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Approaches to Innovation in the Naval Construction Force "Seabees"

December 2022

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Prepared for the Naval Postgraduate School, Monterey, CA 93943.

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ABSTRACT

The increasing competition from China and the resurgence of Russian aggression has emphasized the need for innovation. The naval construction force (NCF) provides general engineering to the United States Navy and similarly needs to innovate to remain relevant and provide value to the warfighter. Innovation can be categorized as small incremental improvements (exploitation) or major disruptive shifts (exploration). This paper looks to define what exploitation and exploration mean to the NCF and what intangible assets and resources will be required to meet those innovation goals. This paper uses principles from literature in business academia and applies them to the research questions to establish a best practice recommendation for the NCF. In order to apply rigor to the paper, it uses metrics of effectiveness to determine which approach to innovation provides the greatest value to the Navy. Based on an evaluation of five measures of effectiveness, the NCF would be best served by pursuing the exploration approach to innovation. To do this, the NCF should create a dedicated Development Company to develop and validate new concepts for wider adoption.

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TABLE OF CONTENTS

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LIST OF FIGURES

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LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

ACB	Amphibious Construction Battalions
ADR	airfield damage repair
ANB	advanced naval bases
BU	builders
CBMU	Construction Battalion Maintenance Unit
CE	construction electricians
CEC	Civil Engineer Corps
CFSMF	Cold-formed Steel Mobile Factory
CM	construction mechanics
CMU	concrete masonry unit
CO2	carbon dioxide
CUI	Controlled Unclassified Information
DEVGRU	Naval Special Warfare Development Group
DMO	Distributed Maritime Operations
EA	Engineering Aides
EABO	Expeditionary Advanced Base Operations
ELCAS	elevated causeway system
EO	Equipment Operators
EXWC	NAVFAC Expeditionary Warfare Center
INLS	Improved Navy Lighterage System
LOCE	Littoral Operations in Contested Environments
MCO	Major Combat Operations
MOE	Measures of Effectiveness
NAVFAC	Naval Facilities Engineering Systems Command
NCD	Naval Construction Division
NCF	naval construction force
NCG	naval construction group

NCR	Naval Construction Regiment
NECC	Navy Expeditionary Combat Command
NMCB	Naval Mobile Construction Battalion
PDR	port damage repair
PEB	pre-engineered building
PLA	China’s People’s Liberation Army
PLAN	China’s People’s Liberation Army–Navy
POE	Projected Operation Environment
RDT&E	Research, Development, Testing and Evaluation
SOP	Standard Operating Procedures
SW	Steelworkers
TTP	tactics, techniques, and procedures
TOA	table of allowance
TRANSCOM	U.S. Transportation Command
UCT	Underwater Construction Teams
UoA	unit of action
UT	Utilitiesmen
WEZ	Weapons Engagement Zone

EXECUTIVE SUMMARY

The need to innovate is neither new nor novel for the United States Navy. The increasing competition from China and the resurgence of Russian aggression has further emphasized the need for immediate improvement. The U.S. naval construction force (NCF), colloquially known as the "Seabees," is the U.S. Navy's general engineering force. The NCF is not immune to these same challenges. They need to innovate to increase their capabilities and capacity to meet the demands of the U.S. Navy and Marine Corps. The NCF operates in an industry that is commonplace in the civilian world, but they do so in uncommon environments. Emerging concepts such as Distributed Maritime Operations (DMO), advanced naval bases (ANB), Expeditionary Advanced Base Operations (EABO), and Littoral Operations in Contested Environments (LOCE) all require general engineering support. In this paper, I researched what approach to innovation the NCF should use to provide the best future value to the U.S. Navy.

Innovation comes through incremental improvements to processes and practices as well as significant leaps of thought and technology (Ioniţă, 2022). These two paths of innovation are commonly referred to as Exploitation and Exploration (March, 1991). Determining what approach to innovation the NCF should pursue will give a better direction for where the limited resources that they are given should be spent.

I used principles from literature in business academia and applied them to the research questions to establish a best practice recommendation for the NCF. To apply rigor to the paper, I used metrics of effectiveness to determine which approach to innovation provides the greatest value to the Navy. I relied heavily on the works of James March, Charles O'Reilly, Michael Tushman, Michael Porter, and Benjamin Jensen. The main topics that I researched were exploration vs. exploitation, organizational structure for innovation, innovation strategy, and organizational change. These business centric concepts were applied to the research question with input from the culture and history of the NCF.

The culture of the NCF is embodied in the Seabees' motto: CAN-DO. This CAN-DO culture describes the unrelenting drive early, and current, Seabees demonstrate to overcome any challenge through ingenuity and determination. The culture in the NCF is important to how the force will approach innovation to be best prepared for potential major combat operations (MCO). The history of the Seabees is full of examples of how the CAN-DO culture was embodied to adapt to unforeseen situations and accomplish tasking with out-of-the-box thinking. One such example was the use of five by five by seven-foot sheet steel boxes (pontoons) fastened together to create 300-foot causeways enabling more expedient amphibious landings under enemy fire (Huie, 1944). This solution was revolutionary to the allied war effort in World War II and proved the value of the Seabees to the U.S. Navy through their CAN-DO culture.

The NCF is currently responsible for two major tasks in a potential conflict in the Indo-Pacific Theater: Airfield Damage Repair (ADR) and Port Damage Repair (PDR). These two tasks are key to allowing forces to flow into the theater for follow-on action against an adversary. Expeditionary base construction is also anticipated tasking that the NCF will be required to accomplish across the islands in the Pacific. These anticipated taskings are the central driving factors to the new NCF Force Design. This change in organization creates more proficiency in the two primary mission sets but has the potential to decrease the ability of NMCBs to flex to meet emergent and unforeseen threats. This reduction in adaptability runs counter to what history has shown to win wars: the side able to adjust more quickly, wins. The approach to innovation that provides the most future value to the U.S. Navy will take these into account while also building adaptability into force.

An exploitation approach to innovation focuses on improvements to already established capabilities. This form of innovation, however, has inherent limits. While emergent technologies and procedures have much room to grow and gain in efficiency, existing industries, such as construction, experience diminishing returns as companies compete to become more efficient for their buyers. To determine the naval construction forces' (NCF) room for improvement, I established a baseline using a general construction contractor. After evaluating the construction industry using Michael Porter's

Five Forces (1979) I determined that the construction industry contains little slack resulting in insignificant in-house innovation. The implication for the NCF is that the exploitation approach to innovation will have an upper limit to gained capacity and capabilities. There is still room for improvement as the NCF logically lags their civilian counterparts due to the need to be proficient at defensive operations as well as the general administrative burden that is inherent to the U.S. Government. This gap in capabilities could be closed by adopting a master and apprentice system that uses master tradesmen from civilian companies to train the NCF on-site during projects.

There are several emergent technologies that are applicable to the NCF and represent what an exploratory approach to innovation would entail for the NCF. These technologies include helical piers, calcium carbonate cement, cold formed steel factories, and 3D printed buildings. Additionally, several paradigm shifting concepts such as tunneling and a return to pontoons represent how out-of-the-box thinking can dramatically change the way the NCF operates. To prioritize an exploratory approach, the NCF needs dedicated groups to validate and develop concepts similar to how Naval Special Warfare's Development Group operates. This structure is referred to as "incubator cells" (p. 17) by Benjamin Jensen (2016) in his book *Forging the Sword*.

When comparing the two approaches to innovation I used five measures of effectiveness (MOE) for evaluation. The first was the relative cost to implement, which determined which approach was cheaper in U.S. dollars to implement. The second was the impact to current operations, either positively or negatively. The third MOE was difficulty of implementation which determined what level of effort was required to implement the approach. The fourth MOE was the impact on adaptability and evaluated whether the approach increased or decreased the adaptability of the NCF. Lastly, the fifth MOE was the potential future value that the approach gave the NCF. When comparing the two approaches, each MOE had a specific measurement that is represented in Table 1.

As Table 1 shows, the exploration approach provides the greatest potential future value as well as giving the NCF a positive impact to adaptability.

Table 1. Side-by-Side Comparison of Exploitation and Exploration

	Exploitation	Exploration
Relative Cost to Implement	Medium	Low
Impact on Current Operations	Positive	Negative
Difficulty of Implementation	Difficult in beginning	Difficult in midterm
Impact to Adaptability	Negative	Positive
Potential Future Value	Limited	Unlimited

Shaded cells indicate which innovation approach is clearly more advantageous to the NCF.

I recommend that the NCF prioritize exploration in their pursuit of innovation. MCO is the true measuring stick for the NCF. As previously stated, history has shown that the side that can adapt more quickly will win. By prioritizing exploration, the NCF will engender the CAN-DO culture at an organizational level that was so evident in the early years of the Seabees. Conflict with a near-peer adversary will present problems that can't be anticipated. The NCF must be prepared to find ways to give the U.S. Navy an asymmetric advantage through paradigm shifting innovations. If the NCF decides to forgo exploration it will risk obsolescence to any civilian contractor that can devote its entire effort to the proficiency of its craft.

To implement an exploratory approach to innovation, the NCF should create a Development Company under the 30th Naval Construction Regiment that would act as an "incubator cell" (Jensen, 2016, p. 17) to validate and develop these new and paradigm shifting ideas. Several key points need to be followed for the Development Company to succeed: 1) The company should be evaluated on a level of effort basis determined by the number of ideas and concepts developed and validated, 2) Once concepts are proven successful, the Naval Construction Groups would be responsible for distributing this the rest of the NCF.

If the NCF is to have the same impact on the next war as they did in WWII, they need to be ready to explore new ways of accomplishing missions and be ready to adapt to eventualities that are yet unknown. By adopting an exploratory approach to innovation, the NCF can accomplish these and be ready to support the U.S. Navy and Marine Corps in whatever challenges they face.

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I. INTRODUCTION

Without proper self-evaluation, failure is inevitable.

—John Wooden

A. PURPOSE

The world is rapidly changing. The United States no longer holds an outright monopoly on the ability to influence global trends due to its military prowess. China, powered by its expanding economy, has asserted itself as a near-peer competitor with the goal of outright leadership on the world stage. Once an overwhelmingly powerful foe at arms, Russia has witnessed its position reduced on the global stage and is now acting with renewed desperation to reclaim its lost prestige. In relation to these new and familiar global competitors, the United States military has been militarily matched, and by some measures, surpassed. To regain control of these global dynamics, the U.S. Armed Services must look to increase the pace of innovation. Innovation can come in many forms and from many places. In business literature, there is general agreement that the two paths to innovation come from exploiting current capabilities or exploring new technologies and creating previously unknown capabilities (March, 1991).

The U.S. naval construction force (NCF), colloquially known as the "Seabees," is the United States Navy's general engineering force. The NCF is not immune to the challenges presented to the U.S. military writ large. They need to innovate to increase their capabilities and capacity to meet the demands of the U.S. Navy and Marine Corps. The NCF operates in an industry that is commonplace in the civilian world but does so in uncommon environments. Emerging concepts such as Distributed Maritime Operations (DMO), Advanced Naval Bases (ANB), Expeditionary Advanced Base Operations (EABO), and Littoral Operations in Contested Environments (LOCE) all require general engineering support. In this study, I define what exploration and exploitation mean to the NCF and what intangible assets and resources will be required to meet those innovation goals.

B. RESEARCH QUESTION

Primary Question:

1. What innovation approach should the NCF use to provide unique engineering capabilities in support of the U.S. Navy and Marine Corps?

Secondary Questions:

2. What does a future NCF look like that meets the needs of the U.S. Navy and Marine Corps enabling them to conduct ANB, EABO, LOCE, and DMO concepts?
3. How should the NCF organize to innovate in ways that meet these needs?

C. IMPORTANCE OF PROBLEM

For the NCF to improve and gain capacity and capability, it must innovate. Innovation comes through incremental improvements to processes and practices as well as significant leaps of thought and technology (Ioniţă, 2022). These two paths of innovation are commonly referred to as Exploitation and Exploration. Determining what balance of innovation the NCF should pursue will give a better direction for where the limited resources that they are given should be spent.

The NCF is a key enabler for DMO, ANB, EABO, and LOCE but does not rank highly on the Navy's overall resource allocation plan. To demonstrate the value the NCF brings to the Naval team, they must efficiently use the resources they are allocated. To realize this efficiency, the Seabees must correctly prioritize exploitation or exploration, utilizing their tangible and intangible resources to create the innovation needed to meet the challenges presented in the context of great power competition.

The ultimate goal of any military unit is to defeat the enemy, protect the homeland, or support the accomplishment of both. The value a unit provides can be evaluated based on how well it accomplishes these goals. Another way to measure the value is whether or not the services provided can be replicated or replaced by other means. For the Seabees, the most common example of replicated services would be civilian contracting, rendering the unit obsolete or undesirable to use due to administrative overhead. This last metric is an additional driving factor for why the NCF must innovate to be able to provide unique capabilities that cannot be replicated.

D. SCOPE

The current pacing threat of the U.S. military is China's People's Liberation Army (PLA) and People's Liberation Army–Navy (PLAN) (Department of Defense, 2022). The threat posed by the growing China military presents the greatest danger to the United States, our global interests, and the well-being of our allies and partners in the INDOPACIFIC Region. I focus intently on the operational requirements that the NCF will be given in a near-peer conflict with China in that theater. Potential tasking from other theaters will be similar in scope but will present a lesser logistical challenge. By aligning to the China pacing threat, the NCF will position itself in the best place to respond to any conflict.

In addition to defining the geographic boundary to which I adhere, I also focus exclusively on the construction capabilities of the NCF. The NCF's defensive capabilities will only be touched on tangentially as they relate to the construction operations that the Seabees will be conducting.

Finally, there are multiple unit types in the NCF with attendant primary mission sets and capabilities. I focus on the Naval Mobile Construction Battalion (NMCB) unit type as they comprise a large majority of the NCF (Department of the Navy, 2010a).

E. LITERATURE REVIEW

1. Exploitation and Exploration

Joseph A. Schumpeter, in his book *The Theory of Economic Development* (1961), described economic life as a circular flow that proceeds with known inputs and outputs. He wrote that economic development arises from disruptive changes to the economic model. He stated that the development of an economy results from new combinations of materials, forces, or other methods. Additionally, he asserted that new combinations can occur over time through adaptive and iterative changes or can come in discontinuous changes, which he goes on to further define as appearing in five ways:

> (1) The introduction of a new good—that is one with which consumers are not yet familiar—or of a new quality of a good. (2) The introduction of a new method of production, that is one not yet tested by experience in the branch of manufacture concerned, which need by no means be founded upon a discovery scientifically new, and can also exist in a new way of handling a commodity commercially. (3) The opening of a new market, that is a market into which the particular branch of manufacture of the country in question has not previously entered, whether or not this market has existed before. (4) The conquest of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created. (5) The carrying out of the new organisation of any industry, like the creation of a monopoly position (for example through trustification) or the breaking up of a monopoly position. (Schumpeter, 1961, p. 66)

Schumpeter's description of these "new combinations" represents the founding of the principle of exploitation (innovation through an iterative refining process of established combinations) and exploration (innovation through disruptive and discontinuous change).

James March (1991) furthers the concepts of exploitation and exploration by applying these principles to organizational learning in the setting of scarcity. He writes about the need for resources to drive innovation and the decision that must be made to allocate more resources to exploiting current processes or exploring new ideas.

March (1991) details the trade-offs that are realized when choosing exploitation over exploration or vice versa. Exploration is necessary for the long-term viability of an organization but is less consistent in its results. In order to compete with capable rival organizations or a near-peer adversary, in the case of the NCF, innovations that dramatically improve capabilities and efficiency can only come through major disruptions in the status quo. Exploitation refines the operations that are currently underway at the organization. The incremental improvements to these current operations can have positive short-term impacts. He writes that innovation pursued via exploitation is more easily realized as it is associated "to its consequences more quickly and more precisely than is the case with exploration" (March, 1991, p. 73).

In reality, an organization does not solely select exploitation or exploration. They choose a balance as determined by their available resources. In Charles O'Reilly and

Michael Tushman's article "The Ambidextrous Organization" (2004), they assert that organizations can be incredibly successful by both "exploiting the present and exploring the future" (O'Reilly III & Tushman, 2004, p. 75). The key that they focus on is the manner in which an organization organizes itself to best capture the positive outcomes of exploration and synch that with the ongoing process improvements that an organization is constantly performing. They present four basic models for an organization that they observed. The first is "functional designs" (p. 76) that keep exploration teams inside the regular hierarchy. The second is "cross-functional teams" (p. 76) that are put together across business lines inside the organization but do not share a common management structure. The third is "unsupported teams" (p. 76) that are pulled outside the existing organization to work on emergent ideas in their own space and method but without the connection and support of the main organization and management. Finally, they describe "ambidextrous organizations" (p. 76) that are organized as a separate unit but are still present inside the main organization with the same management as the current operations. This last model allows for an organization to pursue exploration using means and methods that foster creativity with an associated incentive system but also enable sharing of best practices and scarce resources across the organization.

2. Methods to Innovate

Charles O'Reilly III and Michael Tushman discuss different organizational structures that could be used to achieve an "Ambidextrous Organization" (O'Reilly III & Tushman, 2004, p. 76). They surmised that the best model for effective innovation "were organized as structurally independent units, each having its own processes, structures, and cultures but integrated into the existing senior management hierarchy" (p. 76), as depicted in Figure 1.

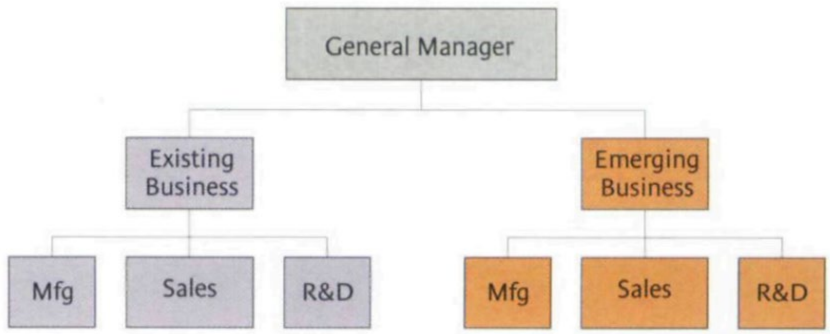

Figure 1. Example structure of an “Ambidextrous Organization.” Source: O’Reilly and Tushman (2004, p. 79).

In addition to the organization that O’Reilly and Tushman recommend, in his study of doctrinal innovation in the U.S. Army, Benjamin Jensen argues that two key groups are required to overcome organizational inertia and pursue dramatic changes in the operational norm. The first group is “incubator cells” (Jensen, 2016, p. 17), which are “subunits free from the normal push and pull of the bureaucratic hierarchy in which professional military officers are free to visualize new theories of victory” (pp.17–18). These “incubators” (p. 17) are operational forces that are tasked with developing and trying new and exploratory ideas that have the potential to cause a paradigm shift. A key aspect of these groups is the ability to operate outside the traditional hierarchy and measure their success by effort and not necessarily results.

The second group is “advocacy networks” (Jensen, 2016, p. 19): “advocacy networks are loose coalitions of defense and civilian officials championing new reform initiatives” (p. 19). The primary goal of the “advocacy networks” (p. 19) is to champion the new concepts and innovations that the “incubator cells” (p. 17) develop. There can be many forms that “advocacy networks” (p. 19) take, but the goal remains to protect “incubator cells” (p. 17) from bureaucrats that favor the status quo. “advocacy networks” (p. 19) also create coalitions across the larger organization that support the implementation of the new innovations.

3. Organizational Change

In order to analyze and recommend a preferred path to innovation, there needs to be a discussion about the challenges of organizational change and change management. In any organization, there exists a dynamic that places the want and need of leadership to pursue new ideas and processes (Explore) and the desire for rank-and-file employees to resist change in lieu of the status quo. Change is necessary for an organization to remain relevant in environments that are themselves changing. By focusing change effectively, leadership can create new capacity and capabilities, or avoid potential stagnation. The costs to change include a loss of efficiency in the initial stages of the change due to an unfamiliarity of the affected employees. The degree to which the organization gains future capacity and capabilities must be balanced with the initial loss in efficiency and impact to employee morale. An organization can build its own inertia—that is, resistance to change—and will potentially keep the organization from improving and can ultimately cause the organization to fail (Auger et al., 2017). In addition to the resistance to change, an organization can develop whiplash from revolving change initiatives that are focused on explorational change but do not result in any discernible difference for the organization (Goss et al., 1993).

Common failures to guide organizational change were included in John Kotter's article "Why Transformation Efforts Fail" (2009):

1. Not establishing a great enough sense of urgency
2. Not Creating a Powerful Enough Guiding Coalition
3. Lacking a vision
4. Undercommunicating the Vision by a Factor of Ten
5. Not Removing Obstacles to the New Vision
6. Not Systematically Planning for and Creating Short-Term Wins
7. Declaring Victory Too Soon
8. Not Anchoring Changes in the Corporation's Culture. (pp. 60–67)

Kotter (2009) uses these eight errors to describe how organizations with the best intention to drive change and innovation end up either in a worse position or with an entirely new set of challenges that could have been avoided. The most relevant of these errors in relation to exploitation and exploration is “Not Systematically Planning For and Creating Short-Term Wins” (Kotter, 2009, p. 65). This error gives additional credence to O’Reilly and Tushman’s (2004) concept of an “Ambidextrous Organization” (p. 76) that balances short-term exploitation wins with long-term exploration innovations.

F. METHODOLOGY

I use principles from literature in business academia and applies them to the research questions to establish a best practice recommendation for the NCF. The evaluation of the NCF regarding exploitation and exploration is done in an idealized environment to deduce potential benefits and shortfalls. In order to apply rigor to the paper, it uses metrics of effectiveness to determine which approach to innovation provides the greatest value to the Navy.

G. ROAD MAP

1. Background of the NCF and Evaluation of Current NCF Capabilities

Once the operational requirements have been established for the potential mission tasking the NCF is likely to receive, the next step will be to determine the current state of the NCF’s capabilities in relation to those requirements. The major capabilities reviewed will be the current construction methods that are employed by the NMCB. A key distinction will be made by what methods of construction (e.g., concrete masonry unit [CMU], timber) are listed in doctrine, and of those, what the NCF is currently capable of.

In conjunction with the ability to execute distinct construction methods, there is also a need to evaluate the environments that the NCF is capable of operating in. The Navy uses the term Projected Operation Environment (POE) to describe the environments, both physical and situational, that units will need to operate in to achieve their designed mission. This will be evaluated taking into consideration where the NCF is tasked with operating on paper compared with where the NCF has any recent experience or proficiency with operating.

2. Evaluation of the CAN-DO Culture

The NCF has a unique culture that is referred to as "CAN-DO." This culture is integral to how the NCF operates and how they innovate. This chapter will discuss the origins of the CAN-DO culture and its importance to the future of the NCF. Specific attention is given to the creativity that is engendered in the CAN-DO culture.

3. Requirements

In order to determine what balance of exploration and exploitation the NCF should pursue, the first step must be to examine the requirements that the Seabees will be given in the INDOPACIFIC theater. In an effort to allow for the widest possible distribution, the requirement as related to potential operations will be kept at a Controlled Unclassified Information (CUI) level or below. These requirements will be bereft of times, places and tactical and operational specifics. They will, however, be detailed enough to provide the framework from which I can build a recommendation for the most impactful allocation of resources toward innovation.

4. What Exploitation Looks Like for the NCF

To determine which course of action the NCF should purse regarding innovation, a base understanding of what exploitation would look like in the NCF is explored. Alongside the evaluation of current capabilities, the room for improvement and capacity will be examined. In an effort to provide a frame of reference, I use a civilian construction contractor as a benchmark to determine the potential room for growth in the NCF construction capabilities.

5. What Exploration Looks Like for the NCF

In addition to evaluating the manner in which the NCF can exploit their current capabilities, there needs to be an evaluation of what exploration would look like for the NCF. As stated earlier, the NCF's primary mission is construction which is a commonplace industry in the private sector. Due to the competitive nature of the construction industry new methods of construction are continually being developed to gain an edge on competitors. Selected emergent construction technologies will be evaluated for their use by the Naval Construction Force and how their inclusion could support their potential tasking in the Indo-Pacific theater.

6. Analysis of Exploitation vs. Exploration

Once an understanding of what exploitation and exploration would look like for the NCF, I analyze the outcomes against Measures of Effectiveness (MOE) as they relate to the pre-stated requirements of the NCF from INDOPACOM leaders. As an additional layer of analysis, a generic civilian construction contractor will be evaluated alongside the Seabees to determine what value the Seabees present to the Navy and whether retention of the NCF is the most beneficial in the near and long term.

7. Recommendations to Pursue the Desired Path of Innovation

Finally, a recommendation to how to implement the proposed path of innovation will be discussed. How innovation is pursued is arguably more important than the actual practice of innovation itself. If the conditions are properly set, innovation will be a byproduct of the established organization, policies, and culture.

II. BACKGROUND

A. A BRIEF HISTORY OF SEABEES

The United States Construction Battalions formally originated in December 1941 but did not receive their "Seabees" moniker until March 1942 (United States Bureau of Yards and Docks, 1947). The Seabees were created out of a need for construction in World War II (WWII) in contested and dangerous environments. The Civil Engineer Corps (CEC), led by the Chief of Civil Engineers, Vice Admiral Ben Morrell, persuaded the U.S. Navy to create specialized units of civilian construction workers and trained them to fight to accomplish this mission. The Seabees had an average age of 37 during WWII due to the makeup of the recruits. The Seabees of WWII came to Navy service with knowledge of the trade. During the island-hopping campaign, they used this knowledge to build airfields, ports, camps, and drydocks throughout the Pacific (Navy History and Heritage Command, 2015b).

The methods of construction used during WWII were both exploitive and exploratory in that they honed well-tried construction methods and new and creative practices. Many of the materials used in the Pacific were locally sourced, and construction methods were adapted to accommodate whatever materials were at hand. An example is how the 14th Construction Battalion used shaved coconut palm trees as piles to build waterfront structures (Huie, 1944).

Another example of early Seabees adopting an exploratory mindset was using pontoons to create rapidly deployable causeways (Huie, 1944). The CEC Captain John Laycock devised a five by five by seven-foot steel sheet box that could be arranged to create any number of shapes. These pontoons were fastened together and arranged to allow the Seabees to establish a 300-foot causeway in under ten minutes. The pontoon causeway concept was demonstrated in Davisville, Rhode Island, to Army and Navy officers who had gathered to test new concepts of amphibious landings. Captain Laycock oversaw the demonstration and commented, "Army and Navy officers seldom gasp, but all gasped at that demonstration" (p. 112).

The U.S. NCF has undergone many changes throughout its history; Figure 2 gives a brief overview of the notable organizational changes.

Figure 2. Timeline of Major Changes in the NCF.
Source: Navy History and Heritage Command (2015b).

During the Korean and Vietnam wars, the NCF again provided much-needed engineering support to U.S. forces in the theater. During the Korean War, the NCF operated the pontoons to aid the amphibious invasion at Inchon. There is also a story of Seabees that stole a train from the fleeing North Koreans to aid in transporting materials (Navy History and Heritage Command, 2015c). In Vietnam, the NCF organized into a smaller unit called Seabee Teams, which allowed the NCF to operate in more areas with special forces and highly maneuverable units (Tregaskis, 1975).

Post-Vietnam saw the NCF participate in many humanitarian operations and large peacetime projects (Navy History and Heritage Command, 2015a). One of the most significant projects the NCF completed was the build-up of the island of Diego Garcia. On the remote Indian Ocean island, the NCF constructed sustainment facilities, a communications station, petroleum storage, ports, and an airfield.

In the last several decades, the NCF played major roles in both Afghanistan and Iraq. While deployed in support of those conflicts, the NCF supported the construction of what was to become Camp Leatherneck and many remote outposts across the countries. During the wars in Iraq and Afghanistan, the NCF had to shift their operations again to accommodate land locked environment and have the U.S. Army as their primary supported unit.

Throughout their storied history, the Seabees have had to adjust and change to overcome the challenges that were presented to them. Most of the changes that the NCF has undergone have been organizational alongside the common advances in technology used for construction. The culture that has been developed as a result of overcoming challenges and changing to meet the demands of the current environment is embodied in their motto, CAN-DO, and will be discussed in the next chapter.

B. THE CURRENT STATE OF THE NCF

1. Organization

The NCF is currently organized under Navy Expeditionary Combat Command (NECC) in Little Creek, Virginia. Subordinate to NECC are the Naval Construction

Groups in Port Hueneme, California (NCG 1) and Gulfport, Mississippi (NCG 2). Subordinate to the two NCGs are the Naval Mobile Construction Battalions, Underwater Construction Teams, and Construction Battalion Maintenance Units for their respective regions. Figure 3 shows the current organizational chart for the NCF. The manner in which the individual units are organized breaks down into rough geographic regions, with NCG 1 covering the Western United States and the INDO-PACIFIC region and NCG 2 covering the Eastern United States and Europe, South America, Africa, and CENTCOM. The organizations shown in Figure 3 (with the exception of the Underwater Construction Teams (UCT)) are the units of action (UoA) when presented to a Commander for tasking and readiness. The current NCF Force Design will restructure these units to bring the UoA down to a company level allowing for more specialized tasking and readiness cognizance. Other units represented in Figure 3 are Construction Battalion Maintenance Units (CBMU) and Naval Construction Regiments (NCR).

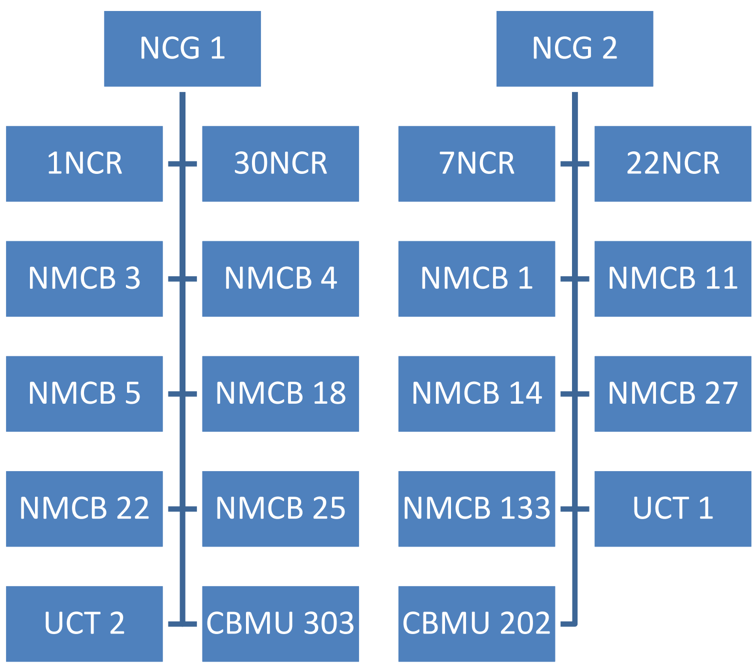

Figure 3. Current Organization of the NCF. Adapted from Department of the Navy (2010a, p. 1-7).

As previously stated, the focus of this thesis will be the Naval Mobile Construction Battalion (NMCB) mission and the potential future tasking that will most likely be assigned to those units. An NMCB is currently organized, as shown in Figure 4.

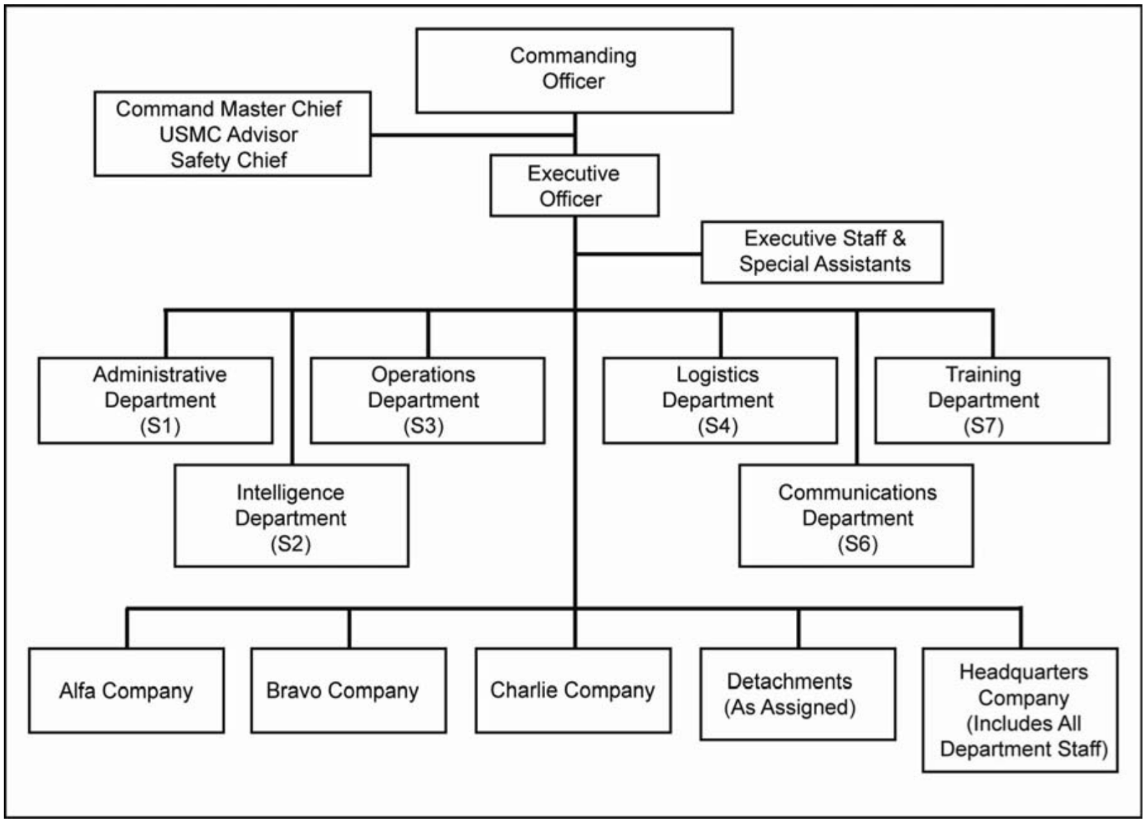

Figure 4. Doctrinal Organization of a Naval Mobile Construction Battalion. Source: Department of the Navy (2010b, p. 1-6)

As Figure 4 shows, the NMCB is administratively organized to group individual capabilities such as carpenters, electricians, equipment operators, etc. (Department of the Navy, 2010b). This organization allows for targeted training and career development with like individuals. The Alfa, Bravo, and Charlie companies contain the seven rates of Seabees divided along traditional construction trade groupings. Alfa company contains the Equipment Operators (EO) and Construction Mechanics (CM). Bravo Company contains the Construction Electricians (CE) and Utilitiesmen (UT). Charlie Company contains the Builders (BU), Steelworkers (SW), and Engineering Aides (EA).

NMCBs will reorganize into more task-tailored units to accomplish specific tasking. An example of this is how the NMCBs deploy 18–25 person Details across the Indo-Pacific theater during the NMCB's regular deployment. These Details are comprised of a mix of Seabee rates as they relate to the tasking the Detail has been given. A Detail tasked with building schools on islands in the Philippines would have a large group of BUs supplemented with lower numbers of CEs, SWs, and UTs. One or two EOs along with a CM would round out the Detail. The Detail would be under the leadership of a Lieutenant or a Senior Enlisted, such as a Senior Chief.

2. Construction Methods

The following section briefly describes the methods of construction that the NCF use to provide a baseline for the current construction capabilities. The NCF performs vertical, horizontal, and specialty construction in accordance with U.S. construction codes and does so by traditional means. Vertical construction is accomplished in several ways:

- Masonry: Concrete Masonry Units (CMU) are the primary method of masonry construction that NMCBs are capable of (Department of the Navy, 2007). CMU block buildings are built by establishing a level first course of CMU and stacking additional CMU blocks on top in a staggered fashion with grout laid in between at a constant thickness. Reinforcing steel (Rebar) is placed vertically and horizontally at set numbers of courses of CMU. The voids of the CMU block are then backfilled to further strengthen the wall. This method of construction is labor intensive and requires a large supply of CMU blocks that can have varying quality dependent upon the location. There is a direct correlation between the number of laborers and the speed of construction.

- Wood framing: Wood framing is built using dimensional lumber (i.e., 2 by 4-foot boards) fastened together, creating standard-height walls that can be enclosed with sheet lumber such as plywood or sheetrock such as drywall (Department of the Navy, 2007). This method of construction is most common in areas that do not have a high risk of flooding or moisture. The walls constructed can be easily modified to accept doorways and windows to fit many needs. Wood framing is dependent on a source of lumber and can be limited in value when building in areas of strong weather events like typhoons.

- Prefabricated Steel buildings: A more modern method of vertical construction is using steel that is prefabricated in a detached location to erect walls and roofs (Department of the Navy, 2007). The building is designed and fabricated in such a way that the builder, in the final stage, needs only to fasten together the disparate pieces to build the walls for a structure. Similar to wooden framing, the walls can be enclosed with plywood or drywall. Altering prefabricated steel walls is more difficult than altering wood as the building is designed for a specific use, and modification can cause a deficiency in materials due to the precise manufacture.

Horizontal construction is accomplished using materials including hard-packed earth, asphalt, gravel, and concrete. Additionally, the NCF has a limited capability to operate its own asphalt and concrete batch plants to support the construction of roads and foundations.

NMCBs are also capable of specialized construction tasks that include crane operations, pile-driving, quarry operations, and water-well drilling. These capabilities are constrained to small, specialized teams within a Construction Battalion and do not require an entire battalion’s effort.

3. Construction Project Management

The NCF follows NTRP 4–04.2.5 Construction Project Management (Department of the Navy, 2012) as its foundational policy for project management. The Navy publication outlines how to plan a project, including the project team, scheduling, quality control, safety, environmental, and project documentation. The methods outlined in

NTRP 4–04.2.5 are best practices that have been developed over the course of the NCF's experience in combination with civilian construction practices.

The publication is infrequently updated, as is common with most military publications. Due to the infrequency of updates, the project management principles used by the NCF are basic and do not incorporate innovations in the industry until well after their adoption by civilian construction contractors.

The NCF builds its project teams from the Alfa, Bravo, and Charlie line companies that contain the previously discussed specialized Seabee rates (Department of the Navy, 2010b). The project team is generally led by a Junior Officer as the project manager and contains the requisite number of team members commensurate with the size of the project. The project team is generally formed upon receipt of tasking from higher commands and begins their project planning and training in the time they are given before the required work begins.

Support for the project comes from the main body of the Construction Battalion. Equipment is "checked out" from Alfa Company, and supplies like tools and consumables like nails are requisitioned from the Battalion's supply department.

NMCBs are only capable of basic construction engineering. Naval Facilities Engineering Systems Command (NAVFAC) provides more in-depth engineering support to the NCF. Engineering design work is generally done outside of the NCF, and completed construction drawings and specifications are given to NMCB for their use.

The NCF has a strong culture and impressive history that has created the incredible reputation of the Seabees today. That same culture will be an obstacle to be dealt with when pursuing innovation, especially when exploring new concepts about how the Seabees operate. This inertia of an organization will factor into what path the NCF should choose.

III. CAN-DO CULTURE

Innovation can occur in almost any environment, but it happens more frequently when an organization has a culture that promotes and supports it (Siegel & Kaemmerer, 1978). Peter Drucker is commonly attributed to have said, "culture eats strategy for breakfast." This clever turn of phrase insists that no matter how prescient or clever a strategy an organization has, its culture will ultimately determine how successful it will be. In the case of the Naval Construction Force (NCF), their culture, built during many conflicts, will lay the foundation for how well they can align to exploitive or exploratory innovation strategies.

A. ORIGIN OF CAN-DO

As illustrated in the previous chapter, the NCF has built a reputation for being able to accomplish engineering support in austere and nearly impossible conditions. This ability to complete assigned tasks regardless of the external difficulties has developed a culture that Seabees would complete any mission. This culture is embodied in the phrase "CAN-DO."

The NCF contributed across every theater during WWII but its most notable contributions occurred in the Pacific theater, specifically across the island-hopping campaign of the Southwest Pacific (Navy History and Heritage Command, 2015b). The next chapter will discuss the specific unique challenges the Pacific theater presents due to the large distances involved for logistical support. During WWII, the NCF needed to utilize local materials as much as possible to complete construction projects. This led to creative methods of construction such as using skinned palm trees for lumber and blasted coral as coarse aggregate when mixing concrete.

In addition to the logistical and material challenges that the NCF faced, it also had to build under enemy fire (Navy History and Heritage Command, 2015b). Construction workers plied their trades and had their rifles by their sides ready to return fire when threatened by Japanese attacks. Combat conditions necessitate a drive to succeed that cannot be replicated in a peacetime environment. These conditions forced the men of the

NCF to be creative in their solutions to constructing the airfields, ports, and bases of the Pacific. The CAN-DO culture was built over the duration of WWII while the U.S. forces pushed across the Pacific.

Another contributor to the creation of the CAN-DO culture was the nature of the men who originally joined the NCF. To establish a construction force capable of completing the required tasks, the Navy's Civil Engineer Corps (CEC) led by ADM Ben Morrell, recruited construction workers from U.S. civilian companies and gave them basic Navy organization and combat skills. These first Seabees came to the Navy with a wealth of experience that they used to overcome the diverse challenges that they encountered. The average age of the NCF was 37 while the average age of the regular Navy sailor was 23 (Kennett, 1997). Those early Seabees showed their natural aversion to established rules as "the age range for enlistment was 18–50, but after the formation of the initial battalions, it was discovered that several men past 60 had managed to join up" (Navy History and Heritage Command, 2015b).

The CAN-DO culture, founded on the islands of the Pacific, and developed by the experience of the first Seabees, instilled a mentality that no problem was too difficult to overcome. An important aspect of this culture came about from the pre-existing skills that the first Seabees entered the Navy with. The carpenters, electricians, and steel workers had been working in their respective disciplines for decades in some cases. This baseline of experience allowed them to focus on advanced techniques and solutions to problems using situations they had seen in their previous work as reference. In this sense, the early Seabees had fully *exploited* their trades and needed to *explore* new methods of construction to advance their capabilities to meet the needs of the Navy.

B. CURRENT CONTRIBUTORS TO THE CULTURE

As an organization, the NCF prides itself on its ability to overcome unique and complex scenarios. The very nature of the current Naval Mobile Construction Battalion (NMCB) organization is built around the administrative line companies (Alfa, Bravo, and Charlie) that can be used as a manpower pool to build task-tailored units for specific tasking (it is important to note that the new NCF Force Design will update this model to create specialized companies focused on a narrow band of tasking, however). By continually reorganizing into task-tailored units, the NCF has fostered a culture that prizes flexibility, breadth of knowledge, and the ability to learn quickly. This in turn reinforces the CAN-DO culture that doesn't consider any tasking to be outside the capabilities of the NCF.

In comparison to sister service engineering organizations such as the Air Force's Red Horse and Prime Beef squadrons, the NCF is capable of a more diverse capability set (Joint Chiefs of Staff, 2016). The Air Force Red Horse and Prime Beef squadrons are highly specialized and focus their efforts on construction to support the operation of an airfield. Marine Corps Engineering Support Battalions focus on mobility and counter-mobility operations with a small focus on sustainment. Army Engineering also focuses on mobility and counter mobility and uses contracting for major sustainment. The NCF is capable of airfield repair, mobility and counter-mobility operations, sustainability construction, as well as waterside construction. The NCF provides a jack-of-all trades capability that allows commanders an operational flexibility that other engineering units cannot provide.

C. IMPORTANCE OF CULTURE IN INNOVATION

It would be an understatement to say that the culture of an organization is important to whether that organization is able to innovate. Innovation requires members of an organization to be willing to look at the current way things are done and to determine that it is worth their time to find a better way to do it. Jin et al. (2019) define an "innovation culture" as "a set of shared beliefs and risk-taking behavior which cherishes a climate of openness to innovation, a mind-set towards change and future market orientation and a willingness to take risks and learn continuously" (p. 610).

While Jin et al. and other scholars attribute an innovation culture to different aspects of an organization, I determined in the specific context of the NCF the following 3 factors seem the most important that these three factors highly contribute to a culture that fosters innovation: leadership, view of failure, and willingness to take risks.

1. Leadership

Leadership is foremost in developing an organization's culture. A culture that generates innovation will prize taking risks and is not afraid of failure. The leadership of an organization sets the goals and priorities that the organization will pursue. A leader who prioritizes innovation will create goals that stretch their members and motivate them to come up with novel ways of doing business. Leaders also are responsible for the personal development of their members, which includes pushing subordinates to self-development and an open mindset.

2. View of Failure

Another factor that contributes to a culture of innovation is the way that the organization views failure. Inherent to innovation and particularly exploration innovation, is the real possibility of failure. The way a member is treated after failing with a new idea will impact whether that member will attempt to innovate again. Other members of the organization will also see how the failure is treated and will be either more or less likely to attempt an innovation themselves depending on the outcome the witness.

3. Willingness to Take Risks

While leadership and the organizational environment may be innovation oriented, it takes individuals who have a willingness to take risks to drive innovation. While related to how failure is viewed, a willingness to take risks also includes an individual's desire to not accept the status quo. Frequently, opportunities for improvement or innovation will present themselves to individuals, and if a risk-taking culture does not exist, the individual will let the opportunity pass without acting.

D. IMPLICATIONS OF CAN-DO CULTURE

The CAN-DO culture also influences the way the NCF looks at innovation. The desire to be able to overcome any challenge and complete any task has created a desire to organize and operate with limited strictures such as doctrine and Standard Operating Procedures (SOP). While doctrine and SOPs are useful and necessary for ensuring consistency and a common understanding, they also stifle creativity and flexibility when overused. The NCF has doctrine and SOPs but uses them as a fallback reference as contrasted with an instruction manual. New ways of organizing and accomplishing tasks are implemented and executed before any change to doctrine is made. This fact is made evident by the fact that a large portion of NCF doctrine is out-of-date. Many still reference legacy units such as the Naval Construction Division (NCD) even though the NCD was decommissioned in 2013 (Cariello, 2014). Outdated doctrine cannot be considered positive, but the underlying motivation of pursuing new ways to accomplish the goals of an organization speaks to the exploratory nature of the CAN-DO culture.

Another important implication of the CAN-DO culture is the how the NCF responds to changing conditions. The NCF is capable of flexing to fit multiple taskings due to its organizational nature and willingness to find solutions to problems using ingenuity and creativity (Cariello, 2014). This aspect is of critical importance when in major combat operations (MCO). As Mike Tyson famously said: "Everyone has a plan until they get punched in the mouth," meaning that a plan can, and will, go awry once it is acted upon by an adversarial force. This fact is what makes the CAN-DO culture so important in MCO. The enemy will change the conditions under which the U.S. military must operate and will thus require units that can be flexible and adapt to those changing conditions.

E. CAN-DO CULTURE IN RELATION TO EXPLOITATION AND EXPLORATION

Exploitation can be defined as improving the competency for existing capabilities. The CAN-DO culture does not explicitly look to improve the manner and efficiency with which tasking is accomplished. The culture instead drives the mindset that if existing capabilities do not exist to accomplish the task, new capabilities need to be created to do so. This culture lends itself much more readily to exploration. Exploration is the search and development of new capabilities that did not previously exist. The CAN-DO culture predisposes the NCF to an exploration mindset. Where the NCF can fall short is knowledge management to capture new innovations and distribute that innovation to following units or across the force. This leads to a cycle of "new innovations" that are facsimiles of each other but feel like new concepts.

Effective innovation should be a byproduct that comes from a top-level strategy emphasizing exploration. Without a top-level strategy, individual units are left to develop new methods of construction without a distinguished end state or resourcing. The CAN-DO culture provides a primer for exploration but emphasizes the individual sporadic innovations without distribution to and refinement with the rest of the NCF. As this chapter illustrated the NCF is comfortable in situations when there is little consistency or direction. When determining the method for which the NCF should use to pursue innovations, the CAN-DO culture will play an important role.

IV. GENERAL REQUIREMENTS FOR THE INDOPACIFIC THEATER

To evaluate the NCF and devise a recommendation on how the organization should be structured to pursue innovation, the anticipated requirements must be defined. This chapter gives a basic overview of what the NCF will be expected to accomplish in the Pacific and in what environments. Specific locations, times, and units are not listed here for classification considerations.

A. LOCATIONS

During WWII, the Seabees used a term "Island X" to refer to the island to which they were currently deployed. They used this generic term in their correspondence with loved ones back in the United States to protect operational security at their location (Cave, 1944). In the same regard, the operational planning for potential future conflict adopts a similar generic planning mindset to prepare for a wide set of eventualities regarding locations out of which the NCF may be required to operate.

There are still specific requirements for anticipated locations in the Pacific however, including major geographic fixtures such as the Philippines and Guam. These strategic locations will be used for specific missions which could shift during an evolving conflict. In keeping with the desire to increase the dissemination of this paper, the specific locations and taskings are omitted in favor of a generic mission set kin to the "Island X" concept.

Common characteristics of anticipated environments:

- Remote—Most potential locations for Advanced Naval Bases will be separated from U.S. established basing by anywhere from 2,500 to 5,000 miles.
- Limited space—The geographic composition of the Pacific theater is comprised almost entirely of island chains. The very nature of islands

limits the amount of space that will be available for use in construction and material laydown for building materials.

- Limited host nation equipment—Most locations that are relevant to the U.S. Navy will not have readily available equipment for use by U.S. forces.
- Hot and humid climate—While the INDOPACIFIC theater includes locations as North as the Aleutian Islands, the bulk of the locations that the Seabees would have potential tasking are located at a latitude that has a high average temperature.
- Wet and Dry season considerations—A distinguishing feature of many pacific island chains is the dynamic weather change between wet and dry seasons. The daily rainfall will dramatically increase during the wet season.
- Limited natural quality lumber—One of the most common building materials is wood. On islands in the Pacific, lumber is in short supply and the amount than can be harvested has an inconsistent quality that makes it difficult to use in construction.
- Limited coarse aggregate sources—Similar to the limited land space available to the Seabees for construction, there is limited naturally occurring materials available to use as coarse aggregate in concrete.

B. FLEXIBILITY

As stated in the first chapter, the scope of this paper identifies the INDOPACIFIC theater as the benchmark for where the NCF will need to increase their capabilities to support the Naval concepts of DMO, ANB, EABO, and LOCE. According to the 2019 RAND report on Distributed Operations (Priebe et al., 2019), the Chinese military has the capability to strike land targets as far away as Guam. This Chinese capability has forced U.S. planners to design concepts that minimize the risk to forces and complicate the targeting of the enemy weapons. In the 2022 NAVPLAN CNO, Michael Gilday describes six "Force Design Imperatives" (Department of the Navy, 2022) that categorize the capabilities the Navy will need to have to meet the anticipated threat from China. One of these imperatives is "Increase Distribution" and is described as such:

> Increase Distribution: Distributing forces geographically and in all domains enables them to threaten an adversary from multiple attack axes. Smaller, lethal, and less costly platforms— including manned, unmanned, and optionally-manned—further complicate threat targeting, generate confusion, and impose dilemmas for our adversaries. (Department of the Navy, 2022, p. 8)

This focus on distributed operations creates gaps in the available basing for U.S. military forces. The concepts of ANB and EABO both require the ability to establish land bases quickly. The major distinction between ANB and EAB is that an ANB will exist outside the Weapons Engagement Zone (WEZ) while an EAB will exist inside. The EABO concept has a faster time frame for construction. The short time at one location is a key characteristic is in maintaining a "Low Signature" (Department of the Navy, 2021), emphasizing that the "Stand-in Force…carefully manage signatures at all times and especially while conducting localized movement and maneuver" (Department of the Navy, 2021, pp. 1–5). These concepts are still under evaluation and refinement and have been challenged by some in the USMC (Ho, 2020). The U.S. Navy is still pursuing solutions to support these new concepts so the NCF will remain on its current trajectory until instructed otherwise.

C. TYPES OF CONSTRUCTION

The Navy will require port facilities to rearm, repair, refuel, revive, and resupply surface and subsurface combatants. As port facilities are stationary targets, long range strikes will be able to accurately target them at will. Port Damage Repair (PDR) is a primary tasking for the NCF in the INDOPACIFIC and will require them to be able to react quickly to repair facilities after adversary strikes. The anticipated construction work required in PDR includes both round and sheet pile driving, concrete placement behind sheet pile, and bollard placement.

In addition to ports, airfields will play a key role in any MCO in the Pacific. Flow of forces into the theater will be a primary objective in the opening stages of a conflict. Airfields will also present major targets for Chinese missiles. Airfield Damage Repair (ADR) will be one of the primary tasks given to the NCF, alongside Air Force Red Horse squadrons. ADR is comprised of identifying impacts to an airfield and repairing them to withstand continued use. The methods of construction used for ADR are very reliant on heavy equipment. All the work falls into the horizontal category including pavement cutting and concrete placement.

Airfield expansion will also be required of the NCF to increase the length of runways to accommodate military aircraft at small regional airfields. The methods of construction used for airfield expansion are similar to ADR but also include placing rebar for long term reinforcement.

Once ports and airfields are operational, the NCF will be required to prepare for the inflow of operating forces by establishing basing. The initial surge will consist of building tent camps which includes clearing and grubbing, tent erection, and landward side access to roads. The NCF without any other tasking will then continually update the camp by constructing wood and masonry buildings that will withstand elements longer.

Along with the construction of tents, the NCF will be responsible for establishing utilities at these ANBs. Electrical, Water, Waste and Wastewater distribution systems will be put into place and maintained by the resident NCF forces.

D. BUILDING MATERIALS

The current plan to supply the construction projects in the Pacific call for [calls for] the NCF to bring in all the building materials that will be required or construction. These materials include lumber, cement, rebar, and coarse aggregate, common to the United States, but have varying quality throughout the Pacific.

The NCF via U.S. Transportation Command (TRANSCOM) will bring in specialized materials into the theater such as Type 3 fast-setting concrete for use in ADR. Type 3 concrete has an accelerated set time of 48 hours compared to a traditional set time of 28 days. Piling will also need to be shipped into theater to be used in PDR whether it is sheet or round piles.

The NCF has conducted limited research as to the quantity and quality of the building materials that are already located on these islands. Construction in most of the Pacific is done with masonry block. The quality of the block, however, is poor compared to that which is produced in the United States. Lumber is also extremely limited, and the lumber that is available is either difficult to work (mahogany) or does not have a consistent quality (palm).

E. TIME REQUIREMENTS

The previously discussed mission sets of PDR, ADR, and Base Construction will need to be completed as quickly as possible. Time requirements are assigned to these tasks to give Naval planners quantifiable measures for when ports, airfields, and bases will be operational.

The ADR mission set has the fastest time requirement of repairing 66 by 4-foot craters in 24 hours. This time requirement does not include the curing time of the concrete which adds more importance to the Type 3 concrete that was previously mentioned. To accomplish this feat, it is assumed that the NCF is onsite at the time of the destruction and can operate without threat of being attacked. This mission set is also tasked to the Air Force Engineering squadrons and many of the requirements and practices are derived from them.

The time requirement for PDR is six days to repair 300 linear feet of quay wall. This too, does not include the curing time for any concrete placement. The assumptions for this time requirement also assume that the NCF is onsite and there is no imminent attack from which they will need to defend.

Finally, the time requirement for a six-hundred-person tent camp is 10 days. This will be a majority of clearing the land and the manual labor of erecting the tents. A major consideration for the base construction is the utilities that will require specialized equipment and skill.

F. IMPLICATIONS FOR INNOVATION

The requirements and environment anticipated for MCO in the Pacific will require the NCF to be able to complete their assigned tasking quickly using specified methods of construction. What the requirements do not address is what will be required of the NCF after initial forces have flowed into the theater and follow-on actions are required. The nature of warfare is that the conditions are always changing and if a military unit is unable to adjust and be flexible, they run the risk of elimination. The following chapters will evaluate the potential for exploitation and exploration through the aperture of both the explicit anticipated tasking as well as the ability to flex when the need arises.

V. EXPLOITATION IN THE NCF

A. LIMITS OF EXPLOITATION

The goal of exploitation innovation is to generate greater output of current capabilities with the same or less input. A term used by Michael Porter to measure this process is “Operational Effectiveness” (Porter, 1996, p. 62). Operational effectiveness describes how well an organization can utilize fixed resources to increase their output (Porter, 1996). Similarly, exploitation seeks to refine existing capabilities to lower the input costs while increasing the output services. At the most effective end of the exploitation scale, a company can use less resources to accomplish greater services than their competitors. This form of innovation, however, has inherent limits. While emergent technologies and procedures have much room to grow and gain in efficiency, existing industries, such as construction, experience diminishing returns as companies compete to become more efficient for their buyers. Porter describes this as a “productivity frontier” (p. 62) that exists in select industries. Companies in the industry continually push this “productivity frontier” forward, but do so at decreasing pace. A Naval Mobile Construction Battalion (NMCB) is unique in that they do not have to compete with rival contractors. An NMCB is given tasking and performs it to the level required by Navy doctrine and instruction. This lack of competition creates a gap between the NMCB and civilian contractors in their capabilities.

An exploitation approach to innovation focuses on improvements to already established capabilities. To determine the naval construction forces’ (NCF) room for improvement, this chapter established a baseline using a general construction contractor. Although the construction industry contains many companies that specialize in unique ways, it also includes general contractors that perform many of the same tasks a NMCB does. To make the comparison as close as possible, all work done by the general contractor will be assumed to be done in-house without subcontracting smaller, more specialized, companies.

The first step to evaluate the exploitation potential of the NCF is to build a picture of the general construction contractor. To do this, the construction industry writ large is evaluated to determine what manner of innovation is required from a competitive general contractor to remain in business. Using the information from the industry analysis, a conclusion is made on what capabilities are required for a general contractor to remain in business. In addition to the industry evaluation, common capabilities will be attributed to the general contractor along with the efficiency with which they are able to perform them. To make an effective comparison, the evaluation of the general contractor will be done in such a way that it can easily be translated to the capabilities of an NMCB.

After the baseline of a general contractor has been developed, the next step will be to compare the general contractor to the NMCB with specific attention paid to the gaps in their shared capabilities. In addition to the shared capabilities, an evaluation and comparison will be made into what capabilities a general contractor possesses that are not replicated by an NMCB. This will then give a measure as to how much potential exists for an NMCB to grow in capability via exploitation.

B. EVALUATION OF A CIVILIAN CONSTRUCTION CONTRACTOR

1. The Construction Industry

According to Michael Porter's Five Forces, an industry can be evaluated based on five forces that can be determined to be a benefit or detriment to a firm inside that industry (Porter, 1979). The five forces that make up Porter's model are: (1) Bargaining power of Suppliers, (2) Bargaining power of Buyers, (3) Threat of New Entrants, (4) Threat of Substitute Products, and finally (5) Rivalry among Existing Competitors, as shown in Figure 5. To best compare the NCF to a civilian contractor, it is necessary to establish the forces that the contractor contends with in order to frame why a contractor makes those decisions.

Figure 5. Diagram Representing Michael Porter's Five Forces. Source: Porter (1979, p. 80).

a. *Suppliers*

The supplies used in the construction industry can be subdivided into building materials such as wood, masonry, glass, doors, and the tools and equipment used to combine those building materials into finished products. Suppliers for building materials come from local wholesalers as well as retail stores such as Home Depot or Lowe's. In large population areas these supply companies exist in great number. Additionally, the large retailers are distributed around the number of available homeowners to which they sell their goods, increasing the number of suppliers in highly populated areas. A gradient in quality of building materials exists. However, the materials found in the United States all meet a minimum threshold for quality and use in general construction. This in turn, creates a wide selection from which a construction contractor can choose from when selecting hey building material supplier.

Tools and equipment can be purchased from brand retailers as well as the same big box retailers as previously discussed. Tools and equipment are not purchased on a job-by-job basis but are instead purchased as needed as old tools and equipment wear out. In the same way there exists a gradient in quality of building materials, a gradient of tools and equipment exist. Also, similarly to building materials, tools and equipment that are sold in the United States are quality enough to allow construction contractors a wide selection to choose from.

Due to the combination of a wide selection of materials and tools from which to choose and sources from which to buy, the bargaining power of suppliers in the construction industry is low.

b. Buyers

The second force is the bargaining power of buyers that the company sells its services or products to. General construction contractors work for both private and public clients across the country. In the construction industry the buyers are referred to as owners. The owners are the entity that will own/operate the facility upon completion. Among the largest single owners are federal and local governments. Roughly twenty-six percent of all construction in the U.S. is done for public organizations with the remainder distributed amongst private organizations (Adolphus & Keller, 2022). Government contracts allow a wide range of companies to bid on projects from a level playing field.

A significant aspect to this force is whether the buyers of the good or service have major switching costs. Switching costs are defined as being the cost to buyers that result from switching from their current supplier to another. In the construction industry the most common service sold is the building of new facilities encompassing design all the way to a ribbon cutting. Due to the nature of the industry, switching from one company to another when starting a new project has little to no cost. The only consideration would be the familiarity between the owner and the construction company; otherwise, no actual cost is observed when switching from one construction company to another.

Another aspect of this force is how many owners exist in the industry. As previously noted, 26 percent of construction is funded by the public sector. The remaining 74 percent is distributed throughout the private sector among many other organizations. The largest single owner of construction services is the Federal

Government which itself is subdivided into separate executive agencies. The diffuse nature of the buyer force creates a low leverage position on behalf of the buyers.

c. Threat of New Entrants

The construction industry is heavily regulated because of the significant impact to the environment and the inherent danger of the work. High regulatory requirements in an industry decreases the accessibility for a new company to enter the industry. In addition to the high regulatory requirements, the construction industry also faces differing regulations dependent on local governments which requires permitting and compliance to the local laws. These regulatory requirements favor existing companies that have already gone through permitting and compliance from the relevant organizations. New entrants may be deterred due to these requirements.

The upfront cost of capital is high to enter the construction industry if the goal is to perform new construction (UKessays, 2018). Equipment such as backhoes and excavators can be rented but will reduce profit margins to the point that a new company cannot sustain business. In addition to the cost for equipment, insurance, bonding, and material procurement all require a large capital investment to enter the industry. This too, creates a low threat of new entrants to the industry.

d. Substitutes

There are limited substitutions to new construction that include renovations and pre-built modular structures such as converted shipping containers. For major infrastructure projects such as roads, airfields, and ports there are no ideal substitutes. The only route that buyers can pursue would require changes to their operations and organizational structure. In summary, there is low threat of substitution.

e. Rivalry Among Existing Competitors

Construction companies vary in size from multinational companies with thousands of employees to small businesses with fewer than ten. Rivalry amongst construction companies is defined by the geographic regions that the companies operate. For example, a small construction contractor located in California will not compete with a similarly sized company that does business in Virginia. This becomes less relevant as the size of the companies increase. The large multi-national companies such as The Tuner Corporation., Bechtel, and Flour all compete to win the large construction contracts over large geographic areas, and many operate worldwide.

The top 10 U.S.-based construction contractors had revenues of $91 billion in 2021 compared to the overall U.S. market space of $395.3 billion (Adolphus & Keller, 2022). The diffusion of companies to overall market size leads to increased rivalry as no one company controls the general business practices and companies resort to competing over the same contracts in a zero-sum scenario. The competition among rivals is high in the construction industry.

f. Overall Evaluation

After application of Porter's Five Forces, four can be determined to have a low, or favorable, impact on the construction industry. The only force that presents a high, or adverse, impact to the construction industry is rivalry among competitors. With this understanding, it would be easy to conclude that the construction industry provides a favorable environment for profitability. In truth, the rivalry amongst competitors drives profits down due to the competitive nature when bidding for work from owners. Porter states in his article that when competitors compete on a strictly price basis it dramatically reduces the profitability of the industry. Contributing to this dynamic is the fact that many contracts are awarded on a cost basis. There are alternative competition factors, such as best value, time to completion, and environmental impact but they tend to play a limited role in award.

This cost-centric environment leaves little room for slack. Without the room to explore new ideas, general construction companies favor exploitative innovation methods to reduce costs to outbid rival competitors.

2. General Makeup of a General Construction Contractor

a. Organization

A general construction contractor is typically organized by project. The size of the crew assigned to each project scales with the size of that project. The makeup of a crew will include general laborers who have a moderate competency in carpentry and masonry. More experienced and competent construction workers lead the production of the individual divisions of construction. Each project is assigned a project supervisor which oversees the onsite production and operations of the construction site. Additional management members on a project include a quality control manager, a safety manager, and leads for specific trades such as plumbing electricity and carpentry.

b. Business Model

General construction contractors earn revenue by completing awarded projects for owners. The typical method a construction contractor is awarded projects is through a request for proposal (RFP) or solicitation process. The RFP process involves bidding on project solicitations to win the opportunity to build the project. Most construction projects earn money after expenses have been incurred. Profit is made through a variety of award contract methods such as cost-plus fixed fee, cost-plus award fee, or firm-fixed-price. This leads construction contractors to front the capital to buy construction materials, equipment, tools, and labor, prior to receiving payment from their clients. Cash flow becomes a major consideration for general construction contractors and rely on partial completion payments from owners to continue the work. Contractors will secure loans to procure the required materials thereby operating at risk should an owner the unable or unwilling to pay (Schleifer et al., 2014).

Another business model consideration is the required bonding and insurance required of construction contractors to ensure work will be completed. Additionally, local regulations and permitting play heavily into the productivity of construction projects. These additional requirements can create work stoppages that negatively impact the cash flow. Contractors have a reduced incentive to explore innovative technologies at the risk of continuing work and maintaining a healthy cash flow. This is another reason construction contractors favor dependable exploitation over exploration.

3. General Capabilities of a General Construction Contractor

General construction contractors are capable of common methods of construction. These methods include vertical construction using materials such as wood framing, masonry, including CMU and brick, and metal framing. Horizontal construction methods include placing of concrete for foundations and roads. Within the construction industry, specialization is one strategy used. These specialized construction contractors determine a specific type of project or method of construction (waterside construction, heavy transportation, skyrise construction) that is in high demand, and they fit their company to that method to give themselves an advantage when bidding for that specialized work. A general contractor typically does not specialize to maintain the flexibility to work on straightforward projects such as building a new retail store or restaurant like Starbucks (Schleifer et al., 2014).

The time to construct a coffee shop like Starbucks takes roughly six weeks from the moment the physical work begins (Tice, 2004). A typical Starbucks is around 1,000 sqft. in size and is built can be built by a general contractor without need of specialized contractors. The construction of a Starbucks is an example of the speed with which a civilian general contractor can complete a project.

C. COMPARISON TO A CIVILIAN CONTRACTOR

1. A Quantitative Comparison

To quantitatively compare a general construction contractor to an NMCB, this chapter establishes three categories for the comparison. The first is speed of construction, or how many working days it takes for the constructor to complete a project, measured in sqft/day. The second category is the cost of the project and will be measured in $/sqft. The third will be a qualitative analysis on the complexity of work that the builder can put in place.

Table 1 lists two government construction projects with their respective cost, time to completion, and general scope of work. These projects will be used to compare the capabilities of a general construction contractor to that of an NMCB. Table 2 lists recent NCF projects that have similar major elements of construction. Both sets of projects contain one straightforward building and one Pre-Engineered Building (PEB) for comparison.

Table 1. Examples of Civilian General Contractor Projects

Project Name	Duration	Cost	Size
Command & Control Facility/Interagency Fusion Center	380 days	$451,647.31	5,500 Sqft
Multipurpose Warehouse and Maintenance Facility PEB	419 days	$1,362,741.75	38,750 Sqft

Adapted from Shen (2019b, 2019a).

Table 2. Examples of NCF Projects

Project Name	Duration	Cost	Size
Four-Room Schoolhouse	116 days (734 man-days)	$346,617.00 + $110,070.64 = $456,687.64	4,000 sqft.
Operational Vehicle & Maintenance Facility PEB	915 days (1,220 man-days)	$1,446,177.69 + $182,951.20 = $1,629,128.89	PEB 1: 3,200 sqft. PEB 2: 1,400 sqft Total: 4,600 sqft

The costs reported on NCF projects only include the material cost. To give a full cost of a project the cost of labor must be added in. To do this the crew is normalized to an average rank of E4 which has a regular military compensation salary of $38,990.13. This is divided by calendar working days (260) to give a daily wage of $149.96($38,990.13 / 260 = $149.96). The reported worked days per crew member (Man-Days) are then multiplied by that rate to receive the labor cost. Source: NMCB 5, (2022)

Using these four projects, a rough comparison can be made to the capabilities of an NMCB and general construction contractor. The Command and Control Facility and the Four-Room schoolhouse share similar methods of construction as do the Multipurpose Warehouse and Maintenance Facility and Operational Vehicle and

Maintenance Facility. These two sets of projects are compared in Tables 3 and 4 using the metrics described above.

Table 3. Comparison of Basic CMU Block Construction

Project	**Sqft. / Day**	**$ / Sqft.**	**Complexity of Work**
Command & Control Facility/Interagency Fusion Center (Contractor)	5,500 sqft. / 380 days = 14.47 sqft. /day	$451,647.31 / 5,500 sqft. = $82.12/sqft.	Basic CMU block construction and concrete placement. Full bathrooms requiring plumbing. A/C installation.
Four Room Schoolhouse (NCF)	4,000 sqft. / 116 days = 34.48 sqft. /day	$456,687.64 / 4,000 sqft. = $114.17/sqft.	Basic CMU block construction and concrete placement. Prefabricated metal trusses installed on roof. Basic Electrical.

Table 4. Comparison of PEB Construction

Project	**Sqft. / Day**	**$ / Sqft.**	**Complexity of Work**
Multipurpose Warehouse and Maintenance Facility (Contractor)	38,750 Sqft / 419 days = 92.48 sqft/day	$1,362,741.75 / 38,750 sqft. = $35.17/ sqft	Open sided PEB structure. Concrete foundation and pad placement. Basic Electrical
Operational Vehicle & Maintenance Facility (NCF)	4,600 sqft. / 915 days = 5.03 sqft/day	$1,629,128.89 / 4,600 sqft. = $354.16/sqft.	Two closed sided PEB structures. Basic Electrical.

Table 3 details the comparison between two straightforward CMU block buildings. This construction method is common in the Pacific and is demonstrative of what would be required of the NCF when constructing small buildings. Table 4 details the comparison between PEB projects. PEB projects are used for larger structures that require space for items such as heavy equipment and gear storage.

The comparison in Table 3 is deceiving regarding the speed metric of sqft/day. The NCF project was built at 34.48 sqft/day while the contractor project was built at 14.47 sqft/day. This would lead to the assertion that the NCF is more expedient in their straightforward construction. The reality is that the contractor project had a much higher degree of difficulty, including the construction of restrooms and the installation of air conditioning. The cost metric shows the NCF project costing \$114.17/sqft while the contractor project cost \$82.12/sqft. For straightforward block construction, the NCF is close to a contractor regarding speed and falls short regarding cost and complexity.

The comparison of PEB construction shown in Table 4 demonstrates the clear divide between the NCF and civilian construction contractors. The NCF PEB was constructed at 5.03 sqft/day whereas the contractor PEB was constructed at 92.48 sqft/day. There is also a great disparity of the metric of cost with the NCF PEB costing \$354.16/sqft and the contractor PEB costing \$35.17/sqft. The NCF PEB does have siding which adds to the complexity but are much smaller. The difference in capability to construct large structures clearly falls outside the normal capacity of an NMCB when compared to a general construction contractor.

2. The Biggest Gaps of an NMCB in Comparison to a General Contractor

The quantitative comparison of the previous section showed that an NMCB is less capable than a general construction contractor counterpart. The difference between the two lies in the speed and efficiency with which the two organizations complete projects. The contractor can complete more work in less time at a lower cost while being able to manage more complex projects. The contractor can do this because they focus on efficiency to win contracts which keeps them in business.

The NCF will never be able to compete with a general construction contractor in these terms as they cannot devote 100 percent of their time to becoming efficient at their trades due to additional requirements such as defensive operations. In addition to the inability to complete, the NCF is less capable the more complex a project becomes which increases the disparity between them and a contractor.

The largest gap between the NCF and general construction contractors is the experience that the individual workers possess. This experience accounts for the speed with which construction is done and allows for more complex projects to undertaken. A typical crew member on an NCF project has less than five years of experience and little of that time is spent on construction projects. A general construction contractor has crew members that range in experience but are led by foreman that have completed a journeyman program and have at least five years' experience and typically much more (*Construction Career Guide -- Specialties, Salaries, and Prospects (Updated 2022)*, n.d.). This gap in experience is the single greatest reason that the NCF is not as capable as a contractor.

D. CONCLUSION

In conclusion, experience of the workforce is the single greatest reason that the NCF lags the construction industry in capability. To address this gap, the NCF could take a master and apprentice approach to gain experience. To implement this strategy the NCF would need to bring in master tradesmen from industry as the NCF does not have the intrinsic experience currently. By hiring master tradesmen to collaborate with the battalions they would be able to exploit their current processes and become more efficient at what they do. In this way the NCF would be able to produce more with less inputs inline with an exploitation approach to innovation.

VI. EXPLORATION IN THE NCF

In the same way that the previous chapter defined what exploitation would look like in the Naval Construction Force (NCF), this chapter defines what an exploratory innovation pursuit would look like by presenting several potential, emergent construction technologies. These emergent technologies are applied in the context of the INDOPACOM requirements that were defined in Chapter IV. In addition to current emergent technology, this chapter posits paradigm-shifting ideas that would dramatically shift the way the NCF builds. Finally, an organization structure is discussed as to how the NCF can apply an exploratory innovation pursuit and implement leading edge innovations.

A. EMERGENT CONSTRUCTION TECHNOLOGY

I observe four current emergent construction technologies currently in development and initial use. A brief description of the technology will be given followed by the applicability of the technology to the current NCF INDOPACOM requirements.

1. Helical Piers

Helical piers, "also known as anchors, piles or screw piles, are deep foundation solutions used to secure new or repair existing foundations" (PierTech, n.d.). These piers are large screws that are "drilled" into the ground to a specified torque rating which creates a secure foundation on which to place a slab.

The equipment used to install the helical piers are helical drive heads attached to standard excavation equipment such as a skid steer or excavator. The NCF has both pieces of equipment in their Table of Allowance (TOA) and would therefore only need to add the helical drive heads to be able to use the helical piers.

This method of construction is relevant to the NCF because it would reduce the material requirement and footprint, thus reducing the signature presented to an adversary. Chapter IV described the possible conditions that the NCF will need to operate in. A distinguishing feature of island construction is the sandy soil. Building on loose sandy soil necessitates a robust foundation plan which requires excessive amounts of concrete and rebar. Therefore, helical piers allow the NCF to build on the sandy soil typical in their expected operating environment while also reducing the need for large foundation plans.

2. Calcium Carbonate Cement

Similarly to using helical piers to reduce the building material requirement, calcium carbonate cement uses calcium from recycled concrete and Carbon Dioxide (CO2) to replicate the "hard calcium carbonate deposits from dead organic matter" (Maruyama et al., 2021). to create a new form of concrete. This form of concrete could be used to build basic structures using recycled materials that could be found on a remote island, reducing the need to ship in those materials. Calcium carbonate cement has the additional benefit of being a net reducer of CO2, the opposite of regular Portland cement.

The NCF does not currently possess the requisite equipment to produce calcium carbonate cement. Figure 6 shows the proposed process for creating calcium carbonate cement. The process involves creating a calcium bicarbonate solution through the mixture of a calcium source, deionized water, and CO2. The calcium bicarbonate is then pumped into a mold that contains an aggregate and is heated to form the desired concrete structure.

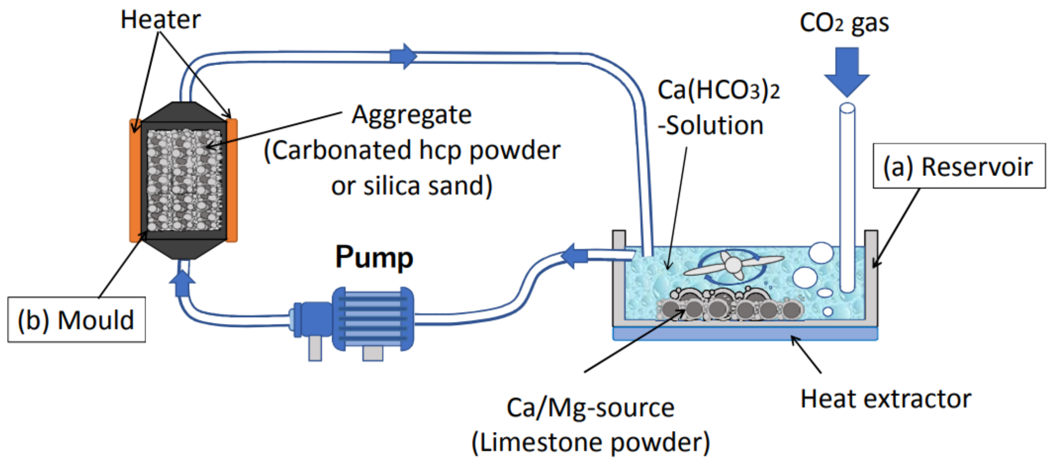

Figure 6. Diagram for the Production of Calcium Carbonate Cement. Source: Maruyama et al. (2021).

The required manufacturing process shown in Figure 6 would require a stable base of operations for production. The requirement of a stable base would limit the locations in the Indo-Pacific the NCF could deploy the solution but could be used at strategic centers where a lot of construction is anticipated.

3. Cold Formed Steel Factory

The NCF was already experimenting with the Cold-formed Steel Mobile Factory (CFSMF) as late as 2021. The concept includes a machine that is mounted on a trailer that takes rolled steel and can form it into a variety of shapes to include metal studs that are used in constructing walls and roofs. The machine can fit in a 40-foot shipping container, which allows it to be easily transported.

The benefits that this machine provides the NCF reduces the space that would be required for traditional dimensional lumber or steel studs to a more compact form of a roll of steel. An additional benefit is that steel is stronger than wood per weight and allows for more customization for in-wall utilities. Anytime manufacturing can occur at the distributed site it provides greater flexibility. With the CFSMF, the NCF would be able to quickly assemble structures and become more agile with the customization ability of the machine (Pierce, 2021).

4. 3D Printed Buildings

Additive manufacturing encompasses the process of taking medium such as plastic or metal and heating it to a flowable form and layering that medium to create desirable objects. Companies are now experimenting with industrial scale machines that use flowable concrete to build structures without the need for human labor except for monitoring the machine.

The obvious application to the NCF is that a concrete additive manufacturing machine would allow structures to be built with a minimal crew and done at an increased speed. The company Icon can print 500 sqft. homes in 24 hours (iconbuild, n.d.). With the ability to build structures with that speed, the NCF would be more agile and able to quickly establish EABO sites across an island.

B. PARADIGM SHIFTING IDEAS

The previous section discussed technologies that are currently in development and could be applied to NCF operations and dramatically increase their capabilities. This section looks further afield and postulates ideas that would be paradigm shifting innovations that would completely alter how the NCF supports the Navy and Marine Corps.

1. Tunneling

While the primary mission sets for the NCF are Airfield Damage Repair (ADR) and Port Damage Repair (PDR), base construction will still be required especially if the conflict lasts longer than several months. The structures that the NCF currently construct cannot survive missile strikes and would be at risk of destruction from an adversary. To build survivable structures, extremely thick concrete must be used, or heavy metal paneling installed to withstand missile strikes.

Additionally, the NCF could learn to tunnel underground to create subterranean structures. By going underground, the NCF would be able to put a substantial amount of earth overhead and increase the survivability of the structure. Also, tunneling would not require extensive amounts of materials by utilizing the strength of the surrounding earth to their advantage. Additionally, this method of construction would dramatically reduce the signature of the construction by placing it underground.

A major hurdle to adopt tunneling as a method of construction would be the purchase of the equipment and extensive training required to tunnel safely and efficiently. This type of dramatic change to NCF operations is one example of how the NCF could alter the way they support the Navy and Marine Corps.

2. Pontoon Redux

As mentioned in Chapter II, the NCF and Civil Engineer Corps (CEC) during WWII produced many unique and exploratory methods to accomplish their assigned tasking. One such method was the construction of the pontoons. The pontoons enabled expedient amphibious landings and were built simply out of sheet steel. These floating steel boxes were instrumental in littoral operations and provided the Navy a multitude of options to bring supplies ashore. The pontoons were eventually advanced to become the current Elevated Causeway System (ELCAS) that is used by the Amphibious Construction Battalions (ACB) as well as the Improved Navy Lighterage System (INLS) (Globalsecurity.org, 2011). These new takes on the pontoon are more robust and capable but also require more maintenance and do not exist at scale like the simple five by seven by five-foot boxes of WWII.

If the NCF, and Navy writ large, could develop an improved system of those original pontoons that could be produced at scale and transported in a compact way, the NCF could create ports at any island and move them in and out of harm’s way. This innovation would enable the distributed lethality that the Navy, Marine Corps, and Joint forces so urgently require.

C. EXPLORATORY ORGANIZATION

To pursue the aforementioned technologies or ideas, the NCF will need to commit to being an exploratory organization. To achieve this mindset, the NCF will need to organize accordingly. The models set forth by O’Reilly, Tushman, and Jensen provide a framework that the NCF can use to build an organization that prioritizes exploratory innovation. Both models feature a subunit whose primary tasking is the development of innovative ideas and concepts. This subunit must exist inside the management hierarchy but outside the strictures of the established bureaucracy to allow for an unfettered freedom of action to pursue high risk concepts without fear of failure.

The last chapter will discuss, in detail, recommended units to fulfill the role of “incubator”(Jensen, 2016, p. 17) and what “Advocacy Networks” (p. 19) will be required to enable the implementation of the these new innovations.

VII. ANALYSIS

Both approaches to innovation have been discussed and applied to the Naval Construction Force (NCF). This chapter compares these two approaches, assigning Measures of Effectiveness (MOE) as a means to evaluate exploitation and exploration innovation. A brief description will be given of the MOEs and the reason for their inclusion in this analysis.

The following MOEs will be used in this analysis:

- Relative Cost to Implement
- Impact on Current Operations
- Difficulty of Implementation
- Impact on Adaptability
- Potential Future Value

A. RELATIVE COST TO IMPLEMENT

Any operation, whether it be in business or the military, has an associated cost. The cost of an operation can be categorized several ways: cost in dollars, workforce, time, materials, etc. For this chapter, cost will be defined as the cost in dollars. As this paper is qualitative in nature, the cost will be presented in general terms such as high, medium, and low.

1. Exploitation

As discussed in Chapter V, if exploitation is pursued, the efficiency with which a general construction contractor operates is the theoretical limit for Naval Mobile Construction Battalion (NMCB). The cost to become more efficient in already established construction trades requires a commitment of time and repetitions to gain experience. This experience can only be gained while working hands on.

There are two primary methods to gain this hands-on experience: technical training in a controlled environment, or through the experience gained when working on actual construction projects. There are advantages and disadvantages to both. Technical training can be done at pre-established locations on bases and with the close observation of mentors and subject matter experts. The disadvantage of technical training is that the member in training is given straightforward work and does not need to overcome real-world challenges that they may encounter on a real jobsite, such as poor quality of materials.

Jobsite experience has the potential to provide the most beneficial experience to a member due to the nature of real-world problems and the natural motivation to overcome challenges to complete a project. The disadvantage to on-the-job training is that there can be limited oversight which could lead to an inexperienced member developing bad habits that ultimately reduces the efficiency of the overall unit.

A master and apprentice system is the most effective way to gain experience and allows new members to work alongside experts while in a real-world environment. This partnership provides the upside of both methods of gaining experience while reducing the risks of failure. The cost to implement a master and apprentice system for a general contractor is low as it is the standard in the construction industry already. The NCF does not have the luxury of employing many master craftsmen and would therefore need to bring in outside help to bring the apprentice and journeyman members up to the desired proficiency. This supplemental workforce would come at a moderate cost and would need to be maintained until there is sufficient mastery within the NCF ranks for a self-sustaining process to take over.

Cost to implement Exploitation: Medium.

2. Exploration

Whereas the cost for exploitation can be determined in a straightforward manner, the cost to implement exploration is not. More funding certainly allows more research and development to be undertaken but it does not guarantee that innovations will be made. The way the funding is spent has a greater impact on the successful outcome of the endeavor. Leadership needs to give a clear vision as to the requirements for innovation.

The greatest change for the NCF will not be the amount of money that is spent on Research, Development, Testing and Evaluation (RDT&E) but on the organization and management of the process. As discussed in Chapter VI, the NCF will need to dedicate operational forces to function as "incubators" (Jensen, 2016, p. 17) to develop and validate new ways of supporting the Navy and Marine Corps through construction. This realignment will not come at a direct cost as the "incubator" (p. 17) unit would be established with pre-existing forces. This would result in a low cost of implementation for the NCF to adopt exploration as its approach to innovation.

Cost to implement Exploration: Low

B. IMPACT ON CURRENT OPERATIONS

I outline the possible approaches to innovation that the NCF could take and makes recommendations on which approach would best position the NCF for the future. Choosing an approach to innovation inherently assumes that innovation is required, and that the status quo is not a desirable end state. Whichever path is chosen, it will necessitate changes in the NCF. Change is necessary but so too is the ability to maintain readiness until such a time that an innovative approach takes root and becomes the new normal. These changes will have varying degrees of impact on the current operations, and this MOE assesses the potential impact that would result from the respective path of innovation in terms of positive, neutral, or negative.

1. Exploitation

The nature of exploitation is that an organization continues using its current methods and practices. Innovation takes place by seeking to improve the efficiency and effectiveness of those same methods and practices. Incremental improvements will be implemented; therefore, change in direction will occur in lesser amounts and will not reflect a wholesale change in the way the organization operates.

In the case of the NCF, bringing in outside mentors would infuse current operations with talent and provide a boost to operations. This method of instruction has the benefit of not only continuing current operations but also having the potential to increase the pace and quality of the current work. For this MOE, exploitation would have a positive impact on current operations.

2. Exploration

To pursue exploratory innovations, an organization must commit resources to attempting high-risk, high-reward endeavors. When these endeavors fail, they do not add to the productivity of current operations. In addition, a truly exploratory organization will have a relatively low success rate (Hanisch, 2010), leading, conversely, to many failures and loss of momentum in current operations (He & Wong, 2004). This method of innovation favors near-term sacrifices to long-term large payoffs.

Exploration in the NCF would require the establishment of discrete subunits to function as incubators and thus remove them from current operations. This model would not convert the organization en masse but would segment portions of force. The segmented teams would focus solely on the development of new and disruptive technologies at the expense of contributing to current projects or missions. Due to the lost labor resources, current operations would be negatively impacted by pursuing an exploration innovation approach.

C. DIFFICULTY OF IMPLEMENTATION

Change is difficult. When pursuing major changes to the way an organization will allocate resources and organize for innovation, the friction and difficulty that will be faced must be taken into consideration. Typically, the more radical the change, the more difficult the change will be. The extent of how radical a change seems to an organization is relative to that organization. A radical idea for the NCF may not be radical in the world of quantum computing. With regards to comparing exploitation and exploration, this MOE will evaluate them relative to each other, employing a relative rating.

1. Exploitation

Improving an entire organization through incremental steps without creating weak links is a challenge when pursuing exploitation. If a majority of an organization's membership adopts the incremental improvements while a number of its members do not, the organization risks becoming out of synch, causing quality and communication issues that reduce the overall competence of the organization.

The NCF must apply incremental changes across the entirety of the force and across all the NMCBs. An imbalance across the NMCBs would create problems when a project is started by one battalion and finished by another. The consistency of capabilities is more difficult to control when the manner of improvement is at the individual skills level.

The NCF would face another difficulty in the availability of master tradesmen for hire for instruction either as government employees or on a contract basis. Master tradesmen require extensive experience and time to learn their trade, there is no replacement for this experience, and it creates a scarcity of these tradesman. Master tradesmen are already employed by civilian general contractors and would therefore need to be enticed to work with the NCF away from their current employment.

2. Exploration

The challenges found in exploration are not as straightforward as those in exploitation. In pursuing an exploration approach to innovation an organization will need to shift the goal orientation to future timeframes and acknowledge the near-term risks that they will assume. The NCF would require a shift in organizational priorities and a shift in the organizational culture. This change will require time and effort from top leadership to take effect and produce the environment that is required for disruptive technologies to be produced and applied.

In addition to a concerted effort to realign the culture to accept more risks, there needs to be a change in the measurement of success. The teams designated as "incubators" (Jensen, 2016, p. 17) need to be evaluated based on effort of innovation rather than whether the ideas come to fruition. This shift in evaluation needs to be globally adopted; otherwise, the NCF risks hindering any potential break-through innovations.

3. Comparison

Exploitation will require work on the procurement and hiring of master tradesmen and the quality control of the incremental improvements of these individuals. Exploration finds its difficulties in the organizational behavior and mindsets. Pursuing exploration will require less effort up-front but become more difficult as current operations experience diminished quality. Exploitation will be more difficult initially but becomes easier as practices become commonplace and the master tradesmen are incorporated.

D. IMPACT ON ADAPTABILITY

The approach the NCF will take in innovation will either increase or decrease their adaptability in the future. Adaptability is how an organization can change their current techniques and capabilities to better align to changing external conditions. This is relevant to the military because they face changing conditions constantly when engaged in Major Combat Operations (MCO). The NCF already maintains a high adaptability due to their CAN-DO culture that was discussed in Chapter III.

1. Exploitation

Refining current capabilities to allow for a greater output with similar or less input is key to exploitation. The very nature of this approach to innovation focuses on doing the same thing repeatedly and refining the process to become better. This pattern of repeated operations can have a negative impact on the ability of an organization to adapt and be flexible when conditions change.

The NCF has been tasked with their primary missions of Airfield Damage Repair (ADR) and Port Damage Repair (PDR). If all effort is given to become highly proficient to these mission sets using the existing methods, the NCF will be following the exploitation approach. The downside of hyper focus on these mission sets and the current method of construction is that the NCF will be less able to flex to an unrelated task if the need arises. Shifting a team working on ADR to build a bridge will require out-of-the-box thinking that is not required in exploiting methods for ADR. Exploitation would thus decrease the adaptability of the NCF.

2. Exploration

Producing entirely new methods of operating requires an organization that not only thinks creatively, but prizes those who do. The exploration approach to innovation inherently involves taking risks in how an organization operates. The goal of exploration is to create dramatic innovations that have the impact of completely changing the way the organization operates. This aspect of exploration creates an environment that thrives in unknown situations and can look outside normal practices and routines to create a tenable solution.

The NCF can increase the exploratory nature of the CAN-DO culture to be applied at a greater scale by adopting this approach as an organization. By doing so, the CAN-DO culture will permeate not only the individual Seabee but the way that the NCF organizes and operates. This organization wide culture will allow for greater flexibility in overcoming new and unforeseen conditions or missions. Exploration will increase the adaptability of the NCF.

E. POTENTIAL FUTURE VALUE

The final MOE that I use is: how does the chosen approach to innovation alter the trajectory of the value the NCF brings to the Navy? I define value to the Navy as the capabilities that the NCF gives to a commander to which NCF units are assigned. This value comes in terms of capability of diverse types of construction, speed of construction, and ability to operate in every environment. The approach of innovation will have an impact as to how the NCF will be constituted and what capabilities they will have in the future.

1. Exploitation

The challenge in pursuing exploitation innovation is in the principle of diminishing returns. The closer an organization gets to their practical theoretical limit, the more resources are required to increase productivity by the same amount. This concept is referenced in Porter's "What is Strategy" (1996) article that he refers to as the "productivity frontier" (p. 62). This limit is "the sum of all existing best practices at any given time" (p. 62) and describes what technological leaders are capable of in their respective industries.

It is logical for the NCF to lag behind their civilian construction counterparts. They cannot dedicate the same amount of time to improving their craft, due to requirements for defensive operations training as well as the general bureaucratic burden of administration that is encompassed in the U.S. government. This results in the NCF remaining comparatively less effective than their civilian counterparts as detailed in Chapter V.

The value that the NCF could bring to the Navy when pursuing an exploitation-based innovation approach will be concentrated on their ability to perform ADR and PDR. These critical tasks will be incredibly important to the Navy in any MCO in the Pacific. By exploiting current technologies and becoming more expedient at the tasks, the NCF would allow the opening and reopening of ports and airfields in shorter timeframes. The value this provides a commander is evident in the ability to keep supplies and forces moving into areas in which they are needed. Where this approach loses value is in the variety of construction that the NCF will be capable of and the ability to operate outside those two mission sets.

The implication here is that the NCF would be highly valuable if they are only required to perform these missions and will not be required to do anything outside that skillset. This hyper-specialization decreases the value to a commander in that they will be unable to flex to meet changing conditions that a thinking adversary would create. The determination of value largely rests with a commander, but the exploitation approach to innovation will narrow the value of the NCF.

2. Exploration

Future value, as it is defined above, will be evaluated on types of construction, speed, and flexibility. The exploration approach to innovation has the potential to excel in all those categories. Exploration has the greatest upside in comparison to exploitation.

The advent of new disruptive technologies creates paradigm shifts in how an organization can approach challenges and break through previously acknowledged limits. The key drawback to exploration is the high risk that is taken early in the process. This risk in current operations is paid for with the value that is reaped when the ideas, technologies, and practices come to fruition.

In addition to the potential that is possible in exploration, the act of exploring also engenders a culture that does not accept the status quo and pushes itself to think outside-the-box to overcome challenges as previously mentioned. The very nature of MCO is that there will be challenges that cannot be anticipated for the NCF. This attribute gives commanders a unit that can be placed in situations that have a high degree of uncertainty and a knowledge that they will overcome whatever comes their way.

F. CONCLUSION

Table 5 consolidates the outcomes of the previous sections and displays the approaches of exploitation and exploration side by side.

Table 5. Side-by-Side Comparison of Exploitation and Exploration

	Exploitation	Exploration
Relative Cost to Implement	Medium	Low
Impact on Current Operations	Positive	Negative
Difficulty of Implementation	Difficult in beginning	Difficult in midterm
Impact to Adaptability	Negative	Positive
Potential Future Value	Limited	Unlimited

Shaded cells indicate which innovation approach is clearly more advantageous to the NCF.

Finally, as Table 5 shows, an exploration approach to innovation will give the NCF the greatest advantage and capabilities in the future. The category of difficulty of implementation results in a manner of a tie as the difficulty would be similar but occur at contrasting times in the process.

VIII. CONCLUSION AND RECOMMENDATIONS

Exploitation and exploration do not need to be mutually exclusive in their pursuit, but the NCF needs to design a way to balance them to achieve the types of innovation that will be needed to meet the requirements on the NCF in the future. I demonstrated that the NCF will provide more value to the Navy if they pursue an exploratory approach to innovation. The Indo-Pacific theater will not become irrelevant in the foreseeable future. The United States must match the speed with which China is growing and innovating. The NCF must be ready to operate in environments and conditions that have not been seen since WWII and do so in ways that allow the U.S. Navy to accomplish their missions.

If the NCF chooses to pursue exploitation, they risk becoming obsolete against civilian construction companies that can refine their operations without the burden of defensive operations and government bureaucracy. The NCF should explore gaps in the capabilities of civilian contractors that they could fill via exploratory means. By presenting the U.S. Navy a general engineering force capable of unique and adaptable capabilities they would establish the value that they bring to the fight over what contracting could provide. If the NCF unwittingly attempts to re-create a general contractor it could lead the U.S. Navy to determine that the mission of the NCF could be better handled by contractors, thus eliminating the need for Seabees.

A. RECOMMENDATIONS

1. NCF Development Company

The NCF needs to organize itself to allow for more exploration than it does currently. A recommended organization is to create a Development Company that operationally falls under the 30th Naval Construction Regiment, as shown in Figure 7. This company would be led by a Lieutenant Commander and contain all Seabee rates allowing the company to be self-sufficient. The Development Company would be tasked with working with leading edge construction techniques and applying them to current and future problem sets that the NCF anticipates. Naval Special Warfare uses their

Development Group (DEVGRU) in a similar fashion. DEVGRU operates independently from the traditional teams and is tasked with "developing new equipment and tactics for the general Navy SEAL organization" (Pruitt, 2018). Designating a distinct unit that is responsible for innovations will attract the best talent from the NCF to be a part of this innovative team similar to DEVGRU.

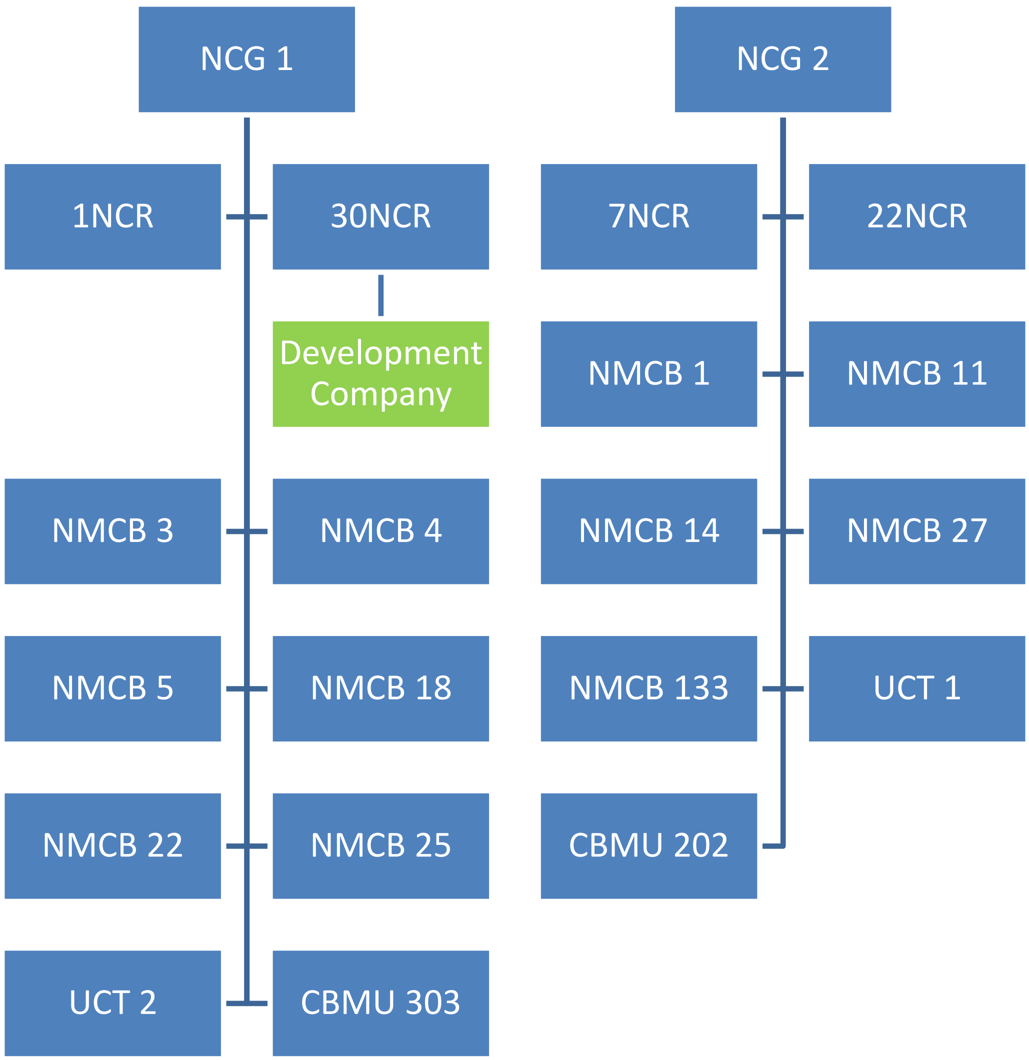

Figure 7. Updated Organization Chart Depicting the New Development Company in Green.

The measure of success for this Development Company would be the number of attempted innovative ideas and accompanying lessons learned, regardless of whether they were successful. This information would be taken by the Naval Construction Group and distributed to all the NCF. In this way the Development Company would be kin to Benjamin Jensen's (2016) framework of "incubator cells" (p. 17) and "advocacy networks" (p. 19). This framework would allow the NCF to explore new concepts and ideas and immediately put them to use to validate their effectiveness.

In support of the Development Company, NAVFAC Expeditionary Warfare Center (EXWC) would provide the technical oversight and RDT&E for the emerging concepts. These two organizations working in concert would give the NCF a path to solve tomorrow's problems before they are evident.

2. Continuation of the CAN-DO Culture

The NCF is moving away from the traditional Alfa, Bravo, and Charlie line companies in their Naval Mobile Construction Battalions (NMCB) in favor of task specialized companies to address the major taskings of Airfield Damage Repair and Port Damage Repair. This change in organization creates more proficiency in these two mission sets but has the potential to decrease the ability of NMCBs to flex to meet emergent and unforeseen threats. This reduction in adaptability runs counter to what history has shown to win wars: the side able to adjust more quickly, wins.

To counter the potential decrease in adaptability, the NCF needs to prioritize the CAN-DO culture. A method for doing this would be to cross-train their specialized companies in methods that differ from their prescribed tasking, by assigning these specialized companies projects that are outside their specialty during exercises. This would stretch the companies and require them to reach out to other adjacent units for assistance which in turn, creates a more diversified force. The goal in cross-training would not be for excellence but for the experience in having to think outside the normal boundaries that their specialty exists inside. This, in conjunction with deck plate leadership that remains faithful to the heritage that the Seabees have built over 75-plus years, will help to reduce the impact from losing adaptability via specialization.

3. Prioritization of Doctrine

As stated in Chapter II, NCF doctrine is largely out-of-date. This is due to the decommissioning of NCD and the subsequent establishment of NECC. Doctrine plays an important role in how military organizations operate; and is the cornerstone that units return to when facing new challenges and tasks. Without sound and accurate doctrine, the NCF continually re-invents new (and sometimes tried) ways of accomplishing their mission. Solidified doctrine would enable consistency and prevent wasted effort on establishing tactics, techniques, and procedures (TTP).

NECC's Expeditionary Warfare Development Center (EXWDC) is responsible for managing the NCF's doctrine. Currently one CEC Lieutenant is attached to EXWDC to manage this. Assigning an additional Lieutenant Commander to the command would help in streamlining and driving the changes that need to be made. Once the doctrine is regularly revised and updated, the NCGs can reinforce the use and adherence to the doctrine.

In conjunction with the shift to exploratory innovation, NCF doctrine should be adjusted to reflect the need for risk acceptance with the goal of paradigm shifting innovations. The Development Company would also be written into doctrine with insight to how DEVGRU is run.

B. RECOMMENDATIONS FOR FURTHER RESEARCH

Further research can be made into the emerging construction technology that was briefly detailed in Chapter V. These innovative technologies have the potential to transform the way the NCF conducts operations and would allow the U.S. Navy more capabilities in the future. In addition to research into the individual technologies, a process or system should be developed to monitor how the emergent technologies are integrating into the concept of operations that the NCF chooses to pursue. Without a method for monitoring the integration, there is a potential for wasted effort on a technology that has little value in application to the tasking of the NCF.

The precise plan as to how to man, train, and equip the Development Company should be produced to inform the budget process on what resources will be needed for the company's deployment. In concert with the effort to determine resourcing, a plan on manning and integration into the NCF should be developed to ensure that the concepts and ideas that are developed in the Development Company get pushed out to the entire NCF.

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