | | ● | | |
| R.1.1.3.10 | Display supply inventory, sparing info, for any user-specified part by NIIN | | ● | ● | | ● | | ● | | ● | | ● | | | | | | | | | ● | | | | ● | | | ● | | |
| R.1.1.3.11 | Display DMS data by system/equipment/IRU | | ● | ● | | ● | | ● | | ● | | ● | | | | | | | | | ● | | | | ● | | | ● | | |
| R.1.1.3.12 | Display part numbers and part's usage based on historical data | | ● | ● | | | | ● | | ● | | ● | | | | | | | | | ● | | | | ● | ● | | ● | | |
| R.1.1.4 | Training Data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.4.1 | Display Training Discrepancies from Ship Reports, Tech Assist Visit Report, On-Site Training Report, trip report, Availability report | | ● | ● | | | | ● | | ● | ● | ● | ● | | ● | | | | | | | | | | ● | | | | | |
| R.1.1.4.2 | Display training deficiencies from Casualty Reports (CASREP), 2-kilo reports | | ● | ● | | | | ● | | ● | | | | | ● | | | | | | | | | | ● | | | | | |
| R.1.1.5 | RMA Analysis Data | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.1.5.1 | Display reliability, maintainability, and availability drivers from individual ship, ship baseline, Strike Group and Warfare-Area levels | | ● | ● | | | | ● | | ● | ● | ● | | | ● | ● | ● | | | ● | ● | ● | ● | | ● | ● | | ● | ● | |
| R.1.1.5.2 | Display an assessment of system/subsystem performance | | ● | ● | | ● | | ● | | ● | ● | ● | | | ● | ● | ● | | | ● | ● | ● | ● | | ● | ● | ● | ● | ● | |
| R.1.1.5.3 | Display Operational Availability (Ao), Mean Time Between Failure (MTBF), & Mean Down Time (MDT) data per ship baseline | | ● | ● | | | | ● | | ● | ● | ● | ● | | ● | ● | ● | | | ● | ● | ● | ● | | ● | ● | | ● | ● | |

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| R.1.1.5.4 | Display unclassified and clssified Maintenance Figure of Merit (MFOM) indicators | | ● | ● | | | | ● | | ● | ● | ● | | | ● | ● | ● | | | | | | | | ● | | | | ● | |
| R.1.1.6 | Reports | | ● | ● | | | | ● | | ● | ● | ● | ● | | | | | | | | | | | | ● | | | | | ● |
| R.1.2 | Physical Charateristics | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.2.1 | Human System Integration | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.3 | Reliability | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.4 | Maintainability | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.1.5 | Environment Condition | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.2.0 | Design and Construction | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.2.1 | Data Collection | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.2.2 | Accessible by authorized NMCI Users | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.2.3 | Data Reporting | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.2.4 | NMCI Compliance | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.3.0 | Component Level Requirements | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.3.1 | Hardware | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| R.3.2 | Software | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 79. Mapping Requirements to System Functions**

| NAME | DEFINITION | INPUT TO | OUTPUT TO | TRIGGERS |
| --- | --- | --- | --- | --- |
| **# of CASREP per Ship per Year** | Data relative to number of CASREP generated per ship per year | Function F.5.0 Report Data Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **# of Issues per System per Year** | Data relative to number of equipment issues (anomalies) per system per year | Function F.5.0 Report Data Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **Access Data** | Data requested by stakeholders | | Function Ext.Func.3.0 Access Data | |
| **As Needed** | Control line. Action is executed as needed only | | | Function Ext.Func.3.0 Access Data |
| **Automatic** | Control line. Action is executed automatically | | | Function Ext.Func.[illegible] Display Aggregation Data Function F.0 Provide Data Aggregation Capability Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.3 Collect Fleet Training Discrepancy Data Function F.2.3.4 Collect Fleet RMA Data Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.1 Provide SME POC info by Organization/System Function F.3.1.2 Provide system info based on hierarchy structure Function F.3.1.3 Provide Frequent Ask Question Data Function F.3.1.4 Provide Blog and Forum Data Function F.3.2 Process Maintenance Data Function F.3.3 Process Logistics Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Discrepancy Data Function F.3.5 Process RMA Data Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data Function F.4.2 Conduct System Performance Trending Analysis Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.2 Generate |

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|---|---|---|---|---|
| **Blog and Forum Data** | Data is extracted from Blog and Forum shared by ship personnel and fleet support agents | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.1 Display FAQ, Blog and Forum data | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.4 Provide Blog and Forum Data | |
| **By Request** | Control line. Action is executed by request | | | Function Ext.Func.1.0 Ship Sends Data to Shore Function Ext.Func.2.0 Collect and Disseminate Fleet Data Function Ext.Func.3.0 Access Data Function F.0 Provide Data Aggregation Capability Function F.2.0 Obtain Data Function F.2.2 Obtain Data from Fleet Function F.2.2.1 Import Data from Remote Assessment Report Function F.2.2.4 Import Fleet Data from On-Site Assessment Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.3 Collect Fleet Training Discrepancy Data Function F.2.3.4 Collect Fleet RMA Data Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.1 Provide SME POC info by Organization/System Function F.3.1.2 Provide system info based on hierarchy structure Function F.3.1.3 Provide Frequent Ask Question Data Function F.3.1.4 Provide Blog and Forum Data Function F.3.2 Process Maintenance Data Function F.3.3 Process Logistics Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Discrepancy Data Function F.3.5 Process RMA Data Function F.4.1 Analyze Maintenance Data Function F.4.2 Conduct System Performance Trending Analysis |
| **CASREP Metrics** | Metrics relative to CASREP | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |

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| **Common Equipment Failures** | Data relative to common equipment failures | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.3 Display Corrective Maintenance Information Function F.6.3.1 Display Historical System Maintenance Action | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **Cost of Parts Replacement per system/ship/year** | Data relative to part replacement cost expenditures per ship per year | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.6.0 Display Data Function F.6.4 Display Logistics Information | Function F.4.0 Analyze Data Function F.4.4 Conduct Cost Analysis | |
| **Cost Saving by using Distance Support** | Saving cost by using DS | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.4 Conduct Cost Analysis | |
| **DMS Data** | Data relative to DMS | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.6.0 Display Data Function F.6.4 Display Logistics Information | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **FAQ Data** | Technical interchange data between ship personnel and fleet support agents | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.1 Display FAQ, Blog and Forum data | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.3 Provide Frequent Ask Question Data | |

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|---|---|---|---|---|
| **Fleet 3M Data** | Fleet 3M data provided by NSLC | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.3 Collect Fleet Training Discrepancy Data | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | |
| **Fleet Logistics Data** | Logistics data provided by NSLC/ NAVSUP | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.2.2 Import Parts Inventory Data | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | |
| **Fleet Maintenance Support Data** | Data relative to fleet maintenance actions | Function F.2.0 Obtain Data Function F.2.2 Obtain Data from Fleet Function F.2.2.1 Import Data from Remote Assessment Report Function F.2.2.2 Extract Data from Ship's Data Recording Function F.2.2.3 Import Fleet Tech Assist Data Function F.2.2.4 Import Fleet Data from On-Site Assessment | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | |
| **Fleet RMA Data** | Fleet historical data relative to RMA | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.4 Collect Fleet RMA Data | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | |
| **Fleet Support Infrastructure Data Base** | Data provided by fleet support infrastructure data base | Function F.0 Provide Data Aggregation Capability Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | Function Ext.Func.2.0 Collect and Disseminate Fleet Data | |

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|---|---|---|---|---|
| **Formatted Fleet Maintenance Support Data** | Maintenance Data provided by SME | Function F.3.0 Process Data Function F.3.2 Process Maintenance Data Function F.3.3 Process Logistics Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Discrepancy Data Function F.3.5 Process RMA Data | Function F.2.0 Obtain Data Function F.2.2 Obtain Data from Fleet Function F.2.2.1 Import Data from Remote Assessment Report Function F.2.2.2 Extract Data from Ship's Data Recording Function F.2.2.3 Import Fleet Tech Assist Data Function F.2.2.4 Import Fleet Data from On-Site Assessment | |
| **Formatted Fleet System Maintenance Data** | Maintenance Data from Fleet | Function F.3.0 Process Data Function F.3.2 Process Maintenance Data Function F.3.3 Process Logistics Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Discrepancy Data Function F.3.5 Process RMA Data | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.3 Collect Fleet Training Discrepancy Data | |
| **Formatted General System Information Data** | Formatted general information relative to SMEs, ship information, system information | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.2 Provide system info based on hierarchy structure Function F.3.1.3 Provide Frequent Ask Question Data Function F.3.1.4 Provide Blog and Forum Data Function F.3.3 Process Logistics Data Function F.3.5 Process RMA Data | Function F.2.0 Obtain Data Function F.2.1 Obtain Data from User Inputs Function F.2.1.1 Receive Data via Web Form Function F.2.1.2 Import and Format Data Entered by User | |
| **Formatted Logistics Data** | Formatted data relative to logistics supply support, inventory | Function F.3.0 Process Data Function F.3.3 Process Logistics Data Function F.3.5 Process RMA Data | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.2.2 Import Parts Inventory Data | |
| **Formatted SME POC List** | Formatted data relative to SME POC Information | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.1 Provide SME POC info by Organization/System | Function F.2.0 Obtain Data Function F.2.1 Obtain Data from User Inputs Function F.2.1.1 Receive Data via Web Form Function F.2.1.2 Import and Format Data Entered by User | |

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| **Formatted System Reliability Data** | Formatted data relative to ship system RMA information | Function F.3.0 Process Data Function F.3.5 Process RMA Data | Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.4 Collect Fleet RMA Data | |
| **Highest LRU Failures** | Information regarding LRU that has the highest failure rate | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **Historical Maintenance Data** | Historical fleet maintenance data | Function Ext.Func.4.0 Display Aggregation Data Function F.7.0 Print & Save Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.3 Display Corrective Maintenance Information Function F.6.3.1 Display Historical System Maintenance Action | |
| **Historical System Performance Trends Data** | Historical data relative to system performance trends | Function Ext.Func.4.0 Display Aggregation Data Function F.7.0 Print & Save Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.5 Display RMA Analysis Data | |
| **Internet Access** | Control line. Action is executed when internet access becomes available | | | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface Function F.3.1.4 Provide Blog and Forum Data |

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| **Known Equipment Problem** | Data relative to known equipment problem/failure | Function F.5.0 Report Data Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.3 Display Corrective Maintenance Information Function F.6.3.1 Display Historical System Maintenance Action | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data | |
| **List of SME POC by System by Organization** | Data relative to SME POC information listed by organization | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.2 Display SME POC Info | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.1 Provide SME POC info by Organization/System | |
| **Logistics Cost Data** | Data relative to logistics supply cost | | Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.4 Display Logistics Information | |
| **Logistics Data** | Data relative to Logistics supply, parts usage, cost, expenditures, etc... | | Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.4 Display Logistics Information | |
| **Logistics Reports** | Reports contain logistics information such as parts usage, part cost, ship expenditures, LRU highest cost/expenditure, etc... | Function Ext.Func.4.0 Display Aggregation Data Function F.7.0 Print & Save Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.2 Generate Logistics Report | |
| **Maintenance Cost Data** | Cost data relative to ship's equipment maintenance | | Function F.5.3 Generate System Status Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.4 Display Logistics Information | |
| **Manning Level per Work Center per Ship** | Data relative to manning level per ship per baseline | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |

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|---|---|---|---|---|
| **Manual** | Control line. Action is executed manually | | | [illegible] Function F.0 Provide Data Aggregation Capability Function F.2.0 Obtain Data Function F.2.1 Obtain Data from User Inputs Function F.2.1.1 Receive Data via Web Form Function F.2.2 Obtain Data from Fleet Function F.2.2.1 Import Data from Remote Assessment Report Function F.2.2.2 Extract Data from Ship's Data Recording Function F.2.2.3 Import Fleet Tech Assist Data Function F.2.2.4 Import Fleet Data from On-Site Assessment Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.3 Collect Fleet Training Discrepancy Data Function F.2.3.4 Collect Fleet RMA Data Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.1 Provide SME POC info by Organization/System Function F.3.1.2 Provide system info based on hierarchy structure Function F.3.1.3 Provide Frequent Ask Question Data Function F.3.2 Process Maintenance Data Function F.3.3 Process Logistics Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Discrepancy Data Function F.3.5 Process RMA Data Function F.4.0 Analyze Data Function F.4.1 |
| **MTBF per System/Ship/Year** | Data relative to equipment/LRU MTBF per system per ship per year | Function F.5.0 Report Data Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |
| **MTTR per System per year** | Data relative to MTTR per system per year | Function F.5.0 Report Data Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |
| **Network Interface Connection** | Control line. Action is executed when network interface connection becomes available | | | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface |

| | | | | |
|---|---|---|---|---|
| **Periodic** | Control line. Action is executed periodically | | | Function Ext.Func.1.0 Ship Sends Data to Shore Function Ext.Func.2.0 Collect and Disseminate Fleet Data Function F.0 Provide Data Aggregation Capability Function F.2.0 Obtain Data Function F.2.3 Obtain Data from Fleet Support Infrastructure Function F.2.3.1 Collect Fleet Maintenance Data Function F.2.3.2 Collect Fleet Logistics Data Function F.2.3.2.1 Import Parts/Supplies Data Function F.2.3.3 Collect Fleet Training Discrepancy Data Function F.2.3.4 Collect Fleet RMA Data Function F.3.0 Process Data Function F.3.5 Process RMA Data Function F.4.1 Analyze Maintenance Data Function F.4.2 Conduct System Performance Trending Analysis Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.4 Display Logistics Information Function F.6.5 Display RMA Analysis Data |
| **Print Reports** | Reports generated via Print | | Function F.0 Provide Data Aggregation Capability Function F.7.0 Print & Save Data | |
| **Processed Logistics Data** | Logistics data have already been processed | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis | Function F.3.0 Process Data Function F.3.3 Process Logistics Data | |
| **Processed Maintenance Data** | Ship maintenance data have already been processed | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data Function F.4.2 Conduct System Performance Trending Analysis Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis | Function F.3.0 Process Data Function F.3.2 Process Maintenance Data | |
| **Processed Reliability Data** | Ship reliability data have already been processed | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis | Function F.3.0 Process Data Function F.3.5 Process RMA Data | |

| | | | | |
|---|---|---|---|---|
| **Processed Training Data** | Ship personnel training data have already been processed | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data Function F.4.4 Conduct Cost Analysis | Function F.3.0 Process Data Function F.3.4 Process Training Data Function F.3.4.1 Process Training Descrepancy Data | |
| **Q&A Data** | Data captured from Q&A, forum posted by ship personnel and fleet support agents | Function Ext.Func.4.0 Display Aggregation Data | Function F.0 Provide Data Aggregation Capability Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.1 Display FAQ, Blog and Forum data Function F.6.3 Display Corrective Maintenance Information Function F.6.3.1 Display Historical System Maintenance Action | |
| **RMA Data** | Data relative to ship RMA | | Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.5 Display RMA Analysis Data | |
| **Safety Issue Related to Maintenance** | Data relative to safety isssue while performing equipment maintenance | Function F.5.0 Report Data Function F.5.3 Generate System Status Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data | |
| **Ship and System Info** | Data relative to ship and system information | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.3 Display Ship and System Info | Function F.3.0 Process Data Function F.3.1 Process General Information Function F.3.1.2 Provide system info based on hieararchy structure | |
| **Ship and System Information** | Ship Name System Nomenclature and Configuration (APL, Part Number) | | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.3 Display Ship and System Info Function F.6.4 Display Logistics Information | |
| **Ship Data** | Ship data such as homeport, work centers, POCs, INMARSAT phone numbers, etc | Function Ext.Func.2.0 Collect and Disseminate Fleet Data Function F.0 Provide Data Aggregation Capability Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | Function Ext.Func.1.0 Ship Sends Data to Shore | |

| | | | | |
|---|---|---|---|---|
| **Ship force Training Discrepancies per Ship** | Data relative to ship force training discrepancies reported from tech assist, system assessment, and INSURVs, etc... | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |
| **Ships, Systems and POCs Info** | Data relative to ship, system , ship personnel POCs information | Function F.2.0 Obtain Data Function F.2.1 Obtain Data from User Inputs Function F.2.1.1 Receive Data via Web Form Function F.2.1.2 Import and Format Data Entered by User | Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | |
| **SME POCs Information** | Data relative to SME POCs information | | Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.2 Display SME POC Info | |
| **Supported Data** | Data relative to fleet support information | Function Ext.Func.3.0 Access Data | Function Ext.Func.4.0 Display Aggregation Data | |
| **System Assessment Reports** | Reports generated from system assessment conducted by fleet support agents | Function Ext.Func.4.0 Display Aggregation Data Function F.7.0 Print & Save Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report | |
| **System Availability to Support Warfare Area** | Data relative to system performance status that are required to support ship's mission | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |
| **System Configuration Data (APL, AEL, AAP, ...)** | Data relative to system configuration such as APL, AEL, AAP, COSAL, COSBAL, etc... | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.6.0 Display Data Function F.6.1 Display Fleet Support Information Function F.6.1.3 Display Ship and System Info | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data | |

| | | | | |
|---|---|---|---|---|
| **System Mean Down Time (MDT)** | Data relative to ship system MDT | Function F.5.0 Report Data Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.3 Compute System Ao/Ai based on RMA data | |
| **System Performance Trends by Ship** | Data relative to historical system performance trends by ship by baseline | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **System Performance Trends Data** | Data relative to system performance trends | | Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.5 Display RMA Analysis Data | |
| **System Status Reports** | Reports relative to ship system status | Function Ext.Func.4.0 Display Aggregation Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report | |
| **System RMA Reports** | Reports relative to ship system RMA | Function Ext.Func.4.0 Display Aggregation Data Function F.7.0 Print & Save Data | Function F.0 Provide Data Aggregation Capability Function F.5.0 Report Data Function F.5.4 Generate System RMA Report | |
| **Tech Assist Cost per System/Ship/Year** | Data relative to cost spent for tech assist per system per ship per year | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.4 Conduct Cost Analysis | |
| **Tech Assist Metrics** | Data relative to tech assist metrics conducted by fleet support agents | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data | |

| | | | | |
|---|---|---|---|---|
| **Top Equipment Take Longest Time To Repair** | Data relative to a system or equipment that has the highest MTTR | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.5 Display RMA Analysis Data | Function F.4.0 Analyze Data Function F.4.2 Conduct System Performance Trending Analysis | |
| **Top Replaced LRU with the highest Cost per System for last 5 years** | Data relative to a LRU that has the highest cost per system for last 5 year | Function F.5.0 Report Data Function F.5.2 Generate Logistics Report Function F.5.3 Generate System Status Report Function F.5.4 Generate System RMA Report Function F.6.0 Display Data Function F.6.4 Display Logistics Information | Function F.4.0 Analyze Data Function F.4.4 Conduct Cost Analysis | |
| **Training Data** | Data relative to ship personnel training | | Function F.6.0 Display Data Function F.6.2 Display Historical Fleet Data Function F.6.5 Display RMA Analysis Data | |
| **Troubleshooting Lesson Learned** | Data relative to equipment troubleshooting lesson learned | Function F.5.0 Report Data Function F.5.1 Generate System Assessment Report Function F.6.0 Display Data Function F.6.3 Display Corrective Maintenance Information Function F.6.3.1 Display Historical System Maintenance Action | Function F.4.0 Analyze Data Function F.4.1 Analyze Maintenance Data | |
| **User Enter Data** | Data is entered by the user | Function F.0 Provide Data Aggregation Capability Function F.1.0 Provide External Interface Function F.1.1 Execute System Interface | Function Ext.Func.3.0 Access Data | |

**Table 18. System Function Data Exchanges**

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# APPENDIX C. RISK ANALYSIS THROUGH COSYSMO

Figures 80, 81, 82, 83, and 84 diagram the results from the Cost Analysis performed by this group. Using COSYSMO software, the team conducted a Cost Analysis of what it would cost to create a new system and what it would cost to modify the current ESDS system.

NOTE: Inputs have RED Text. All other values are calculated.

| | Requirements | Definition | Complexity | | NEW DS SYSTEM: NEW REQUIREMENT? | NEW DS SYSTEM: NEW EASY | NEW DS SYSTEM: NEW NOMINAL | NEW DS SYSTEM: NEW DIFFICULT | NEW DS SYSTEM: Algorithms (New) Easy | NEW DS SYSTEM: Algorithms (New) Nominal | NEW DS SYSTEM: Algorithms (New) Difficult | | ESDS +: NEW REQUIREMENT? | ESDS +: REUSE EASY | ESDS +: REUSE NOMINAL | ESDS +: REUSE DIFFICULT | ESDS +: NEW EASY | ESDS +: NEW NOMINAL | ESDS +: NEW DIFFICULT | ESDS +: Algorithms (New) Easy | ESDS +: Algorithms (New) Nominal | ESDS +: Algorithms (New) Difficult |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R.1.1.1 | External Interface | This system shall be capable of interface with other systems including human interface and data base to collect and provide necessary data to perform all the functions. | DIFFICULT | | 1 | | | 1 | | | | | 1 | | | | | | 1 | | | |
| R.1.1.2 | Fleet Maintenance Support Data and Metrics | Group Title | | | | | | | | | | | | | | | | | | | | |
| R.1.1.2.1 | Display a list of system/subsystem on each platform | The system shall provide a list of system/subsystem on each platform. | EASY | | 1 | 1 | | | | | | | 1 | | | | 1 | | | | | |
| R.1.1.2.2 | Display SME contact information for each system/subsystem | The system shall display SME contact information for each system/subsystem | EASY | | 1 | 1 | | | | | | | 1 | | | | 1 | | | | | |
| R.1.1.2.3 | Display a list of Open CASREP, Trouble Tickets, and Help Desk items open for a speciific ship or an entire Strike Group | The system shall display a list of Open CASREP, Trouble Tickets, and Help Desk items open for a speciific ship or an entire Strike Group | NOMINAL | | 1 | | 1 | | | | | | 1 | | | | | 1 | | | | |
| R.1.1.2.3 | Search and Display CASREP data based on category, ship, element, system subsystem, sympton, status | The system shall be able to search and display the CASREP data based on category, ship, element, system subsystem, sympton, and status | NOMINAL | | 1 | | 1 | | | | | | 0 | | 1 | | | | | | | |
| R.1.1.2.4 | Display Area of Responsibility (AOR) requirements/Standing Orders (Classified) for all platform in a Strike Group | The system shall display Area of Responsibility (AOR) requirements/Standing Orders (Classified) for all platform in a Strike Group | NOMINAL | | 1 | | 1 | | | | | | 1 | | | | | 1 | | | | |
| R.1.1.2.5 | Display outstanding/open CASREP, 2 Kilo, Tech Assist Visit Request | The system shall display outstanding/open CASREP, 2 Kilo, Tech Assist Visit Request | NOMINAL | | 1 | | 1 | | | | | | 1 | | | | | 1 | | | | |
| R.1.1.2.6 | Display Technical Assist Visit Reports (TAVRs) by system | The system shall display Technical Assist Visit Reports (TAVRs) by system | EASY | | 1 | 1 | | | | | | | 1 | | | | 1 | | | | | |
| R.1.1.2.7 | Display the past and current ISEA investigations at the systems, equipment, and LRU levels | The system shall display the past and current ISEA investigations at the systems, equipment, and LRU levels | NOMINAL | | 1 | | 1 | | | | | | 1 | | | | | 1 | | | | |
| | Display status on installed engineering alterations and engineering alterations under | The system shall display status on installed engineering alterations and engineering alterations under | EASY | | 1 | 1 | | | | | | | 1 | | | | 1 | | | | | |

**Figure 80. Function Count and Complexity Analysis**

NOTE: Inputs have RED Text

| | | NEW SYSTEM | | | ESDS + | | | |
|---|---|---|---|---|---|---|---|---|
| | Complexity | EASY | NOMINAL | DIFFICULT | New Interface? | EASY | NOMINAL | DIFFICULT |
| MRDB | DIFFICULT | | | 1 | | | | |
| FLTMPS/EPM COGNOS | NOMINAL | | 1 | | 1 | | 1 | |
| CASREP DATABASE | NOMINAL | | 1 | | | | | |
| AREA OF RESPONSIBILITY INFO | NOMINAL | | 1 | | 1 | | 1 | |
| 2 KILO DATABASE | EASY | 1 | | | | | | |
| SAILOR TO ENGINEER | NOMINAL | | 1 | | 1 | | 1 | |
| PMS | DIFFICULT | | | 1 | | | | |
| INTERFACE DIAGRAMS | NOMINAL | | 1 | | 1 | | 1 | |
| NSLC | NOMINAL | | 1 | | 1 | | 1 | |
| NAVSUP | NOMINAL | | 1 | | | | | |
| MFOM | NOMINAL | | 1 | | | | | |
| ORTSTARS | NOMINAL | | 1 | | 1 | | 1 | |
| | Sum | 1 | 9 | 2 | | | 6 | |

**Figure 81. Interfaces Analysis**

| | | | |
|---|---|---|---|
| Requirements Understanding | H | 0.77 | |
| Architecture Understanding | N | 1.00 | |
| Level of Service Requirements | H | 1.32 | High due to Classified Content and IA issue |
| Migration Complexity | N | 1.00 | |
| Technology Risk | N | 1.00 | |
| Documentation | VH | 1.28 | |
| # and diversity of installations/platforms | EH | 1.86 | |
| # of recursive levels in the design | N | 1.00 | |
| Stakeholder team cohesion | VL | 1.50 | |
| Personnel/team capability | N | 1.00 | |
| Personnel experience/continuity | H | 0.82 | |
| Process capability | N | 1.00 | |
| Multisite coordination | N | 1.00 | |
| Tool support | H | 0.85 | |
| | | 2.55 | composite effort multiplier |

**Figure 82. COSYSMO Size Multiplier Inputs for a New System**

**Results**

**Cost and Schedule**

Effort =102 Person-months
Schedule = 6 Months
Cost = $819347

**Effort Distribution (Person-Months)**

| Phase / Activity | Conceptualize | Develop | Operational Test and Evaluation | Transition to Operation |
|---|---|---|---|---|
| Acquisition and Supply | 2.0 | 3.7 | 0.9 | 0.6 |
| Technical Management | 3.8 | 6.6 | 4.4 | 2.6 |
| System Design | 10.4 | 12.3 | 5.2 | 2.8 |
| Product Realization | 2.0 | 4.6 | 4.9 | 3.8 |
| Product Evaluation | 5.7 | 8.6 | 12.7 | 4.8 |

**Figure 83. Expert COSYSMO Output - ESDS+**

**Results**

**Cost and Schedule**

Effort =258 Person-months
Schedule = 9 Months
Cost = $2065068

**Effort Distribution (Person-Months)**

| Phase / Activity | Conceptualize | Develop | Operational Test and Evaluation | Transition to Operation |
|---|---|---|---|---|
| Acquisition and Supply | 5.1 | 9.2 | 2.3 | 1.4 |
| Technical Management | 9.7 | 16.7 | 11.0 | 6.6 |
| System Design | 26.3 | 31.0 | 13.2 | 7.0 |
| Product Realization | 5.0 | 11.6 | 12.4 | 9.7 |
| Product Evaluation | 14.4 | 21.6 | 32.0 | 12.0 |

**Figure 84. Expert COSYSMO Output - New System**

# APPENDIX D. PROJECT MANAGEMENT PLAN

This appendix contains the Project Management Plan (PMP) for the NPS MSSE Distance Learning Cohort 311–113O. The PMP was prepared by the NSWC PHD Distance Support team during their first of three quarters of the capstone project. This document identifies and outlines the plan the Distance Support team used to conduct this research project. The team used the PMP to define project goals and objectives, plan and organize the effort and resources needed to accomplish the tasks necessary to complete the project, establish a system engineering approach, and to specify timelines for completion. The PMP was approved and signed by the Chair of the Department of Systems Engineering, Dr. Clifford Whitcomb on September 4, 2012.

It is important to note that there have been a few modifications to the project plan since the PMP was signed and approved. For instance, the systems engineering (SE) process, shown in Figure 2 of the PMP, and the SE project activities, shown in Figure 3 of the PMP, were both modified to ensure the project could be completed within the time allowed. Due to the time constraints and in order to provide a more in depth research project, the team decided to focus on the left hand side of the V-shaped SE model shown in Figure 2. The capstone team worked with and obtained approval from the stakeholders and project advisors to make the Stakeholder Requirements Definition, Requirements Analysis and Architecture Design technical processes the focal points of the project. The updated SE model can be seen in Figure 4 of the capstone report. In terms of the SE project activities, shown in Figure 3 of the PMP, the team worked with the stakeholders and advisors to modify and focus on a portion of the activities. The team completed Activity 1.0, Define Stakeholder Needs, and its sub-activities, Activity 2.0, Requirements Analysis, and its sub-activities, and Activity 3.0, System Architecture Design, and its sub-activities. The updated SE project activities can be seen in Figure 5 of the capstone report.

# NAVAL POSTGRADUATE SCHOOL

**MONTEREY, CALIFORNIA**

# PROJECT MANAGMENT PLAN

**INCREASING FLEET READINESS THROUGH IMPROVED DISTANCE SUPPORT**

by

MSSE Cohort 311-113O

August 2012

Capstone Project Advisors: Mark Rhoades
Brigitte Kwinn

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**INCREASING FLEET READINESS THROUGH IMPROVED DISTANCE SUPPORT**

NPS MSSE Cohort 311-113O

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN SYSTEMS ENGINEERING**

from the

**NAVAL POSTGRADUATE SCHOOL**
**MARCH 2013**

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Dr. Clifford Whitcomb
Chair: Dept. of Systems Engineering

ii

**TABLE OF CONTENTS**

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## LIST OF FIGURES

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## LIST OF TABLES

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## LIST OF ACRONYMS AND ABBREVIATIONS

| Acronym | Term |
|---|---|
| AoA | Analysis of Alternatives |
| CBA | Cost Benefit Analysis |
| CNSF | Commander of Naval Surface Forces |
| CONOPS | Concept of Operations |
| DoDAF | Department of Defense Architecture Framework |
| DS | Distance Support |
| FFBD | Functional Flow Block Diagram |
| HSI | Human Systems Integration |
| IPR | In Progress Review |
| KPP | Key Performance Parameters |
| LCS | Littoral Combat Ship |
| M&S | Modeling & Simulation |
| MOE | Measure of Effectiveness |
| MOP | Measure of Performance |
| MS | Microsoft® |
| MPT&E | Manpower, Personnel, Training and Education |
| NAVSEA | Naval Sea Systems Command |
| NPS | Naval Postgraduate School |
| NSWC PHD | Naval Surface Warfare Center , Port Hueneme Division |
| OPNAV | Office of the Chief of Naval Operations |
| PEO | Program Executive Office |
| PMP | Project Management Plan |
| ROI | Return On Investment |
| SE | System Engineering |
| SME | Subject Matter Expert |
| T&E | Test & Evaluation |
| TOC | Total Ownership Cost |
| TYCOM | USN Type Command |

| Acronym | Term |
|---|---|
| USN | United States Navy |
| WBS | Work Breakdown Structure |

# I. INTRODUCTION & PROJECT OVERVIEW

This is the capstone Project Management Plan (PMP) for the Naval Postgraduate School (NPS) Masters of Science in Systems Engineering (MSSE) distance learning cohort 311-113O. This project management plan lays out the organizational and technical approaches the team will use during the course of the project. Specifically, the PMP describes the specific problem or issue that the project will address, the project objectives, the systems engineering approach, the technical and programmatic activities planned, and the team's organization. It will also present the project schedule with major milestones and deliverables (NPS 2006).

## A. BACKGROUND

Requirements of homeland defense, national security, and the war on terrorism have made a ship's mission more critical than ever (Office of Homeland Security 2002). When equipment fails there is little time to wait for engineers or technicians to fly to the deployed ship to help resolve the problem. By bringing leading-edge distance support technology to our sailors at sea, twenty four hours a day, seven days a week, the engineers, logisticians, and technicians of Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) are working to help our ships return to operational readiness without leaving their positions. Distance support is important due to (Camanag 2012):

- Reduced-Manned Ships (such as the Littoral Combat Ship [LCS])
- Increasing complexity of systems due to technology advancements, integration of emergent capabilities, and foreign combat system elements
- Pressures to reduce Total Ownership Cost (TOC)

Current distance support is often slow and ineffective. Numerous distance support tools exist but need to be consolidated and/or integrated more effectively. In addition, distance support activities are often not captured for knowledge retention and reutilization. Knowledge that is captured is difficult to access and utilize in a timely manner. Better tools need to be developed to allow knowledge to be captured and utilized when needed to help improve distance support and ultimately fleet readiness.

This capstone team will investigate the requirements and parameters needed to provide a technically feasible, cost effective, and efficient approach for NSWC PHD to provide distance support to the United States Navy (USN). This project will investigate improvement options for providing distance support to the fleet. In addition to helping the fleet, it will benefit the command, NSWC PHD, which all team members represent.

## B. PROBLEM STATEMENT

### 1. Initial Problem Statement

When this capstone project was started, the initial problem statement was: A decline in sailors' ability to operate, maintain, and sustain combat systems necessitates the need to optimize distance support from Fleet field support activities to meet current and future Fleet Readiness demands (SEA 21 2010). As new surface ship programs emerge, the complexity of combat systems has increased. In recent years, the Navy has identified reducing manning levels as a key approach to reduce costs. The Navy's decision to reduce manning dropped the Fleet's availability levels to "below the levels required to support material readiness requirements" (Balisle 2010). Inadequate distance support results in reduced fleet readiness, increases shore activity and Subject Matter Expert (SME) manpower requirements, decreases fleet independence, decreases efficiencies, and increases total ownership costs.

After further investigation and research, the team discovered that fleet distance support covers a wide area of ships operation and maintenance. The Commander of Naval Surface Forces (CNSF) defines distance support as: "Distance support is a Navy Enterprise effort that combines people, processes, and technology into a collaborative infrastructure without regard to geographic location," and "distance support projects reactive, proactive, and predictive support to sailors across functional areas in order to achieve the right readiness at the right time, at the right cost" (CNSF 2010).

The CNSF categorizes distance support by the following four functional areas:

- Logistics
- Maintenance and Modernization
- Manpower, Personnel, Training and Education (MPT&E)

- War fighting

In addition, each of the four categories listed above also have many sub functions and unique processes. The magnitude and volume of fleet distance support activities that occur across these functional areas is enormous. The team soon realized that a capstone project that improves fleet distance support across all four functional areas is beyond our ability given the limited resources and time to complete the project. The team agreed that the project had to be scoped to a manageable level, so it was re-focused to the distance support areas that NSWC PHD currently supports. NSWC PHD is primarily involved in limited aspects of logistics, maintenance, and modernization of combat systems installed on surface ships. Since most of the team's work is related to maintenance, the team limited the scope to maintenance functions.

#### 2. Revised Problem Statement

NSWC PHD has several methods for conducting distance support for ship maintenance. NSWC PHD's capabilities include both remote systems monitoring and technical assistance (tech assist). Both services are provided in real time, near real time, and on a periodic basis. Each of these levels of distance support has unique processes and requirements which again would require significant investigation and research.

Since time was of the essence, the team decided to seek guidance from several stakeholders to help scope the project. After meeting with several key stakeholders at NSWC PHD, the team decided to focus on improving distance support knowledge capturing and knowledge reutilization primarily because a solution was needed to aggregate data from multiple distance support data collection sources. The stakeholders advised that they were specifically interested in capturing and maximizing the reuse potential of distance support activities and experiences to increase fleet self-help and improve equipment reliability thru design changes and new manufacture of combat systems.

Therefore, with the stakeholder preferences in mind, the team revised the problem statement as follows:

NSWC PHD needs to improve distance support knowledge capturing in order to reutilize this knowledge to provide more effective distance support capability to the fleet and perform more effective trend analysis to improve equipment reliability utilizing existing shore support resources and processes (Scheid et al. 2012).

## C. PROJECT SCOPE

The team has scoped the project to focus on the area of improving distance support knowledge capturing and reutilization, as it applies to NSWC PHD. The team will apply a system engineering approach and techniques to clearly define the problem, define and prioritize stakeholder requirements, determine the measures of effectiveness perform a functional analysis, research and compare possible solutions, and develop conclusions and recommendations.

As the revised problem statement suggests, the team will focus on finding a solution to determine what methods and tools are needed to allow distance support knowledge and experience to be captured and utilized to help improve distance support and ultimately fleet readiness. Therefore, the team will focus primarily on developing a solution that will aggregate data from numerous existing distance support sources and export data to the fleet to promote self-help and export data to help facilitate trend/failure analysis opportunities.

Below is a list of initial research questions that will be pursued for this capstone project:

- What are the specific fleet needs for distance support?
- What tools and processes currently exist?
- What technology is available to modernize and evolve distance support capabilities?
- What methods/approaches have other organizations successfully implemented?
- What tools/technology have other organization successfully utilized?

Expected deliverables include a formal system engineering report and presentation. The team will also provide recommendations for implementing solutions that will meet stakeholder expectations. Resources, at a minimum, will include existing distance support processes and tools, past distance support studies, and interviews from personnel currently responsible for managing and conducting distance support.

## D. PROJECT OBJECTIVES, CONSTRAINTS, & ASSUMPTIONS

There are two main academic objectives of the capstone project. The first is to apply the system engineering knowledge, skills, and techniques acquired in the NPS MSSE curriculum to solve an applicable real world problem. The second is to successfully complete the capstone project, including delivering all academic and stakeholder deliverables, within the given time frame.

Below is a list of project constraints:

- The project must be completed in 3 academic quarters.
- The project must be accomplished within the time and manpower available.
- The project must be accomplished without incurring any monetary costs.
- Deliverables must meet NPS guidelines.

Below are the assumptions made to guide the project:

- There is significant benefit to improving distance support knowledge capturing and reutilization.
- There are better methods and/or better tools for capturing and reutilizing distance support knowledge.
- Demand for distance support will increase or remain constant.
- Regional Maintenance Centers (RMC) and/or In Service Engineering Agents (ISEA) technical expertise is stable.
- RMCs/ISEAs are committed to distance support knowledge capturing and reutilization.

## E. ORGANIZATION STRUCTURE WITH ROLES & RESPONSIBILITIES

The team is organized by competency areas to support the capstone project, as shown in Figure 1.

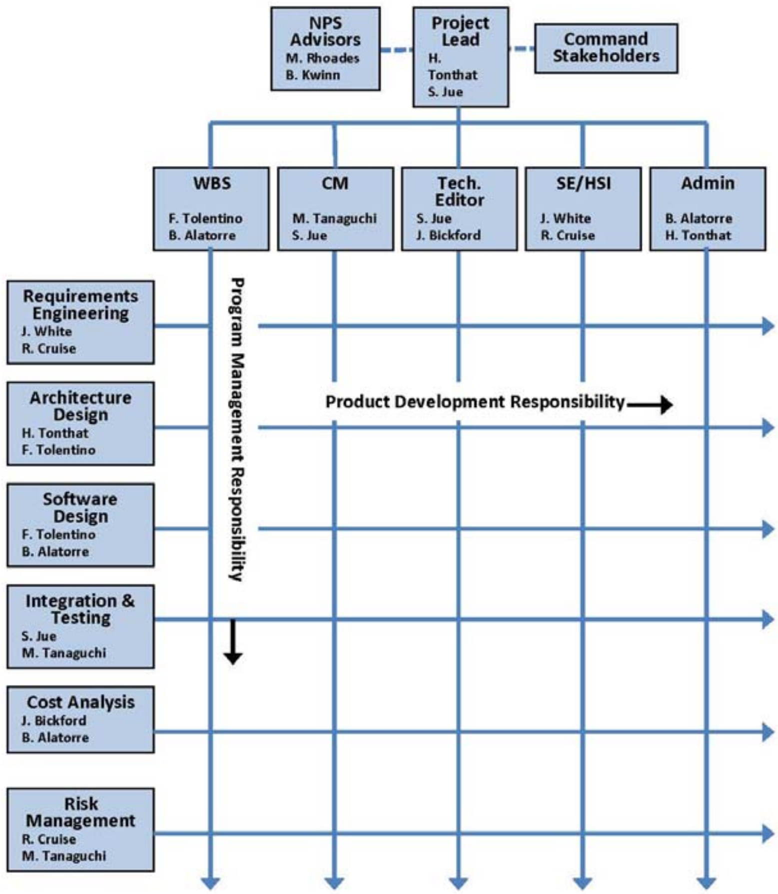


**Figure 1.** Organization Chart (After Kerzner 2011)

### 1. NPS Advisors

Advisors shall guide students in the formulation of project topics, guide students in the development of the PMP and the Capstone Project Report, help identify project sponsors when appropriate, help lay out a schedule of milestones, monitor the students' progress, provide consultation and direction, and review documents for accuracy and completeness and products which result from the project (NPS 2006).

### 2. Technical Roles

The systems engineering product development responsibilities, as shown in Figure 1, show which product areas each team member is responsible for during the project development. The product development responsibilities are divided into six system engineering principals: requirements engineering, architecture design, software design, integration and testing, cost analysis, and risk management.

- Requirements Engineering - Responsible for the iterative elicitation, elaboration, verification, and documentation, and evaluation of all capstone project requirements.
- Architecture Design - Responsible for the development and design of the system architecture. Creates the Department of Defense Architecture Framework (DoDAF) views and documents the architecture artifacts. Translates stakeholder needs and objectives into system functional requirements and decomposes these requirements into functional architecture. Performs functional and gap analysis to determine which data and software tools that are required to be integrated into the data aggregation system. An Analysis of Alternatives (AoA) will also be conducted to determine the alternate solutions for the data aggregation system based on the cost analysis and performance effectiveness of each alternative system.
- Software Design - Develops or improves existing software tool that will aggregate data from numerous existing distance support sources and

export data to the fleet to promote self-help and export data to other tools to help facilitate trend/failure analysis opportunities.

- Integration & Testing - Responsible for conducting any necessary system integration and testing that may occur during Modeling & Simulation (M&S) to make sure the system performance meets its requirements based on Key Performance Parameters (KPP). Integration and testing may also occur during the design and implementation of the selected architecture.
- Cost Analysis - Responsible for all cost related analyses, including conducting a Business Case Analysis (BCA) and provides Return of Investment (ROI) estimation.
- Risk Management - Responsible for conducting risk management, performs risk assessment and provides risk mitigation.

### 3. Administrative Roles

The project management responsibilities, as depicted in Figure 1, show which overarching tasks each team member is responsible for during the project development. The project management responsibilities are divided into five categories: project lead, Work Breakdown Structure (WBS) lead, Configuration Management (CM) lead, technical editor (Tech. Editor), Systems Engineering (SE) and Human Systems Integration (HSI), and Administration (Admin).

- Project Lead - Acts as the overall visionary and monitors the progress toward meeting capstone project objectives. The project lead is responsible for managing and executing the project according to the project plan and to maintain a balance between the technical, schedule, and administrative requirements of the project and the organization of team efforts. The project leader's responsibilities include: facilitate team meetings and information exchange, monitor and guide the overall project activities, foster team member participation, and promote collaboration among the team members.
- WBS Lead – Responsible for creating, tracking and monitoring the WBS through the project term.

- CM Lead – Responsible for ensuring all products created by the group follow a proper change process to ensure consistency in review and certainty of content.
- Technical Editor - Ensures all the technical reports and publications generated by the team will meet the style guide and well written.
- SE & HSI Lead – Verifies that sound systems engineering principles, techniques and theory are utilized in all tasks associated with the project. Also responsible for ensuring human factors are considered during the project.
- Administration - Responsible for taking notes during team meeting and keeping track of action items, keeping minutes of meetings, assembling drafts, consolidating inputs to all project documents, and managing the data repository.

## F. STAKEHOLDERS

A list of potential stakeholders and the team's best estimate of their primary concern with regards to this project is given in Table 1 below.

| Stakeholder | Primary Concern |
|---|---|
| Fleet | Improve fleet readiness, reduce TOC |
| Waterfront Activities | Improve distance support capabilities, capture knowledge |
| USN Type Commander (TYCOM) | Improve fleet readiness, DS effectiveness. System Performance Metrics |
| Naval Sea Systems Command (NAVSEA) | Improve distance support capabilities, reduce Life Cycle Cost (LCC) , System Performance Metrics, Failure Trends |
| Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) | Improve fleet readiness, improve distance support capabilities, capture knowledge, and reduce LCC/TOC |
| Program Executive Office (PEO) | Improve distance support and reduce TOC, Failure Trends, Acquisition Impacts |
| Office of the Chief of Naval Operations (OPNAV) | Improve fleet readiness and reduce TOC |

**Table 1.** Stakeholders

## G. PROJECT SPONSORS

All the sponsors are from NSWC PHD. The sponsors for this capstone project are listed in Table 2.

| *Sponsor* | *Title* |
|---|---|
| **Mr. Timothy Troske** | Technical Director |
| **CAPT Theodore Olson** | Office of Logistics (OOL), Deputy Commander |
| **Mr. Fabio Vitale** | Office of Logistics (OOL), Director |
| **CAPT (Sel) Scott Davis** | Chief Engineer (CHENG), Office of Engineering Technology (OET) |
| **Mr. David Scheid** | OET, Knowledge Management and DS Advocate |
| **Mr. David Williams** | OET DS Community of Practice Lead |
| **Ms. Coralyn Akers** | Fleet Liaison |
| **Mr. John Lester** | SE - A Department Lead |
| **Mr. Noel Camanag** | SE – L Department Lead |
| **Mr. James Childs** | SE - S Department Lead |

**Table 2.** Project Sponsors

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# II. SYSTEMS ENGINEERING APPROACH

## A. OVERVIEW

The team will adopt the new 2009 DoD SE Model (DAU 2011) as shown in Figure 2 below, as a framework for the project systems engineering process due to its standard applicability to system engineering projects. The 2009 DoD SE Model consists of two major processes; the technical management processes form the executive or control logic that steers system development to meet project or phase objectives. The technical processes are depicted in a V-shaped pattern. This pattern portrays the top-down design that occurs as requirements are progressively allocated from the system level down to lower-level elements. In addition, the V-shaped model of the technical processes more explicitly shows the bottom up realization from lowest level components to higher assemblies to achieve the complete system. The technical processes are applied iteratively and recursively across the life cycle and at different levels in the system hierarchy to elaborate and mature the system.

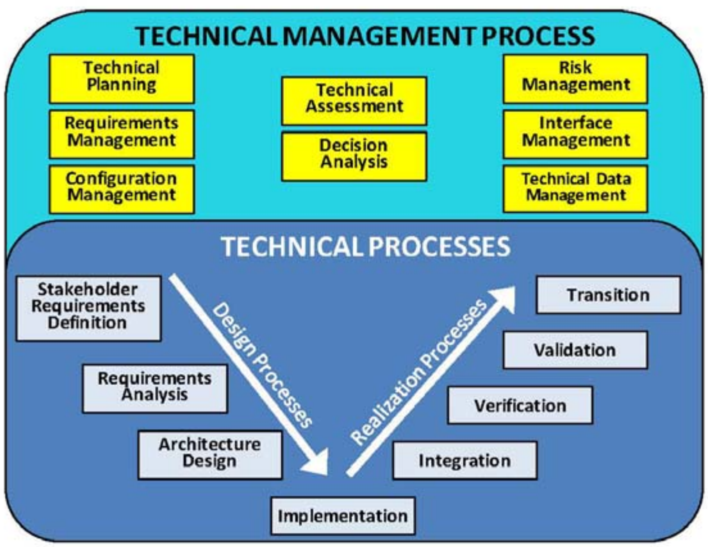


**Figure 2.** 2009 DoD System Engineering Model (From DAU 2011)

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The team will use the tailored SE process as illustrated in Figure 3 below for activities in the development of the capstone project.

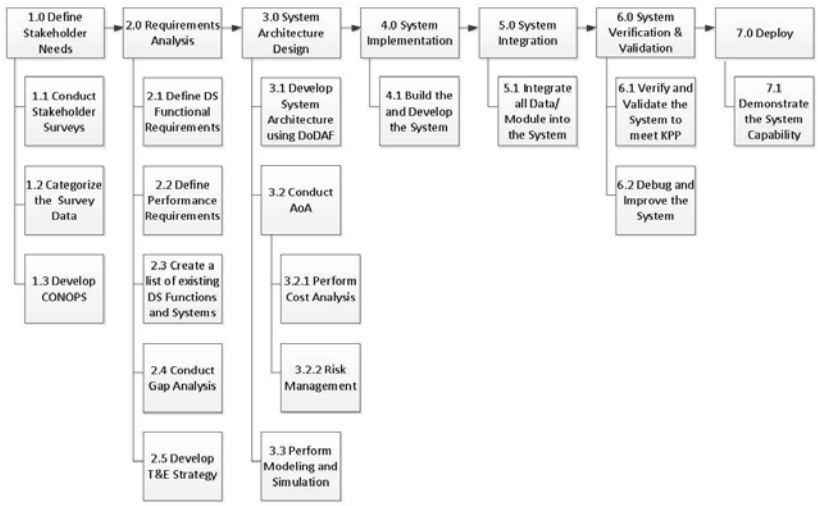


**Figure 3.** SE Process to Project Activities (After DAU 2011)

## B. TECHNICAL PROCESSES

### 1. Define Stakeholder's Needs

The first step of the SE process is to conduct interviews with users and stakeholders to determine the needs, requirements, and objectives for the use of data aggregation system using the data products generated from the shore support infrastructure. From the interviews, the team will also develop a Concept of Operations (CONOPS).

### 2. Requirements Analysis

During this phase, the team will define the distance support functional and performance requirements, such as the Key Performance Parameters (KPP) of the system, based on the stakeholder's needs analysis. The team will then conduct the research and create a list of existing DS functions and systems currently used in the fleet, which include the data products that are generated from each function and system. These existing functions will then be mapped against the functional requirements based on stakeholder's needs to determine if there are any capability gaps.

The team will also develop the test and evaluation strategy which will be used in the system verification and validation phase later in the process based on the developed functions and requirements.

### 3. System Architecture Design

In this phase, the team will develop the detailed architecture design of the system by decomposing the functions using hierarchy structure and publish the results in compliance with the Department of Defense Architecture Framework (DoDAF). The Functional Flow Block Diagram (FFBD), which is a multi-tier, time-sequenced, step-by-step flow diagram of system's function flow, will be used to provide an easy-to-follow graphical representation for illustrating the system based on its functional elements. The FFBD will serve as the System Functionality Description (SV-4a) model. Also, a functional allocation matrix will be created to accompany the SV-4a, as this will help to map system functions to system elements.

Following the development of the architecture, the team will then conduct an Analysis of Alternatives (AoA) to determine alternate solutions. In conducting the AoA, a basic cost analysis of all options will be conducted to help determine the most feasible and cost effective. Before system implementation, a more substantial cost analysis will also be performed to determine the cost effectiveness as well as the ROI benefits for implementing the chosen alternative system.

### 4. System Implementation

As authorized by the command sponsor, the team is allowed to use the existing hardware available at NSWC PHD for system implementation. During this phase, the team will develop or improve existing software tools such as database and other analysis tools which will be used for data aggregation as defined in the architecture design phase.

### 5. System Integration

In this phase, the team will assemble all the data and software modules and integrate into the system in preparation for system verification and validation phase. Integration and testing will occur during M&S and possibly during design and implementation of the selected architecture. The team will model candidate solutions, as applicable, and test for compatibility and performance. Numerous data sources currently exist so the modeling processes will attempt to integrate data from multiple sources into a single system so that data can be collected and utilized to satisfy requirements. Once integrated, the system should be capable of providing information that can be used to improve sailor self-help and used to improve equipment reliability.

### 6. System Verification and Validation

During this phase the system will be tested against Verification & Validation requirements defined in the requirements analysis phase to make sure the products will satisfy the stakeholder's needs. Any discrepancies and issues with the design that captured during this phase will be debugged, corrected, and re-designed.

### 7. Deploy

As desired by the command sponsor, the system desired will be a common tool across all NSWC PHD supported systems. These systems include combat systems (e.g. AEGIS), weapons (e.g. MK 38 Machine Gun System (MGS)), radars (e.g. SPQ-9B radar), Hull Mechanical and Engineering (HM&E) systems (e.g. MK 41 Vertical Launch System (VLS)), equipment groups (e.g. switchboards), other systems (e.g. Collaborative Engagement Capability (e.g. CEC)), and Force protection (e.g. Acoustic Hailing Device). With many systems under consideration, the plan is to select a specific system from which to perform a beta test. A community of stakeholders will be solicited to be a part of the test, which is expected to provide feedback such as user interface to overall logic and usefulness. Upon satisfactory completion by the command sponsors, the feedback will be adjudicated, and the product will evolve to include all the systems under NSWC PHD purview.

## C. TECHNICAL MANAGEMENT PROCESSES

The capstone project requires management in several areas of concern. Management is required to ensure the end product is completed on schedule and to the satisfaction of stakeholders and NPS. These areas of concern are project risks, configuration, and information assurance.

### 1. Risk Management

Risks to this project will primarily be managed in accordance with the Risk Management Guide for DoD Acquisition (DoD 2006). Although written in general terms, it will be tailored to this project. Figure 4 describes the process promulgated in the guide; It is important to note the focus on mitigation or control aspect. Project management can also use acceptance, avoidance and transfer strategies to respond to risks (Kerzer 2009, 784).

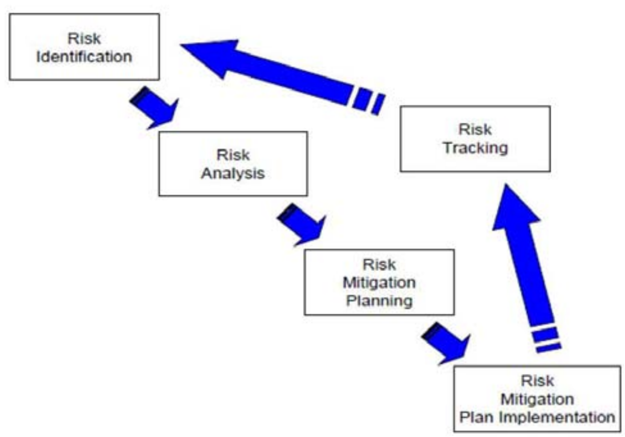


**Figure 4.** Risk Management Process (From DoD 2006)

Reporting each risk identified will be performed through the use of a risk matrix shown in Figure 5 below, which classifies each risk by likelihood and consequence. When project risks need to be conveyed to capstone professors or stakeholders, this reporting matrix will be used.

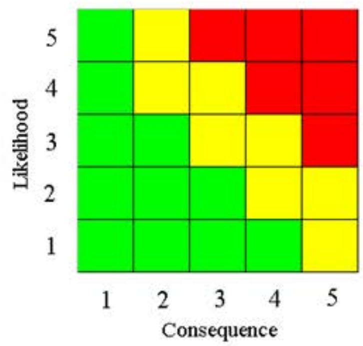


**Figure 5.** Risk Assignment Matrix (From DoD 2006)

The consequence for a risk will be determined by using Table 3 below.

| *Level* | *Schedule* |
|---|---|
| **1** | Minimal or no impact |
| **2** | Able to meet key dates<br>Slip < 1 week |
| **3** | Minor schedule slip. Able to meet key milestones with no schedule float<br>Slip < 2.5 weeks |
| **4** | Program critical path affected<br>Slip < 1 month |
| **5** | Cannot meet key program milestones<br>Slip > 1 month |

**Table 3.** Risk Consequence Classification (After DoD 2006)

The likelihood of each risk will be determined by using Table 4 below.

| *Level* | *Likelihood* | *Probability of Occurrence* |
|---|---|---|
| **1** | Not Likely | ≤10% |
| **2** | Low likelihood | ≤30% |
| **3** | Likely | ≤50% |
| **4** | Highly likely | ≤90% |
| **5** | Near Certain | ≤100% |

**Table 4.** Risk Likelihood Classification (After DoD 2006)

Response to risk by controlling, transferring or avoidance will be designed to lower probability, severity or both. This would be reflected in a new risk matrix that could move risks in the "red" boxes to "yellow" or "green". The last option, acceptance, will not change the risk matrix; it is used for a risk that is tracked but no course of action is developed until occurrence happens.

### 2. Configuration Management

The team will use Dropbox™ (www.dropbox.com) and Sakai® as archive tools throughout the project. The deliverables will be in the form of Microsoft (MS) Word® documents, MS Excel® spreadsheets, MS Power Point® presentations, drawings, and architecture artifacts developed in CORE®. The revision process will be tracked using the file name with an incremented alpha numeric number with the team member's initial (i.e., PMP Draft Rev A HT). Once a deliverable is ready for submission it will be published using numeric revisions (i.e., PMP Rev 1). The numeric revision number will be incremented upon subsequent submissions (i.e., PMP Rev 2). All revisions will be maintained chronologically in an archive. This archive will be maintained by the technical editor.

## D. RESOURCES

To assist in this project, a number of software tools will be utilized, which include but are not limited to:

- System Architecture (CORE®)
- Data Storage (Dropbox)
- Research (Dudley Knox Library)
- Database Development (SQL Server®)
- Statistical Analysis (MATLAB®)
- Modeling & Simulation tools (ExtendSim®)
- Microsoft® (MS) Office Suite (Word®, Excel®, Power Point®, Outlook®, Project®, and Access®)
- NPS Thesis Project Office Website
- Sakai®

## III. MILESTONES AND DELIVERABLES

The milestones associated with the capstone project are listed in Table 5 below. Every milestone represents an important achievement in the capstone project. Through each of the listed milestones, the team will show progress and advancement with the goal of completing all listed deliverables within the given timeframe. The capstone Project will span for three academic quarters. At the end of each quarter, the team will use an In-Process Review (IPR) as a forum to brief NPS faculty and stakeholders on the project's status and progress and to present deliverables completed up to that point in time.

At the end of the first academic quarter, the team will present an overall view of the project, using the PMP as a reference, during the first IPR. The products included in the PMP will be used to present the project's scope and objectives, team's organization, systems engineering process, and technical and programmatic activities planned to successfully complete all listed deliverables. Furthermore, the team will present a comprehensive stakeholder need analysis; including a detailed explanation of the process taken to determine needs, requirements, and objectives from stakeholders. Additionally, a detailed requirements analysis will be presented to show how the team used the stakeholder needs to translate them into specific functional and performance requirements as part of the requirement analysis. Finally, a gap analysis will be completed and presented during the first IPR.

The plan is for the team to complete the system architecture design by the end of the second academic quarter. The architecture design will be presented using DoDAF artifacts during the second IPR. Additionally, the team will complete and present an analysis of alternatives, cost analysis, and risk management plan to NPS faculty and stakeholders. Moreover, M&S will be completed by the team and results will be presented during the second IPR.

During the final third portion of the project, the team will develop or improve existing software systems based on the system architecture design. Furthermore, the team will perform system integration in preparation for the system validation and verification phase. The validation and verification phase will be then completed to ensure the system was built right and to verify the right system was developed. Once the validation and verification phase is completed, a system prototype will be ready to present to NPS faculty and stakeholders. All completed deliverables, products, and artifacts developed up to this point will be included in the final capstone project report and will be presented during the final IPR.

| ***Milestones*** | ***Deliverables*** | ***Completion Date*** |
|---|---|---|
| Final Project Management Plan Due | Project Management Plan | 09 August 2012 |
| In-Process Review No. 1 | Stakeholder Need Definition and Requirements Analysis | 13 September 2012 |
| In-Process Review No. 2 | System Architecture Design (DoDAF Artifacts), Analysis of Alternatives, Modeling and Simulation, and Risk Management Plan | 06 December 2012 |
| Final Report Due to Advisors | Draft Capstone Project Report | 14 February 2013 |
| Final Report Due to Thesis Processing Office | Final Capstone Project Report | 28 February 2013 |
| Final In-Process Review | System Prototype and Final Capstone Project Presentation | 14 March 2013 |
| Final Report Due to Department Chair | Final Capstone Project Report | 15 March 2013 |

**Table 5. Milestones and Deliverables**

The preliminary schedule of major events for this capstone project is depicted in Figure 6. The schedule also captures the initial deliverables as outlined in the Capstone Project Guide (NSP 2006). The schedule will be further developed throughout the duration of the project and each of the major events will be broken down to show additional detail for each of the tasks required to complete all deliverables.

| ID | | Task Name | Duration | Start | Finish | Predec |
|---|---|---|---|---|---|---|
| 1 | | **Distance Support Casptone Project** | **180 days** | **Mon 7/16/12** | **Fri 3/22/13** | |
| 2 | ✓ | **Initiate Project** | **17 days** | **Mon 7/16/12** | **Tue 8/7/12** | |
| 7 | | **Status Update (Sign up on Sakai)** | **95 days** | **Thu 7/19/12** | **Thu 11/29/12** | |
| 27 | | **PMP Development** | **18 days** | **Mon 7/16/12** | **Thu 8/9/12** | |
| 33 | | **Stakeholder Requirements Definition** | **145 days** | **Mon 7/16/12** | **Fri 2/1/13** | |
| 34 | | Identify Stakeholder(s) | 5 days | Mon 7/16/12 | Fri 7/20/12 | |
| 35 | | Define Stakeholder Needs | 5 days | Mon 7/23/12 | Fri 7/27/12 | 34 |
| 36 | | Conduct Stakeholder Surveys | 10 days | Mon 7/30/12 | Fri 8/10/12 | 35 |
| 37 | | Categorize Survey Data | 10 days | Mon 8/13/12 | Fri 8/24/12 | 36 |
| 38 | | Develop System CONOPS | 10 days | Mon 1/21/13 | Fri 2/1/13 | 78 |
| 39 | | **Requirements Analysis** | **45 days** | **Mon 8/27/12** | **Fri 10/26/12** | |
| 40 | | Define DS Functional Requirements | 10 days | Mon 8/27/12 | Fri 9/7/12 | 37 |
| 41 | | Define Performance Requirements | 10 days | Mon 9/10/12 | Fri 9/21/12 | 40 |
| 42 | | Create List of Existing DS Systems | 15 days | Mon 9/24/12 | Fri 10/12/12 | 41 |
| 43 | | Conduct Gap Analysis | 10 days | Mon 10/15/12 | Fri 10/26/12 | 42 |
| 44 | | Develop T&E Strategy | 10 days | Mon 9/3/12 | Fri 9/14/12 | |
| 45 | | **IPR #1** | **10 days** | **Fri 8/31/12** | **Thu 9/13/12** | |
| 48 | | **System Architecture & Design** | **90 days** | **Mon 7/23/12** | **Fri 11/23/12** | |
| 49 | | **Develop System Architecture Using DoDAF** | **45 days** | **Mon 7/23/12** | **Fri 9/21/12** | |
| 66 | | **Conduct AoA** | **20 days** | **Mon 10/29/12** | **Fri 11/23/12** | **43** |
| 67 | | Perform Cost Analysis | 10 days | Mon 10/29/12 | Fri 11/9/12 | |
| 68 | | **Risk Management** | **20 days** | **Mon 10/29/12** | **Fri 11/23/12** | |
| 71 | | Perform Modeling and Simulation | 15 days | Mon 9/17/12 | Fri 10/5/12 | 44 |
| 72 | | **IPR #2** | **10 days** | **Thu 11/22/12** | **Thu 12/6/12** | |
| 75 | | **System Development & Implementation** | **20 days** | **Mon 11/26/12** | **Fri 12/21/12** | |
| 76 | | Build and Develop the System | 20 days | Mon 11/26/12 | Fri 12/21/12 | 48,6 |
| 77 | | **System Integration** | **20 days** | **Mon 12/24/12** | **Fri 1/18/13** | |
| 78 | | Integrate all Data/Modules into the System | 20 days | Mon 12/24/12 | Fri 1/18/13 | 76 |
| 79 | | **System Verification and Validation** | **20 days** | **Mon 2/4/13** | **Fri 3/1/13** | |
| 80 | | Verify and Validate System to Meet KPP | 10 days | Mon 2/4/13 | Fri 2/15/13 | 38 |
| 81 | | Debug and Improve the System | 10 days | Mon 2/18/13 | Fri 3/1/13 | 80 |
| 82 | | **Deploy** | **10 days** | **Mon 3/4/13** | **Fri 3/15/13** | |
| 83 | | Demostrate System Capability | 10 days | Mon 3/4/13 | Fri 3/15/13 | 81 |
| 84 | | **Final IPR** | **25 days** | **Thu 2/7/13** | **Thu 3/14/13** | |
| 88 | | **Casptone Report** | **180 days** | **Mon 7/16/12** | **Fri 3/22/13** | |

**Figure 6.** Schedule

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