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US Navy Underwater Construction Team Operations: Knowing the Risks

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US Navy Underwater Construction Team Operations: Knowing the Risks

By

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Date

Submitted in partial satisfaction of the requirements for the

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in

Ocean Engineering

in

The Marine Technology and Management Group
University of California, Berkeley
Berkeley, California

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1 ABSTRACT

Human and Organizational Factors account for eighty percent (80%) of high consequence accidents in engineered systems (Bea 2001). To achieve high quality in the lifecycle of increasingly complex engineered systems, it is imperative that we assess and manage the risks attributed to human and organizational factors of the system. A key step in mitigating these risks is to capture and build on the knowledge gained from previous experience. To this end, a repository of Best Practices and Lessons Learned (BP/LL) that is stored for efficient future recall is proposed. By learning what has and has not worked in the past, project planners with little experience can more proactively manage the risk inherent in complex engineered systems and ultimately achieve higher quality.

Unfortunately, a repository alone will not suffice. There needs to be a method for capturing and sharing information; the technology that supports the transfer of the BP/LL needs to facilitate storage and retrieval; those that contribute to the repository must be recognized as the experts in the field; the content of the repository must be relevant and up-to-date. The philosophical base of Knowledge Management attempts to address these issues. The US Navy and, subsequently, Naval Facilities Engineering Command (NAVFAC) have adopted the principles of KM to facilitate the transfer of BP/LL.

This project explores the development of a tool that captures BP/LL regarding the risks involved in the operation of the Underwater Construction Teams. This tool aids the operator in assessing risk using the principles of Operational Risk Management (ORM) while planning a project using the UCT Project Planner. The report also identifies the need for a tool that captures BP/LL regarding quality in an updated version of the UCT Project Planner. The content review process of the BP/LL and the storage and accessibility considerations for the

material is discussed in light of the philosophies of knowledge management and the advantages of collecting knowledge in this framework are discussed. Finally, recommendations are made regarding the formal establishment of the Underwater Construction Community of Practice (UC CoP) and the further development and implementation of the upgrade to the UCT Project Planner.

2. Quality and Reliability

2.1. Quality

Most organizations strive to achieve "quality" in their product. The term quality, however, means different things to different people. It could refer to workmanship, the material used, price or a number of other items or, more likely, a combination of definitions. Whatever the product a firm produces, it is important to define the attributes of quality. Bea (Bea, 2001) defines quality with the following attributes (Figure 1):

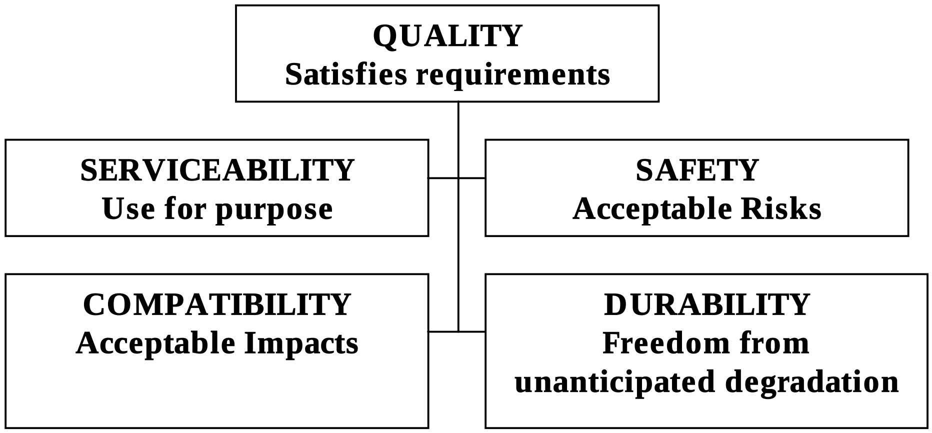

Figure 1 - Quality Attributes (Bea 2001)

Compatibility - The product is on time, on budget and does not have any unnecessary or negative impacts on the environment and society.

Serviceability - The product is fit for its intended purpose. The guarantee the system is used for the agreed purpose and under the agreed conditions of use.

Safety - The freedom from undesirable or hazardous situations. The capacity of the system exceeds the demands on the system.

Durability - The freedom from unanticipated degradation in the safety, serviceability or compatibility of the system.

Quality is the freedom from unanticipated defects in the compatibility, serviceability, safety, and durability of the designed system.

2.2. Reliability

Closely linked with quality is reliability. Bea (Bea 2001) defines reliability (Ps) as the probability that a given level of quality will be achieved during the lifecycle of the system. The lifecycle is defined as the conception, design, construction, operation, maintenance, and decommissioning of the system. A reliable system has acceptable safety, serviceability, compatibility and durability throughout the lifecycle.

Failure to achieve any one of the quality attributes will lead to failure of

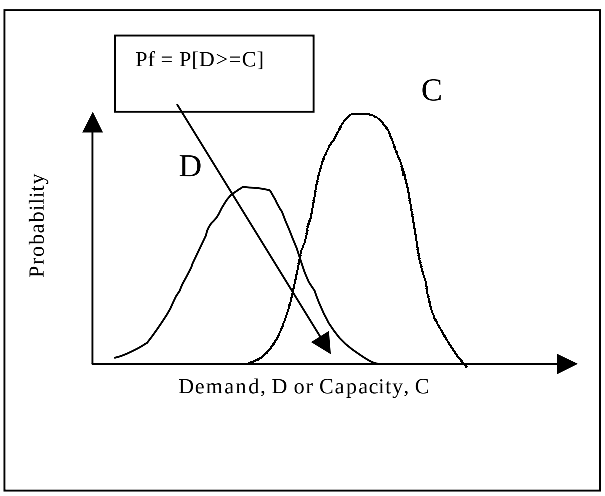

Figure 2 - Probability of Failure given Capacity (C) and Demand (D)

the system. As the demands (D) on a system become greater with respect to the capacities (C), the system is more likely to fail. See Figure 2.

Equation 1

$$Pf = 1 - Ps = P(D>C)$$

Bea goes on to point out that failure in a system develops from intrinsic or extrinsic causes. Intrinsic causes include factors such as extreme environmental conditions and other uncertainties. Extrinsic causes are due to Human and Organizational Factors.

Bea contends that eighty (80) percent of high consequence accidents are due to Human and Organizational Factors (See Figure 3). These failures are linked back to operator error in the design, construction, operation and/or maintenance phases of the system. While the operator may be at the "root" of the problem, the errors can be and often are caused or compounded by error inducing influences from organizations, equipment, the structure, procedures, environments (internal and external) and the interfaces between all of these.

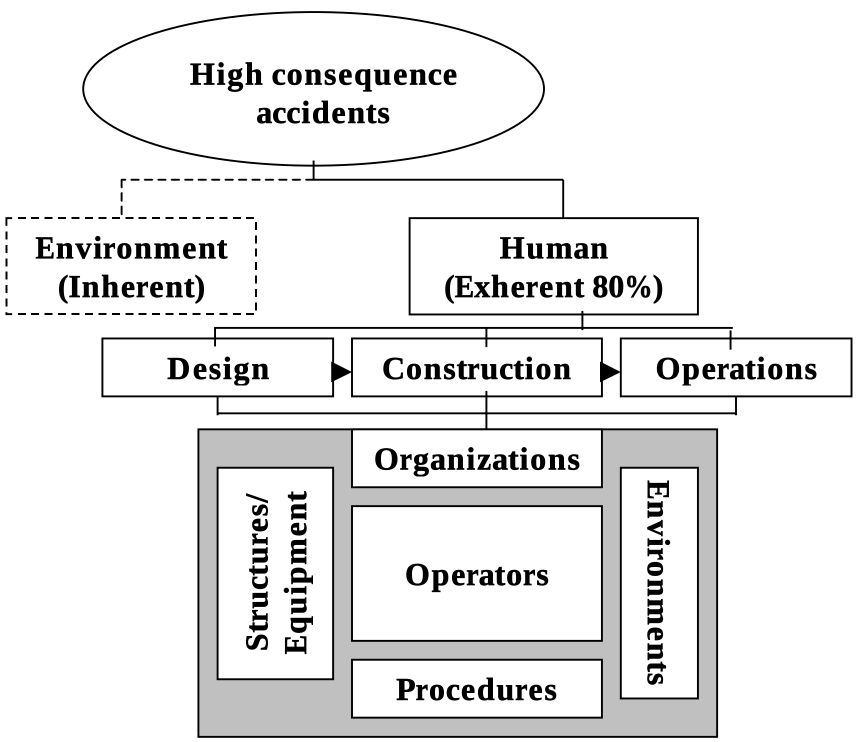

Figure 3 - High Consequence accidents (Bea 2001)

If we let the following be true:

i = the quality attributes (safety, serviceability, compatibility, durability)

I = intrinsic factors

E= Extrinsic factors,

then the probability of failure of the system to develop quality attribute (i), is

Equation 2

$$\mathbf{P(F_{Si}) = P(F_{SiI}\ U\ F_{SiE})}$$

Where $\mathbf{P(F_{SiI})}$ is the failure of one of the quality attributes due to the randomness of intrinsic events and $\mathbf{P(F_{SiE})}$ is the probability of failure of one of the quality attributes due to Human error. So,

Equation 3

$$\mathbf{P(F_{Si}) = P(F_{SiI} | E_{Si})P(E_{Si}) + P(F_{SiI} | \bar{E}_{Si})P(\bar{E}_{Si}) + P(F_{SiE} | E_{Si})P(E_{Si})}$$

Where,

$\mathbf{P(\bar{E}_{Si}) =}$ probability of no Human and Organizational Errors, and

$\mathbf{P(A | B)}$ indicates the probability of occurrence of **A** conditional on the occurrence of **B**.

The first term in Equation 3 means the probability of failure of the attribute due to an intrinsic event given a human error. In other words, the loads (demands) on the system were miscalculated. The second term means that the failure in the attribute was due to some unforeseen intrinsic event. The third term means that the failure of the attribute was due directly to human error.

2.3. Human and Organizational Factors

2.3.1. Human Performance

Bea (2001) cites J.H. Stamler's definition of HOE as being "a deviation from acceptable or desirable practice on the part of an individual (human error) or group of individuals (organizational error) that can result in an unanticipated and/or undesirable result."

To define how human errors occur, Bea (2001) looked to the work of Rasmussen (knowledge, rule and skill based behavior) and James Reason (Evaluation, Goal Setting and Execution) to illustrate the thought pathways as illustrated in Figure 4. The figure is valuable in that it demonstrates for each level of cognition there is a series of steps that need to be taken. The more practiced one becomes in a particular task, the responses will move from knowledge based to rule based and eventually to skill based. As this happens shortcuts are developed in the cognitive process and reaction to given situations becomes almost automatic.

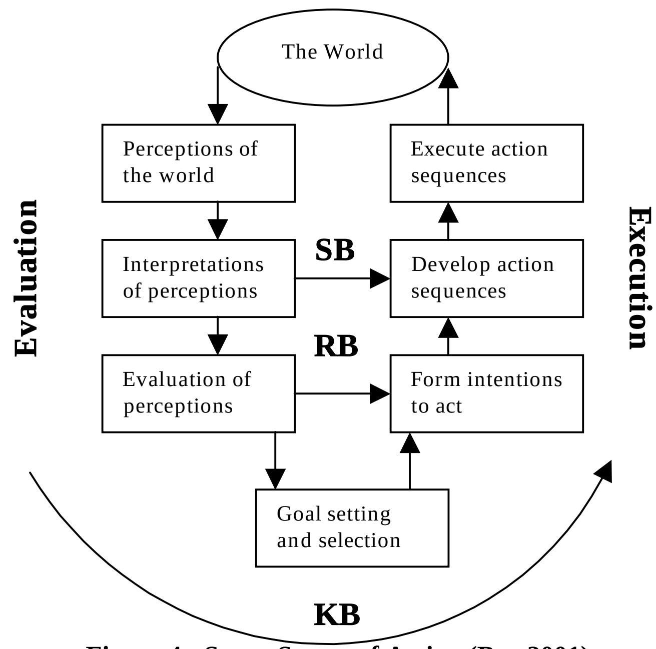

Figure 4 - Seven Stages of Action (Bea 2001)

1. Knowledge based - Knowledge based performance requires a great deal of thought. There are no previously established models from which to work. This means that the thought process requires all of the individual's attention. "Errors at this level originate from resource limitations (attention, cognition and or time) and incomplete or incorrect knowledge." (Bea, 2001)

2. Rule based - This is the next level in the cognitive process. The individual calls on previously developed thought patterns for a given situation. These thought patterns are developed through training and experience. "Solutions are selected automatically, but conscious thought is used to verify that the solution is appropriate."(Blumenberg, 1996) The types of errors in rule-based behavior are that the rule does not fit the situation or that it could be recalled incorrectly.

3. Skill based - This level of the cognitive process requires the least cognitive effort of all. Skill based behavior is developed through repeated recall of the actions needed to perform the task that they are automatic. Driving a car is a good example of skill-based behavior.

Bea points out that mishaps happen because of Errors as defined by Reason and violations as defined by Dougherty. See Table 1.

Table 1 - Error and Violation types per performance level (Bea 2001)

Performance level	Error Type	Violation Type
Skill based	Slips and Lapses	Erroneous or unintended
Rule-based	Rule Based mistakes	Routine
Knowledge based	Knowledge based Mistakes	Exceptional

Errors are committed by accident where violations are committed on purpose. This does not mean that violations are performed with intent to harm. Lapses are defined as errors that result from a failure in the storage of the action plan and slips are errors in execution.

2.3.2. Organizational Performance

In the study of organizations, Bea (2001) cites the work of a large number of people in the study of High Reliability Organizations (HRO). The attributes associated with HROs are the following:

Migrating decision making - The recognition that the people at the top of the wire diagram of an organization are not the ones that make the key operational decisions in the time of crisis. The organization pushes the authority to the lowest level possible, however the responsibility to properly train the operators remains with the organization.

Redundancy - The system does not rely on the skills or attributes of just one entity.

Procedures and rules - The guidelines in which operations are run are clear, concise, and not overly complicated.

Training - The organization provides operators and management in training of scenarios that are normal, abnormal and unbelievable. The purpose is to develop rule and skill based behavior in those that operate and manage the system.

Appropriate awards and punishments - The organization has integrity. What it says and what it does are in sync and the reward and punishment system is based on the furtherance of the organization's goals or the failure to do so.

Management's ability to see the big picture - Management is continuously checking the heading of the organization to ensure its words (policy and procedures) and its actions (operations) are in line and heading in a safe and reliable direction.

Preoccupation with failure - Instead of worrying about what it will take to succeed the HRO determines what success is and then spends its time trying to identify the obstacles that keep the organization from achieving success. Once identified the organization works to eliminate or side step the obstacle. Once all the obstacles are identified, the organization may also redefine success to make it achievable.

Culture - Appropriate awards and punishments listed above falls under this category. To reiterate, the organization is consistently concerned with increasing the reliability and safety of its system. The culture is not part of just management or just the operators, but is instilled throughout the organization.

Sensitivity to operations - The organization realizes that its output is a function of its frontline, the operators. All policies and procedures are developed to increase the reliability of the operators. The safety and welfare of the operators is the organization's top priority.

2.3.3. Human and Organizational Errors and Malfunctions

An engineered system as defined by Bea (2001) is made up of organizations, operators, procedures, hardware and structures, environment and the interfaces between them. The types of errors or malfunctions for each of these components of an engineered system, again cited by Bea (2001), are listed below in Table 2.

Table 2 - Errors types for the components of an engineered system (Bea 2001)

Operator	Organization	Procedure	Environment	Hardware and Structure
Communications - Ineffective transmission of information	Communications	Incorrect - faulty	Internal	Serviceability - Inability to satisfy purposes for intended conditions
Slips – accidental Lapses	Culture - Inappropriate goals, incentives, values and trust	Inaccurate - untrue	External	Safety - excessive threat of harm to life, demands exceed capacities
Violations - intentional infringements	Violations	Incomplete - lacking the necessary parts	Social	Durability - occurrence of unexpected maintenance and less that expected useful life
Ignorance - unaware or unlearned	Ignorance	Excessive complexity		Compatibility - unacceptable schedule, budget or finished product
Planning and Prep - lack of sufficient program, procedures and readiness.	Planning and Prep	Poorly organized		
Selection and Training - not suited, educated or practiced for activities	Structure and Organization - ineffective connectedness, interdependence, lateral and vertical integration	Poorly documented		
Limitations and Impairment - excessively fatigued, stressed and having diminished senses	Monitoring and controlling - inappropriate awareness of critical developments and utilization of ineffective corrective measures			
Mistakes - cognitive malfunctions of perception, interpretation decision, discrimination diagnosis and action	Mistakes			

Figure 5 is included to give an indication of how often errors could occur in a system. Table 3 is a list of Performance shaping factors. These performance-shaping factors will have an impact on the rates at which humans will make errors.

Table 3 - Performance shaping Factors (Bea 2001)

Error Producing Conditions	Multiplier	Error Producing Conditions	Multiplier
Unfamiliarity	17	Time shortage	11
Low signal to noise ratio	10	Features over-ride allowed	9
Spatial/functional incompatibility	8	Design model mismatch	8
Irreversible action	8	Information Overload	6
Technique unlearning	6	Knowledge Transfer	5.5
Performance Ambiguity	5	Misperception of risk	4
Poor feedback	4	Inexperience	3
Communication Filtering	3	Inadequate Checking	3
Objectives Conflicts	3	Limited diversity	2.5
Educational mismatch	2	Dangerous incentives	2
Lack of exercise	1.8	Unreliable instruments	1.6
Absolute judgements	1.6	Unclear allocation of functions	1.6
Lack of progress tracking	1.4	Limited physical capabilities	1.4
Emotional Stress	1.3	Sleep cycle disruption	1.2

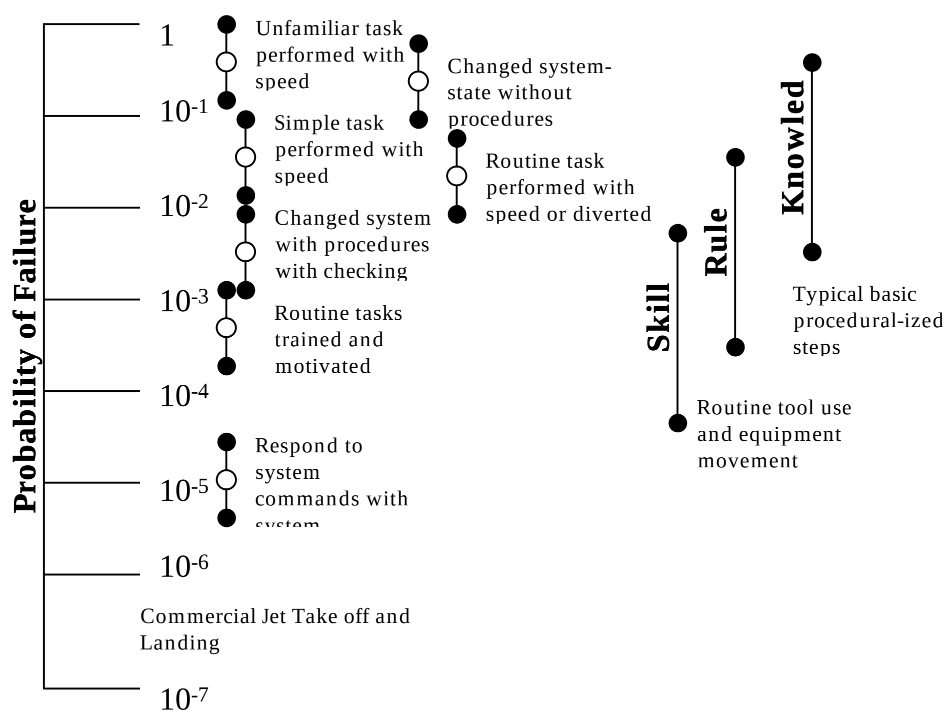

Figure 5 - Rates of errors for Knowledge, Rule and Skill based behavior (Bea 2001)

The point of showing Figure 5 and Table 3 is to provide a quantitative base to see where and how often errors are likely to occur. The goal is to reduce the likelihood of error in the system and increase the chances of achieving quality. Bea defines quality as the Compatibility, Durability, Serviceability, and Safety of a system. These quality characteristics can be applied to any part of the lifecycle of an engineered system to include design, construction, maintenance and operation, and decommissioning.

2.4. Summary

When one considers there are four quality attributes, five major components of the lifecycle, eight types of operator errors, it is easy to see how Human factors can have serious impacts on the engineered system. The problem is compounded when we consider the affects of the environment, procedures, organization, equipment and the structure on the operator. As stated earlier, it is approximated that 80% of the significant engineering failures are due to Human and Organizational Factors. If one could reduce the probability of Human and Organizational errors, the likelihood of sufficient quality will increase. Further, if one understands that Human error is inevitable, than the system can be designed with the idea that humans will be constructing, operating and maintaining the system.

3. Risk Assessment and Management

3.1. Risk Assessment and Management

Bea (2001) defines risk as the product of the likelihood of an event and the consequences of the event. Risk assessment is the evaluation of the sources, effects and consequences of risks. Risk Management "attacks both the likelihood of compromises in quality and the consequences associated with those compromises." There are three ways in which to manage risk:

1. Proactive Risk Management- Identifying and mitigating the knowable or predictable risks or hazards in a system.

2. Reactive Risk Management - The process of analyzing failures or near misses of a system, determine the cause and implement measures to prevent future failures of the system.

3. Interactive Risk Management - This is the real time evaluation and subsequent intervention with a system to return it to a safe condition.

It is the author's contention that these phases of risk management are applicable at different levels. For a particular task, the risks involved in that task can be planned proactively, influenced interactively, and, once the task is complete, remedied reactively. The process does not and should not stop here. Proper analysis, documentation and storage for efficient retrieval of the interactive and reactive risks encountered and mitigated is the most valuable tool to proactively manage risks on similar or related tasks in the future. A Best Practices/Lessons Learned knowledge base that identifies hazards encountered in the past and what was done to decrease the risk would be very useful in analyzing and mitigating risk proactively. Without a repository of information we must rely on these four elements to evaluate potential errors:

Judgement - This requires experience with the system in general being studied combined with an understanding and sensitivity to the peculiarities of the specific system being studied. There are many experts in the military who have sound judgement in a variety of different fields. Over the course of an assignment, an individual will gain a thorough understanding of his job and for all intents and purposes is an expert. When that person transfers, he takes his expertise with him. Given the transitory nature of Military however that expertise is not always readily available and the judgement must be made by someone with less experience.

Simulation - This is an attempt to replicate the conditions that will impact the system and see where potential errors could occur. The purpose would be to train the operators how to handle potential systemic problems.

Experiments - Experiments in different activities involved in a system, could be helpful in pointing out potential errors in a system. Care should be taken though in that studying only part of a system will not give insight into the interfaces of the system as a whole.

Process Review - The study of what went wrong in the past is a key element in determining what could go wrong in the future. Especially in a high-risk environment, an insight into the stresses and pressures that existed and their causes will guide an organization in the development of proper mitigation of the causes.

Risk assessment and management involves a step-by-step process whether it is done proactively, interactively or reactively. The Joint Australian / New Zealand Standard on Risk Management provides the following flow chart on the analysis and Management of risk. See Appendix A.

It is important to consider the application of this flow chart will be dependent on the time one has to implement them. It is obvious that proactive risk management will be the most thorough as one will have sufficient time to plan and train to mitigate the risk. An important part of this process is to consider the successful and unsuccessful attempts to manage risk on similar projects and / or similar environments in the past. This is the key to detection and mitigation of possible errors in the future. Unfortunately, this thought process is not currently emphasized. Interactive risk management is done on the spot. Training will work towards developing the skills to respond under pressure and stress to save the quality of a system interactively.

3.2. Operational Risk Management: The Navy and Marine Corps Solution

In 1997 the Chief of Naval Operations (CNO) and the Commandant of the Marine Corps (CMC) put out a joint instruction OPNAVINST 3500.39A / MCO 3500.27A ordering the use of Operational Risk Management in the Navy and Marine Corps. The Navy and Marine Corps adopted ORM because, "Historically, the greater percentage of losses during combat operations was due to mishaps." (OPNAVINST

3500.39A) And, "Unnecessary losses either in battle or during training are detrimental to operational capability." (OPNAVINST 3500.39A)

Table 4 - Statistics for losses since WWII (Naval Safety Center Web Site)

	WWII 1942-45	Korea 1950-53	Vietnam 1965-72	DS/DS 1990-91
Mishaps	56%	44%	54%	75%
Friendly Fire	1%	1%	1%	5%
Enemy Action	43%	55%	45%	20%

3.2.1. How ORM is Organized

The Naval Safety Center's web site has a very good explanation of ORM and how it works. The "handout" breaks ORM down into the following principles, levels and steps:

3.2.1.1. Principles in Applying ORM

1. Accept Risk when the Benefit is greater than the risk.

   - Risk is part of military action; all risk cannot be eliminated

2. Accept no unnecessary risk.

   - An unnecessary risk does not contribute to the mission and the outcome is not foreseeable

3. Anticipate and manage risk by planning.

   - Proactive planning provides more time and resources to manage risk

4. Make risk decisions at the right level.

   - If risk is greater than the benefit or help is needed to implement controls, communicate with higher authority.

3.2.1.2. Three levels of Applying ORM

1. Time Critical ORM

- In combat or in situations where risk must be assessed and managed interactively or reactively, there will not be time record decisions on paper.

2. Deliberate ORM
   - Risk Management that is done proactively, when the resources of the command can be leveraged against the risk.
3. In-depth ORM
   - Long-term risk management used for "complex operations, introduction of new equipment, tactics or training curricula."

3.2.1.3. Five Steps in Applying ORM

1. Identify Hazards
   - Determine the activities involved in the operation
   - Identify the hazards involved in the activities
2. Assess Hazards and Determine Risk
   - Determine the probability or likelihood a hazard will happen
   - Determine the severity or consequences if the hazard happens
   - Use the following matrix to determine level of risk:

Table 5 - Risk Assessment Code Matrix (Naval Safety Center Web Site)

RAC Matrix		**Mishap Probability**			
		Likely	Probably	May	Unlikely
Hazard Severity	Critical	1	1	2	3
	Serious	1	2	3	4
	Moderate	2	3	4	5
	Minor	3	4	5	5

3. Make Risk Decisions
   - Develop controls to decrease the likelihood or the consequences or both.
   - Start with the most serious hazards first
   - Reassess risk if controls are put in place

- Communicate with higher authority if the risk is still greater than the benefit

4. Implement Controls
   - Standard Operating Procedures, Orders, briefs, training and rehearsals.
5. Supervise
   - Ensure tasks are being performed to standard
   - Watch out for changes that require interactive intervention.

ORM is valuable in that it provides Sailors and Marines with a step-by-step way to manage risk both on the job and in their off time. The process slows people down so that they think of the consequences of what they are doing before they act. It is also structured in such a way that it is easy to perform a risk analysis "on the fly."

3.2.2. ORM is Great, But…

ORM is a great step in managing mishaps, but it can be perceived negatively. The Navy and Marine Corps policy is that risk management is to be performed in all day-to-day operations. The training examples used are often very simplistic. While this is necessary, to complete the training in a short amount of time, it subverts the power of the lessons being taught and loses credibility not only with the sailors and marines but with their leaders as well. A Navy Lieutenant Commander commented on how he saw ORM implemented in the planning of a Change of Command and one of the risks was that one of the attendees may trip on the carpet walking to the podium. While it is easy to argue that doing an ORM analysis on a command event is good training on the ORM process, identification of such "hazards" makes ORM seem trivial. These examples are fuel for a cynics fire. And, with an organization as large as the Navy and Marine Corps, there are bound to be many cynics.

If the projects have multiple risks, (as do most projects worth doing a risk-analysis on) which risk should take priority? If a Seabee construction project has 10 activities (which would be a very small project), and each activity has three to five potential hazards there are 30 to 50 hazards to be analyzed. This certainly is a significant administrative burden to the planners to keep track of all the hazards and prioritize them. ORM becomes one more item on the "things-to-do" pile and may not receive the attention it needs.

In grooming tomorrow's leaders today, it is necessary to place young Sailors and Marines in positions of increased responsibility. If part of this responsibility is planning the execution of a task, could we reasonably expect them to appreciate the task's inherent risks or its subtleties? As discussed earlier, without supporting information on a task, judgement is used to determine risk. Can we expect these young Sailors and Marines to have the requisite experience to make judgments on the tasks they are to work on? Also, as shown in Table 3, a Performance Shaping Factor of 17 is assigned for unfamiliarity, a PSF of 11 for time shortage, a PSF of four for misperception of risk 4, and a PSF of 3 for inexperience. These performance-shaping factors are influences that can result in an increase in the mean rates of human errors (Bea, 2001). Obviously, an increase in the rate of human errors means a decrease in reliability and quality and an increase in risk.

3.2.3. Step 6: Review Controls

To proactively manage risk effectively in the future it is necessary to capitalize on the Lesson's Learned from the past. To this end a sixth step is proposed for ORM. The step is to review the controls that were put in place to mitigate the risks. Those involved in the task must determine if the controls worked or not. If they worked, indicate that they worked and make any further recommendations for the future. If they did not work, why and what could be done in the future to improve the risk?

3.3. *The Engineered System Approach*

When developing controls to be put in place, it is necessary to look at the problem as a whole not the individual parts. The Safety Center's Handout cites the following as causes of mishaps:

Individual failure. Marine knows and is trained to standard but elects not to follow the standard (self-discipline).

Support Failure. Equipment/material improperly designed or not provided.

Leader Failure. Leader does not enforce known standard.

Training Failure. Marine not trained to known standard (insufficient, incorrect, or no training on task).

Standards Failure. Standards/procedures not clear or practical or do not exist.

As stated earlier the engineered system as defined by Bea (Bea, 2001) contains the following seven elements (Figure 6):

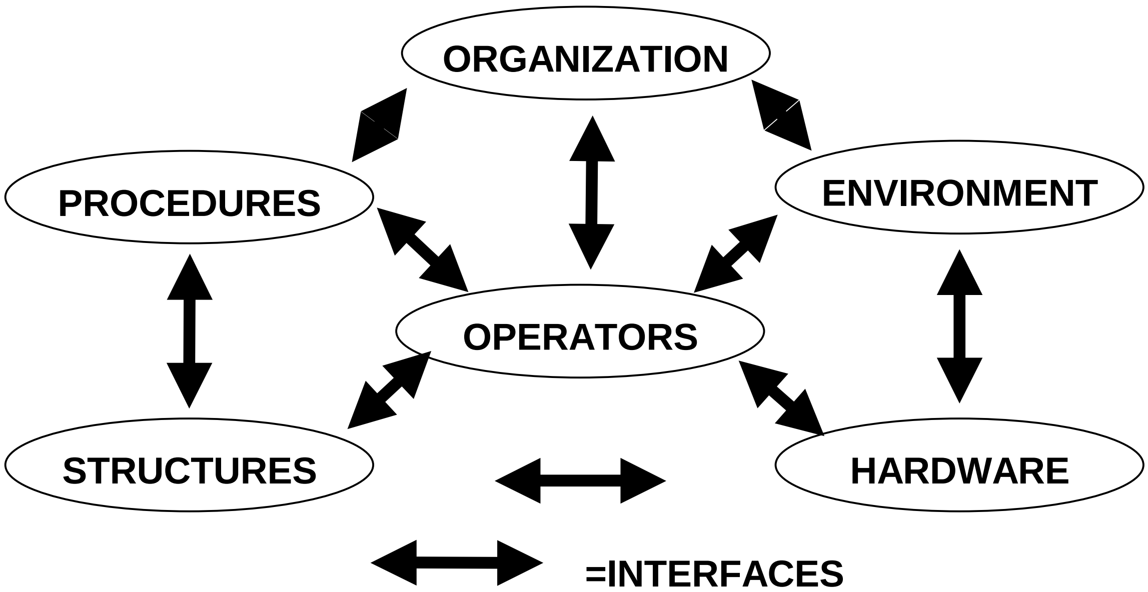

Figure 6 - The Engineered System (Bea, 2001)

Operators - the individuals performing a given task.

Organization - The group responsible for the operators or for whom the operator is performing the work.

Procedures - The written and unwritten methods of performing a task.

Environment - The external environment considers weather, noise, etc. while the internal environment has to do with the emotional state of the operator.

Structure - The structure on which the operator is working.

Hardware - The equipment that is being used by the operators in the performance of the task.

Interfaces - The links between each of the categories listed above.

This taxonomy is intended to provide the "hows" of errors (Bea,2001). Comparing the two lists of mishap causes, it is clear that they are very similar: Individual error and Operator error; Leadership error and

Organizational error; Support error and Structures and Hardware (Equipment) error; Standards error and Procedural error.

In addition to those just cited, Bea also includes two additional categories. These are environmental influences and the interfaces between all of these elements. The environment will always play an important role in the performance of any task and it would be a mistake to not consider it. The interfaces between the other categories are also significant. A particular category alone may not cause a significant risk but the interface with another category could have dire consequences. As for the training error cited on the Naval Safety Center's web sit, that could be a failure of the operator in that he is not educated or practiced for the activity or a failure of the organization in not providing the operator with the proper training.

Looking back at Table 2 we start to see the reason for errors for each of the categories. It is unreasonable to expect sailors and marines to remember these tables, but it would be helpful when performing a risk analysis to consider these items. Addressing the items in Table 2 will help better implement controls to decrease the risk involved in a task.

3.4. Proposed Tools

3.4.1. Risk Assessment and Management Tool

A database that allows a user to input the major activities and the hazards associated with those activities would be useful in decreasing the administrative burden to the operators. Obviously, this will only be useful for deliberate or in-depth Operational Risk Management. The database can be organized to walk the user through the steps of ORM, reminding him of the principles. This tool will produce a prioritized list of hazards associated with a project and will walk the user through the different issues to consider in order to implement the most thorough and effective controls. Finally, the tool can be used to review the controls used to mitigate the risks as to how well they worked and what could be done in the future to improve risk.

3.4.2. Lessons Learned Repository

A Lessons Learned knowledge base that identifies hazards encountered in the past and what was done to decrease the risk would be very useful in analyzing and mitigating risk proactively. Until now, the tools necessary to capture what we learned, store the information and access that information for future use is lacking. The practice of Knowledge Management strives to address these issues and will be discussed in detail later.

3.4.3. Tool Considerations

It is important to consider the organization that will be using the tool being constructed. No one tool will be used universally. Instead, a particular tool must be configured to meet the needs of the immediate organization. If the users do not feel the tool meets their needs, they will be less inclined to use it.

Another consideration is that the tool cannot add work to an already full In-box. If the tool requires additional effort, the people it was intended for won’t use it.

There are certainly other issues to be considered and they will be addressed later in the report as the tools are discussed in greater detail. The intent of this report is to look at the US Navy's Underwater Construction Teams and what can be done to help the UCT's manage risk in their operations. Before these tools can be described it is necessary to study how the organization works. The Underwater Construction Teams are outlined in Chapter 4.

3.5. Summary

Risk Assessment and Management is key to keeping the operators that work on and with engineered systems safe and increasing the probability of a quality project. The Navy and Marine Corps have developed a system to facilitate the process of risk assessment for Sailors and Marines. It is a solid program, but adds a significant workload to the operators, requires a simplistic training program to teach the fundamentals of ORM which in turn subverts the importance of the exercise. Finally, ORM requires Sailors and Marines to use their judgement on the risks involved with tasks with which they may not be very familiar. The Engineered system was introduced and offered as a way to add context to risk assessment and determine where significant hazards lie. Two tools were proposed that would aid sailors and marines in the performance of risk assessment. The first is a database that will look at each of the activities of an operation and the hazards associated with those activities. The second is a repository of Best Practices and Lessons Learned to capture what others have learned in the past to build on successes and improve on failures.

4. UCTs

The US Navy has two Underwater Construction Teams, UCT ONE in Little Creek, VA and UCT TWO in Port Hueneme, CA. Their mission is

> …to perform complex in-shore and deep ocean underwater facility life-cycle management in any climate to meet Navy, Marine Corps or Joint Force operational requirements. The UCTs are a specially trained and equipped unit that provides underwater engineering, construction, repair and inspections capabilities.

In short, "if a task has to deal with facilities that are located anywhere on or seaward of the beach, the Navy's UCTs are probably involved." (Balk et al., 1998)

The Underwater Construction Teams were formally established in 1973 and commissioned into service in 1974, although Seabee Divers have existed since WWII. These specially trained divers were attached to the Mobile Construction Battalions and took on projects such as underwater demolition of reef obstructions, and in-shore construction necessary for development of channels, harbors, and mooring facilities for the fleet. During the same period, several small, semi-independent units were being formed to perform combat underwater demolition, limited salvage, and underwater construction. These units were the predecessors of the Underwater Demolition Teams, and originally included SEABEE divers who were led by Civil Engineer Corps Officers. (Balk et al. 1998)

During the Vietnam War, diving SEABEEs served with the NMCBs deployed to Southeast Asia. Their primary tasks included repair of war-damaged waterfront facilities, and construction of bridges, piers, and POL (petroleum, oils and lubricants) facilities. Because they were often the only diving personnel available, they also performed small boat salvage operations and security inspection swims on bridges, piers, and underwater fuel lines. (Balk et al, 1998)

In support of its wartime mission, the US Navy assigned its Underwater Construction Teams Required Operational Capabilities (ROCs) and Potential Operational Environments (POEs). The Underwater Construction Team must be prepared to apply their ROCs in any of the POEs.

4.1. Organization

4.1.1. Chain of Command

Appendix B shows the Chain of Command in which the Underwater Construction Teams fall. The UCTs currently report directly to Brigade for their operational tasking. There are a number of other entities that provide support to the UCTs and are important to discuss.

The Chief of Naval Operations is responsible for the employment of all Naval Forces world-wide. To this end, the CNO establishes each unit's mission and what their ROCs and POEs are. Both the Pacific and Atlantic Fleets have divisions of the Naval Facilities Engineering Command, PACDIV and LANTDIV. The Commanders of each of these divisions are also the Commanders of the Naval Construction Brigades.

The Naval Construction Brigades divide the responsibility of Seabee employment between the Atlantic and the Pacific. There is one Underwater Construction Team per coast. The Brigades are the coordination points for commands that would like to have Seabees work on projects. In the past, the Brigades have been less involved in the employment of the UCTs, but have taken a much more active role of late.

The Naval Facilities Engineering Command (NAVFAC) is responsible for the planning, design, construction, maintenance and repair of Naval facilities worldwide. NAVFAC's areas of expertise are listed in Table 6.

Table 6 - NAVFAC's areas of expertise

- Base Development, Planning, and Design
- Military Construction
- Public Works
- Utilities & Energy Services
- Base Realignment and Closure
- Environmental Programs
- Weight Handling
- **Military Operations and Contingency Engineering**
- Acquisition
- Real Estate
- Family & Bachelor Housing
- **Ocean Engineering**
- Transportation Planning & Management

The Engineering Innovation Criteria Office (EICO) is a headquarters field office that reports directly to the NAVFAC Chief Engineer and is the primary transfer mechanism for engineering and architectural knowledge to the Command and our contractors. EICO consists of a highly qualified staff of engineers and architects, all professionally registered, and all capable of providing technical guidance associated with facilities design, construction, and maintenance criteria. Their job is to provide management, direction, coordination, and oversight for the search, assessment, development, and pursuit of innovative products and services throughout the NAVFAC. They interface with the fleets, major claimants, program offices, NAVFACHQ, Engineering Field Divisions (EFDs), Engineering Field Activities (EFAs), Public Work Centers (PWCs), Naval Facilities Engineering Service Center (NFESC), other activities and LANTDIV divisions to gather, evaluate and promote innovative possibilities. (http://criteria.navfac.navy.mil/criteria/)

Also part of NAVFAC is the Seabee Logistics Center at Construction Battalion Center, Port Hueneme, California. The Center is tasked with the ensuring Seabee commands like the UCTs are properly outfitted to perform their wartime mission. This involves making sure the Table of Allowance for each command is complete and up to date.

The Naval Facilities Engineering Service Center (NFESC) was established in 1993 to consolidate the missions of six components of the Naval Facilities Engineering Command. These components are listed in Table 7.

Table 7 - NFESC's competencies

• **Ocean Facilities** • Environmental Engineering • Amphibious and Expeditionary Logistics	• Shore Facilities • Energy and Utilities • Visual Media Center

The Ocean Facilities Department (Code ESC50) is "responsible for developing, improving and implementing the Navy's capability to plan, design, construct, inspect, maintain, repair and dispose of ocean facilities." The programs are included in Table 8.

Table 8 - NFESC's Ocean Facilities Department's programs

• Marine Geotechniques • Anchor Systems • Mooring Systems • Underwater Cable Facilities • Ocean Structures • Ocean Construction	• Magnetic Silencing Facilities • Underwater Inspection • Coastal Facilities • Pipeline Integrity • Hyperbaric Facilities

The Naval Construction Regiments provide training primarily for the Naval Mobile Construction Battalions. The UCTs are able to "piggy back" on the training provided to the Battalions to fulfill their mission. It is the UCTs' responsibility to adapt their schedule to fit that of the Regiments. 20th NCR is located in Gulfport, Mississippi while UCT ONE is located in Little Creek, Virginia. As a result, UCT ONE does not do a lot, if any, training with the regiment. UCT TWO, however, is on the same base as the 31st NCR, which facilitates the interface between the two commands.

In short the UCTs are responsible for conducting or coordinating their own training.

The Naval Diving and Salvage Training Center (NDSTC) is the US Navy's diving training center. The Seabees that belong to the UCTs go through this school for First and Second Class Dive school and also the advanced and basic underwater construction curriculums. The Underwater construction curriculum is included as part of the Ocean Facilities Program.

4.1.2. Underwater Construction Teams

The UCTs have grown considerably since they were commissioned in 1974. The command position is now a Commanding Officer rather than an Officer in Charge. Each UCT has a slightly different manning as seen in Table 9.

Table 9 - UCT ONE and TWO manning

UCT ONE	UCT TWO
Sea 3 Officers 42 Enlisted Seabee divers (basic and advanced) 4 Diving Medical Technicians **Shore** 10 Non Divers <u>12 Divers</u> 71 required Current Manning = 62	**Sea** 4 Officers (one is a Diving Medical Officer) 42 Enlisted Seabee divers (basic and advanced) 4 Diving Medical Technicians **Shore** 10 Non Divers <u>12 Divers</u> 72 required Current Manning = 60 personnel

Both teams are significantly undermanned. What's more, the Fleet Manning Document is being reviewed to increase the billets for each team to around 100 personnel. This number is justified in the mission of the UCTs and their operational tempo. The teams are divided up into sea and shore contingents. The Sea contingent consists of the SEABEES that deploy to carry out the Command's mission. It is made up of three Air Detachments (Air Dets) Alfa, Bravo and Charlie. Air Detachments, each with 15 enlisted SEABEE divers, typically deploy 6 months out of the year. Each is similar in capability and composition, and is fully capable to carry out all of the UCT mission areas. Each air detachment is normally headed by a Chief Petty Officer, who has spent considerable time in the UCTs, is Dive Supervisor qualified, SCWS (SEABEE Warfare Combat Specialist) designated, and has completed a rigorous training and evaluation program.

The shore contingent organizes the operations training and maintenance operations of the team. They consistently work to ensure the logistical needs of the Air Detachments are met. This requires a great deal of advanced planning and work. The personnel that comprise the shore contingent are mostly SEABEE divers with some non-diver and non-SEABEE personnel as well.

4.1.3. Ocean Facilities Program

The Navy's Ocean Facilities Program (OFP) is managed within NFESC. The OFP is made up of the UCTs, NFESC's Ocean Facilities Department and the Underwater Construction Training School at NDSTC. The OFP manages the personnel, engineering / technology base and the ocean construction equipment. Their service and support capabilities are listed in Table 10.

Table 10 - OFP's service and support capabilities

Specialized service capabilities include:	Specialized support capabilities include:
• Underwater inspection of waterfront facilities and mooring systems • Waterfront repairs • Pipeline inspection and assessment • Precision underwater blasting • Oceanographic surveys • Coastal engineering • Specialized anchoring and anchor systems • Arctic and cold water diving and support capabilities	• Diving • Amphibious and support craft • Remotely operated underwater vehicles (ROVs) • Ocean construction support platforms • Deep ocean simulation pressure vessels • Site survey tools • Fiber optic and submarine cable test facilities • An extensive Ocean Construction Equipment Inventory (OCEI) of other specialized tools and equipment.

NFESC provides support to the UCTs through the OFP. This is not to say that the OFP's sole responsibility is to the UCTs. Also, the Officer in Charge of the Ocean Facilities Program is not in the Chain of Command of the Underwater Construction Teams. The UCT School at NDSTC does not fall in the Chain of Command of the OFP director either. However, all these entities work together to advance the mission of the Navy's Ocean Facilities Program. The Navy's OFP is a very small community. Most people that have been in the program for a while know most of the others in the program. The Seabee divers that make up the teams rotate between NFESC, the Underwater Construction school in Panama City, and the UCTs both Sea and Shore. It is not unusual for a person to be attached to one of the teams for 10 or more years just rotating between the sea and shore components.

4.1.4. Funding

The funding to directly and indirectly support the UCTs comes in different ways.

Table of Allowance - The Table of Allowance is the tools and equipment a command has assigned to them to fulfill their war time mission. The funds for purchasing new TOA comes through NAVFAC and goes to the Seabee Logistics Center in Port Hueneme.

OPTAR - This is money (about $500,000 each) allocated to the UCTs through the respective Fleets. It is sent through the Brigades and is for the operation and maintenance of the UCTs. The funds for the re-capitalization of the Table of Allowance are sent through the Brigades as well. This is an important issue because unlike the Mobile Construction Battalions, the UCTs deploy with and use the same equipment in peacetime that would be used in wartime. Obviously this equipment undergoes significant wear and tear. For the UCTs to be fully operational, they need the re-capitalization funds.

Project Support - Money is provided from various customers to the teams through the Brigades on a reimbursable basis to execute projects. As the team purchases material or makes travel plans they cite the line of accounting provided by the customers.

OCEI Equipment - NFESC receives $275,000 Other Procurement Navy (OPN) to buy and maintain the equipment for the Ocean Construction Equipment Inventory (OCEI). This material is available to be loaned out on a short or long term basis to the UCTs, NFESC or other entities that may have a need.

Support - NFESC also receives $300,000 Operation and Maintenance Navy (OMN) funds to support the UCTs and maintain the OCEI. $220,000 pays for the contract personnel that maintain and inventory the equipment at the OCEI facility among other things. $80,000 is intended to be used for support to the UCTs. The support comes in the form of planning, design, research and development, etc.

Year end Dump - These are funds that are left over at the end of the fiscal year. If a department has a need to be fulfilled, money that has not been obligated that will expire on 30 September can be sent to fulfill the need. This money cannot be guaranteed. Usually a good, executable plan stands a good chance of being funded.

The amounts of money that each source receives is budgeted a number of years in advance. If a new need is discovered, there is a large amount of documentation needed to support an increase in the budget. The documentation needs to indicate a need to support the war-fighting mission. An example of this is the requirement for a bottom survey system to support the installation of Elevated Causeways (LCAS). LCAS are installed by Amphibious Construction Battalions (ACB) to facilitate ship-to-shore offload of materials and equipment in the littorals. The LCAS require piles to be driven in the ocean floor. Currently the UCTs take borings of the bottom, but these only give the composition of one spot. A number of these borings are taken, but the picture is not complete. A number of times, the ACBs started driving piles in less than optimal places which delays the off load of the ships. As a result a need has been identified for a sub bottom survey system that will use sound to determine the make up of the sea floor. The operational importance of this is obvious, yet the additional funding needed for the research development, testing and evaluation has been difficult to come by.

4.2. Operators

4.2.1. Underwater Construction Team Personnel

The personnel that man the UCTs are mostly Seabees that have been specially trained in SCUBA and surface supplied diving at the Naval Diving and Salvage Training Center (NDSTC) in Panama City, Florida. These personnel are typically smart, physically fit, highly motivated and resourceful. The Seabee's motto is "Can Do." The Seabee Divers are the Can Do of the Can Do. Their training starts with Second Class Diving School. Diving school is followed by a nine-week course in the basic underwater construction also at NDSTC. Successful completion of the basic underwater construction course merits award of the NEC 5932. After completing three to four years at a Team, UCT personnel have the opportunity to go to First Class dive School at NDSTC. This course is followed up with the Advanced Underwater Construction course, which awards the NEC 5931. After many years of successful performance, a skilled Seabee diver may apply to become a Master Diver.

4.2.2. Naval Facilities Engineering Service Center Personnel

The Ocean Facilities Department at NFESC has about 90 people 45 of which are engineers. The disciplines are varied (Ocean, civil, mechanical, electrical, etc.) but all are related to work in the oceans. Of the 45 engineers it is approximated that eight of them are divers. As the Navy's Ocean Engineering expertise, the range of their experience is broad. The average number of years of experience in the field is 15. The engineers are very willing to work with the UCT personnel, but are somewhat limited by funding constraints. As pointed out earlier, $80,000 per year is allocated to support the teams.

4.3. Procedures

How the UCTs operate and, subsequently, how they train is based on their mission and the ROCs and POEs imposed on them in fulfilling that mission. The deployment cycle for each UCT is the same in that they go through a maintenance phase, a training phase and a deployment phase. Each phase is six months long. How each team executes the deployment cycle is different, however. UCT ONE deploys primarily between April and September. Air Dets Alfa and Bravo will have six months of training (October through March) and six months deployed. During this time Air Det Charlie is in a heavy maintenance phase and is considered the "ready Det." When the year is over, Air Det Bravo becomes the "ready Det" and Air Dets Alfa and Charlie deploy and soon. UCT TWO has one Air Det in one of the three phases all the time, i.e. Alfa is in maintenance, Bravo is in Training and Charlie is deployed and every six months it rotates.

4.3.1. Maintenance

The maintenance phase is the first phase of the cycle. This is not to say that maintenance is only done during this phase. Obviously the tools and equipment the divers use is maintained throughout the deployment cycle. The heavy duty maintenance is done during this phase. Maintenance of the tools and equipment is extremely important in UCT operations. The equipment not only helps the divers do their job, but also keeps them alive. The types of activities done during this phase are:

<u>Certification of the systems</u> - These are certifications that ensure the teams are qualified to perform diving operations and operate the transportable recompression chambers.

Preventive Maintenance - Preventive maintenance is done to keep equipment in good working order. The piece of equipment can still be used, but is more prone to failure due to the lack of maintenance.

Corrective Maintenance - Something has gone wrong with a piece of equipment and it needs to be fixed. The piece of equipment cannot be used until this problem is fixed.

Re-capitalization of the Table of Allowance (TOA) - This involves identifying and reordering equipment that is part of the unit's Table of Allowance. This could involve a piece of equipment that was lost or that was broken and is beyond repair.

4.3.2. Training

As stated earlier the UCTs are responsible for conducting their own training. Given the adverse conditions they work in and the vast operational capabilities they are required to maintain including defensive military operations, training is significant in preparing the UCTs on their mission. Some of the training is conducted at the UCT while some of the training the divers must be sent to different schools such as the school in Panama City. The different types of training include:

Diver Training (JQR) - These are regulations that are designed by both UCTs that specify the training requirements for UCT personnel. These are in accordance with the Navy Diving Manual, Revision four.

Military Training and Seabee Combat Warfare Specialist (SCWS) training - The UCTs have a military mission as well as a construction mission. The skills need to be retrained every year. The SCWS program is the warfare qualification for Seabees. It demonstrates professionalism and is a requirement for advancement.

Job Specific Training - This is training that is geared toward a specific job that the Air Det will be doing on their next deployment.

Project development - While this is not technically a training item, it is done during the training phase to prepare the Air Det for its upcoming deployment. Project development will indicate what job specific training is needed. This is also where a good deal of the logistics are being determined for upcoming deployments.

Project planning - Again this is not a training item, but is important in the execution of projects while deployed. This is the mapping of how the project will progress from start to finish. This is also a key step in determining the job specific training that will be needed during the deployment. This is where the Dets develop a schedule based on the activities required to accomplish the project and do their deliberate Operational Risk Management. The UCTs have an MS-Access based project planner to help facilitate the planning of jobs. Both project development and project planning are overseen by the Operations Department.

4.3.3. Deployment

The execution phase of the deployment cycle is the deployment itself. During a deployment, an Air Det will do approximately six different jobs all in different parts of the world. For instance, a diverse deployment schedule beginning in March may find UCT TWO members participating in Joint Fleet Exercises, repairs to earthquake damage at a Naval wharf, inspection and maintenance repairs in Alaska, Washington, Japan, Korea, Hawaii, the Far Eastern Pacific, or along the California coast. This wide area of coverage keeps the Operations and Logistics Officers busy tracking the progress of the various jobs, and anticipating the logistical requirements as the Detachments move from site to site. (Balk et al, 1998) The days are long and the pace is furious. When a Det Officer in Charge is not working on a project he is planning on how to get to the next project and worrying about the status of the material and equipment.

The areas that make up the deployment phase are:

Mobility - This is the moving of people, equipment and materials from homeport to the deployment site and then from one deployment site to the next. Each team has different mobility issues. UCT One Air Dets typically go back to headquarters after they finish each job. UCT Two, however, will deploy and then return 6 months later. Each scenario has its own challenges.

Execution (Exercises and Projects) - This is where the UCTs "make their money." This is what the maintenance, training, development and planning have been about. The Dets do the work that has been planned throughout the training and maintenance phases. The deployment is where the operators get the most experience in dealing with real situations and adapting to change. The most valuable lessons are learned and best practices developed during the execution phase. The Dets also learn if the controls they put in place to help decrease the risks work or don't work and what could have been done or should be done in the future to make the project go smoother. As the Dets are deployed, they report back to the operations department on their progress on a biweekly basis.

Logistics - This includes funding, berthing, work space, meals, equipment receiving, etc.. Each deployment and each project on that deployment will have its own challenges.

Training - The Dets will give safety lectures and perform training while deployed to keeps their military, diving and construction skills honed.

Maintenance - As mentioned earlier, maintenance does not stop. Preventive maintenance must be performed to keep tools and equipment in top operating condition.

4.3.4. Information Sources

4.3.4.1. Manuals

To give the teams a place to start, they use manuals that were compiled based on their ROCs and POEs. Some, but not all, are listed below:

US Navy Diving Manual, Revision 4

The Diving Manual is produced by Naval Sea Systems Command and provides diving guidance for all diving operations in the Navy. This is the primary manual from which Dives are planned.

NAVFAC P-990 Conventional Underwater Repair Techniques Manual

This manual is written by NFESC and the OFP and is "intended to be a guide for UCT personnel when conducting conventional operations." The basis of this manual are the Required Operational Capabilities put forth by the CNO. The substance of the manual has been developed through field experience and by referring to other manuals. Chapter seven of the manual has an extensive list of references.

Other manuals that UCTs use as a reference are the NAVFAC P-991 Expedient Repair Techniques Manual, NAVFAC P-992 UCT Arctic Operations manual and numerous other operation and maintenance manuals for tools and equipment.

4.3.4.2. *Past Experience*

While the manuals are a good starting point for the UCTs, they typically rely on in-house experience to plan and execute their jobs. As stated earlier, the personnel in the UCT can spend much of their career at one team. The feeling is that there is someone in the team that has some experience in a task that has been performed before.

4.3.4.3. *Area Experts*

While the teams primarily try to plan and execute jobs on their own, sometimes they need help from the experts in a particular field. The teams try plan the jobs as much as they can on their own, because they will not have the experts to count on in a time of war. These experts, as previously discussed, are at NFESC. The teams are very good about asking these folks for help.

4.4. *Structures*

The UCTs work on a variety of different types of structures pier and cable inspections; repairs to piers, pilings, and cables; maintenance and construction of underwater discharge out-falls; support of amphibious operations; and participation in naval amphibious exercises.

4.5. Equipment

4.5.1. Table of Allowance

The teams are outfitted with a Table of Allowance (TOA) based on their Mission and ROCs and POEs. This includes underwater tools, Civil Engineering support Equipment (CESE), weapons, dive gear, diving platforms, transportable recompression chambers, etc..

4.5.2. Ocean Construction Equipment Inventory

The OCEI is maintained by the OFP and is Ocean Construction Equipment that is used by NFESC or the UCTs that is not part of the UCT TOA. The OCEI contains over 100 major items or systems of loan-able specialized equipment and facilities components.

The Ocean Construction Support Facility, which manages and maintains the OCEI is located at St. Juliens Creek Annex in Portsmouth, Virginia. This equipment is available for loan on a cost recovery basis to other Navy and Department Of Defense (DOD) activities, and their contractors.

4.5.3. UCT Project Planner

To facilitate the planning of projects, NFESC developed the UCT Project Planner. This is a Microsoft Access database that ties the steps involved in the planning of projects together. The personnel of the UCTs like the Project Planner, but there are some problems with it. The largest issue is compatibility. The UCT PP was written in Access 97. The Navy has since upgraded all of its computer software to Office 2000, which includes MS Access 2000. Unfortunately Access 2000 cannot read databases created in Access 97. In short, the UCT PP is useless to the Teams right now. This creates an opportunity, however. As discussed in Chapter 3, a set of tools that would help the project planners analyze the risks associated with a task and give them immediate access to the lessons learned and documented best practices would be most beneficial. The fact that the

UCT PP is currently not compatible allows an opportunity to add features to it as it is revised. How we do this will be discussed in Chapter 6.

4.6. Environment

It would be easier to define where the UCTs do not dive than where they do. Their diving mission takes them from the equator to the arctic and around the world. They dive deep sea and high altitude fresh water. They must also be prepared to dive in any kind of weather day or night. Additionally, they must be prepared to perform their mission in a foreign country during wartime or in a remote area with limited support. In performing their mission they could operate as independent details, augment or support other units or deploy as an integral UCT.
Suffice it to say, the Underwater Construction Teams have a number of Potential Operating Environments for which they must be prepared.

4.7. Interfaces

The potential interfaces when discussing a command like this are infinite. The environment can have an impact on the equipment need to do the job, the procedures they use and how the dive team is organized. A change in mission could mean a change in procedures which could affect the tools and equipment needed to do the job. Since a good deal of the UCT funding depends on the mission, the better the information that goes up the Chain-of-Command, the better the chances the Teams will receive the funding they need. This funding can come in the form of procurement of missing or broken items in the TOA or for research and development of new items to enhance mission performance.

One of the most significant interfaces however, is that of the job the Teams have to do and the environment and method by which they have to do it. Construction itself is traditionally a dangerous business. Research shows that around 40% of high consequence accidents are due to errors in construction (Bea, 2001). Considering the seven elements of the Engineered system, and the potential things that could go wrong, it is not hard to understand why construction is so dangerous. Now compound the problem by performing the construction tasks underwater. Now there is one complicated Engineered system being used to work on another complicated system.

4.8. Summary

The Underwater Construction Teams are a highly skilled group of SEABEE Divers. They have a large number of required capabilities and a large number of environments in which all those capabilities must be employed. These ROCs and POEs are set forth by the CNO. They not only have a construction and diving mission but they have a combat mission as well. Their operational tempo is fast and furious yet they are significantly undermanned. They execute their mission by means of the deployment cycle, which consists of a maintenance phase, a training phase and a deployment phase. The deployment phase is where the most valuable lessons are learned on how to execute construction, inspection, maintenance, and repair projects. The UCTs are supported through various entities in the chain of command. Decisions on funding for the UCTs are made based on the information that makes it up the chain.

5. Knowledge Management

As mentioned earlier, the tools necessary to capture what we have learned, store the information and access that information for future use are currently not available. The theories of Knowledge Management, however, provide a framework in which a robust system can be built that will allow commands to capture what they know. This chapter is provided to give some background into Knowledge Management. For further more detailed information, the reader is encouraged to look at www.FoundationKnowledge.com under e-learning and the Department of the Navy's Knowledge-Centric Organization Toolkit as these are valuable sources of information on the subject.

5.1. Definitions

The following definitions are from leaders in the field of Knowledge management and can be found on the Department of the Navy's Knowledge-Centric Organization Toolkit:

- "The acquisition, sharing and use of knowledge within organizations, including learning processes and management information systems"
- "…Embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings"
- "Creation, acquisition and transfer of knowledge and modification of organizational behavior to reflect new knowledge and insights"
- "Finding out how and why information users think, what they know about the things they know, the knowledge and attitudes they possess, and the decisions they make when interacting with others"

- "Getting the right knowledge to the right people at the right time so they can make the best decision"

5.1.1. The "Springboard Story"

Each organization that puts the theories of Knowledge Management into practice has their own definition of what Knowledge Management is. These definitions may mean something to the organizations that developed them, but they do not fully answer the question, "What is Knowledge Management?" Stephen Denning in his book, The Springboard Story, uses stories to illustrate the meaning of Knowledge Management. In an attempt to illustrate what knowledge management, here are two stories to consider. The first is without knowledge management and the second is with knowledge management.

Without Knowledge Management:

Air Det Charlie of Underwater Construction Team Two is tasked with sealing the entrance of a tunnel 120' below the surface for a dam in a lake in the Rock Mountains. The work involves installing two bulkheads each weighing 12000 pounds. UCT 2 has done a project like this before, but it was years ago. A number of the personnel involved in the job have been promoted and moved on to other jobs and are currently not available to assist in the planning. Some of the others are still in the command, but are deployed with Air Det Bravo. Still others are in a shore billet at UCT 2, but are so tied up in their job to plan the training for Air Det Alfa or sorting out the logistics for Air Det Charlie that they cannot devote the time to fill in the details on that job. In both cases, their memory of the job is hazy. After all, the Det does about six jobs on a deployment and there were three more deployments after that one. Also, the details of each job start to fade with time. The ones that do remember, remember that two divers almost died on that project and there was some quick thinking done to save their lives. They remember that there was something wrong with the seal of the bulkheads so they needed to remove and rework the gates. There were poor lockout/tag-out procedures and that a piece of equipment fell of the working vessel, but that was it. What could have been done to keep the seals from fouling in the first place? What were the circumstances that lead to the near miss? How was the deck of the surface vessel configured? What were some of the considerations diving at such a high altitude? All these questions are asked and answered through incomplete memory of the situation and do little to help Air Det Charlie plan for the new job. They plan the job on their own and inevitably make and relearn the same issues that were learned by UCT 2 years before.

<u>With knowledge Management</u>:
Air Det Charlie of Underwater Construction Team Two is tasked with sealing the entrance of a tunnel 120' below the surface for a dam in a lake in the Rock Mountains. The work involves installing two bulkheads each weighing 12000 pounds. UCT 2 has done a project like this before, but it was years ago. This doesn't matter though because the experiences of the last job are well documented and easily retrieved from the Underwater Construction Team database. This is a web-based asset that collects lessons learned and best practices from UCT One, UCT Two and the Ocean Engineering Department at NFESC.

There were some problems on the job the last time with some fouled J-seals. Having been asked to help design the job for the Det, Gene the Engineer refers to the database and recognized the problem with the installation. Gene, now cognizant of the problem, has come up with a design that will facilitate installation at the depth and conditions at which the Det will be working.

There were a number of things that went wrong last time UCT 2 did this job. There were some poor lock-out/tag-out procedures, poor communication between the Det and the civilian contractor on site, and some lessons learned about securing equipment to the deck of the working vessel. All these issues were identified and addressed during the execution of the project and were stored in the database so they are not tainted by fading memories. Additionally, solutions to the problems encountered were developed during the after action review and stored in the database for future reference.

Finally, the Det knows there have been advances in high altitude diving, but does not have the latest guidance. One of the Petty Officers sends out an e-mail to the Community of Practice to see what the community knows on the subject. In a matter of two days he hears back from someone at UCT 1 who had just executed a job in the Appalachian Mountains. He also receives an e-mail from the Navy's Experimental Dive Unit on their latest research.

As a result of the input years before and the instant connectivity with other members within the community, Det Charlie is now out in front of some of the risks UCT 2 had faced in the past and is able to implement controls to mitigate these risks.

Both of these stories are based on truth. UCT TWO did in fact have a project in Lake Abiquiu, New Mexico in which a number of things went wrong. The full article is enclosed in Appendix C. A short time later, the team did a similar job on the Green Mountain Project in Colorado. Because the projects were so close together, the Team was able to foresee a number of the risks and put well thought out controls in place to mitigate the risk involved. LCDR Pickrell, the Commanding Officer of UCT 2 at that time, indicated that the problem went off with out a problem, but admits if the project were done a number of years down the road many of the same mistakes may have been made over again. This is not to say the results would have been the same. They could have been better or they could have been worse.

5.2. How does one manage knowledge?

In their White Paper, Program Management 2000: Know the Way, LTC George Cho (USAF), LTC Hans Jerrell (USAF), CAPT William Landay (USN) answer the question this way:

> You manage knowledge by developing a framework or system that enables organizations to capture, analyze, share, apply, and reuse knowledge to make better, faster, and smarter decisions across geographic, functional, and team boundaries.

Depending on the product or service that a particular organization provides will depend on how they manage knowledge. To effectively manage knowledge for an organization it is important to determine what the goal is in collecting knowledge in the first place. Karla Odell in her book "<u>If Only We Knew What We Know</u>" cites three "value propositions" that indicate where the best results could be obtained from implementing a Knowledge Management initiative. These are as follows:

<u>Customer Intimacy</u> - Focus is on capturing knowledge about customers, developing and transferring knowledge and understanding of customers needs preferences, and business to increase sales, as well as bringing knowledge of the organization to bear on customer problems.

Product-to-Market excellence - Focus is on reducing time-to-market, and designing and commercializing new products more quickly and successfully to increase revenue, retain market lead and grow profit margins.

Achieving Operational Excellence - Focus is on the transfer of operational processes and know-how from top-performing units and processes to less-well-performing units, ultimately improving the organization's overall performance.

5.3. *The US Navy's Philosophy*

The Department of the Navy's Definition is:

> Knowledge Management can be viewed as a process for optimizing the effective application of intellectual capital to achieve organizational objectives.

Intellectual Capital is the summation of the human capital, the social capital and the corporate capital of an organization (Figure 7).

Intellectual Capital =

Human Capital (expertise, experience, capability, capacity, creativity)

+

Social Capital (Networks, relationships, interactions, language)

+

Corporate Capital (intellectual property, processes, databases)

Tacit → Explicit

Figure 7 - Intellectual Capital

Tacit Knowledge is defined is that knowledge that a person has acquired over time in the performance of his job. Explicit knowledge is information that is kept in manuals - sort of a set of directions on how to accomplish a task. Driving a car is a good example of what is meant by tacit and explicit knowledge. One can read a manual on how to operate and drive a car. Step one: Put the key in the ignition. Step two: With right foot on the break and left foot on the clutch, turn the key clockwise until the motor catches and release. Etc. While these explicit directions would in fact allow a person to drive the car, it would probably not be safe to be on the road or in the car. Tacit knowledge is how most people operate a car. A number of things are done without even thinking about it. It is difficult to pass tacit knowledge on to others or to make tacit knowledge explicit.

Looking back at Figures 5 and 6 in Chapter Two, the cognitive processes are defined as knowledge, rule and skill based behavior. Knowledge based behavior in the context of tacit and explicit knowledge would be considered explicit while skill based behavior would be considered tacit. Webster's defines knowledge as "the fact or condition of knowing something with familiarity gained through experience or association or, acquaintance with or understanding of a science, art, or technique." For this reason instead of "knowledge Based Behavior," "Information" or "Data" Based Behavior would be more appropriate. Despite the terminology, explicit knowledge made tacit will increase an individual's reliability of performance in their job thereby increasing the quality of the finished product.

LTC George Cho (USAF), LTC Hans Jerrell (USAF), CAPT William Landay (USN) cite people, processes, and technology as the cornerstones of any KM framework or system. Building on this idea the Department of the Navy's Chief Information Officer (DONCIO) has developed "a model to serve as the framework for knowledge management projects underway." Components of this model can be seen in figure 8 below.

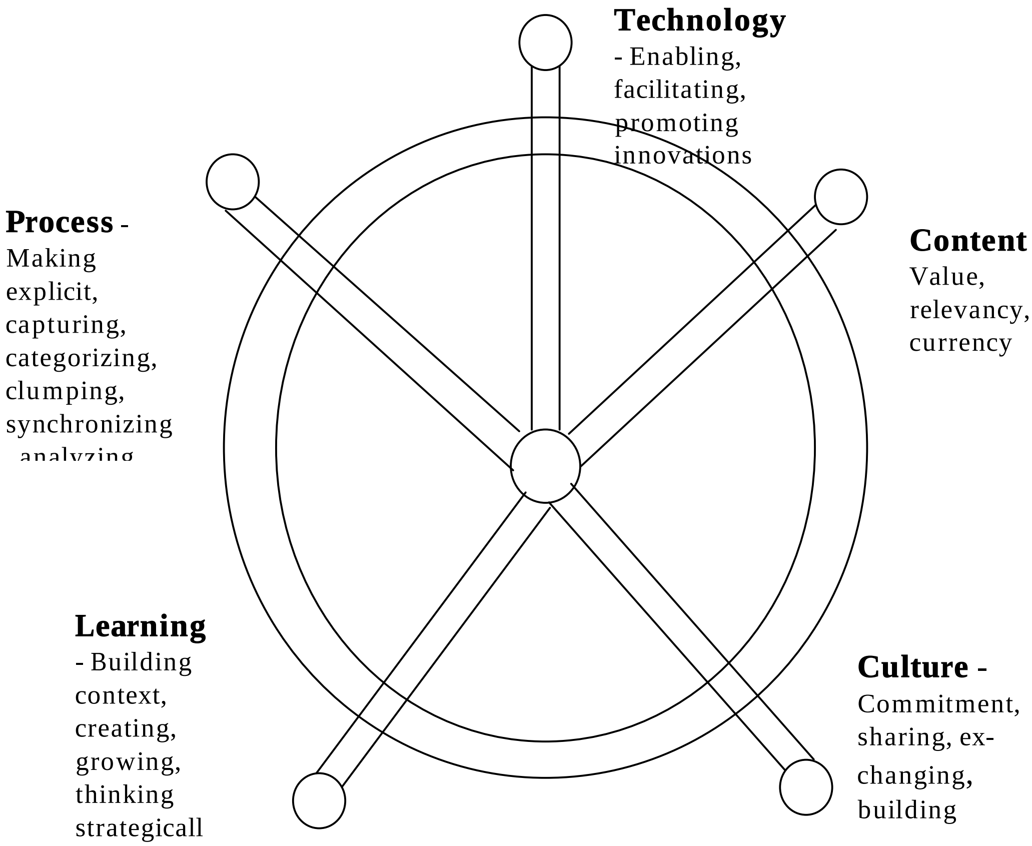

Figure 8 - Balanced Knowledge Management

It is important to understand that each of these components cannot be emphasized at the expense of another. If the processes or the technology are in place, but the culture of an organization is such that sharing knowledge is not a priority, the efforts will be for nothing.

5.3.1. Culture

While all five spokes of the wheel are necessary to the success of the Knowledge Management initiative, culture may be the most important. Unfortunately, culture is the most difficult to change. Culture is about the people up and down the Chain-of-Command and across organizational boundaries. If the culture is one that people feel they need to hoard knowledge to receive a promotion or a more superior evaluation than their peers, knowledge sharing will never happen. On the other hand if the culture is one that encourages the collecting and sharing knowledge through relationships developed on trust, then the only thing to do is work to facilitate the process. O'dell offers a few items to consider in building a culture based on sharing. These are:

1. Believe people want to share - She points out that people want to see their knowledge and expertise used; they want to learn from their colleagues, and; they want to learn form those that they trust and respect.
2. Prepare to Lead by doing - If a knowledge sharing culture is the goal, then the leadership has to be out in front. This means the leaders must contribute to the knowledge base and stress the importance of others to share as well. This may mean establishing awards and incentives for those who do share.
3. Develop Collaborative relationships - This involves the establishment of Communities of Practice. These communities are made up of people that share a passion for a particular topic. They don't just come from one part of the organization, but stretch across the boundaries of the organization. The Community of Practice brings the entire organization's resources to bear on a problem not just the local organization.
4. Instill personal responsibility for knowledge creation - People are at the core of the knowledge management initiative. They need to feel the responsibility to seek out knowledge from the knowledge network and add to it when they have something to offer.
5. Create a collective sense of purpose. - The knowledge management initiative needs to have a purpose. Sharing knowledge without a focus will lead the initiative astray. Everyone has to be working toward a common goal.

5.3.2. Technology

There is a tendency to confuse Knowledge Management with Information Technology. Information Technology *facilitates* the Knowledge Management initiative. The goal is to not just connect people to information, but to connect people to people. The idea is to have a virtual, collaborative website that facilitates sharing. Odell offers the following examples of how technology can facilitate knowledge sharing:

1. Structure document repositories - These are databases that have "structured content consisting of regular, alphanumeric data.
2. Document exchange - These are documents, presentations, etc that contain information that can be used by others in the future.
3. Discussion threads - These are discussion groups that connect members of the communities of practice.
4. Pointers to expertise - These are lists of people and their contact information that are recognized experts in particular fields.

Technology also involves making sure the system is up to date and serves the intended purpose of the knowledge management initiative.

5.3.3. Learning

Data leads to information, which leads to knowledge. To create knowledge, information must be backed up with the context in which it was created. The person that is searching the knowledge base will then add his own context and create new knowledge.

The collaboration point needs to be set up to facilitate the learning process. Everybody learns in a different way. Some people are visual and need videos and pictures, where others want to talk to an expert, still others want to read explicit knowledge and internalize it. To this end, each of these methods must be included in the collaborative web site.

5.3.4. Process

Odell points out that the most effective means of collecting knowledge is when it is done while actually doing one's job. Making sure the Knowledge Management initiative lines up with the focus of the organization is the key to figuring out how to collect Best Practices and Lessons Learned.

The "process" of collecting, reviewing and storing content for fast retrieval when needed is complicated. Because the strength of the knowledge management initiative is in its ability to stretch across organizational boundaries, accountability needs to be assigned to members of the community for specific roles. Who will work on collection? Who will work on making sure the technology is the most current? Who will review new content and weed out outdated material? The roles go on.

5.3.5. Content

The people that will turn to the Knowledge base will want to know that the information contained in it is the most relevant available. To this end a formalized content review process must be developed. They need to trust that the content is accurate, relevant and timely.

5.4. NAVFAC's solution

Naval Facilities Engineering Command's Chief Engineer has started to implement Knowledge Management theories within NAVFAC. As NAVFAC's workforce grows older and retires, there is an increasingly large potential to lose a great deal of human capital. A report called "Sailor 21: A Research Vision to Attract, Retain, and Utilize the 21st Century Sailor" by the Navy Personnel Research and Development Center in San Diego illustrates the effect this has in the following statement:

> Today, Navy M&P [Manpower and Personnel] organizations are faced with a persistent loss of knowledge accumulated by their staffs. Continuous turnover of uniformed personnel results in a devastating erosion of expertise and corporate knowledge of the business functions that support the Navy's M&P processes. Many of these functions require extensive knowledge and analytical ability gained only from years of experience working in the functional area. Without this core knowledge and the benefit of past trial and error, process managers make uninformed and sometimes costly decisions.

While this statement was made considering Personnel Management, its message rings true for NAVFAC as well. NAVFAC is therefore starting to implement Knowledge Management principles into the organization.

5.4.1. Organization of NAVFAC's Knowledge Management Initiative

The Organization is divided up into five Chief Technical Engineers and is then divided into Technical Disciplines. This is illustrated in Figure 9.

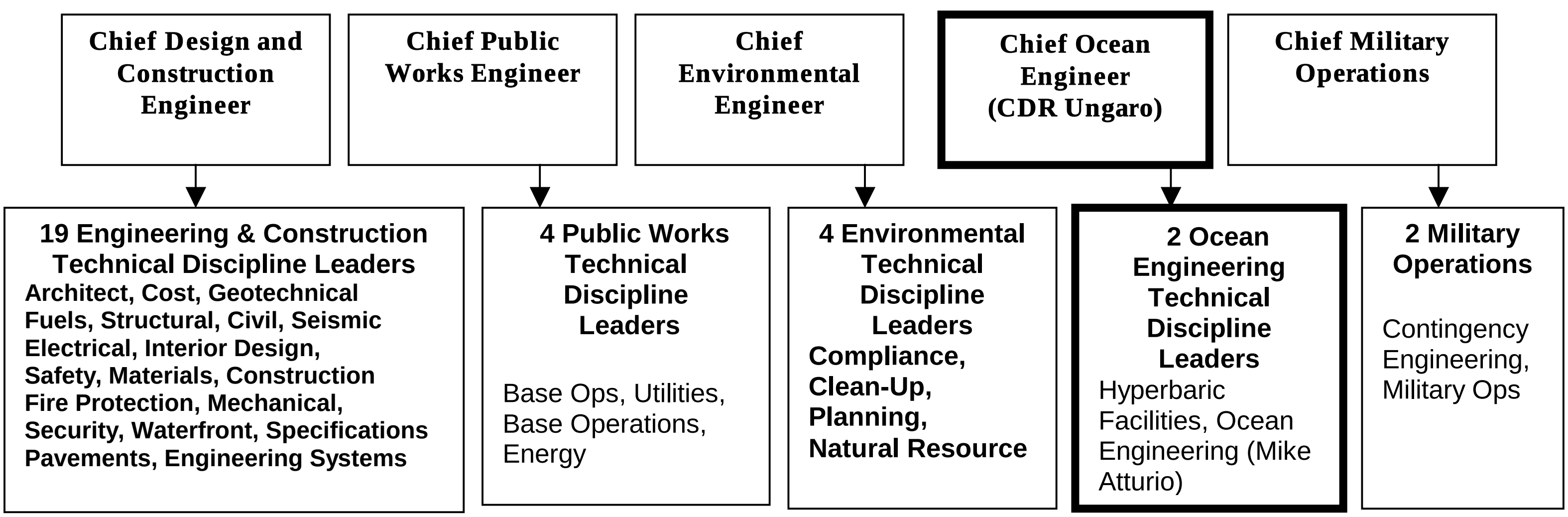

Figure 9 - NAVFAC's Engineering Network

Each of these Technical Disciplines is further sub-divided into Technical Centers of Expertise (TCE). These TCEs exist through out the NAVFAC organization and are located at the different Engineering Field Divisions, Public Works Centers and the Engineering Service Center.

5.4.2. Culture

The Knowledge Management initiative is relatively new at NAVFAC, but the seeds are being sewn in fertile ground. Having lived through "do more with less," many of the senior leaders, civilian and military, have recognized the need to reach across the organization to look for answers. How to achieve this level of operation is a concern. Knowledge Management provides the framework to make the reaching easier. It is not hard to imagine Communities of Practice developing around the world as people begin to see the power of a Knowledge Centric Organization.

The problem right now is that many people are still tying to understand what knowledge management is. Total quality came under a great deal of scrutiny primarily because people tried to implement it without fully understanding it. As a result, it didn't really take. Care needs to be taken that the same thing does not happen to the Knowledge Management initiative.

5.4.3. Technology

NAVFAC has connected across the organization via the Engineering Network (E-Net) and Foundation Knowledge.com. The purpose is to leverage the expertise in each of these technical disciplines across the organization. The purpose of these two tools is for the exchange of knowledge. It is a place to find Lessons Learned & Best Practices and establish collaboration threads. Collaboration threads are e-mails that are "threaded together" on topics someone could be searching for information. There is also a tool to post documents that can be used across the organization. E-Net is not publicly accessible where Foundation Knowledge (www.FoundationKnowledge.com) is. The vision of foundation knowledge is to be a "Knowledge Management Starter kit" and a basis for collaboration between DOD, federal Agencies, Private Sector Professionals and Academia.

5.4.4. Learning

There has been a great deal of effort to capitalize on the efforts of the Navy as a whole and other Communities of Practice with in the Navy. NAVSEA has developed a Guide for Communities of Practice that NAVFAC is using. They have also tried to appeal to the different learning style of people as well.

5.4.5. Process

The process of capturing tacit knowledge and making it explicit varies from one Technical Discipline to another. One example is the Knowledge Exchange Input form. This is a web-based form that a contributor to the Knowledge Base uses to submit a Best Practice or Lesson Learned. This is a great method and an easy way to collect Best Practices, but it requires that:

1. The person know about the community of practice
2. The person feels that he has something worth sharing,
3. The Person is willing to contribute.

The process of collecting BP/LL is still under development with in NAVFAC.

5.4.6. Content

Members of the Community of Practice for a particular Center of Expertise are encouraged to submit Best Practices and Lessons Learned to the knowledge base. The submissions are sent to the Technical Discipline

Leader who either reviews the document himself or forwards it to the appropriate Technical Center(s) of expertise. Once the TCE(s) have reviewed the document it is e-mailed back to the TDL who either posts it in a searchable database or, if it does not add value to the knowledge base, in a non-searchable database.

5.5. Summary

Knowledge Management provides the framework from which a robust methodology of leveraging Intellectual Capital (Human + Social + Corporate) across an organization by means of the effective use of Information technology. Knowledge Management provides benefits to the individual through enhanced job performance, a way to collaborate with others and a more effective way to learn a new task. Knowledge Management provides advantages to the organization by enhanced mission performance, improving decision making, facilitating accessibility to expertise within the organization, promotes process improvement and reducing duplication of effort. (DON KCO Toolkit)

However, because Knowledge Management is a relatively new business strategy, it is still in the first stages of development at NAVFAC. Many of the more senior officers and civilians are aware of knowledge management, but have yet to get their arms around its potential. Many of the key players that will be involved at the Centers of Expertise level are just beginning to learn what their roles will be. While implementation is planned at the top of the organization, how to implement it at the operational level is just getting underway.

6. Risk Management through Knowledge Management

Before starting this section, consider what has been covered so far. Human and Organizational Factors contribute to 80% of the high consequence accidents (Bea, 2001). To increase the reliability and subsequently the quality of a facility throughout its lifecycle, it is necessary to mitigate the risks attributed to human and organizational factors inherent in designing, constructing, maintaining, repairing and decommissioning a facility. Using a systematic approach (such as ORM) to identify these potential hazards and implement controls to mitigate them is a good start, but may not be enough. To more thoroughly understand the risks in upcoming projects, the planner must study similar past projects to understand which controls worked and which did not work. How can this be done effectively? The philosophy of Knowledge Management properly applied can work toward answering this question.

In an effort to learn from the mistakes of the past, this chapter starts off with a discussion of why Knowledge Management fails in organizations and offers some items for consideration during implementation. The "value proposition" (Section 5.2) for the UCTs is offered based on the information provided in Chapter 4. The report gets more specific by looking at the "Process Function"(Section 5.3.4) of collecting knowledge when the tool for assessing risks and collecting BP/LL regarding risks is introduced. The recognition of the need for a more complete revision of the UCT Project Planner is made based on the UCT operators' definitions of risk and quality. The focus turns to Knowledge Management on the whole again then becomes wider as the content review and storage processes are discussed as well as the need for the other four spokes of the wheel (Technology, Culture, Learning and Content) are identified.

Some assumptions are made regarding Technology, Culture, Learning and Content based on the research done regarding the Underwater Construction Teams and, to a lesser degree, the Ocean Facilities Program. This is an important point. These assumptions are those of *one* person that is not yet part of the Underwater Construction Community of Practice (UC CoP). These assumptions should be questioned throughout the UC CoP before following the recommendations. For a different Community of Practice, these assumptions should be challenged without question. As Knowledge Management is being implemented across the Navy and NAVFAC, it is important to consider how it is implemented at the operational level. Some entities will see the value of implementing Knowledge Management while others will be less receptive. For this reason, each entity must be studied individually to see where they fall on the scale of acceptability of new ideas

6.1. Implementation Considerations

The following are some issues to consider when implementing the program. These are relevant regardless of the Community of Practice.

6.1.1. Why Knowledge Management Fails

When considering the implementation of a new program it is important to consider the potential obstacles (risks) that may keep the program from succeeding and then mitigate those risks. LTC Cho (USAF), LTC Jerrell (USAF), CAPT Landay (USN) cite categorize the obstacles to successful implementation of Knowledge Management as People, Process and Technology.

<u>People</u>

Commitment - Management needs to be fully involved in the Knowledge Management effort. If this process is not stressed and lived by the boss, it will not be important for the operators. The operators also need to know that there is something in it for them.

Culture - If the culture of an organization is one that does not encourage sharing or promotes a culture where it is disadvantageous to share, the knowledge management program is over before it gets started.

Capability - The organization must have good implementation skills. This involves not only collecting content, but making it available to a person when and where they need it.

Buzzwords – Using buzzwords send the message that Knowledge Management is the Chain of Command's management flavor of the day. The program will not get the support, because the operators will feel that if they wait it out long enough, "this too shall pass."

Process

The Knowledge Management program must start with a vision of what the organization will look like when the project is up and running. Once the vision is developed by the organization, steps need to be developed to get there. Metrics must also be developed to ensure that the desired results are being achieved and that the program is worth the effort.

If sharing what one knows or being part of a Community of Practice is one more thing on the To-do list, people will not participate willingly. The implementation needs to happen in a way that makes life easier and shows a benefit early on. One of the main reasons that people don't share information is that there is not a system set up that will facilitate the process. If the system can be set up in a way that will make their life easier while they are sharing knowledge, the chances of success will increase.

Technology

If the technology being used for the program is too difficult or is insufficient to achieve what is hoped for the Knowledge Management effort will be a losing one as well.

6.1.2. High Reliability Organizations

It would also be worth reexamining the traits of High Reliability Organizations studied by Bea and Roberts and outlined in Chapter 2.

Redundancy - The system is developed throughout the community of practice. Instead of one or two people understanding how to perform a task, now people across the Community of Practice can learn from each other.

Procedures and rules - The guidelines in which operations are run are clear, concise, and not overly complicated. Also, these rules and procedures must be up to date. The person that has gone to "the book" to find the answer needs to know that the information is the most up to date and reliable available.

Training - Training is provided to the managers and operators to help them deal with normal, abnormal and unbelievable scenarios. The system should be set up so that it can develop these different scenarios.

Appropriate awards and punishments - The awards system should be aligned with what the organization and the Community of Practice want to achieve.

Management's ability to see the big picture - Management is continuously checking the heading of the organization to ensure its words (policy and procedures) and its actions (operations) are in line and heading in a safe and reliable direction. This involves the implementation of metrics and continuously monitoring the heading of the Community of Practice.

Preoccupation with failure - The system should help identify potential hazards and how to mitigate them. Once a goal is established what are the obstacles that will keep that goal from being achieved

Culture - The culture should be one in which emphasizes the importance of collecting what we know.

Sensitivity to operations - The most valuable content will come from the people on the front lines. The system needs to be developed with them in mind. It needs to make their life easier and they have to see the benefits of participating.

These issues should be kept in mind when developing the system.

6.1.3. Navy Lessons Learned System

The CNO has sanctioned the Navy Lesson Learned System (NLLS) and there is an OPNAV instruction guiding them. This system is part of the Naval Warfare Development Center. Obviously a centralized collection point of Lessons Learned is beneficial in developing warfare doctrine. If the Navy already has a Lessons Learned System (NLLS) why reinvent the wheel? The answer is that the KM program is much more focused than the NLLS. The detail of the BP/LL specifically for UCTs would be so fine that it would not hold relevance to others in the fleet.

Accessibility is also a concern. To access the Lessons Learned directly a Secret line is needed. Only one of the Teams has this line and there is only one of them in the command. The NLLS also sends CD-ROMs to commands, but getting access to them is difficult as they are locked in the classified material vault. The author did get a copy of a CD of the unclassified Lessons Learned. A review of this CD showed that the last Lessons Learned submitted by an Underwater Construction Team was 1992. The system may exist, but it is not being used. This is because the NLLS is not part of the business process of the UCTs, so even though they might submit BP/LL to the system they will probably never access them again.

6.2. What do we want to know?

Considering the three value propositions offered by Odell and cited in Chapter 5, Operational Excellence is the most appropriate for the Underwater Construction Teams. Looking at the critical procedures (Maintenance, Training and Deployment) for the UCTs outlined in Chapter 4, the most critical of these would be the deployment execution phase. Therefore, the goal of the Knowledge Management initiative for the UCTs would be to improve operational excellence during deployment.

6.3. Risk Assessment Tool

As outlined in Chapter 3, Risk Assessment and Management is critical to increase the reliability, quality and safety of a product or task. The Navy and Marine Corps implemented Operational Risk Management as a means to control risk involved in operations. Performing ORM can be a burdensome administrative task. To this end a database driven ORM analysis tool is a potential way to help decrease this burden. A tool, however, must fit in with the people that will be using it. The Underwater Construction Teams are the target users for the tool being introduced here.

6.3.1. The Underwater Construction Team Project Planner

The UCTs in the past have used an MS Access database driven program to plan their projects (Figure 10). They do not currently use the program

Figure 10 - Underwater Construction Team Project Planner

because the Navy has upgraded to MS Office 2000, which includes MS Access 2000, and the database is written in MS Access 97. Access 97 and Access 2000 are not compatible. The UCTs have expressed an interest in using the program, however. It is a great way to manage the logistics of

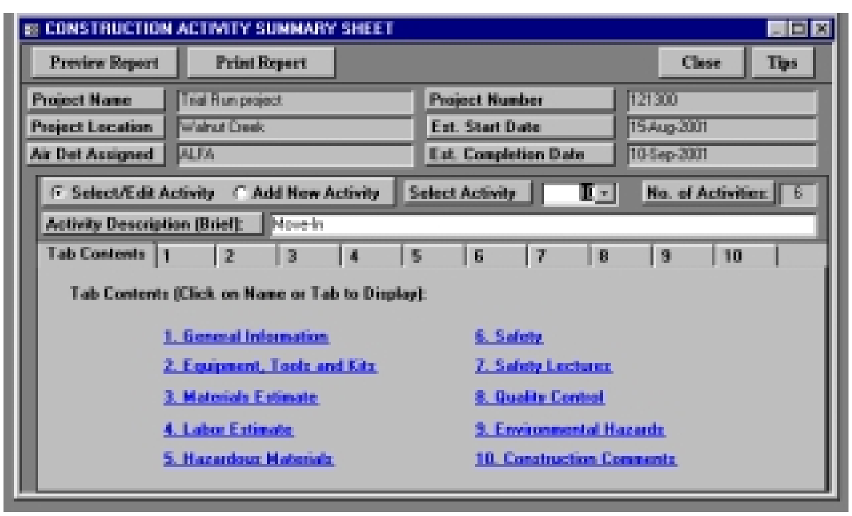

Figure 11 - UCT PP Construction Activity Summary Sheet

planning a construction project. Since the program will have to be upgraded, there could be a couple of additions to the software that will help the Operators Manage Risk and Capture Lessons Learned.

The tool being proposed in this report is designed to fit in with the UCT Project Planner. Having identified the Activities in the Construction Activity Summary Sheets (CASS Sheets, Figure 11) and their associated Hazards in Folder 6 (Figure 12), the operator can then press a button to perform an ORM analysis.

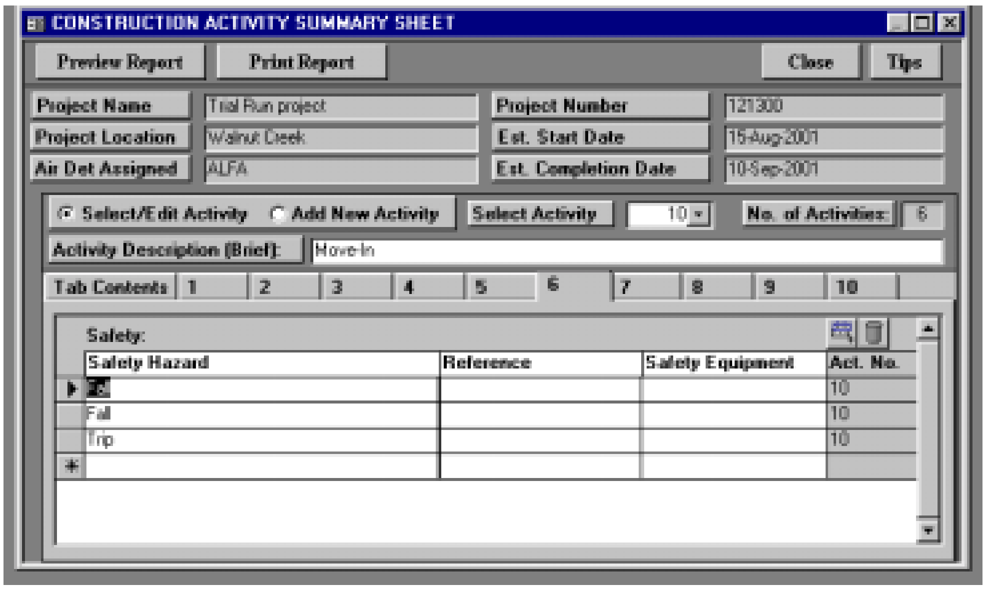

Figure 12 - UCT PP Activity Hazard Input Form

6.3.2. The Proposed Tool

Considering the ORM process Step One: Identify Hazards is complete. Step Two: Assess Hazards is next. The interface to assess the Hazards is illustrated in Figure 13. A mixed qualitative and quantitative analysis is used to determine the probability and severity of the Hazard. Bea describes this as a process where "linguistic variables are translated into numerical variables." Liberatore points out that "without sufficient and reliable human error databases, this approach offers the best method to assess the influence of human and organizational factors." The scores are

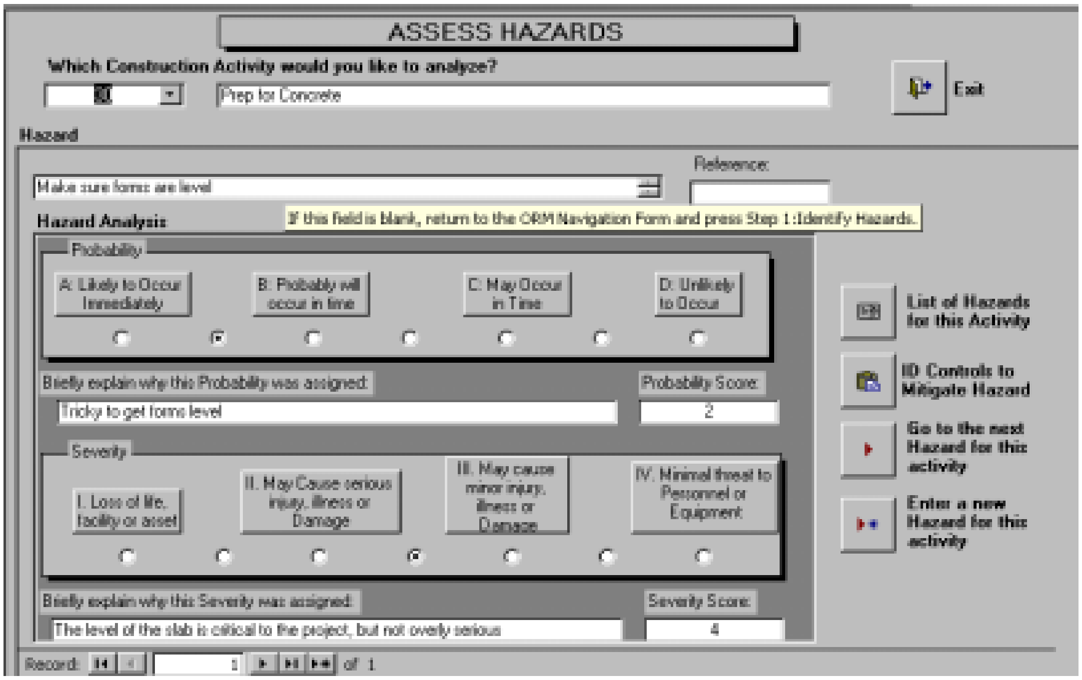

Figure 13 - Hazard Assessment Form

from 1 (most severe) to 7 (least severe). The associated risk is then calculated between 1 and 49. The grades are then converted t the Risk Assessment Code Matrix in the following way:

Table 11 - Risk Score vs Risk Assessment Code

Calculated Risk Score	Corresponding Risk Assessment Code
1-4	1
5-14	2
15-20	3
21-34	4
35-49	5

The tool allows the planner to choose which activity to analyze and which hazard with in the activity. The planner can also identify risk mitigation controls from this form, but this is not recommended. The reason this is not recommended is because once all the hazards are identified and assessed, the tool will sort them according to the risk from most severe to least severe. If the planning has to happen in a short time period, it is recommended to start with the most severe. If time is spent mitigating lesser risk hazards, more severe risks may be missed.

Step Three: Make Risk Decisions is illustrated in Figure 14. The risks illustrated through this form appear in order of severity with the most severe first. The form shows the severity and probability scores that were given, the calculated risk and the corresponding Risk Assessment Code.

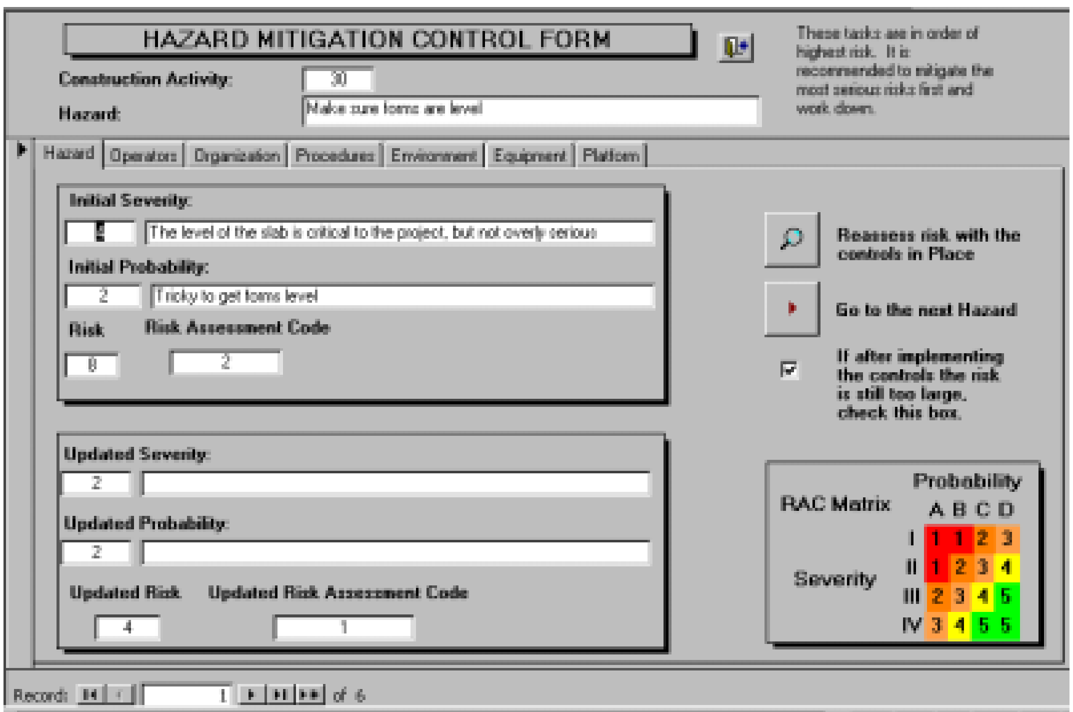

Figure 14 - Hazard Mitigation Controls Form

Based on the System Approach to managing risk, there is a section for each of the components of the system. This is where the controls for the risk are written down (Figure 15 is an example). Once this is complete, there is a button that allows the operator to go back and reassess the risk based on the controls that are to be implemented. If the risk is considered acceptable, the operator can move on to the next risk. If the risk outweighs the benefit, the operator can check the block to have the Chain of Command review the hazard and the suggested controls. There is a report that can be generated with a list of all the hazards that need the Chain of Command's attention.

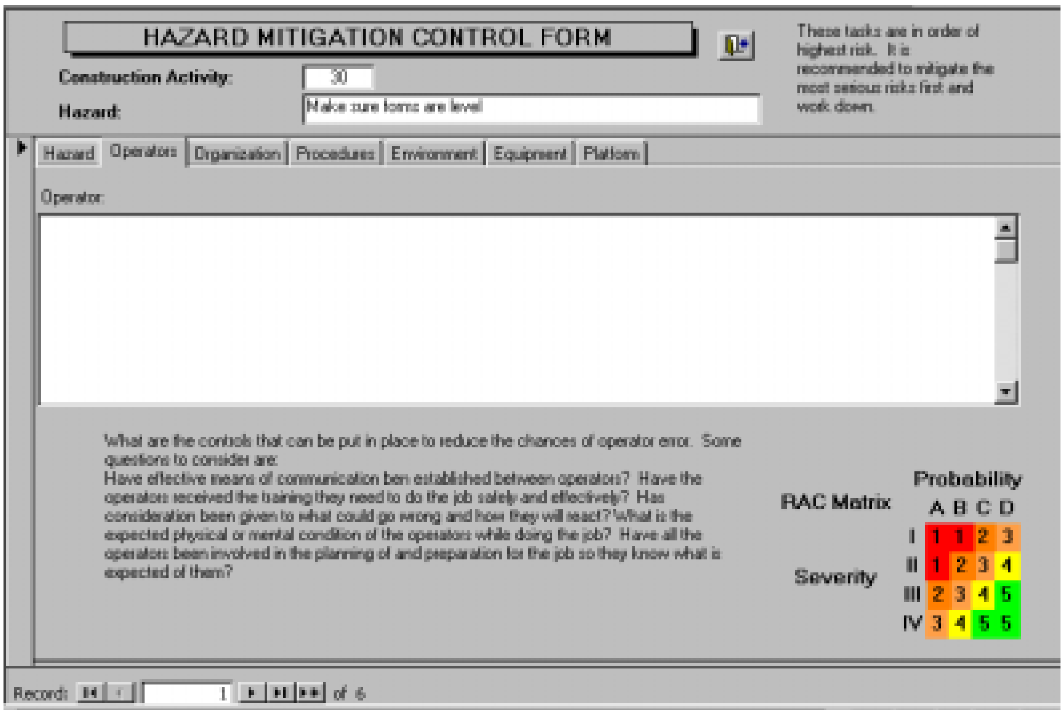

Figure 15 - Sample of Input for controls relating to "operators"

While Step 4: Implement Controls and Step 5: Supervise are not something that can be included in the database, there is one more step that can be added. Step 6: Mitigation Control Review (Figure 16) allows the planner to go back and review the controls that were suggested after the activity is complete. The planner can indicate what happened, how well the controls worked or did not work and what would be the recommendation for the future. While Step 6 is not part of the ORM process, it could possibly be the most important step in the process.

Once the entire project is complete, there is a database of all the activities, involved in the project, the controls to decrease the risk of those activity's inherent hazards and documentation if the controls worked and what

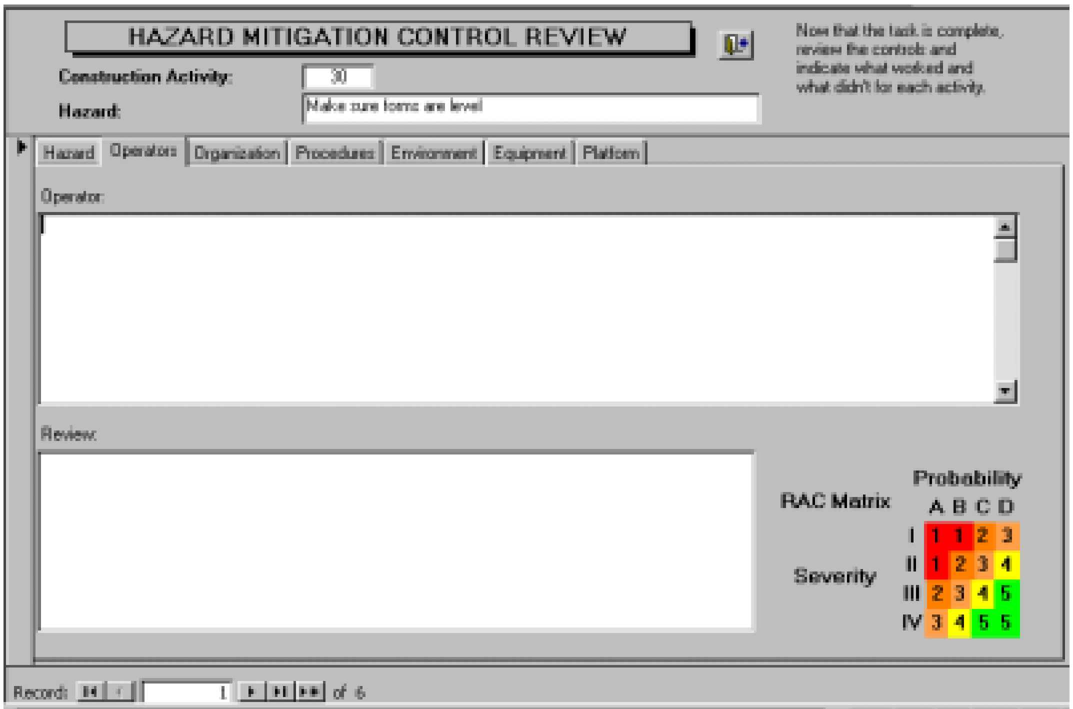

Figure 16 - Sample control Review Input form for "Operators"

could be done in the future to make the activity even safer. If operators take the time to fully document this information, the next person to plan a job can benefit from the first person's experience. If these are then extracted and reviewed and placed in a central database, then planners in other Dets or Teams can learn from these as well. With two Underwater Construction Teams each with two operational Dets per year doing approximately six jobs each, the database would grow quickly in a short amount of time.

6.4. Collecting Best Practices and Lessons Learned

6.4.1. Quality vs. Risk?

This report has shown that risk and quality go hand-in-hand. To increase the quality of a product it is necessary to increase the reliability, which translates into decreasing the risk. The ORM tool, in theory, should work to improve the overall quality of a product. Unfortunately, research has shown that many people do not consider risk and quality to be related. This was found to be true when visiting the Underwater Construction Teams. Quality is seen as the outcome of a task and the method by which it was completed, where risk is seen as the potential danger that could result in performing the task. Mitigation of risk is to improve the safety of the task while the resulting quality is a separate issue.

6.4.2. Best Practices and Lessons Learned

Lessons Learned imply that a project was planned a certain way and did not go as planned resulting in something being learned. This learned item will be taken into consideration the next time the task is performed to increase the success rate. What about the plans that work, though? Best Practices are very rarely documented for future implementation.

So, while collecting a repository of Lessons Learned regarding risk is useful, it will be incomplete. There needs to be a way to collect Lessons Learned and Best Practices not only in the mitigation of risk, but also in the performance of tasks and their impact on the overall quality (compatibility, durability, safety and serviceability) of the end product.

The current method of collecting Lessons Learned and to a lesser extent Best Practices is to wait until the end of a deployment. At the end of a deployment, however, many of the subtleties involved in the lesson being learned are lost. Once the subtleties are lost, the context in which the lesson was learned is forgotten and it no longer holds the power that it did at the time it was learned. If the goal is to build a repository of meaningful information, the Lessons Learned and Best Practices must be documented as they occur. So, how can this be done?

6.4.3. Real Time Collection of BPLL

The strength of the proposed tool is that while the operators are doing their job of planning work accomplishment and mitigating risk, they are concurrently building a repository of Lessons Learned. The important part of this is, "while doing their job." As mentioned earlier, the UCTs' operational tempo while deployed is high. If documentation of Best Practices and Lessons Learned (BPLL) is considered an additional thing to do, it most likely will not get done. The answer is to make the collection of BPLL a part of the job. This requires a couple of changes to how business is currently conducted:

1. The Chain of Command must include BPLL as part of the bi-weekly reporting requirements.
2. Reporting of BPLL must fit naturally into the reporting process.
3. The reporting process needs to become easier.

The Project Planner can be configured so that the operators can, with minimal effort, input information, including BPLL, on a daily basis. The information collected by the database is used to generate the bi-weekly Situation Report that is required by the Chain of Command. While collecting BPLL other than those associated with risk is beyond the scope of this project, recommendations as to how this could be accomplished and what the benefits would be are included in Chapter 7.

6.4.4. After Action Review

The US Army has implemented a method of collecting Best Practices and Lessons Learned after an exercise. The After Action Review (AAR) gets all the people involved in the exercise, junior and senior, together to give a run down of what went right and what went wrong and what could be done in the future to improve. The reviews are run in such a way that all member's insights and opinions are valued, not jut those of the leadership. The Center for Army Lessons Learned (CALL) has representatives at these reviews when they happen on major exercises or operations. The representatives from CALL document what was said during the review and then add context to it. Those involved in the exercise, to ensure it accurately reflects what was learned, review the content of what was documented. Once checked, the information is posted Army wide and is retrievable the next time an operation is conducted.

The UCTs could implement this process as well albeit to a lesser degree. It would be beneficial to do this at the completion of the projects on deployment, but the operational tempo may preclude that from happening. In this case the Chain of Command could give the returning Det time to do an AAR and identify and document the items that worked and did not work.

6.5. Content Considerations

6.5.1. Content Review Process

Now that the Best Practices and Lessons Learned have been collected they need to be reviewed. Some of what will be documented will not be relevant to the entire community while other issues may not be a good practice to include. Still others may need more clarification. A formal review process then needs to be established to ensure that the Lessons

Learned are worth sharing the Best Practices are, in fact, best. The flow chart is in Appendix D.

The review process takes advantage of the Underwater Construction Community of Practice. Dr. Phil Vitale, the Deputy Director of the Ocean Facilities Program and Leader of the Technical Center of Expertise for Underwater Construction reviews the BPLL generated by the Dets and screened by the respective Team's Operations Department. He can review the document himself and / or send it to other TCE(s) (i.e. Underwater Inspection) for their review. Once the BPLL is clarified, it can be forwarded to the Technical Discipline Leader at NFESC Code 50, Mr. Mike Atturio. Once cleared through Code 50, the BPLL is loaded into the repository in the appropriate area so it can be easily retrieved in the future.

6.5.2. Storage

How the BPLL are stored is an important consideration for getting the relevant information to the user when they need it. As stated earlier, the Underwater Construction Teams refer to the NAVFAC P-990 Conventional Underwater Repair Techniques Manual for their job. A proposed storage taxonomy is to use the Table of Contents of this manual. The P-990 reflects the mission of the Underwater Construction Teams and includes a great deal of valuable information. Also many of the operators are familiar with the lay out of the P-990 so would be better able to find what they were looking for.

The documents would be posted with a description underneath that would contain "key words" that would be referenced if one were searching by means of a search engine. The key words are important because, sometimes an entry under one category may have relevance in another category. For instance, a certain hydraulic tool may not work well in extremely Arctic conditions. This LL would be filed under the section in the P-990 that relates to that particular tool. If an operator conducts a search using the key word arctic, and the entry for that tool has the key word arctic, the operator will discover that that particular tool will be useless. If there is no key word, the operator may miss that piece of information.

6.5.3. Effects of Collecting good Content

As the repository fills with useful content, there are some interesting items that could result.

6.5.3.1. Changes to the P-990

As certain tasks are performed and feedback is being made to the Technical Centers of Expertise, it may be discovered that what is currently in the P-990 is no longer relevant and that a new Best Practice may be more appropriate. To this end the experience gained will provide the background to update the manual. This is in fact the spirit in which the P-990 was written to begin with. The introduction of the manual sums it up as follows:

> It is based on analysis of past UCT operations and equivalent commercial practice. It is to be viewed as a living document, subject to continual revision and updating as new or improved equipment and work techniques are developed. Feedback to the Naval Facilities Engineering Service Center of UCT Field Experience in using the techniques described herein, or modifications of these techniques, is strongly encouraged sot that all UCT personnel can benefit from the experience of the individual team members.

That said, the system proposed would be fulfilling the intent of the manual's authors. The process flow chart for this is seen in Appendix E.

6.5.3.2. Need for improvement in Equipment

Documentation of how the UCTs do on projects will also indicate where a new piece of equipment is needed or if an improvement to an existing piece of equipment is warranted. An example of this would be the Bathymetric Land and Sea Survey system that the UCTs use for hydrographic reconnaissance. The teams would use the BLASS system and report daily on the problems, if any, they encountered. If these reports were collected in the appropriate area, the Engineers at NFESC would be in a better position to determine where the real problems lay. This is important given the financial constraints on NFESC to help the UCTs. If there is a finite amount of money to spend, it is important that the issues being worked on are understood up front.

The documentation could also indicate that a new piece of equipment is needed to better fulfill their mission. Good documentation and operational examples of where the mission has suffered may not guarantee money to research, develop, test and evaluate new equipment, but it may improve the chances that money will become available.

6.6. Web Site: Home of the Repository

Now that the BPLL have been collected and the content has been reviewed and there is a method by which the information could be stored, it is time to consider where the repository will be stored. In order for the information to be of benefit to the most people, it needs to be web based. The website has to be a point of collaboration for the entire Underwater Construction Community of Practice. This needs to be the spot that the operators turn to first to find the answers they need to accomplish the mission. In order for this to happen, the operators must know that they will be able to find what they are looking for. This means that the information has to be the most relevant and current available. It also means that if the information is not there that they will be able to find someone that could provide the information they are looking for. What more, this means that people must willingly want to contribute to the Community of Practice.

As mentioned earlier, NAVFAC has developed the Engineering Network (E-Net) on the NAVFAC Intranet. At present, the UCTs, NFESC and the Ocean Facilities Program all have their own web sites. In fact they have at least two. Ideally the UC CoP would have one website on the E-Net from which all the members of the community work. This would be the "virtual meeting place" where the operators could go to find answers to questions from other operators.

While the E-Net would be the place to establish the UC CoP website, there would also be a need for a publicly accessible site as well. This would be the place where members of the community could share with civilian organizations, former members of the UC CoP that are no longer in the military, and Civil Engineer Corps officers in the OFP pipeline at graduate school. The OFP website as it currently exists is set up to connect the entire community. There are lists of past and present OFP members and access to the Seabee Divers Association. A web site set up like this, if not this site itself, would be an ideal place to encourage collaboration.

6.6.1. Construct

Taxonomy - How the web site is set up is important, as it will provide the map to navigate around the site. The taxonomy proposed in section 6.5.2 will be an effective way to organize the content. Once the BPLL has made it through the review process it would be posted by the Leader of the Technical Center of Expertise under the appropriate section.

This taxonomy, however, only deals with the UCT operations. As more operators start to contribute to and count on the web site, more information will be needed. These items could include maintenance, training and logistics. It is important to start with a narrow focus and, as the program gains momentum, be able to expand later.

Search Engine - While a well documented taxonomy will help an operator find what they are looking for a search engine will help those that are not sure where to look for information.

Threaded E-mails - A valuable feature the new technology has to offer is the use of threaded e-mails and/or discussion forums. This is where a question could be posted or a new initiative introduced to the community for consideration and input. All members of the community would be allowed to contribute insight to the issue. All the different responses would be linked together. This gives the initiative being proposed variety in perspective.

6.6.2. Adding content

The current technology allows adding content to the website very easy. The question that needs to be answered is *who* would be allowed to add content and to what extent. For BPLL, only the Leader of the Technical Center of Expertise will be allowed to add content. This ensures that the item has been thoroughly reviewed and is considered worthy of posting.

6.6.3. Security Considerations

Serious thought needs to be given to the security of the system. The Navy's Lessons Learned System goes to great lengths to ensure the security of the information is maintained. The classified lessons are available from the Naval Warfare Development Command's Lessons Learned database, but this requires a secure data line. They are also available on CD-Rom. The CD is available via the Defense Courier Service. Once obtained, the CD is locked in the command's vault. Even the unclassified lessons are difficult to obtain. While this does not promote the "free exchange of knowledge," it does maintain security.

The question then has to be asked what is too much information to be posted on a publicly accessible site or even on NAVFAC's intranet site. The type of information that would be posted to the Community's web site is not necessarily classified (i.e. what is the best way to clean a pile on a pier in Hawaii), but it does give some indication to the capabilities of the unit. A string of this type of lesson could paint more of a picture of what a unit can do or is about to do to a potential enemy.

6.7. Summary

There is a tendency to see a difference between risk and quality in the UCTs. Quality is and attribute of the finished product where risk is seen as the potential dangers to the individual in completing the project. If there is no danger in performing the task there is no risk, but there are quality concerns. For this reason further work needs to be done to improve the UCT Project Planner to not only collect Best Practices and Lessons Learned regarding Operational Risk Management, but also regarding quality of the finished product. The further development of the Project Planner (which is a process function) cannot happen independently of the other aspects (Culture, Technology, Learning and

Content) of effective Knowledge Management. The most important consideration is the formal establishment of the Underwater Construction Community of Practice. Once people are brought together with a common interest for the purposes of improved communication and sharing of information, the questions surrounding the other elements of successful knowledge management will begin to be answered.

7. Recommendations

The best way to proactively manage risk is to have a more thorough understanding of the risks involved before beginning a task. This understanding will be gained by studying the risks that were encountered on similar tasks in the past, how they were controlled and how effective the controls were. Knowledge Management provides the philosophical base to implement a Knowledge Centric Organization that captures what is learned and leverages it across the organization. This report deals with the process of collecting and storing best practices and lessons learned regarding risk. Just having a process in place to collect BPLL is not enough, though. To effectively implement a KCO, the culture of the community must be one that is willing to share knowledge, the knowledge must stored in a way that facilitates learning, the techniques for collecting knowledge must fit in with how the organization does business. To this end the following recommendations are made. I strongly encourage those interested in implementing these items refer to the Department of the Navy Knowledge-Centric Organization Toolkit. Also the e-learning pages on www.foundationknowledge.com provide a great deal of information on knowledge management. Success of the implementation depends on everyone involved understanding what is trying to be achieved and bringing their expertise and experience to bear.

7.1. Formally Establish the Underwater Construction Community of Practice

The most important item to be accomplished is the formal establishment of the Underwater Construction Community of Practice (UC CoP). The UC CoP already exists, albeit informally. It is made up of Seabee Divers, Ocean Facilities Program Officers and the civilian engineers at NFESC Code 50. Getting these people together to discuss common items of interest and bounce ideas off each other is the place to start. To formalize the community it is necessary to bring the leadership of these three entities together and explain knowledge management and its role in leveraging BP/LL across the community. The leadership then needs to make knowledge management a priority. Getting the leadership on board is the first step in encouraging a culture that encourages sharing. The leadership can be introduced to Knowledge Management at the annual UCT conference held in November and at the bi-annual OFP conference (next one is scheduled for May '02).

Once the community is formed roles and responsibilities must be established to ensure the initiative takes root and grows. Who will maintain the website? Who reviews content? Who will develop the taxonomy for the website for the ease of finding information? How will security of the information be maintained? These questions and many more must be answered. The NAVSEA Community of Practice Practitioners Guide will be a valuable resource in implementing the Community of Practice.

Other issues the community must address:

- What is the organization’s value proposition? This report suggests that it is operational excellence, but it could be customer intimacy or maybe it is both.
- How to collect Best Practices and Lessons Learned? - A method to collect BP/LL is offered in this report.
- What is the desired result of collecting BP/LL? - This report views operational excellence as the focus of the KM initiative.
- What incentives will be used to get people to share?

- Who reviews content? - This report offers a proposed flow chart for content review.
- Who maintains the collaborative website?
- How will the community know the KM initiative is moving in the right direction?

    To this end, metrics should be used. To help in establishing these metrics, the Department of the Navy's Chief Information Officer's "Metrics Guide for Knowledge Management Initiatives" is a great source of information.

- Many more questions need to be addressed by the leadership and the Community of Practice.

7.2. Develop a collaborative web site

The Community must establish a collaborative website on the E-Net so that there is a central, virtual place to develop the community. The members of the UC CoP are in many different commands across the country and around the world. Not everyone will be able to make every meeting to provide insight into the development of the community.

The website will be the place where ideas are introduced and discussed for the improvement of the community. Most importantly, it will be the place where Best Practices and Lessons Learned are posted. These will be the items that make the Community safer and more reliable in the future. As knowledge is passed from one operator to another and successes that result from the KCO emerge, the program will gain momentum.

7.3. Fix the Project Planner

If the focus of the Knowledge Management initiative is, in fact, improving operations then the UCT Project Planner is the tool that holds the key.

Not only can the Planner be configured to assess and manage risk, but it could also be used to capture Best Practices and Lessons Learned regarding quality of the finished product.

If the Community is established and there is a virtual place to collaborate then there is a place to provide feedback regarding the improvements to the Planner. The Project Planner needs to evolve continually. As technology improves the power of the planner will increase. The more people use it and see its value, the more they will want to use it to track additional information, such as training, maintenance of equipment and logistics.

There will also be problems with the planner and bugs to be worked out. The communication between the developers of the planner and the users must be constant. As developers make improvements, the users need to be made aware of the improvements. If the users discover bugs, the problems need to be communicated to the developers. To this end, a pre-designed feedback system must be developed.

7.4. Collect Lessons Learned and Best Practices from the files

Both Underwater Construction Teams have paper files of many years of projects. These files undoubtedly hold valuable information that could be filed in the knowledge base. Once the UC CoP and the collaborative website are established and the content review process is in place, a contract could be let to go through the files and catalogue Best Practices and Lessons Learned.

7.5. Establish ties with Academia to research initiatives

Many of the students that go to graduate school through the Navy to become OFP officers, want to take on a project that will have some benefit to the OFP and the Navy. As new initiatives develop, these officers would be ideal to "flush out" the intricacies involved in the initiatives. These students have access to leading experts in the field of Ocean Engineering and Construction Management. They also have the time to focus on a particular issue where other members of the community have their regular job to do. There are mutual benefits to this arrangement. The community gets "free labor" to pursue the initiative and the student, who is now a new member of the community, gains an understanding of how the community operates and also feels like he is contributing to the community.

7.6. Educate at NDSTC about repository

If most of the valuable lessons will be learned from the operators then the operators need to be educated of the existence of the knowledge base as early as possible. The place to do this is at the Underwater Construction School at the Naval Diving and Salvage Training Center. The operators need to be educated not only on the power of the knowledge base in helping plan jobs, but also on the importance of contributing lessons learned.

8. The Next Step

8.1. The Underwater Construction Community of Practice

The first thing that needs to be done is to formally establish the UC CoP. This will not be difficult because it already exists. The trick is to give the entire community something to work on together, in other words a pilot project. A suggestion for the pilot is the revision of the UCT Project Planner. A number of the operators have said that they would like to see the Planner revised so that it could be used in planning projects. During the revision the items discussed in this paper could be considered as well as the application of knowledge management principles. Such as a website where members of the community could collaborate on the improvement of the Project Planner.

8.2. University of California, Berkeley

The pilot project would make a great report topic for a graduate student. It will give them insight into the Ocean Facilities Program and the Underwater Construction Teams and indoctrinate them into the Community of Practice. Additionally, the project will complement the work being done in Risk Assessment and Management of Marine Systems being done by Professor Bob Bea at the University. The student should contact the Commanding Officers of the Underwater Construction Teams and the Assistant Director of the Ocean Facilities Program at the Naval Facilities Engineering Service Center's East Coast Detachment to discuss the logistics (access to the UCTs and for funding) behind this project.

9. Conclusions

To achieve consistently high quality in the lifecycle of facilities, it is necessary to mitigate the risks associated with the various stages of the lifecycle. The most effective way to do this is to learn from the best practices developed and the lessons learned from past projects. This report is primarily focused on the development of a tool to collect Best Practices and Lessons Learned regarding risk in the Underwater Construction Teams. Research has indicated that risk and quality are, for the most part, viewed as mutually exclusive. Therefore, if the goal is to maintain high quality in the lifecycle it is necessary to collect not only Lessons Learned regarding risk, but also Best Practices and Lessons Learned regarding quality.

Just having a tool to collect BP/LL however is not enough. The culture of the target organization has to be one that encourages one to seek out and contribute knowledge from and to the knowledge base. There needs to be a process to put the information in a format that is retrievable when needed and stored in a place that is universally accessible. People need to trust that the information is the most relevant and up to date available. The information needs to be in a format that appeals to various learning styles.

This report has tied together Risk Assessment and Management, specifically Operational Risk Management, and Knowledge Management in an effort to help mitigate risks associated with the operations of the Navy's Underwater Construction Teams and increase quality. Recommendations are offered to implement a knowledge-based community of practice in the UCTs and indicated the next steps toward implementation. This process once started will never be finished. The goal is continuous improvement in the communication between members of the community and the safety and quality of the engineered system.

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