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THESIS

RECOMMENDED ARCHITECTURE FOR A KNOWLEDGE MANAGEMENT SYSTEM FOR THE UNDERSEA LAUNCHERS DIVISION AT THE NAVAL UNDERSEA WARFARE CENTER

by

Steven Bousquet

September 2010

Thesis Advisor:	Gregory Miller
Second Reader:	Rene G Rendon

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This thesis used systems engineering to create an architecture description for Knowledge Management (KM) at the Launchers Division of the Platform and Payload Integration Department at the Naval Undersea Warfare Center. The Launchers Division stores and shares technical information poorly, resulting in inefficiencies and design rework. A formal KM system could improve the situation. The architecture description addresses stakeholder needs while using KM best practices. This study consisted of problem definition, requirements development, and an architecture description. The resulting system top-level requirements include create, store, analyze, and report submarine launchers knowledge across Naval Sea Systems Command (NAVSEA) and the Fleet. The resulting architecture description integrates people, processes, and technology. The architecture description is recommended for use in developing a more detailed system design for the Launchers Division.

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Steven Bousquet
Civilian, United States Navy
B.S.M.E., University of Massachusetts, 2001

Submitted in partial fulfillment of the
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NAVAL POSTGRADUATE SCHOOL
September 2010

Author: Steven Bousquet

Approved by: Gregory Miller
Thesis Advisor

Rene G Rendon, DBA
Second Reader

Clifford Whitcomb, PhD
Chairman, Department of Systems Engineering

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ABSTRACT

This thesis uses systems engineering to create an architecture description for Knowledge Management (KM) at the Launchers Division of the Platform and Payload Integration Department at the Naval Undersea Warfare Center. The Launchers Division stores and shares technical information poorly, resulting in inefficiencies and design rework. A formal KM system could improve the situation. The architecture description addresses stakeholder needs while using KM best practices. This study consists of problem definition, requirements development, and an architecture description. The resulting system top-level requirements include create, store, analyze, and report submarine launchers knowledge across Naval Sea Systems Command (NAVSEA) and the Fleet. The resulting architecture description integrates people, processes, and technology. The architecture description is recommended for use in developing a more detailed system design for the Launchers Division.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	**Term**
AIMTC	Advanced Interactive Management Technology Center
CPRS	Common Problem Reporting System
DoD	Department of Defense
COTS	Commercial off the Shelf
IA	Information Assurance
KM	Knowledge Management
NAVSEA	Naval Sea Systems Command
NAVAIR	Naval Air Systems Command
NNPI	Naval Nuclear Propulsion Information
NUWC	Naval Undersea Warfare Center
OPNAV	Office of the Chief of Naval Operations
TOMIS	Tomahawk Information System
SIPRNET	Secret Internet Protocol Router Network
SE	Systems Engineering

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I. INTRODUCTION

A. BACKGROUND

Technology and competition have significantly changed knowledge management.

> We are living in a world of rapid change driven by globalization, the knowledge-based economy coupled by ever-fast development of information, communication and technology. This change, however, not only poses some challenges, but also offers opportunities for both private and public sectors alike. (Cong & Pandya, 2003)

The opportunities provided by formalized knowledge management are intended to improve handling and communication of technical information in the Platform and Payload Integration Department at Naval Undersea Warfare Center Division Newport.

Knowledge management has many definitions and means many things to different people. The Department of the Navy Chief Information Officer defines knowledge management (KM) as the integration of people and processes, enabled by technology, to facilitate the exchange of operationally relevant information and expertise to increase organizational performance (Wennergren, 2005). Love, Irani, and Fong (2004) define KM as “sharing and leveraging knowledge within an organization and outwards toward customers and stakeholders.” There are multiple definitions of KM but each has a similar theme, which is sharing and leveraging knowledge to increase understanding. This is where knowledge management can help to improve the Platform and Payload Integration Department.

The Naval Undersea Warfare Center (NUWC) Division Newport is a Naval Sea Systems Command field activity. NUWC Division Newport employs 2544 individuals. Seventy-five percent of the workforce is made up of scientists and engineers, and the remaining 25% is support personnel. Over 45% of the scientists and engineers have advanced degrees (Lefebvre, 2008). NUWC performs research, development, test and evaluation, engineering, analysis and assessment, and Fleet support to the United States and foreign navies (Lefebvre, 2008). Its primary customer is the U.S. Navy and is involved in foreign military sales. NUWC has eight technical departments, which are involved in support, development, or analysis of the systems and programs shown in Figure 1, Figure 2, and Figure 3. The systems include submarines, surface ships, weapons, and unmanned vehicles. NUWC is a Navy Working Capital Fund, which means it operates similarly to a privately owned business. It is like a business because it is accountable for efficient delivery of products and services, in exchange for funding it recieves from sponsoring commands (Lefebvre, 2008). It differs from private business because it acts like a nonprofit organization that does not compete with private industry.

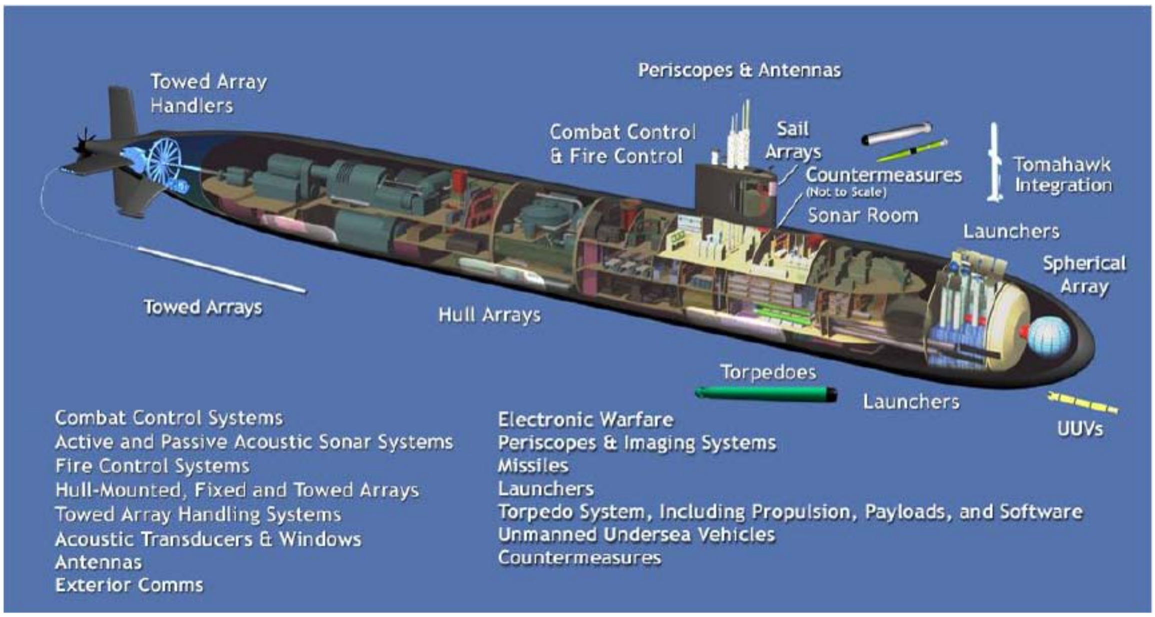

Figure 1. Submarine systems under NUWC responsibility.

This figure shows all of the systems that NUWC is responsible for. The launchers division works on launchers which include the torpedo system, unmanned undersea vehicles, and countermeasures. From (Lefebvre, 2008).

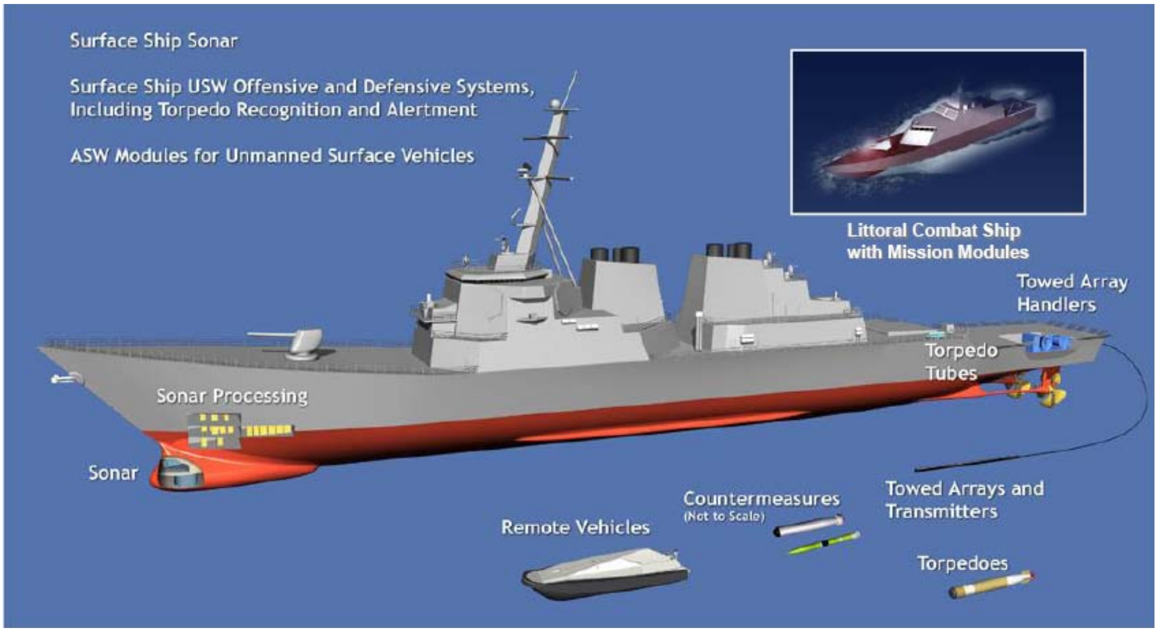

Figure 2. Surface ship systems under NUWC responsibility.

This figure shows the areas that NUWC is involved in on surface ships. The launchers division works on countermeasures and torpedo tubes. From (Lefebvre, 2008).

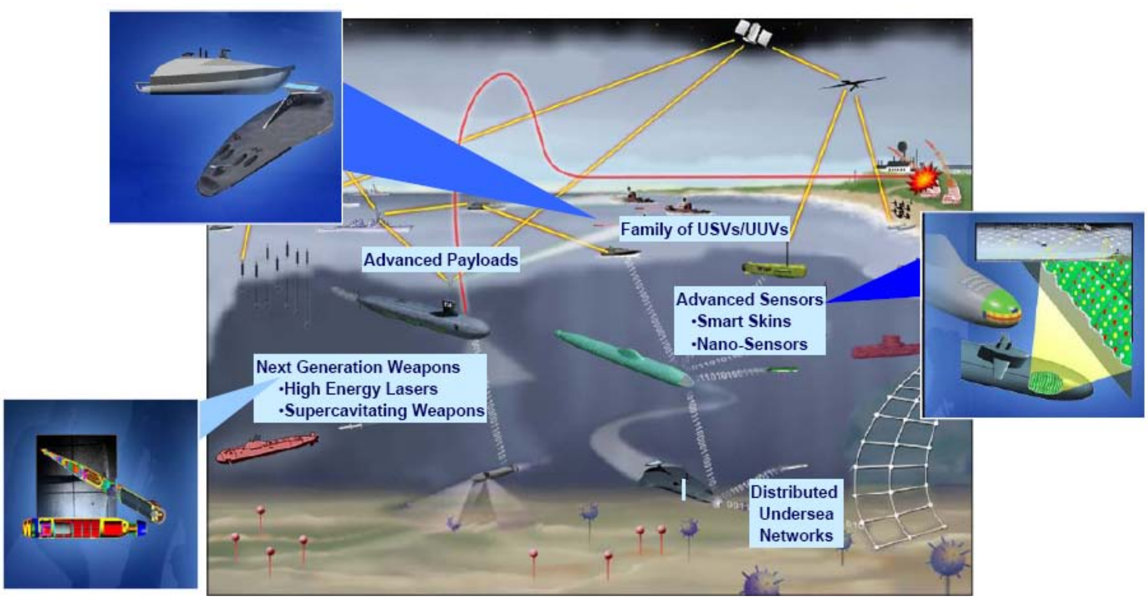

Figure 3. Future NUWC projects under development.

This figure shows the development projects that NUWC is working on. The launchers division works on advanced payloads, and Unmanned Vehicles. From (Lefebvre, 2008).

The Platform and Payload Integration Department is one of the eight technical departments at NUWC. The Platform and Payload Integration department has 240 employees that perform research, development, test and evaluation, engineering, analysis, and Fleet support to the United States and foreign navies (Lefebvre, 2008). Its primary role is to develop and support submarine launcher systems and integrate payloads into submarine launcher systems. The integration role includes insertion of new payloads, weapons and vehicles into submarines and surface ships. The payloads, weapons, and vehicles include unmanned vehicles, countermeasures, torpedoes, and tactical missiles. The department consists of two divisions, which are the Missiles Division and the Launchers Division.

If implemented correctly, improved KM can provide improved organizational performance through the integration of people, processes, and technology. It could provide the opportunity to improve the design of future systems, improve current systems, and reduce maintenance turnaround times of Fleet systems. Implementation of KM has the potential to improve the organizational performance of the Launchers Division.

B. PURPOSE

The purpose of this thesis is to conduct research and provide recommendations for improved knowledge management within the Launchers Division of the Payload and Platform Integration Department at the Naval Undersea Warfare Center. It not only will support internal needs for the conduct of everyday tasking, but will also meet external needs for long-term initiatives.

There are many Department of the Navy challenges that the Platform and Payload Integration Department is undertaking. These challenges support the future of undersea warfare and the United States Navy. One of the more important priorities of the Navy is reduction of total ownership costs, which "will be key components of all programmatic discussions and decisions" (Roughhead, 2009). The purpose of the reduction of total ownership cost initiative is to reduce the life-cycle costs of Navy Ships as a response to shrinking budgets. Another initiative is support of the "the Ohio Class replacement which will replace the Ohio Class Ballistic Missile Submarines" (Government Accountability Office, 2010). The Ohio Class replacement program is scheduled to "enter the technology development phase in the third quarter of 2010" (Government Accountability Office, 2010). The Launchers Division provides technical expertise, which includes systems knowledge, to support each of the challenges.

There are also many submarine community needs that can be addressed by a KM system. Recent meetings with the submarine community have revealed that "there does not appear to be any method to capture and implement lessons learned" and there is "lack of money for basic needs or requirements" (Ybarrondo, 2010). The Fleet also has "requested explanations to better understand the engineering standpoint" (Ybarrondo, 2010) in cases where the technical direction does not make sense to the end user. There are other instances of the Fleet needing increased understanding of technical decisions and products, and elimination of redundant problems. Improved system knowledge and communication of technical status of systems between the Fleet and Naval Sea Systems Command (NAVSEA) is needed.

In order to meet these challenges and needs, the Launchers Division must create, communicate and retain launcher system knowledge. The knowledge includes documentation of design decisions and operational support for existing submarines. Launcher system knowledge in the Launchers Division is dependent on personal experience and individual filing systems. No central repository exists, resulting in losses of relevant system data. An improved KM system is needed to capture system knowledge from all engineering activities, ranging from research and development to operational support. An improved KM system may enhance the Launchers Division's ability to provide the data to reduce the number of life-cycle problems.

C. BENEFITS OF STUDY

This study directly benefits the Payload and Platform Integration Department and the Navy by potentially reducing costs and the misunderstanding of technical status between organizations. Cost reduction can be achieved by elimination of lost technical knowledge and improved system maintenance. Technical knowledge is difficult and costly to recreate. The architecture description could also serve as a model for other program offices, Navy laboratories, DoD organizations, and in-service engineering agents that are involved in development, construction, and repair of Naval Vessels.

The direct benefit of this thesis to the Platform and Payload Integration Department and the Navy is due to the potential of the KM system to generate significant cost savings through the reduction of redundant efforts. Cost savings from the reduction of redundant efforts will allow allocated funding to be used on other problems. Resolution of additional issues allows more efficient use of Navy resources. The additional resources could be used to improve launcher system performance.

The KM system could also provide lessons learned from similar systems. Use of lessons learned has the potential to avoid system design problems and improve launcher system personnel performance. Reduction of system design problems could reduce the overall cost through elimination of rework, reduction of maintenance and system operation issues of future platform and payload development. Improved performance of launcher division personnel will have direct effects on the life-cycle costs of launcher systems. This could have direct benefit to future Virginia Class platforms and the Ohio Class Replacement Program. It also could serve as a model for development and implementation of other Navy KM systems.

D. RESEARCH QUESTIONS

This thesis answers the following questions:

- What is an improved way to manage technical data ranging from design to operational support for the Launchers Division at NUWC?
- What is the best high-level architecture description for the technical KM system?

E. SCOPE AND METHODOLOGY

This section describes the scope and methodology for this thesis. The scope defines the narrowly focused areas researched and the problem space explored. The methodology includes conduct of research.

1. Scope

The scope of this project is limited to the Payload and Platform Integration Department Launchers Division technical knowledge management. The intent is to create an open architecture description that meets the Launcher Division needs. The systems architecture description is subject to all of the DoD security requirements, primarily the OPNAV 5000 series but will not provide a method for implementation of these guidelines. The architecture description supplements existing systems from higher tier organizations but does not replace them. The architecture description reflects the constraint that the initial solution on which it is based will be implemented in the next three years. The development of a systems architecture keeps cost in mind but does not provide a cost analysis.

2. Methodology

A tailored systems engineering process is applied to resolve the problems associated with KM in the Platform and Payload Integration Department. The high-level process is shown in Figure 4. This process generated requirements that results in a recommended system architecture description that makes use of KM best practices.

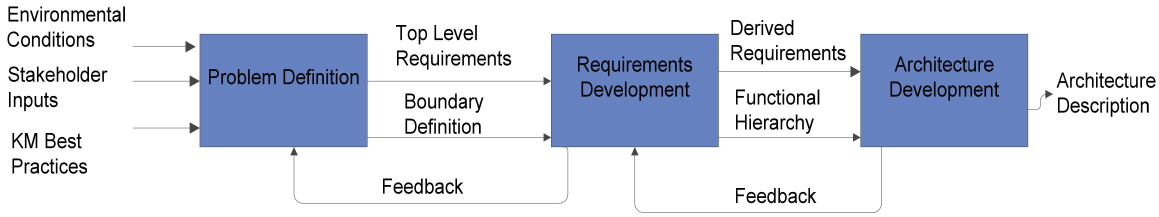

Figure 4. Process layout

This figure shows the three step systems engineering process layout. The steps correspond to each of the chapters.

The Figure 4 process has three distinct sections: problem definition, requirements development, and architecture development. The problem definition process identifies the problem, performs a detailed situational analysis, and performs a review of KM best practices. This process yielded the top-level requirements and selection of stakeholders, which are used in the requirements development process. The requirements development process consisted of a functional analysis, requirements generation, and requirements analysis. The requirements development process outputs are derived requirements, and a functional hierarchy, which are used in the architecture development process. The architecture development process consisted of concept generation, concept evaluation, and recommended architecture. The output of this process is an architecture description. The feedback loop in each of the sections is included, because the problem is constantly refined and bounded as the solution is developed. Each section corresponds to a chapter in this thesis.

The process was created to provide the framework for creation of a KM architecture. The process is based on implementation of a successful system. Chan (2002) concluded that success depends on understanding strategic business needs, employee buy in, and a system tailored to user's needs.

The system for the Launchers Division was created for meeting the stakeholders' needs as identified in the surveys and observations. The best system is the one that meets or exceeds all of the top-level requirements and is better than the other concepts. This thesis answers the best way to implement a technical KM system for the Launchers Division by providing an architecture description based on the Figure 4 systems engineering process.

The Figure 4 processes were selected to answer each of the thesis questions. The problem definition process provides the criteria for answering the thesis questions. The process takes inputs from the stakeholders and combines them with KM best practices. This combination provides the criteria for creation of the best architecture description. The requirements and architecture development are structured processes to translate the criteria generated into the architecture description. The architecture meeting the top-level requirements makes the system the best architecture description when compared to the other concepts.

F. CHAPTER SUMMARY

The first chapter introduces the KM problem, the benefits of the study, research questions, and scope and methodology. It provides an overview of the Launchers Division at NUWC and KM. The problem is a need to improve the documentation and communication of information within NAVSEA and to the Fleet. An enhanced KM system could improve the Launchers Division support of the Fleet and development of new technologies. The following chapters use systems engineering to develop an architecture description.

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II. PROBLEM DEFINITION

A. INTRODUCTION

Problem definition is the most important step in systems engineering. The success or failure of a project depends on it. The problem definition process used in this thesis has four phases shown in Figure 5. The phases include stakeholder identification and need, situational assessment, KM best practices review, and synthesis of results. The feedback loops in Figure 5 are important because each of the phases used the information to build on one another. This chapter generates top-level requirements that are utilized in the requirements development process.

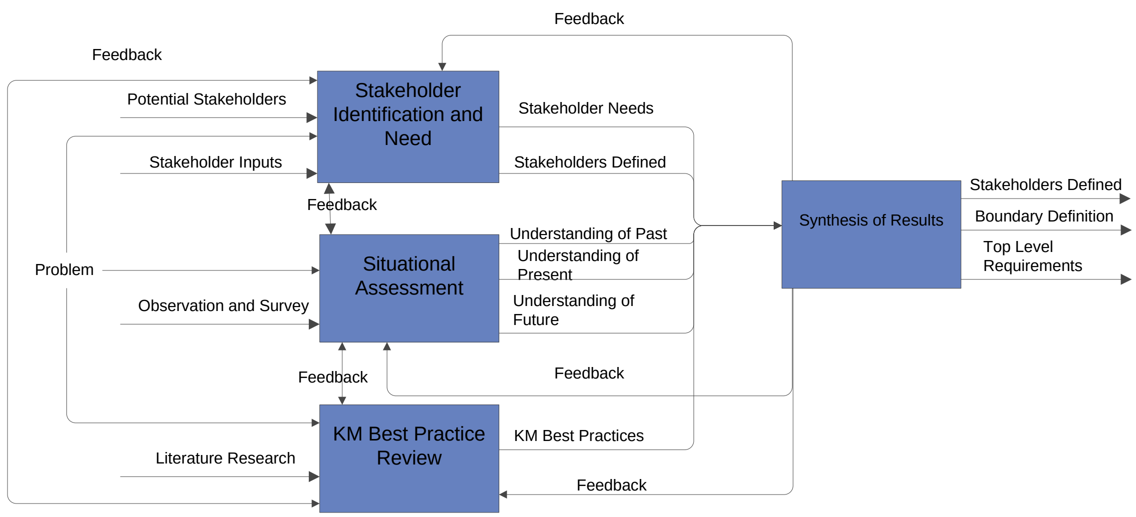

Figure 5. Problem Definition Process

The problem definition process combines stakeholder need identification with a situational assessment and best practices review.

The development of Figure 5 resulted from reviews of Buede (2009), Blanchard and Fabrycky (2006), Sage and Armstrong (2000), and Langford (2009). The stakeholder identification and need phase identifies stakeholders internal and external to Launchers Division, finds their needs, and bounds the problem. The stakeholders and their needs are the outputs. The situational assesment evaluates the past, present, and future state of the Launchers Division KM to further refine the needs of the stakeholders. The output of the situational assessment is refined stakeholder needs, which results from better understanding of the stakholders and their environment. The KM best practices review conducts a literature review that provides insight into the knowledge management cycle and other successful systems. Its outputs are an understanding of the KM cycle and key elements of a KM system. The synthesis of results phase takes the inputs from the other three phases creating the top-level requirements, system boundaries, and defined stakeholders.

The feedback loop in Figure 5 is included due to the necessity to constantly refine the top-level requirements throughout the SE process. When a problem is encountered with the requirements, it can have an effect on the higher level and lower level requirements. Problems encountered include changing requirements, funding, conflicting requirements, and roadblocks that cannot be overcome.

There are differences between internal stakeholders within the Launchers Division and external stakeholders outside of the Launchers Division. Internal to the Launchers Division means the NUWC employees who work for the division and those who have access to its information systems. These include government and contractor personnel. External stakeholders are the customers, such as NAVSEA headquarters, contractors, and the Fleet that do not have access to all of the division's information systems. Access to information differs between the internal and external stakeholders.

B. STAKEHOLDER IDENTIFICATION AND NEED

Stakeholder identification and need is an important part of the SE process. Without stakeholders needs there is no problem. The inputs into this section were generated from observation and the surveys described in Appendix A. The outputs of this section are stakeholder identification and their needs.

Identification of stakeholders is a major part of the problem definition process. Stakeholder identification is intended to find all of the personnel who are going to be involved with development, fielding and disposal of the intended architecture description. Feedback from the other phases in the problem definition process resulted in the selected stakeholders. The stakeholders include Launchers Division management, Launchers Division engineers, selected customers, and contractors. The selected customers include Naval Sea Systems Command program offices and technical warrant holders, and submarine Fleet representatives.

Once the stakeholders were identified, their needs were analyzed. The stakeholder needs were generated from surveys, and the situational assessment. Not all of the stakeholders were surveyed. Only the selected stakeholders who responded to the request for conduct of the survey participated. Twelve people responded to the survey. Results and additional information on the survey are presented in Appendix A. Note that there are solution neutral and solution specific needs in Appendix A. The primary needs identified are a system to store and retrieve data, and improvement of communication between the stakeholders. The system should be easy to use, and provide means of archiving design decisions and system history.

The following are primary results of the survey. The ranking of the stakeholder needs are based on the frequency of each response.

1. Provide a searchable database that stores division technical documentation.
2. Provide a usable system.
3. Facilitate communication of technical knowledge within and outside of the Launchers Division.
4. Provide backup of data. This system should be redundant.
5. The data generated by the system shall last at least 30 years.

The results reported above eliminate solution-specific requirements. These include use of Google™ desktop, Microsoft Access®, and Wikipedia®. The survey results show varying levels of understanding and experience throughout the organization.

The stakeholder identification and need process also identify system boundaries. One of the more important ones is the system is limited to the Launchers Division product line. This thesis will not address transfer of unclassified documentation from a higher classification system. Transfer of information from one system to another is very hard to complete and outside of the scope of thesis.

C. SITUATIONAL ASSESSMENT

The situational assessment further defines and evaluates the initial problem identified. It accomplishes this by assessing how the KM system operated in the past, how it operates in the present, and the possible future state of the Launchers Division projects. The situational assessment methodology is based on Sage and Armstrong (2000) and Maier and Rechtin (2000). The data for the situational assessment is generated from research on and observation of the available systems and stakeholders in action.

1. Past

The description and results of internal and external evaluations of the past state of the Launchers Division KM are described in this section. The internal KM evaluation focuses on the processes and technology in place in the Launchers Division. The external evaluations consists of the Missiles division and other departments within NUWC. The inputs are the problem, observations, and surveys. The output is insight into how NUWC division Newport KM was conducted in the past.

The internal evaluation consists of the Launchers Division KM processes and technologies that are used. This evaluation was accomplished through survey responses and observation of the current system. The survey reveals that the Launchers Division KM processes rely on system experts to retain documentation and unwritten system knowledge. This process is highly dependent on the diligence and the willingness of the individual to share, document, and archive information. Paper and microfiche files are used to store technical data. If the system expert left the department for retirement or a new position, knowledge transfer is dependent on that individual sharing both written and unwritten information with new employees.

The Missiles Division KM system was purchased by NAVAIR from Boeing in the early 1990s. It was created to provide a system to support life-cycle planning and history of the Tomahawk Missile program. It is called the Tomahawk Information System. It provides many functions including configuration and financial management, a data repository, in-service problem reporting, and design information. Tomahawk Information System (TOMIS) is available to relevant stakeholders using a secure Web site. The stakeholders include the Fleet, program office, and contractors (Sujecki, 2010).

Other departments at NUWC have other systems that are used for Knowledge Management. One of the systems, Advanced Interactive Management Technology Center (AIMTC), is used for submarine combat systems and has existed since the 1990s. Since 2001, AIMTC has provided real-time chat with deployed platforms, which was considered by the Fleet to provide outstanding support for the submarine fire control systems (Iriye, 2004). AIMTC also has a data retention capability that allows maximization of data collection and retention (Iriye, 2004).

The Platform and Payload Integration Department knowledge management in the past and present is division dependent. Each division has its own process. The Missiles Division runs a comprehensive KM system for the Tomahawk Missile program office at Naval Air Systems Command (NAVAIR), which is their primary sponsor. The Launchers Division does not have a similar system in place. Other divisions and departments run other KM systems at NUWC Newport.

2. Present

The evaluation of the present was conducted to understand how the existing system is operating. The evaluation of Launchers Division knowledge management consisted of problems faced and existing systems used in the division. It included a similar look at external organizations. The outputs of this were an understanding of the current and future state of the Launchers Division.

The current state of the Launchers Division KM system has several aspects that are undesirable. The Launchers Division KM system functionality today is no different than it was in the past. In addition to the past problems, there are Fleet concerns with submarine technical support and data calls for the Ohio replacement program. There appears to be a lack of communication between the Fleet and the technical community.

The analysis of the present state included an evaluation of the information technology systems that retain technical data. The information systems used to provide technical data are described in Table 1. The data presented in Table 1 was generated by observing available databases and information provided from the survey conducted (Appendix A). Each of the systems identified perform a function and provide access to the information required for work at the Launchers Division. In some cases, these systems are hard to use due to security requirements.

Table 1. Available systems to the Launchers Division

Name	Description
Naval Marine Corps Intranet (NMCI)	Provider of hardware and software for the Navy. Primary information technology provider for the stakeholders identified in this chapter. Has specific software and hardware that are approved for use. If one wants to add software it has to be certified. Additional storage of data and software for a fee.
Research Development Test and Evaluation Network	Provides unique software and hardware that are not available from NMCI. It is primarily used for design and analysis projects. Not all users have access to the Network. It has a network storage capability that is available to all users for file sharing.
TEAM	Provides financial data management. Provides means of tracking project milestones and funding allotted to tasks.
Enterprise Resource Management System	Intended to be Navy wide. Provides Project Management tools including milestones, earned value management etc. NAVSEA is implementing it in FY2010 and NUWC in FY2011.
NUWC Knowledge Net (Intranet)	Provides a link to the technical library and other technical sites. The technical library provides specification data. Published technical reports. It also provides links to outside organizations and department Microsoft SharePoint sites.
ATIS	Provides comprehensive list of ship drawings for all classes supported.
CITIS	Provides a means of communicating sensitive information. It also provides ship drawings and the deviations related to them. It provides shipbuilder baseline test procedures and the completed/signed test procedures. It also contains the document databank with the majority of letters that have been written by Electric Boat Corporation.
Code 4123 Technician Homage	Provides technical data. It includes links to Joint Fleet maintenance manual, Ship Systems Manuals, and other types of technical data. It also has engineering inputs into problems solved but this function is not consistently used.

Code 412 Access Database	Provides date information, letter serial numbers, and titles of letters. It does not have a data repository where division letters are retained. It also documents communications between the In-service Engineering Agent and outside customers
SIPRNET	Provides Classified Processing of Data. Provides information on ships and means of communication via email.
Code 40 Internal Network	Provides a means of file sharing and transfer between internal Code 40 employees that have access to the network. Recently the network has been disconnected due to the partition between NMCI and the Research Development Test and Evaluation Network. Many of the files it contained are inaccessible or hard to find to most users.
Tomahawk Information System	Currently provides technical highlights to be provided to leadership. These are entered by Code 40 Users. This system is available to Fleet and contractor users. It serves as a means of file transfer. It also provides system status and logistics data to external customers.
NAVY ELAR System	The Electronic Liaison Action Request (ELAR) system provides in-service requests for technical resolution. It allows users to enter technical resolutions into its database.
Microsoft Excel Action Tracking sheet	The tracking sheet is to track incoming technical correspondence from the VIRGINIA Class Program Office. It provides need dates and basic information on the technical correspondence.
Scanned Data	The VIRGINIA Class scanned technical data that is not accessible to all users. It includes technical reports, answers to technical correspondence, and design decisions.
NUWC Technical Library	This includes Information Handling Services, which provides specification data. If provides a repository for technical reports and other technical data.

NAVSEA technical correspondence database	The NAVSEA technical correspondence database provides letters that have been issued by NAVSEA. There are many issues with this database. First, it is hard to search. Even when the correspondence exists it is hard to find. Certain users understand how to use it and are somewhat successful in using it. It is not accessible to Launchers Division personnel.
SUBMEPP Homepage	The SUBMEPP homepage provides the Joint Fleet Maintenance Manual. SUPMEPP provides other technical data.
TEAMWARE	Internet-based provider of file sharing and work tasking run by Naval Surface Warfare Center and used by NAVSEA program offices. It is used by some projects but not all projects. Data stored is available for a certain amount of time and then is removed when not used. Access is by hard and soft key encryption.
Risk Radar	Code 40 database for managing and tracking risks related to projects.

The scope of data provided by the systems in Table 1 is too large for a single system for use by the Launchers Division. This is due to the scope, cost, and availability of information. Some of the systems have constantly changing information which is produced or maintained by other organizations. Maintaining information that is under the cognizance of other organizations is almost impossible when the data is constantly changing and is large in volume. Some of the information and the software in these systems provided by other organizations is proprietary. In some cases, the government would have to pay the contractor for these systems and this is undesirable due to the cost of the data.

Table 1 shows that the data the Launchers Division works with is similar across the life cycle of the products it works on. This includes calculations, drawings, drawing changes, manuals, specifications, and technical correspondence. This shows the data the technical community works on is similar and can be standardized. Standardization of data allows designers of new systems to obtain data on systemic problems on previous designs. This would make the internal system searchable to find the data that they need to improve their technical product.

AIMTC and TOMIS are continuously evolving to meet customer needs and DoD security requirements. TOMIS has about 25 personnel that are working on it with a 3–5 million dollar budget annually. TOMIS has over 1100 active users at 150+ sites. It currently has 38 unique modules and 434 software changes were made in FY09 (Sujecki, 2010). Both the AIMTC and TOMIS systems are required to be up to date with Navy Security policies, which include two site registrations and cryptographic log-on technology.

Evaluation of the current state of KM provides additional insight into the KM systems at NUWC Newport. NUWC Division Newport departments have different levels of formality, which they have applied to knowledge management. The level of formality varies between division or department, or even work group. The Launchers Division at NUWC Newport has no formal process for knowledge management, resulting in incomplete information and knowledge about the systems it works on. The generation of technical documentation should be standardized across the life cycle. Not all technical documentation can be stored on one system, and the system will have to rely on outside systems to obtain the required data. The system will be more cost effective and up-to-date for the Launchers Division if it can rely on outside systems to provide data. Other divisions and departments in some cases, have more comprehensive KM systems in place.

3. Desired Future State

The desired future state provides an evaluation of where the divisions' projects will be in the future. This includes status of current and future programs. The programs include the Virginia Class Submarine, Ohio Class Submarine and Ohio Replacement Program, existing ISEA programs, and Seawolf and Los Angeles Class Submarines.

The first Virginia Class Submarine was commissioned in 2004, at a cost of approximately 2.8 billion dollars (Little, 2008). It is planned to be a thirty-ship class. The life cycle of the Virginia Class is 33 years. The Block III Virginia Contract builds Virginia Class submarines until 2018 (Little, 2008), and brings the total number of submarines to 18. The number and life cycle of the Virginia class requires the system shall support Virginia Class submarines and the Launchers Division until at least 2050. The construction and total ownership costs are continuously being reduced through design and construction improvements. The combination of ISEA and design support for Virginia Class will require retention of launchers knowledge until 2050.

The Ohio Class and Ohio class replacement program will require support until at least 2030 and beyond. Initial Operating Capability in 2029 of the Ohio class replacement program corresponds with the first Ohio class ballistic missile submarine being decommissioned (O'Rourke, 2010). The Ohio class submarine is the United States Sea Based Nuclear deterrent. Application of technical lessons learned may provide the opportunity to reduce costs and improve quality (Government Accountability Office, 1994) of the Ohio Replacement Program. Lessons learned from Virginia and previous classes are important to prevent problems, already encountered on existing and new designs.

The Los Angeles and Seawolf Class Submarines are in the operational support and decommissioning stages of their life cycles. The 62 Los Angeles Class Submarines, which entered service between 1976 and 1996, have an approximate 33-year life cycle and will be continuously retired from now until 2030 (O'Rourke, 2009). The Seawolf class consists of three submarines commissioned between 1996 and 2005, will also be retired in the 2020–2030 timeframe (O'Rourke, 2009). Retention of the knowledge gained from support of these two classes is important for reduction of costs on current and future programs.

Centralized retention of knowledge is important for future support of current and future submarines. It supports the Navy initiatives by providing historical technical data and elimination of redundant efforts. Support of the submarine launchers systems will be at least until 2050, which means the knowledge generated has to survive until then. This shows that a centralized technical KM system is better than a stove-piped KM system.

D. KM BEST PRACTICES

The KM best practices phase reviews literature to help define the best architecture description for the Launchers Division. The review addresses the knowledge management cycle and the key elements of a KM system and forms the conceptual basis for the system. The key elements provide the fundamentals of a successful system based on literature and benchmarking studies. The combination of understanding of both of these provides KM best practices.

The steps to the knowledge management cycle are knowledge creation, sharing, capture and application. The steps in the cycle are shown in Figure 6. Knowledge creation is where the product knowledge is generated. Knowledge capture is where the knowledge is “translated into objective and transferrable knowledge or explicit knowledge” (Nonaka, 2008). Knowledge sharing is socialization through the interested parties. Knowledge application is use of the knowledge in the applicable situation. The KM cycle is important to a company because “individuals’ personal knowledge transformed into organizational knowledge is valuable to the company as a whole” (Nonaka, 2008).

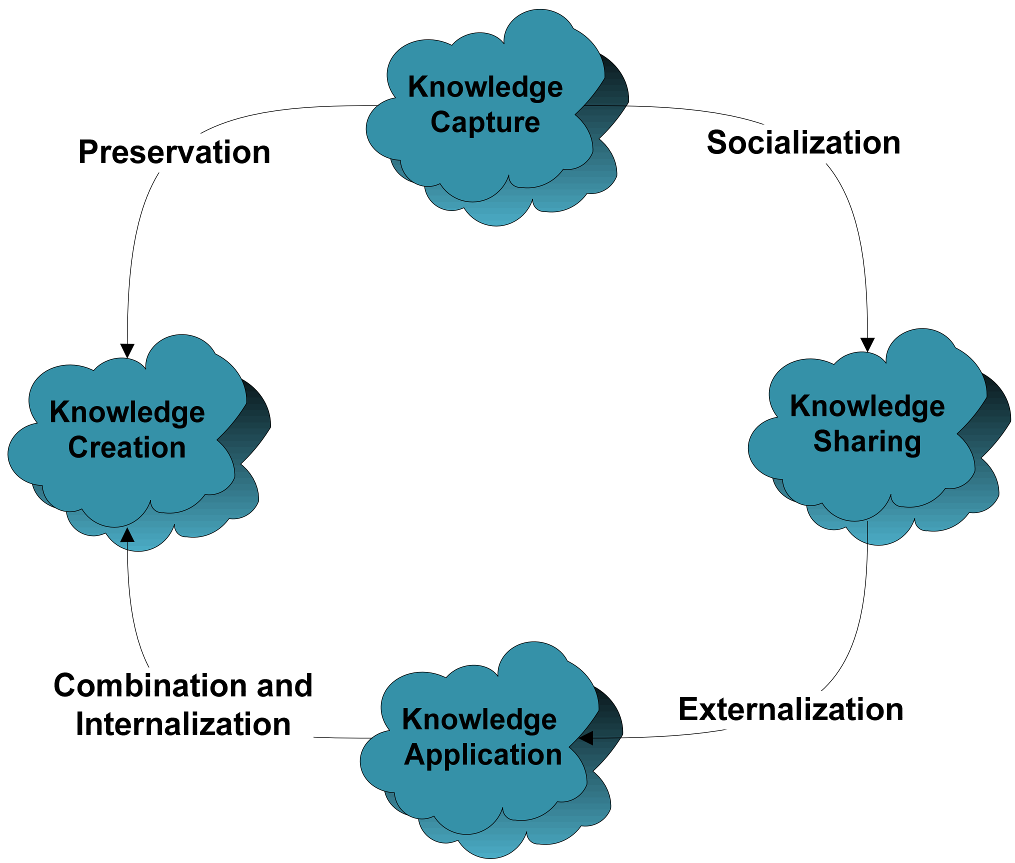

Figure 6. Knowledge Management Cycle.

The knowledge management cycle shows the continuous cycle of knowledge creation, capture, sharing and application. The continuous cycle is intended to build on already known information. From Love, Irani, & Fong (2004).

There are two types of knowledge: tacit and explicit. Explicit information is easily written and codified. Tacit information is highly personal and hard to formalize, which makes it difficult to communicate (Nonaka, 2008). Tacit knowledge is partly technical know-how, such as the skills of a master craftsman, which are informal skills and are hard to replicate (Nonaka, 2008). “It consists of mental models, beliefs, and perspectives so ingrained that we take them for granted and therefore cannot easily articulate them” (Nonaka, 2008). Transformation of tacit to explicit knowledge and back are important parts of the knowledge management cycle.

The key elements of a KM system are people, processes, and culture, with technology being the enabler (Love, Irani, & Fong, 2004). There is a perception that information technology software is the most important part of the solution. It is not. Eighty percent of KM is people, process, culture, and the other 20 percent is technology (Liebowitz, 1999). The American Productivity and Quality Centers Benchmarking Study (2000) also identified people, process, culture, and technology as key factors in a successful KM system. The specific factors the benchmarking study identified are the following: senior champion or management endorsement, budget, communities of practice, culture, and information technology are key to successful implementation of a KM system. The American Productivity and Quality Centers Benchmarking Study (2000) is based on a survey of 49 companies, 10 of which were identified as having strong KM initiatives in place.

Chan (2002) evaluated the NUWC Submarine Electromagnetic department KM practices. The Submarine Electromagnetic department performs a similar ISEA role to the Launchers Division. Chan's work was based on loss of tacit knowledge due to employee attrition through workforce retirements. Chan (2002) suggested using a systematic approach to the development of a KM system through understanding of the organization's core competencies. One of the benefits of KM is it leverages the intellectual capital of the entire organization, "instead of working as individuals is the only way to gain a competitive advantage" (Chan, 2002). Chan's work provides the following conclusion:

> Firstly, for knowledge management to succeed, an organization must articulate its strategic business needs, create a common framework for understanding, secure employee buy-in, and maintain open communications. Secondly, an optimal knowledge management system design must take into account the user's perspective since efficient knowledge flow and knowledge transformations depend on people's willing participation. (p. 94)

The NAVSEA ship design department identified its inability to find documentation through a NSWC-funded study (Junod, Read, & Kaistha, 2007). The study had clear requirements and provided potential technical solutions. It focused on the knowledge cycle presented in Figure 6 to share, create, and apply the knowledge to create innovative surface ship designs. The documentation needed to create surface ship designs was difficult to find even though it was stored on the network drives, which is a similar situation the Launchers Division faces.

This section provides KM best practices for a successful system. These practices include the knowledge management cycle and key success factors for a KM system. Understanding of the knowledge management cycle (Figure 6), and how knowledge is generated is important for understanding knowledge management. The transfer of tacit to explicit knowledge is an important part of the knowledge transfer process. An improved KM system should incorporate key factors for success, which include a senior champion or management endorsement, budget, communities of practice, culture, and information technology. A better solution is based on stakeholder inputs.

E. SYNTHESIS OF RESULTS

The synthesis of results phase creates the top-level requirements for the system. This is done by combining the outputs of the stakeholder identification and needs, situational assessment, and KM best practices outputs. Each of the outputs is solution-neutral and provides problem definition.

Each of the assessments in Parts B, C, and D, and the follow-on chapters, have led to the top-level requirements.

- The KM system shall provide a data repository to capture and communicate technical knowledge for all aspects of the lifecycle of Undersea Launcher Systems from development to disposal.
- The KM systems implementation shall be based on culture change, having a senior champion, incentives for use, and available budget.
- The KM system shall perform the following functions: store technical data, generate knowledge, analyze the number of

documents input to and output by the system, recognize recurrent technical problems, handle classified information, organize, retrieve, and report internal and external data.

  - Data includes letters, calculations, technical data packages, calculations, analysis files, drawing files, waivers, departures from specification, and deviations, technical manuals, and maintenance data. The system shall support at a minimum storage of Microsoft Office documentation, Adobe® PDF formats, and viewing file formats (i.e., .jpeg, .tiff).

- The KM system shall generate knowledge-based knowledge creation cycle (Figure 6).
- The KM system shall be easily searchable by internal and external personnel to the Launchers Division. Internal personnel include people who are employees of the Launchers Division. External personnel include technical warrant holders, program office, and Fleet personnel. "Easily searchable" means document lists are returned within a minute of query, and the user interface is easy to read.
- The data generated shall last 30 years and a means of backing up the data shall be included.
- The KM system shall be a system of systems and use data from available systems. The processes generated can use legacy systems. The system shall not replace outside organizations' systems. These include Table 2 (CITIS, ATIS, ELAR) and other systems.
- The KM system shall be available to NAVSEA, the Fleet, and contractors.

- The KM system shall provide a method of translation of tacit to explicit knowledge, and back.
- The KM system shall comply with all of the DoD information security requirements.
- The KM system shall be able to operate on the Naval Marine Corps Intranet.

F. CHAPTER SUMMARY

The top-level requirements generated in this chapter were analyzed and refined into system requirements, which was the first step in generation of the systems architecture. The initial stakeholder analysis and situational assessment were performed to analyze who the stakeholders are, the past and current state of affairs, and a study on the current state of knowledge management. A KM best practices review was also conducted. The combination of the three processes led to the synthesis of top-level requirements and definition of stakeholders.

The surveys, situational assessment, and literature research indicate that a comprehensive technical KM system is better than a stove-piped KM system. This allows the life-cycle needs of the Launchers Division to be met. The technical documentation needed for the Launchers Division across the life cycle is similar from design to operational support, allowing for creation of a comprehensive system. The system will be more cost effective, and up-to-date, if it relies on already existing external KM systems to provide technical data. KM requirements and funding are changing constantly; a system that can change is better than a system that cannot change. For the system to have the potential to be optimal, or the best, it has to be developed based on stakeholders’ needs.

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III. REQUIREMENTS DEVELOPMENT

A. INTRODUCTION

The process used in this chapter translates the top-level requirements into derived requirements. Figure 7 shows this process. It is broken into two sections: functional analysis and requirements generation. The outputs of this chapter are derived or detailed requirements and a functional hierarchy.

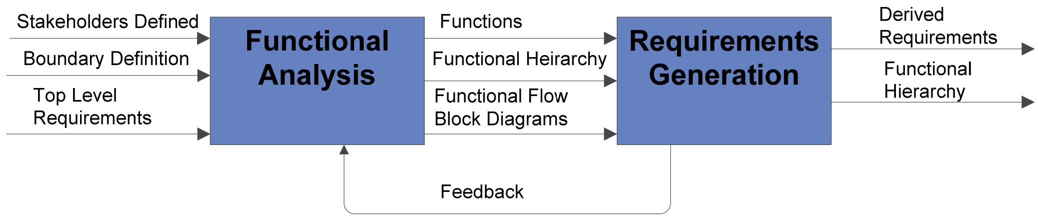

Figure 7. Requirements Development Process

The development process consists of two steps. The two steps create part of the functional architecture and generate requirements.

The functional analysis has three primary steps: generation of functions, creation of a functional hierarchy and functional flow block diagrams. A functional analysis is an iterative process of translating requirements into detailed design criteria (Blanchard & Fabrycky, 2006). Functions are generated from the top-level requirements. “A function is a definite purposeful action that a system must accomplish to achieve one of the systems objectives” (Sage & Armstrong, 2000). The functions are then placed into a functional decomposition. The purpose of the functional decomposition is to break the needs into smaller pieces. The functional flow block diagrams describe the system and its elements in functional terms (Blanchard & Fabrycky, 2006). Each of these analyses help with further definition of the problem and generation of requirements.

The requirements generation process results in the derived requirements for the system. It starts with an evaluation of functions followed by creation of a functional hierarchy, functional flow block diagrams, and writing a requirement for each of the functions. The requirements are written so they are traceable to the higher-level functions and top-level requirements.

B. FUNCTIONAL ANALYSIS

Functional analysis includes creation of functions, organizing them into a functional hierarchy, and creation of functional flow block diagrams. Each of these steps helps develop the problem. The outputs of this phase are functions, functional flow block diagrams, and a functional hierarchy.

The functions are created by translating the top-level requirements into a listing of the actions the system is expected to perform. The first step was to list all of the functions the system is to perform within the boundaries and top-level requirements identified. An example of an action by the system is to collect data. Generation of data represents creation of the data that is used in the systems. Additional functions were added with generation of the functional hierarchy and the functional flow block diagrams.

The functions include generate data, collect data, input data, store data, analyze data, report data, and share knowledge. The input data function follows data collection (described above). It is used to partition data prior to storage to ensure that it can be found and it is sent to the correct area for classification. The data storage function is to keep the data until it is used. Analyze data provides statistics on use and launcher system health status. Data reporting provides the data requested by users and reports generated by the system.

The functions are arranged into a functional hierarchy, which shows the system function as a whole. The functional hierarchy with numbering is shown in Figure 8. It has two levels and can be decomposed further when the system is further defined. The functional hierarchy was also compared to the top-level requirements to ensure that it meets their intent. In a of couple cases, the hierarchy was modified to ensure the top-level requirements' intent was met. Additional functions were added after the functional flow block diagram was created and the functional hierarchy was developed. The functional hierarchy is considered to be the functional architecture by Buede (2009).

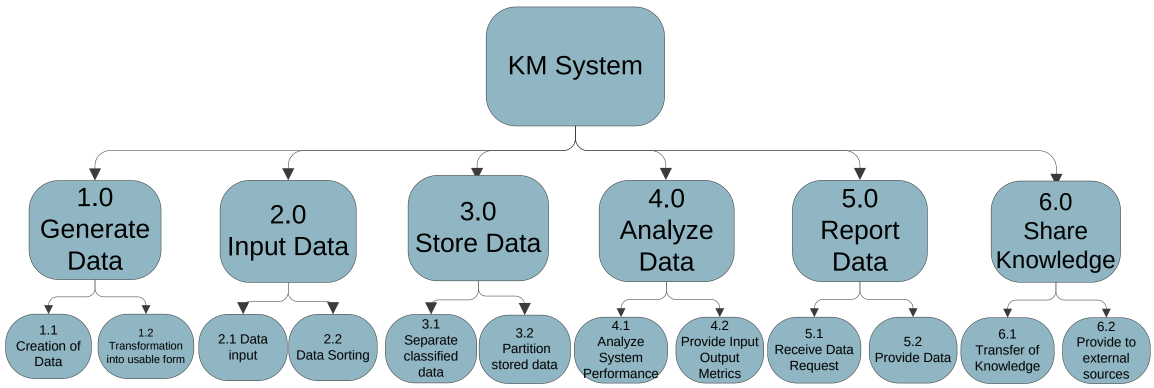

Figure 8. Functional Hierarchy.

The functional hierarchy further defines the system. It consists of six functions and their sub functions.

Following the creation of the functional hierarchy, a functional flow block diagram was created for the system. The system functional flow block diagram is shown in Figure 9. It provides a more detailed understanding of the functions and the interactions between the functions. The creation of the functional flow block diagram results in the addition of knowledge sharing to facilitate the transfer of knowledge between individuals and organizations. It also provides an overview of how the system functions.

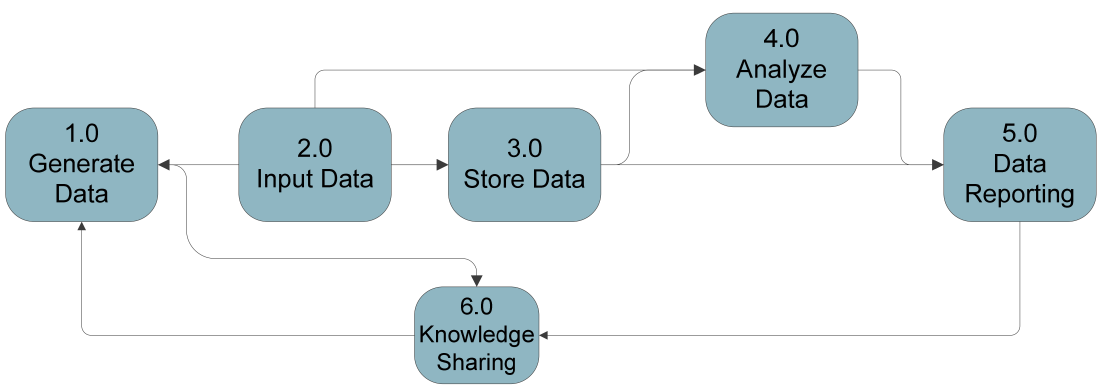

Figure 9. Functional Flow Block Diagram

The functional flow block diagram shows the continuous flow of information. It provided insight into interactions between the functions of the system.

Generation of functions, creation of a functional hierarchy, and the functional flow block diagrams allow system requirements generation. The functions provide the actions. The functional hierarchy partitions the system into smaller parts and allows traceability to the top-level requirements. The functional flow block diagrams provide a view of the interactions between the functions. Each step of the process results in further definition of the problem and feeds into generation of requirements.

C. REQUIREMENTS GENERATION

The requirements generation process translates the problem definition, top-level requirements, and the functional analysis into more specific system requirements. Requirements generation analyzes each function, resulting in requirements for each function. Verification and validation steps were added to ensure the written requirements were testable. This section also required considerable iterations to the current and previous phase for a variety of reasons. The output of this phase is a list of system requirements.

The requirements generation process used is iterative and consists of multiple steps. The first step was writing specific requirements for each function. Then, the requirements were evaluated to see if they could be verified and validated. The requirements were then refined following the addition of the verification and validation of the requirements. The use of the process resulted in a refined set of requirements.

Verification and validation of the requirements is important to ensure they meet the intent of the individual and system requirements. Verification is to ensure the elements of the system meet their individual requirements (Buede, 2009). Validation ensures that the system meets all requirements specified by the customer (Blanchard & Fabrycky, 2006). Verification and validation in this section are broken into test, inspection, analysis, and demonstration. Some of the requirements had to be modified. For example, the requirement “the data shall be searchable” did not define what data. The requirement was rewritten to:

all documentation contained within the system (shall be searchable). Other requirements were either removed or reworded to make them verifiable.

The requirements are set up in a table that provides traceability from the top-level to the derived requirements. This table includes the tie of the derived requirements to the functional hierarchy and top-level requirements. Each of the functions in the functional hierarchy has been numbered and individual requirements are numbered with a “KM” and the number corresponding to the functional hierarchy. The requirements matrix is provided in Table 2.

Table 2. Requirements matrix

Function Number	Requirement Number	System Requirement	Validation/Verification			
			Test	Inspection	Analysis	Demonstration
1.0	KM1.0	The system shall be able to generate data. Generation of data includes facilitation of the Figure 6 knowledge cycle. This includes standard templates for generation of letters, calculations, and drawings.				x
1.1	KM1.1	The system shall be able to create data. This includes standard templates for generation of letters, calculations, and drawings.		X		
1.2	KM1.2	The system shall be able to assist in translation of tacit to explicit data. This shall include shadowing of experts to understand how the task is completed. Followed by translation of the tacit knowledge by changing it into a form that can be used by others. Other methods can be used to accomplish this task.		X		
2.0	KM2.0	The system shall provide the ability to input data. This includes data that is generated on Naval Marine Corps Intranet and external to the Naval Marine Corps Intranet.				x
2.1	KM2.1	The data shall be able to be entered by all users. Users include Launchers Division personnel, NAVSEA headquarters employees, and Fleet Personnel with access to NMCI.	x			

Function Number	Requirement Number	System Requirement	Validation/Verification			
			Test	Inspection	Analysis	Demonstration
2.2	KM2.2	The system shall have the ability to sort data by system and project. Systems include torpedo tube, weapon shipping and handling, internal countermeasure launcher, external and internal countermeasure launchers, trash disposal unit, surface vessel torpedo tubes, weapon shipping and handling, and vertical launch systems. The system shall include the ability to sort data by project.	x			
3.0	KM3.0	The system shall provide the ability to store data.	x			
3.0	KM3.1	The system shall store technical documentation. Technical documentation includes letters, calculations, liaison action requests, drawings and can be expanded to other documents.			X	
3.0	KM3.2	The data storage capability shall be expandable to meet the needs of the division.			X	
4.0	KM4.0	The system shall provide the ability to analyze data. Analysis includes input and output metrics. Analysis includes identification of system issues (the second part can be a follow on capability)				x
4.1	KM4.1	The system shall be able to analyze launcher system data. This function shall be performed by launchers personnel or a software program.	x			x
4.2	KM4.2	The system shall provide input and output metrics. This is the number and size of documents handled by this system.	x			x
5.0	KM5.0	The system shall provide the ability to report data. This includes providing data				x

Function Number	Requirement Number	System Requirement	Validation/Verification			
			Test	Inspection	Analysis	Demonstration
		files that are contained within the system.				
5.1	KM5.1	The system shall be able to be searchable for all documentation contained within the system.		X		
5.2	KM5.2	The system shall be able to provide data files that are contained within it. Different levels of access shall be used depending on the project and classification.				x
	KM 5.3	Data reporting is providing the data to the users. The data shall include reports generated, letters, white papers, and other technical correspondence that is contained within the system.				x
6.0	KM6.0	The system shall facilitate knowledge sharing. Knowledge sharing is passing information between individuals and organizations.		X		
6.1	KM6.1	The system shall facilitate transfer of knowledge between individuals. Transfer of knowledge shall be accomplished through multiple forms of communication. The forms of communication shall include written and oral.		X		
6.2	KM6.2	The system shall be capable of sharing knowledge to organizations which includes NAVSEA, ONR, the Fleet, and contractors of the Launchers Division.				
	KM7.0	The system shall have the ability to meet the Department of Defense information assurance security requirements.		X		
	KM7.1	The system shall be adapted to meet security requirements. The data stored includes Secret, Confidential, Distribution		x		

Function Number	Requirement Number	System Requirement	Validation/Verification			
			Test	Inspection	Analysis	Demonstration
		D, NOFORN. For Official Use Only, and other classified data.				
	KM8.0	The system shall be able to adapt to new requirements and functionality.		X		
	KM9.0	The user interfaces shall be similar to ones that are already used such as common internet search engines, common data reporting similar to formats used in the Division.		X		x
	KM10.0	The system shall last 30 years		X		
	KM11.0	The system shall have back up data storage, processing, and power supplies.			x	
	KM12.0	The system shall be compatible with the Naval Marine Corps Intranet.		X		
	KM13.0	The system shall be based on KM best practices that include a Management Champion, Community of Practice, Technology, and Processes.			x	

The requirements were further refined as the architecture was developed and will be further defined when the detail system design is defined. The detail system will not be defined in this thesis. Table 2 was a result of the requirements development process.

D. CHAPTER SUMMARY

The derived requirements are created from the top-level requirements. The process of deriving the requirements includes a functional analysis. The functional analysis consists of generation of functions, creation of functional hierarchy and functional flow block diagrams. The result is more detailed requirements. The more detailed requirements and functional hierarchy allow for development of the architecture description.

IV. ARCHITECTURE DEVELOPMENT

A. INTRODUCTION

The process for the architecture description development is described in this chapter. It continues the systems engineering process to create the best architecture description when evaluated against the other concepts. The process consists of functional architecture development, concept generation, and aggregation and evaluation of concepts to satisfy the requirements. The concept generation process translates the requirements into concepts. The concepts are aggregated into a high-level architecture description and evaluated.

The high-level architecture description created is based on Maier and Rechtin (2000), and the Institute of Electrical and Electronic Engineers, (2000). Both recommend that the description used is unique to the problem and the subject of the problem. The high-level architecture means integration of the components at the upper levels of the system (Maier & Rechtin, 2000). The architecture description consists of the purpose of the system, the stakeholders, the requirements, and architectural viewpoints. The architecture description is created in response to the "current stakeholder needs using current and estimated technological capabilities" (Institute of Electrical and Electronic Engineers, 2000).

B. FUNCTIONAL ARCHITECTURE

The functional architecture development continues the development of a KM system. The Figure 8 functional hierarchy and Figure 9 functional flow block diagram combined with an external systems diagram are the high-level functional architecture. This section provides an external systems diagram and functional viewpoints to form the functional architecture.

The external systems diagram shows the system and the components that interface with the system, which is provided in Figure 10. These systems include the classified networks, drawing repositories, manual databases, deviation and waiver tracking systems, ships' casualty reports, other Navy knowledge sites, contractor repositories, and NAVSEA repositories. The external systems are defined as a result of the Table 1 systems matrix and the NUWC employee survey (results detailed in Appendix A). The findings of the situational assessment show that the system cannot be all-inclusive due to the scope and constantly changing nature of the data. The system will include processes and products that are within the control of the Launchers Division.

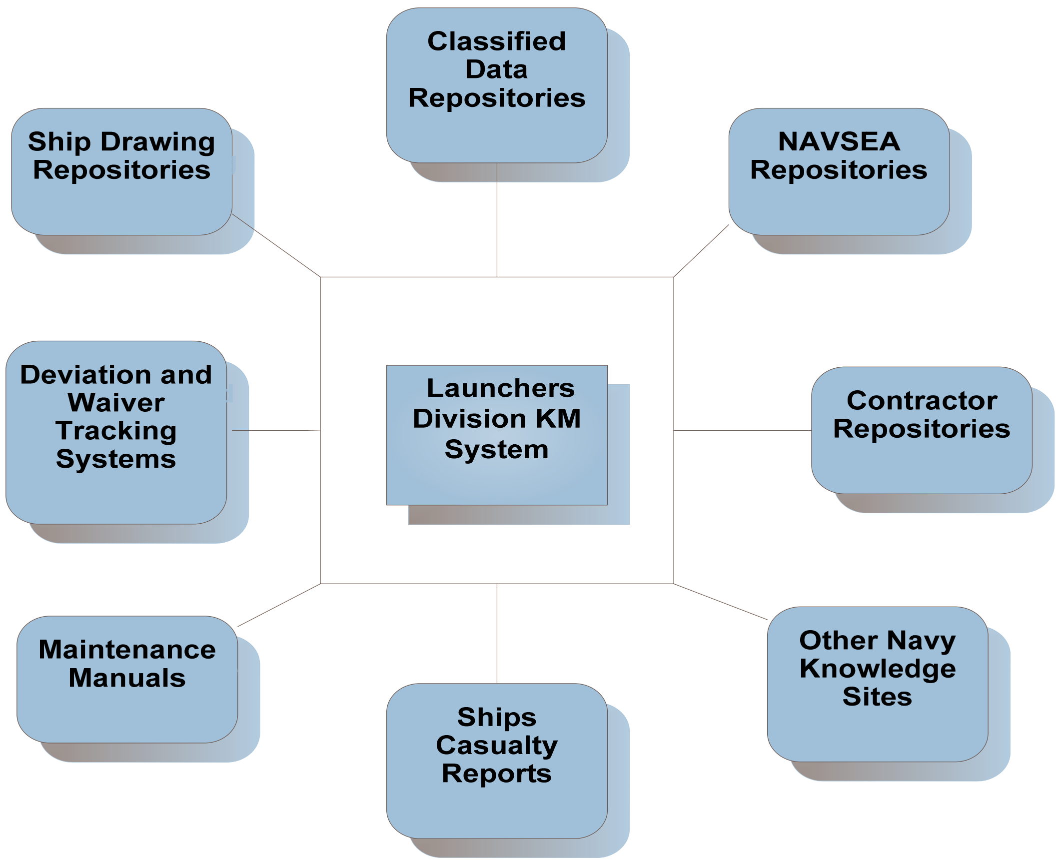

Figure 10. External systems diagram

The external systems diagram provides the interactions between the system and external sources of information. These sources of information are either too large or constantly changing to keep the information with the system.

Each of the external systems identified in Figure 10 interact with the Launchers Division KM system. The CITIS and ATIS drawing repositories provide drawings for multiple classes of submarines. The deviation and waiver tracking systems include the ELAR systems and databases that contain ships' departure from specification information. There are multiple sources of maintenance manuals and Web-based electronic maintenance manual access hosted by the Submarine Maintenance Engineering Planning and Procurement Activity (SUBMEPP). Ships' casualty reports are provided by SIPRNET e-mails and include information on system operation problems ships encounter. Other Navy knowledge sites include TEAMWARE, which provides a Navy-run collaboration system. The TEAMWARE system allows secure transfer of files between users including contractors and Fleet personnel. Contractors also maintain sites similar to TEAMWARE, and databases for storage of technical correspondence. The contractors who run the ships' planning yards provide ships' technical documentation that includes drawings, letters, and other types of technical data. The NAVSEA repositories include the NUWC Intranet and NAVSEA technical correspondence database.

The Launchers Division KM system functional architecture is defined in Figure 8 functional hierarchy and Figure 9 functional flow block diagram. These figures serve as the basis for further definition of the functional architecture. The numbering of the functional viewpoints corresponds to the Figure 8 functional hierarchy, which ensures the flow down of the top-level requirements. Note the viewpoints that further define the functional architecture do not follow IDEF or a functional flow block diagram languages, because they do not support the intent of the architecture description.

The Figure 11 generation of data function includes creation of data and transformation into useable form. It is a decomposition of function 1.0 from Figure 8 and Figure 9. The creation of data function shown in Figure 11 intends to analyze and solve Fleet operational, maintenance, and new construction problems. The analysis could be as simple as providing the answer to a previously answered problem or a material issue that is hard to solve and affects the safe operation of a system. Once solved, the solution to the problem is archived for future use. If the problem cannot be solved easily, either a design solution would need to be created or research would need to be conducted to find a solution to the problem. The policies for creation of design solutions are the Launchers Divisions' hardware development and drawing issue policies. The performance of research creates new solutions or creates new ways of analyzing a previously unsolvable problem. The drawing policy and hardware development policy aid in transformation of an idea into usable form.

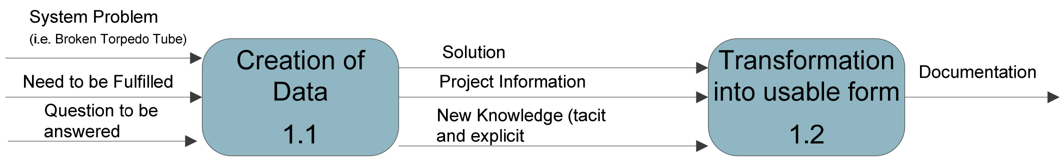

Figure 11. Generate data

This figure provides a viewpoint of the generation of data function. The process includes creation of data and transformation into usable form functions.

The transformation into usable form function also includes additional processes for creation of other types of documentation. The other types of documentation include procedures for documentation of technical analysis and design decisions; this includes white papers, meeting minutes, and letters. The transformation of data function will allow technical analysis results to be documented and stored for future use. The purpose of this documentation is to record the details and methodology used so they can be understood and/or recreated to solve other similar problems.

Input of data takes the generated data and prepares it for storage. Figure 12 shows how data is entered into the system either by manual or automatic input. It is a decomposition of function 2.0 from Figure 8 and Figure 9. Manual input is data that cannot be directly entered into the system. It includes data that needs to be scanned, or is not in a format that is recognized by the system. Automatic data input is in a format the system recognizes, so it can be sorted for data storage. Data sorting can be accomplished either by the system or manually by a processor or by the user. Data sorting can sort by system or project.

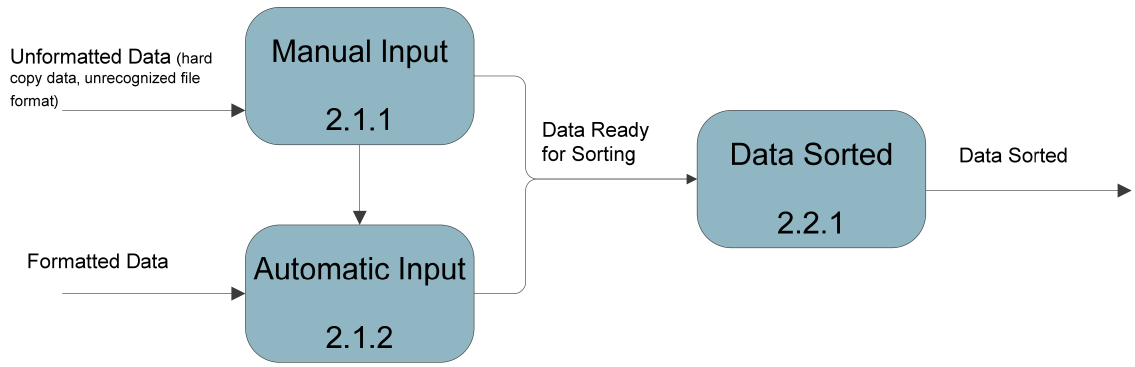

Figure 12. Input data

The input of data function includes data that is not electronic or in a form that cannot be input. It also sorts data for storage.

Data storage and retention functions are intended to file the data until it is needed. Figure 13 shows the storage of the data, including divisions of files by system. It is a decomposition of function 3.0 from Figure 8 and Figure 9. It also shows classified data in a separate repository. The separate repositories include Naval Nuclear Propulsion Information (NNPI) and classified information up to the Secret level. The use of data types X, Y, and Z are to show that the database can be separated by system or project. For example, data type X could be used to store data for torpedo tubes and data type Y could store data for the Virginia Class Project. The development and operation of the repositories will have to follow DoD and NUWC policy for storage of all types of information. The intention is to store the data for at least 30 years, which corresponds to the life cycle of a ship. This means that the system will have to store the data and be able to read the data when some of the current software and hardware may be obsolete and the file format may be unable to be read. It is hard to plan for what is going to happen in the future and that is why the system needs to be flexible to change while retaining the ability to provide the data from older file formats. Each file type stored may have to be evaluated as the systems change, and the software and associated operating systems may have to be kept to read the older files.

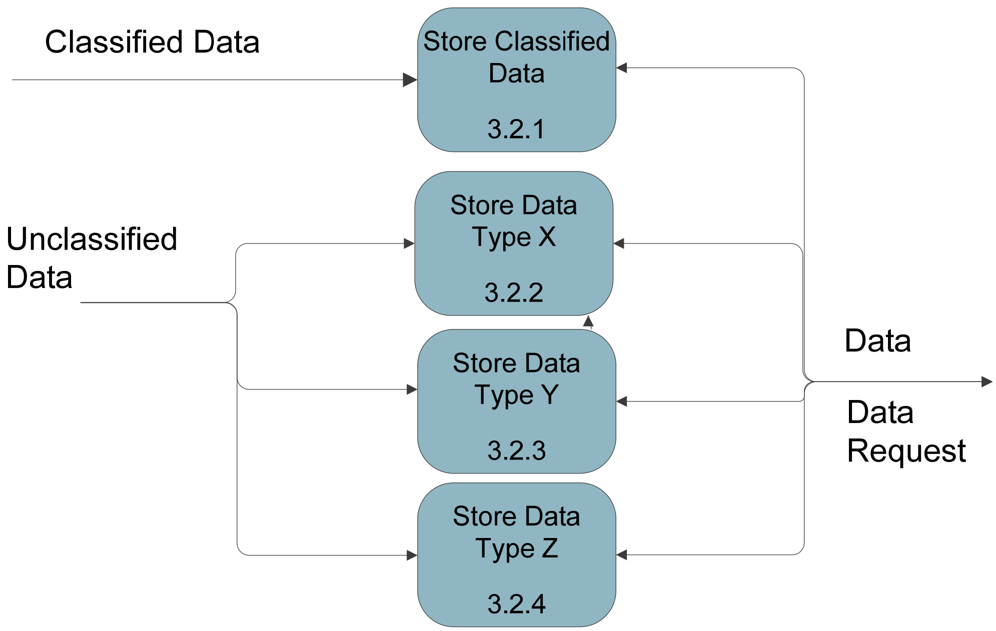

Figure 13. Store data

The store data shows the parsing of data. It includes partition of classified data and unclassified data. The data types X, Y, and Z represent the different systems that the Launchers Division works on.

Figure 14 analyzes data, which tracks system usage and analyzes the recurrence of launcher system problems. It is a decomposition of function 4.0 from Figure 8 and Figure 9. The count numbers of documents' input and output function is intended to determine the effectiveness of the KM system. This allows for determination of weak areas of the KM system operation. It also provides data on the usage and cost of the system to justify budgets. The other area of analysis is problems with launchers systems. The function is intended to identify systemic technical problems and understand the technical status of the systems under the cognizance of the Launchers Division. If the same problem shows up multiple times, it could be identified as a potential systemic problem rather than operator error. The problem areas identified are communicated to the sponsors for consideration of funding to resolve the issue. These areas also provide lessons learned for development of future platforms, such as the Ohio Replacement Program.

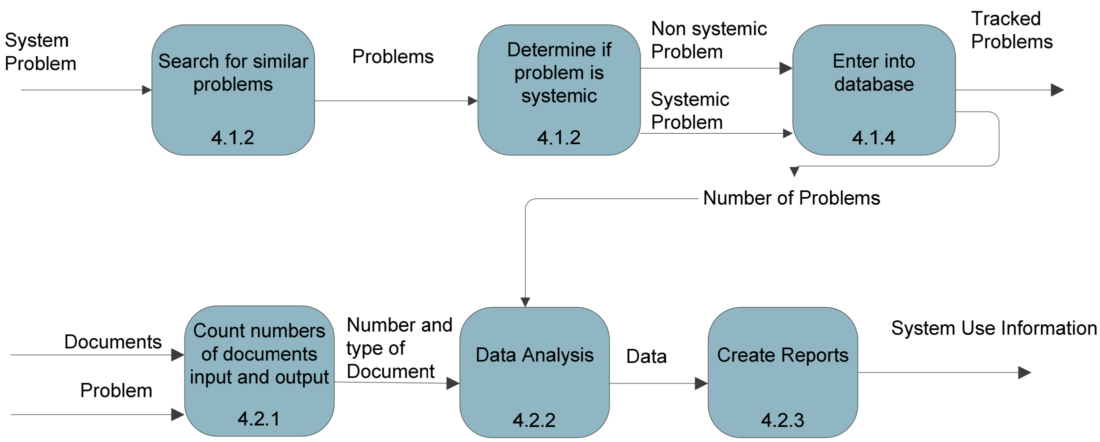

Figure 14. Analyze data

The figure includes two distinct processes. One is for monitoring KM system use and the other is monitoring the status of Launcher systems.

The data reporting function is searching and providing the data to the system users. Figure 15 shows data search, selection, and processing of the data request. It is a decomposition of function 5.0 from Figure 8 and Figure 9. The system search will include a search capability that is familiar to the users such as Google or Wiki. The system will provide the candidate documents for selection of the needed document or database. The user selects the data and the system will provide the data to the user. This function primarily would be accomplished by system software or a filing system.

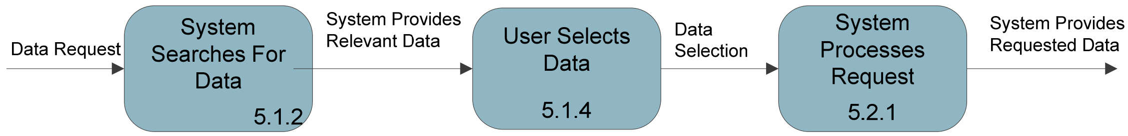

Figure 15. Report data

The report data function includes searching for the data the user is looking for. Then selecting the information the search provides and then the system provides the information to the user.

Figure 16 provides the knowledge sharing function. It is a decomposition of function 6.0 from Figure 8 and Figure 9. The function is based on interaction between individuals within the organization and outside of the organization. The first step in the process is the request of knowledge between employees of the Launchers Division or between Launchers Division employees and either the Fleet, NAVSEA, or contractors. The interaction can be as formal as meetings or as informal as phone conversations. Once the knowledge is communicated, the individual has to synthesize and understand the knowledge so that it can be applied. The interactions between the individuals are intended to reach a shared understanding of the issues at hand, the methodology to solve, or the solution to a problem.

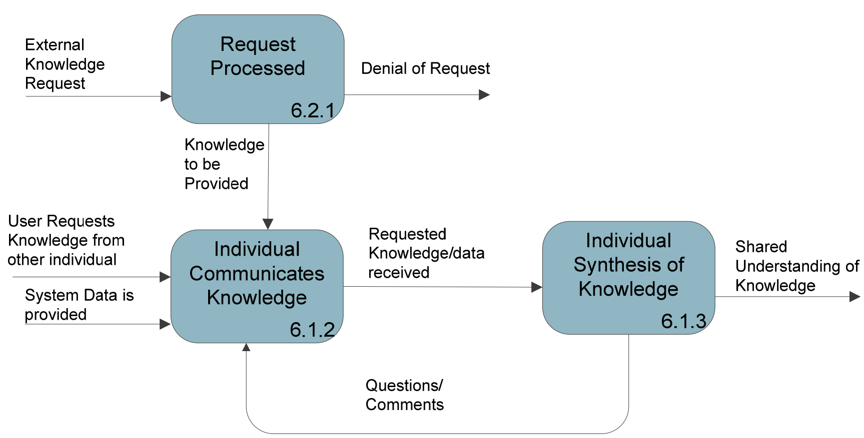

Figure 16. Share knowledge

The sharing knowledge figure provides sharing inside and outside of the organization. It also provides a user processing the data.

C. CONCEPT GENERATION

Concepts are generated following the functional architecture development. The concept generation process is based on Ulrich and Eppinger (2000) and Buede (2009). Each of the Table 2 functions and requirements have at least one concept created for them. The concepts are also consistent with the functional architecture created, since the requirements are generated from the functional heirarchy. This process traces the concepts to the problem definition, and results in changes to the requirements.

The concept creation process uses the morphological box technique described in Buede (2009). The morpological box is a process that "divides a problem into segments and posits several solutions for each segment" (Buede, 2009). The list of ideas or concepts is generated using benchmarking of similar products, suggestions from the surveys, analogy to other systems, imagination, and searching related literature. The result is at least one concept for each requirement.

The concepts generated are described in detail in Appendix B. The goal is to provide multiple concepts for each requirement, combining some of them into a more complex system. The concepts consist of people, processes, and information technology. They range from adding software to use of manual procedures. The software and hardware solutions include commercial-off-the-shelf (COTS) products. The COTS solutions range from usage of wiki software to usage of Google desktop, which provides a search capability. Some of the software solutions advertise that they have DoD software security accreditations that are already complete. The concepts are more detailed than the ones contained in a high-level architecture. Generation of detailed concepts provides further refinement of the problem definition and Table 2 requirements.

The concept generation process results in changes to the requirements and functional hierarchy. The original system requirements did not include the Naval Marine Corps Intranet (NMCI). NMCI is the primary information technology system used by the stakeholders. The requirements were changed to add, "the system shall function on the NMCI system." In addition, the majority of NMCI users have hard key encryption, which allows the system to operate without the use of additional soft key logon, and the security associated with it. NMCI has approved hardware and software for use on NMCI systems. All other software has to be designed to DoD security specifications and tested to the security requirements by the NMCI administrator at a cost. In addition, the process results in revision of the functional hierarchy. The revisions remove the collect data function due to it being redundant with the input data function.

D. CONCEPT EVALUATION

The concepts from the previous section were aggregated and evaluated to create the recommended architecture. Concept aggregation is an iterative process that combines concepts and evaluates them as a whole. The evaluation results in selection of the high-level architecture. The evaluation ensures the stakeholder requirements are met by using the requirements as the evaluation criteria.

Concept aggregation combines the concepts generated in the previous section. The combinations of hardware and software solutions include COTS products, existing systems, and unique software developed for the system. The processes and incentives are identified to facilitate system use and meet requirements the information technology cannot perform. The processes consist of ways of managing the system and generation of technical documentation, including calculations and correspondence. The concepts are based on a system that can be tailored to specific needs, including further definition of system capacities and functionalities. Flexibility of the high-level architecture will allow the system to be changed in the future.

The evaluation of the architecture concepts consists of the use of a scoring matrix. The scoring matrix is based on methodology from Ulrich and Eppinger (2000). The scoring matrix supports the decision-making process by selecting the best combination of hardware, software, procedures, and incentives to form the high-level architecture. The scoring matrix utilizes the requirements as the criteria. The requirements used are KM1.0, 2.0, 3.0, 4.0, and 5.0. The concepts were given values between 1 and 5 (Table 3). The standard is the current system: by definition, it is assigned a score of 3 for all attributes. A value less than 3 means the architecture concept is ranked worse than the standard. A value greater than 3 means the architecture concept is ranked better than the standard. Table 4 provides the scoring results. The top row contains the concepts and the column to the left contains the requirements. This differs from the morphological box technique by combining like themes or similar solution sets. In addition to the core requirements, expected development cost was added to the scoring matrix. This assumption is based on the American Productivity and Quality Center (2000) benchmarking study statement that yearly maintenance costs are equivalent to system start-up costs.

Table 3. Scoring criteria

Scoring Criteria	Rating
Much Better than Standard	5
Better than Standard	4
Equal to Standard	3
Worse than Standard	2
Much Worse than Standard	1

Table 4 represents the results of comparing the concepts against a baseline. The scores in Table 4 show that all of the concepts are equal to or better than the standard with respect to the requirements. All alternatives scored 4 for all the concepts in KM1.0 and KM6.0 because they are all estimated to be better than the baseline by about the same amount. The alternatives scored 3 for all the concepts in KM2.0 because they are all estimated to be the same as the baseline, which may change when the systems are further defined. All alternatives scored either 3 or 4 for KM3.0. The alternatives with scores of 3 are estimated to have the same storage capability as the existing system. The alternatives with scores of 4 are estimated to provide additional storage capability. All of the alternatives for both KM4.0 and KM5.0 have scores of 4 and 5. The alternatives with rankings of 4 for KM4.0 and KM5.0 are estimated to have more functionality than the baseline.

Cost and risk were added to Table 4 to provide additional evaluation of the concepts. All of the alternatives ranked lower that the baseline due to their additional cost and risk for development. Development of any of the alternatives will include additional cost. For example, development policies and procedures will require funding to develop them. Once developed, there is a risk that the stakeholders may not agree on their content or whether they are needed. Increased cost and risk will result from developing software. The software has to be coded and functional before it can be used, which takes time and money. There is a risk in developing the software because it may not function properly and or provide the functionality desired by the user. A score of 1 for both cost and risk was estimated for the alternative that develops procedures and creates software and hardware. The remaining alternatives were given a score of 2 when compared to the baseline.

Table 4. Concept scoring matrix

Function Number	Requirement Number	System Requirement	Use Existing Hardware, Software (Basic System), Develop Procedures, and Create incentives	Use Existing Hardware, Develop Software, Develop Procedures, and Create Incentives	Buy New Hardware, Develop Software, Develop Procedures, and Create incentives	Buy New Hardware and Software, Develop Procedures, and Create incentives	Use Existing System (Benchmark)
1.0	KM1.0	System be able to generate data. This includes generation of letters, calculations, and drawings.	4	4	4	4	3
2.0	KM2.0	System shall provide the ability to input data. This includes data that is generated on Naval Marine Corps Intranet and external to the Naval Marine Corps Intranet.	3	3	3	3	3
3.0	KM3.0	System shall provide the ability to store data.	3	3	4	4	3
4.0	KM4.0	System shall provide the ability to analyze data.	4	5	5	5	3
5.0	KM5.0	System shall provide the ability to report data.	4	5	5	5	3
6.0	KM6.0	The system shall facilitate knowledge sharing	4	4	4	4	3
		Expected Cost	2	2	1	2	3
		Development Risk	2	2	1	2	3

E. RECOMMENDED ARCHITECTURE

The alternative selected is to buy new hardware and software and implement procedures and incentives. It scored similar or better in all areas than the other concepts. The associated cost and risk of the system are worth the additional functionality. However, this assessment may change as funding and requirements are further defined for the system.

System implementation will have to be phased to change the overall way knowledge is managed in the Launchers Division. The system should be sponsored by a senior manager and be mandatory for the employees of the Launchers Division. If implemented, the recommended architecture will have to be defined further. Part of this definition will include more detailed system capability, functions, and capacities. It will also define system and software specific functionality.

F. CHAPTER SUMMARY

This chapter translates the requirements generated in the previous chapter into a recommended high-level architecture. It accomplishes this by generating concepts to meet each requirement followed by aggregating and evaluating the concepts into a system. The recommended architecture description is based on the top-level requirements, functional architecture, and the comparison of alternative concepts.

V. CONCLUSIONS

A. SUMMARY AND RECOMMENDATIONS

As a result of this study, the selected architecture description is based on a top down systems engineering process. The process translates the stakeholders' inputs and KM best practices into the problem definition, functional hierarchy, and requirements. Translation of these requirements and functions into an architecture description provides a better way to implement a KM system, a better way to manage data from design to operational support, and the best architecture relative to the other options for knowledge management for the Launchers Division than the existing system.

What is the best high-level architecture description for the technical KM system? The best high-level architecture is the concept that meets stakeholder requirements at a higher level of effectiveness within cost constraints. In this thesis, the alternative selected is the one consisting of new hardware and software combined with procedures and incentives. It scored higher across all evaluation criteria, which were based on the system level requirements derived from user needs, KM best practices, and well defined interfaces with external systems. The system will be more cost effective and up-to-date if it relies on already existing external KM systems to provide technical data due to volume of information, constantly changing information, and other organizations being tasked to manage that data.

What is an improved way to manage technical data ranging from design to operational support for the Launchers Division at NUWC? This thesis reveals that an improved system for management of technical data ranging from design to operational support of the Launchers Division is based on multiple factors. These factors include documentation, the scope of the system, and changing requirements. The study reveals the types of documentation used are similar across the life cycle of submarine systems, allowing use of a combined system. The surveys, situational assessment, and literature research indicate that a comprehensive technical KM system is better than the stove-piped KM system in place. The situational assessment reveals that a system that interfaces with external systems already in place is better than the standalone system currently in use. The creation of a single system for documentation not already covered by external systems would improve management of technical data at the Launchers Division.

It is recommended that the architecture developed for the Launchers Division be further defined in order to create a KM system. The details of the system need to be created and evaluated. Implementation will depend on available funding and consistent requirements. It is recommended that the architecture developed will be used as the basis for the Launchers Division KM system.

B. AREAS FOR FURTHER RESEARCH

Future study into knowledge management would include questions on measurement of the KM system, development of additional techniques for translation of tacit to explicit information, and methods of implementation and maintenance.

How do you measure the performance of a KM system? It is difficult to measure a system that has human interfaces and is based on the needs of human beings that are constantly changing. Measuring cost of the system and organization performance are possible methods. The questions should include how do you measure the increase of human performance from a KM system? How do you measure the increase in organizational performance?

What are successful methods of translation of tacit to explicit information? Nonaka (2008) uses the creation of a bread maker in his writing as an example of translating tacit information into explicit information. He recommends the use of symbols to transfer the knowledge into explicit information. Further work should include creation of methodology for translation of information.

What is an improved way to reduce costs to implement and maintain a technical KM system in an organization that supports all aspects of the life cycle? Implementation and maintenance of a technical knowledge management system are important to its own success. The American Productivity and Quality Center (2000) states that a successful KM system's maintenance costs are equivalent or greater than systems start-up costs. Future research would include a study into methods and cost of implementation and maintenance of a KM system.

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APPENDIX A: NUWC EMPLOYEE SURVEY RESULTS

The author generated and delivered a survey to gain a better insight into the stakeholders' needs with regard to technical data generation and management, their current processes and procedures, and the desired functionality of a system to support their work. The survey and its conduct were approved by the Naval Postgraduate School Institutional Review Board for protection of the people surveyed. The people surveyed include Launchers Division management, Launchers Division engineers, selected customers, and contractors. The responses are documented in Table 5.

The survey was generated to focus on the Launchers Division KM system. The questions were written to understand how individuals generate data on, understand the processes and procedures in place, the barriers to knowledge management and provide insight into the functionality of the stakeholder's ideal system. The following is the questionnaire that was provided to the stakeholders. The survey questions and results are shown in Table 5.

Questionnaire

The purpose of this questionnaire is to gather information to create an architecture and implementation plan for a VIRGINIA Class Launchers KM system database. This database will support VIRGINIA Class tasking and may evolve into supporting other classes as well. It is intended to support daily work, track system issues (recurring events, etc.), document lessons learned from design to operation, and provide an external reporting system.

Table 5. Raw survey results

What are your current problems with technical data availability in your everyday tasking? "What specific aspects of the current situation are unacceptable?	
	The Launchers Division has no central paper nor digital repository of data, classified nor unclassified. Prior management positions was that files are kept at the TPM level. In current reality, personnel (including TPMs) move often and not all are/have been as knowledgeable/diligent at repository of information.
	As an organization we do not have a repository of ready-access data from which to make educated decisions about the health and performance of systems under our cognizance. For example, recurring or systemic technical problems are handled on a reactive basis as they are discovered. Farming data for emerging trends is not possible at this time.
	Additionally NUWC's responses are never officially recorded. Most activities have a way they document problems they are fixing (i.e., ERs, LARs, etc). NUWC receives phone calls and e-mails and responds the same way.
	Lack of a system to store new data as it is created. The majority of information systems available to us are not user friendly if not used on a frequent basis.
	Data usually exists in someone's desktop files but must be reacquired by each individual on an as needed basis.
	Handling complications required because documents are unnecessarily entered into the U-NNPI(Unclassified Naval Nuclear Propulsion Information) network.
	Current technical data bases are mostly from experience level. The senior engineers/Technicians have the experience in various areas but it is not documented in any overall database. What is unacceptable is that the passing of knowledge is almost at the "tribal" level. The junior people will learn if the senior personnel are outgoing and interested in passing down knowledge. If not, the knowledge is lost.

Conclusion	*Based on the responses, there is no central repository for data. There is no way of transfer of tacit knowledge to explicit knowledge to train new employees. There is no official way of recording data or one mandated. There is no way to understand emerging trends on existing equipment.*
Do you have a system in place? If so, what are the strengths and weaknesses of the system. This can include your own or the organization's knowledge management system.	
	There is no comprehensive system in place. There are individual systems in place, most of them brute-force manual systems.
	There are difficulties managing data with different classification levels.
	The three-inch launcher and Trash Disposal Unit (TDU) In Service Engineering Agent (ISEA) has a paper data base consisting of documents generated since around 1980. The System Manager has about 8 four tier unclassified lockers in his office. Each locker has numbered folders with common information is each folder. A Microsoft Word file has the listing of each locker folder and the title of each separate document in each folder. One has to use the search program to find the locker and folder for the wanted information. The strength of this system is that information on recurring and unique system problem areas is readily at hand and has proven to greatly successful for everyday problem solving. The weakness of the program is locker space to support ever growing data input and that the folders/locker contains superfluous information that never has been thoroughly reviewed.
Conclusion	*There is no comprehensive system in place. There are individual systems in place and data needs to be managed at different classification levels. A comprehensive system of managing data is needed.*
What part of the current system works well? What does not work?	
	The disaggregation of our existing systems do not work well. The manual nature of our existing systems do not work well.
	The collection and implementation process does not work well. In fact, having multiple systems without a clear direction on their use causes them to act as black

	holes.
	Holding individual copies of information works well. However it is not available to others.
	The best systems are user friendly.
	The system is detail oriented and provides great background on recurring problems. The locker area is finite. The creation of folders is labor intensive. Proposed scanning of existing and new files is expensive.
	Individual systems work well. Some have great detail.
Conclusion	*No central system exists. There is a good example of an existing system. The system varies by person and program. The KM system needs to be user friendly.*
What functions do you need for knowledge management in your tasking? A function is a task the system performs.	
	Document management (internally generated or received from external)
	Digital repository with paper capability (for classified or sensitive data)
	Ease of deposit of documents, simplicity of addition of indicative data for each document
	Title, keywords, author/division POC, date, other doc numbers, external organization, funding project, etc (perhaps metadata in a future state)
	Flexible reporting of the KM system (allowing management to pull various statistical information, how many deposits, deposits bound by dates, deposits with no files attached, etc…)
	Robustness of SEARCHING for data (advanced queries, indexing of title, keywords, etc on all indicative data
	Serve as a historical archive, where ongoing and future engineering efforts can understand and incorporate lessons learned in the past.
	Allow external sources, such as supporting contractors and program sponsors to monitor health and performance of the systems in near real-time,

	Allow data farming to identify trends in order to move our work to a more proactive posture.
Conclusion	*The primary functions requested include management of documents, provides means of analysis, allows access from external organizations, and supporting several different ways to search for information in the archives.,*
When looking for Technical Letters what process do you use to find these?	
	I can never find the letters unless I wrote them or reviewed them.
	Ask the secretary OR a TPM OR someone that was involved in the project. Hit or miss.
	In some cases we have to ask external sources that we sent the letter to.
	CITIS but it is sparsely used
Conclusion	*There is no formal process or repository for storage of technical correspondence.*
When looking for drawings or manuals what process do you use to find these?	
	ATIS, CITIS, or ask another person in the department.
	Not certain what process exists for pulling Manuals
	Naval Sea Logistics Center which is required to keep and maintain all ship logistics.
	Drawings, depends on submarine Class. 688, 726 and 21 are available via ATIS; 774 via CITIS. The drawings for the particular equipment I am responsible for are not available on ATIS. I keep them on my hard drive. If the drawings are not available via ATIS or CITIS, you can try DAPS.
	Tech Manuals are available online at TDMIS, but it's not very user friendly. Maintenance Manuals, Ship Systems Manuals including OI's, Naval Ship Technical Manuals, are available on our Department Public Drive. ODs you go to Eric Von Tish, who maintains the ODs. The library has some tech manuals, and has an online catalog that is searchable.
Conclusion	*Drawings and Manuals are provided by external organizations primarily through two databases: CITIS and ATIS. This function should remain in the cognizant organization due to the cost of maintaining an up to date database.*

When looking for Fleet identified problems what process do you use to find them?	
	I am not aware of a comprehensive database that stores Fleet identified problems.
	The Remedy system that was developed to track Fleet problems and resolutions was terrible and was never used. We tried to develop a Remedy-lite system in our branch but because it requires additional (redundant) work to enter information, it is seldom used.
	Equipment problems that are reported by in-service submarines are usually reported as requests for deviations or waivers. There is an E-DFS site, but it is not user-friendly.
	Locally received and approved deviations and waivers, applying to work being performed under contract to NUWC, we keep in a database developed within the Division. But it is only a few years old and doesn't contain a lot of data.
	Fleet identified problems are reported by deployed submarines via Naval Message. (A couple years back they decided to include SUBS in the subject line of these messages to make them easier to discern and track. There is no database that I am aware of that stores Naval Messages beyond 30 days after issue. Similar to technical letters, Naval Messages will only be available if of critical importance. Naval Messages are most likely to be found with the author / originator.
	Ask an ISEA(in-service engineering agent) expert from that system area.
	Review highlights database
	I wait for notification from them via naval message. This has not been an effective method of communication between us as designer and them as end-user. They do not have robust systems on their end so entry of issues at the source is not always occurring.

Conclusion	*There is no comprehensive database to collect launcher related data. In addition, not all problems are reported on the user's end. One thing that did not come out in the surveys is that the Fleet uses a higher classification system to send naval messages. The Launchers Division primarily works on a lower classification network.*
If you are looking for the configuration of a system on a certain ship, what is the process you use to find it? i.e., I am looking for an all the engineering reports for the torpedo tubes how would I find them?	
	ATIS contains some ships configuration data, but is thought out of date. Ship checks are usually required. Or a phone call to Fleet personnel, or others that may be "expert" in that system.
	Conduct a ship check, as I would not believe that configuration management at that level would be reliable.
	The tech homepage (which is described in the Table 2).
Conclusion	*This is a similar question to finding drawings, since the drawings contain the majority of the configuration. The ships drawings are large in multitude and would be hard to maintain them up to date. Ships drawings are the responsibility of the planning yards.*
When looking for calculations what process do you use to find them?	
	To the best of my knowledge, only SSDR calculations are stored. I contact the Planning Yard for the particular submarine class via LAR, and request a copy.
	Going to the cognizant engineer or technical program manager.
	Official Calculations are stored at the library but there are very few that are made official.
	In local directories

	In most cases, you just do a new calculation. Where you know a particular calculation has been required repeatedly, and will be needed for reference in the future, it is best to document such an analysis or calculation in a TM. These are stored in the NUWC library once published.
Conclusion	*A process for storing calculations is needed. Means of generation and a standard format including a system to ensure that they are searchable is needed.*

When looking for technical specifications what process do you use to find these?	
	Contact Electric Boat or Newport News Shipbuilding and issue Liaison Action Request perhaps, if ATIS does not possess (which it would not for tech specs)
	Classified Data repository for Shipbuilding Specifications.
	Internally for specific equipment specifications.
	Information Handling Services is the best place to find up to date specifications.
Conclusion	*Storage of technical specifications is outside the scope of the thesis. Only specific specifications are kept up to date within the department. Commercial specifications are available via the NUWC Library and would be too hard to keep up to date since there is a large number of them and are continuously updated.*

When looking for design decisions, what process do you use to look for them? What process do you use to document them?	
	I would look for drawing Engineering Change Proposal's and Technical Variance Documents.
	CITIS for Engineering Reports
	Unfortunately there is not a division wide repository for such information. Within my own office or position, the files of all predecessors have been digitally scanned, but no front end or interface is available. They are on a disk.
	There is no official process to document them.

Conclusion	*There is no official process to document design decisions made by the Launchers Division.*
What is the most important data required to conduct your tasking?	
	My personal digital files.
	End-user feedback of issues discovered during operation, (i.e., Fleet input).
	Anything that answers the question: how did we get here? That would include background information on the tasking in question, which is usually documented formally in test plan/report front matter, and in the background paragraphs on letters to/from NAVSEA.
	All of the data you have mentioned above: drawings, configuration of a particular ship, deviations and waivers, calculations, tech manuals, test results. In addition, LARs, procurement history (list of previous suppliers, in particular).
	Materials information, detailed requirements documentation, and vendor data.
Conclusion	*Technical documentation needs to be stored. All relevant design data is important including drawings, calculations, and technical manuals.*
What is the least important data required to conduct your tasking?	
	I don't know the entirety of the data I work with
	Extraneous "chatter" in emails, frequently surrounding those 1-2 sentences of information that I actually need. (A more efficient keyword search in Outlook would be nice.)
	Old contracts
	Irrelevant, usually e-mails from other people who are answering commitments that have no relevance to what I am doing.
Conclusion	*This question had some responses and could have been accomplished in a different manner. Overall it is important to document most technical data.*
When looking for test results (at sea, DT and OT) what process do you use to obtain these?	
	Ask those who were likely to have participated in these events in the past.

	Go to Code 25 folks, but unfortunately their objectives center on testing Non Propulsion Electronic System functionality and they often record issues with my system as an afterthought. If our folks participated in the test, I may be able to review their trip reports. Unfortunately, it is not mandatory to fill out a trip report and most that I have gotten were due to my nagging, not their management's.
	Test results are usually documented in the test/trip reports, which are usually found as enclosures –or at least references– to NAVSEA letters. Raw data is usually archived on CDROMs/DVDs or network servers, and can usually be found via the dates, test facilities, and SMEs named in the applicable reports.
	For in-service submarines, I believe SUBMEPP maintains copies of completed test forms. I contact my SUBMEPP POC and ask. If the maintenance activities have forwarded the results, SUBMEPP will have them. For Maintenance Requirement (MR) cards other than K-type, go to the local Intermediate Level Maintenance Activity.
	For new construction submarines, I believe the Shipbuilders maintain copies of completed test forms. For results of K-type MR cards, go to the local Performance Monitoring Team. (Inexplicably, data from K-type MR cards is not made available to ISEAs for evaluation.)
	Go to the Code 25 contractor run deviation tracking system that has all of the test findings
Conclusion	*Test results from equipment tested ashore are easier to find than at sea system testing. At sea system test data is important to understand the strong and weak areas of the systems. Understanding this allows for improvement of the current and development of future designs.*
Would a knowledge management system tool be useful in conduct of your work?	
	Any organized, comprehensive, searchable DOCUMENT MANAGEMENT system would be hugely beneficial.

	I'd say that it is critical and in fact we are not doing our job effectively without out. The submarine community is wasteful at this point in time, working issues over and over again without even knowing it.
Conclusion	*A knowledge management system is important for conduct of work and will be useful to the Launchers Division.*
Do you know of instances where technical data is unavailable that you need. If so what are they? How can this problem be solved?	
	This happens each and every day here. There are no central repositories (within Code 412 at least!) to store and disseminate data. Our technical library has not embraced this, not sure why. Other organizations are moving towards efficient enterprise wide solutions, and we are still relying on manual based processes, or simply "people". Which is great until those people go away.
	Being redundant, but we NEED a centralized solution for document repository. It needs to be simple to upload the document along with any indicative data, and needs to have robust search capabilities.
	A good example would be sea trial results, which are currently classified at a level I can't access simply because it was conducted by a test group that is accustomed to working with data also collected during the test that I don't even need.
	For a current project we are looking for design performance data of a particular piece of equipment in order to assist with computer modeling. The information that we require does not appear to be available. Our options are to keep looking, or try to recreate the data empirically.
	I don't have access to a database that quantifies the failures in my area. There is a "3M" system but I don't have a way of getting to it. Establish a link to it for NUWC, Code 40.
	Yes, there have been several times that I needed 688 class SSDRs and NUWC did not have them.. I had to get them from the 688 Class PY.
Conclusion	*There are many instances of missing technical data.*

If you were going to create the system, what functions would it perform and how would it be set up?	
	See functions above
	It would be accessible and easy to use. Something simple and elegant is required. Too many of the competing systems have a “whiz-bang” feel reflecting a programmer’s interests and not those of the actual users. It would be universal, meaning that all relevant participants of this diverse technical community would see it as the sole repository, as such it would become comprehensive. It would be mandatory because we unfortunately are working in an atmosphere of complacency and entitlement.
	It would be available online, accessible from anywhere. It would be a comprehensive system, containing drawings, deviations, manuals, etc all in one system or at least through a common portal or interface. It would be readily searchable by keywords, dates, author, etc. It would be continuously updated without any additional work on the part of the user. It would be maintained by dedicated personnel who are skilled in archiving. It would be a system that could be relied on to still be in existence and available 5, 10 or 15 years down the road.
	Prior to NMCI, many of us had Google Desktop installed on our computers. This was a great tool to search through all your files, emails, etc. at once.
	Backed up regularly for access should the network become unavailable for a period of time.
Conclusion	*The functions are defined in the question above and in a previous question.*
What type of data are you looking to store? And, how long do you need to keep it? And, what are the known relationships between those pieces of data?	
	Need to store outgoing responses to shipyards, research about problems for future use, test reports etc…

	Types – ALL types. Any “product” that we create. I define a product as any document that we send out to a stakeholder (white paper, presentation, letter), or that we use internally to perform our work (test plan, test report, controlled work package, calculation package, etc).
	How long to Keep? Forever
	Unknown
	For example, shock qualification data should probably be stored as long as the subject system is deployed, i.e., forever (effectively). Available historical data should facilitate reverse-engineering any system, by anyone with relevant technical knowledge/expertise and need-to-know.
	Data needs to be stored for the life of the particular submarine or submarine class. Typically, 30 years or so.
	Ongoing and historical type data. I don’t know. I know ours works but it would be very cumbersome on a Fleet wide level.
Conclusion	*All types of technical data. The size stored will depend on the system defined. The system has to store data for at least thirty years.*

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APPENDIX B: SYSTEM CONCEPTS

Function Number	Requirement Number	System Requirement	Concepts
1.0	KM1.0	System shall be able to generate data. Generation of data includes facilitation of the Figure 6 knowledge cycle. This includes standard templates for generation of letters, calculations, and drawings.	
1.1	KM1.1	The system shall be able to create data. This includes standard templates for generation of letters, calculations, and drawings.	Automatic Templates for technical documentation.
			Create standard procedures developed by the department to create technical documentation including: calculations, test reports, letters, drawings and other technical documentation.
			Create department policy with a person that is in charge of standardization of technical documentation.
1.1	KM1.2	System shall be able to assist in translation of tacit to explicit data. This shall include shadowing of experts to understand how the task is completed. Followed by translation of the tacit knowledge (understanding0 into a form that can be used by others. Other methods can be used to accomplish this task.	Voice Recognition software to capture meeting minutes, write letters, and create other documentation.
			Procedures for standardization of documentation.
			Requirement for documentation in certain cases.
			This can be done in second increment
			Translation trade by one group into documentation.
			Translation of design methodology into details using diagrams and instructions.
			Training on how to do this
			Requirements for personnel to accomplish this.
1.2	KM1.2	System shall create incentive for users to create and share knowledge	Put it in Performance Review which directly affects raises, NUWC is under a pay for performance system.
			Have a bonus for personnel contribute to the overall system.
			End of year award for this.

Function Number	Requirement Number	System Requirement	Concepts
2.0	KM2.0	The system shall be able to assist in translation of tacit to explicit data. This shall include shadowing of experts to understand how the task is completed. Followed by translation of the tacit knowledge by changing it into a form that can be used by others. Other methods can be used to accomplish this task.	
			Upload it electronically into system
			Place it in paper repository
2.1	KM2.1	The data shall be able to be entered by all users. Users include Launchers Division personnel, NAVSEA headquarters employees, and Fleet Personnel with access to NMCI.	
			Easy to use computer interface.
			Paper insertion into the files.
			Automatic input by email or other means.
2.2	KM2.2	The system shall have the ability to sort data by system and project. Systems include torpedo tube, weapon shipping and handling, internal countermeasure launcher, external and internal countermeasure launchers, trash disposal unit, surface vessel torpedo tubes, weapon shipping and handling, and vertical launch systems. The system shall include the ability to sort data by project.	
			Users have to designate what system using a check box
			The system searches for keywords and places it in the right file.
3	KM3.0	The system shall provide the ability to store data.	System operation on an accessible network with hard drives and software to support it.
3	KM3.1	The system shall store technical documentation. Technical documentation includes letters, calculations, liaison action requests, drawings and can be expanded to other documents.	File Cabinets with workers to provide them when needed.
			Electronic Repository to store the documentation.

Function Number	Requirement Number	System Requirement	Concepts
3	KM3.2	The data storage capability shall be expandable to meet the needs of the division.	Additional hardware can be hooked into the system.
			Data partitions in paper file
4	KM4.0	The system shall provide the ability to analyze data. Analysis includes input and output metrics. Analysis includes identification of system issues (the second part can be a follow on capability)	See sub requirements
4.1	KM4.1	The system shall be able to analyze launcher system data. This function shall be performed by launchers personnel or a software program.	Manual search for similar problems by launchers personnel. Statistics generated for failure rates and operational availability.
4.2	KM4.2	The system shall provide input and output metrics. This is the number and size of documents handled by this system.	Software to measure system usage. This includes areas they are used. There is commercially available software for this application
			For paper repository the files can be tracked manually
5.0	KM5.0	The system shall provide the ability to report data. This includes providing data files that are contained within the system.	
5.1	KM5.1	The system shall be able to be searchable for all documentation contained within the system.	
			Google search
			Wiki type interface
			I wish it could be automatically sent to the user.

Function Number	Requirement Number	System Requirement	Concepts
5.2	KM5.2	The system shall be able to provide data files that are contained within it. Different levels of access shall be used depending on the project and classification.	by email files.
			I wish it could be direct access.
	KM 5.3	Data reporting is providing the data to the users. The data shall include reports generated, letters, white papers, and other technical correspondence that is contained within the system.	Software access
			Network access
6	KM6.0	The system shall facilitate knowledge sharing. Knowledge sharing is passing information between individuals and organizations.	
6.1	KM6.1	The system shall facilitate transfer of knowledge between individuals. Transfer of knowledge shall be accomplished through multiple forms of communication. The forms of communication shall include written and oral.	
			Use current ipt structure and force additional individuals to participate.
			Change environment through cultural change.
6.2	KM6.2	The system shall be capable of sharing knowledge to organizations which includes NAVSEA, ONR, the Fleet, and contractors of the Launchers Division.	Representatives could be sent to Fleet post deployment, similar to TOMIS system.
			Technical documentation to be sent to Fleet.
			Fleet representatives should be part of program reviews.
	KM7.0	The system shall have the ability to meet the Department of Defense information assurance security requirements.	

Function Number	Requirement Number	System Requirement	Concepts
	KM8.0	The system shall be able to adapt to new requirements and functionality.	Operating system has the ability to add software and files be able to interact with the software.
	KM9.0	The user interfaces shall be similar to ones that are already used such as common internet search engines, common data reporting similar to formats used in the Division.	Use Upload Buttons.
			Use up to date search tools. These include Google, wiki, Bing search engine and tools that are familiar to people. Google has NMCI capable software.
			Data presentenced in a read able manner.
			Security system partitioned off the system.
	KM10.0	The system shall last 30 years	Use standard file formats, word, pdf that will be able to be read for a while.
			System could maintain older software to pull up the file formats needed.
	KM11.0	The system shall have back up data storage, processing, and power supplies.	
			Back up hard drives that save material
			Dual backups
			Back up operating system.
			Use TOMIS for data storage. The engineers have the experience to complete this type of tasking.
	KM12.0	The system shall be compatible with the Naval Marine Corps Intranet.	
			Design and Test software to comply with NMCI rules.
	KM13.0	The system shall be based on KM best practices including Management Champion, Community of Practice, Technology, and Processes.	Combinations of technologies. Incentives, and processes.

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