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Mapping and Analyzing NSW Blue Network to Leverage Insights for a Competitive World

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MAPPING AND ANALYZING NAVSPECWARCOM'S BLUE NETWORK TO LEVERAGE INSIGHTS FOR A COMPETITIVE WORLD

by

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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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I. INTRODUCTION

The National Defense Strategy (NDS) (United States Government, 2018) identifies great power competition (GPC) as the most pressing challenge for the U.S. Adversaries use all dimensions of power to challenge U.S. interests. For example, the NDS states that China is leveraging predatory economics, influence operations, and military modernization to reach its long-term goals. At the same time, Russia attempts to disrupt relations among North Atlantic Treaty Organization (NATO) partners and employs emerging technologies to subvert democratic processes in neighboring countries and elsewhere. Meanwhile, irregular warfare (IW) remains a critical component of national security and is likely to be one for the foreseeable future (United States Government, 2019). The "future operating environment" in which shifting geopolitical, socio-economic, and technological trends converge calls for Special Operations Forces (SOF), especially Naval Special Warfare Command (NAVSPECWARCOM), to continue to evolve and remain equipped to operate effectively in such an environment and address such challenges as well as many others, such as violent extremism (United States Special Operations Command (USSOCOM), 2019).

With this context in mind, this study's purpose is to examine NAVSPECWARCOM's "blue network" and evaluate its structural strengths and weaknesses, as well as provide recommendations as to how the command can improve its ability to leverage its network and draw insights from it. The "blue network" consists of personnel embedded at various private and academic institutions obtaining advanced education and connecting with private sector experts to attain knowledge and resources that benefit the force. The command's challenge, like most organizations, is assessing its network's structure empirically and efficiently leveraging insights and resources from it while attempting to balance flexibility with accountability. Because it is critical for NAVSPECWARCOM to maintain a comparative advantage with foreign adversaries in key areas, such as strategic competition, advanced technologies (e.g., artificial intelligence and robotics), and other subject-matter domains (e.g., culture awareness in key countries, foreign languages, and licit and illicit social networks), it needs to

understand itself and assess the extent to which it is acquiring knowledge and resources from experts in key domains.

Consequently, this analysis examines this topic from a social network perspective on social capital, which is about acquiring value from one's social relations (Crossley et al., 2015; Glanville & Bienenstock, 2009; Kadushin, 2012; Putnam, 2000; Robins, 2015). Existing social network literature offers useful perspectives on this problem. Several foundational studies have examined informal social networks (i.e., naturally forming networks), similar to NSW's blue network, from structural perspectives that address concepts such as social capital and brokerage (Burt, 1992, 2005; Granovetter, 1973, 1983; Kadushin, 2012; Monge & Contractor, 2003). For instance, the idea of focusing upon ties as an indication of brokerage potential first found popular application through Mark Granovetter's (1973, 1983) work on "weak ties," which found that people were more likely to find jobs through weak rather than strong ties because the former functioned as bridges that tied densely knit clusters of people together. Ron Burt (1992) later expanded Granovetter's argument. He deemphasized the type of tie and focused instead on the gaps in networks, which he calls "structural holes." Burt believes that actors whose ties span these gaps enjoy a competitive advantage over those who do not because bridging ties provide them with an opportunity to broker the flow of various resources that pass through a network. Several other scholars (Crossley et al., 2015; Van Der Gaag & Snijders, 2005) have focused on conceptualizing and measuring individuals' social capital within social networks.

Drawing on extant literature, this research analyzes the command's blue network and offers recommendations from a social network perspective. It begins with a review of existing literature on the role of "informal ties"—naturally forming ties rather than mandated, formal ones—in organizations, much like what defines NAVSPECWARCOM's blue network. The review continues by addressing social capital from a social network perspective and follows with several hypotheses about social processes—how ties form—that may underly the blue network's formation and enable information and resource sharing. Next, it outlines this paper's data, methods, and modeling procedures. Specifically, this analysis leverages questionnaires to collect network data among blue network personnel, as well as to identify the resources, skills,

and expertise to which network members have access. This analysis tests the hypotheses using exponential random graph models (ERGMs). Finally, this analysis describes the descriptive and model results, followed by a set of recommendations for NAVSPECWARCOM to consider for leveraging value from its blue network within a "future operating environment" (United States Special Operations Command (USSOCOM), 2019).

II. LITERATURE REVIEW

A. INFORMAL SOCIAL TIES

Informal social networks, defined as naturally forming social interactions among individuals, are important drivers for the flow of information and employee performance within and between organizations (Kadushin, 2012). In contrast to formal ties—mandated structures (e.g., formal hierarchy) that guide how organizations coordinate activities, processes, and functions—informal ties emerge through voluntary interactions among organization members (Biancani et al., 2014; Kadushin, 2012). Driven to complete tasks and reach strategic objectives, organizational members create informal relations that cross formal boundaries. However, the extent to which they take on these characteristics depends on the organization and context (Kadushin, 2012, p. 95). Common examples of informal relations include family, friendships, communication, advice, and trust-based relations. These are often facilitated by social clubs and activities (hunting, fitness groups), colocation such as shared office space, and shared interests and demographics (i.e., homophily) (McPherson et al., 2001). Furthermore, research suggests individuals are more likely to engage in informal ties than formal ones even though they overlap, are constrained by, and commonly serve the goals of formal organizations (Brennecke & Rank, 2016; Kadushin, 2012; McKelvey, 2002; Monge & Contractor, 2003).

While there are significant differences between types of informal ties, extant research demonstrates they play important roles in individual, group, and organizational outcomes (Kratzer et al., 2005). For example, Ron Burt's (1992) well-known work on "structural holes" suggests individuals located in certain types of brokerage positions can enhance their promotability, partially because they can control the flow of information in informal networks. Other scholars have found similar patterns in organizational mobility (Podolny & Baron, 1997), the development of informal norms and personal accountability (Eisenberg et al., 2015; Romzek et al., 2012), fostering innovation (Molina-Morales & Martinez-Fernandez, 2010; Obstfeld, 2005), and enhancing team performance (Kratzer et al., 2005), to name a few. They are thought to offer benefits to

specific types of organizations, too, such as "knowledge-intensive organizations" and "information driven organizations" (Biancani et al., 2014; Brennecke & Rank, 2016; Kadushin, 2012). Because of their prevalence, as well as their potential positive and negative influences within and between organizations (i.e., they can work against entities' goals too), leaders have tried to establish and manage informal relations in ways that generate efficiency in achieving organizational goals, such as physical colocation of diverse teams and developing knowledge management systems (Biancani et al., 2014).

Krackhardt and Hanson's (1993) early work demonstrates the importance of informal relations in strategic planning. They contend that leadership should focus on informal systems to solve organizational problems. They offer the example of a start-up computer company whose CEO felt it was losing its competitive edge and faced morale problems related to compensation. He formed a strategic committee/task force to address these challenges and initially appointed an experienced company veteran to head the task force and company-wide meetings. Unfortunately, although the task force's first few engagements generated insightful discussions, it achieved little progress toward addressing the company's challenges. However, after examining the company's trust, advice, and communication networks, the CEO realized that he had misunderstood his company's dynamics. For instance, many employees looked to the task force leader for advice on technical issues, but many did not trust him or feel comfortable working with him. Ultimately, the CEO incorporated well-trusted employees into the task force. This helped facilitate more open discussion, and over the next couple of months, the task force made significant progress in addressing the issues facing the company. While this is a single case study, Krackhardt and Hanson note successes in other contexts that have enabled leadership to identify inefficiencies, such as the absence of much needed communication ties between divisions and individuals who had acquired levels of power and control within a communication network that were far beyond what the organization had granted them.

B. SOCIAL NETWORKS AND SOCIAL CAPITAL

A common approach to map and analyze informal networks, as the CEO in the previous example did, is with social network analysis (SNA), which is a way of thinking about *social* systems that are made up of social actors (or nodes in graph theory) and the relations among them (Borgatti et al., 2013; Robins, 2015; Wasserman & Faust, 1994). This perspective places attention on social relations, namely informal ones, and assumes that social networks are locally emergent in the sense that repeated interactions of social entities generate structures in which the "whole is greater than the mere sum of its parts" (Everton, 2012; Lusher et al., 2013; Padgett & Powell, 2012; Robins, 2015). For instance, innovation and leadership are emergent properties that result from interactions among organizational members (Lichtenstein et al., 2006; Padgett & Powell, 2012). Social network researchers also assume social ties function as conduits for the flow of information and resources (i.e., the "flow model") (Valente & Vega Yon, 2020), which is partially why they often analyze social networks using visualizations and statistics to identify strengths and/or vulnerabilities in them (Borgatti & Halgin, 2011). While several foundational theories about social structure exist, many social network researchers study how social networks offer "value" and relate to outcomes at various social network "levels" (Kadushin, 2012; Monge & Contractor, 2003; Robins, 2015).

Social capital is central to the notion that social networks offer value to individuals, groups, and communities (Crossley et al., 2015; Glanville & Bienenstock, 2009; Kadushin, 2012; Putnam, 2000; Robins, 2015). Although the concept goes beyond social networks—and many definitions and types of social capital exist—it generally refers to entities investing in social relations to facilitate the achievement of their goals (Glanville & Bienenstock, 2009). In this sense, social ties are not inherently beneficial, but they can be when they offer access to numerous forms of "capital" that are. Hence, the "social" aspect of the term refers to personal relations, whereas "capital" implies something "fungible" that offers benefits. Unlike with financial capital, in which money is the sole value, the "return" on investment with social capital can take several forms, such as social support or access to new information and/or resources in competitive contexts. Yet, that does not mean that the accumulation of social capital is based solely

on an individual's, group's, or community's "wise" investment strategy. In many cases, for example, people benefit from their structural location in a social network, whereby social capital can lead to more benefits. As Kadushin (2012, p. 168) explains, "social networks are essentially unfair" in the sense that being well-connected only takes you so far in some contexts (e.g., isolated rural town in Appalachia) unless a network can offer value (e.g., many connections to Wall Street).

Building upon Bourdieu's (1986) and Coleman's (1988) foundational work on the topic, social network researchers have examined social capital from three broad perspectives: (1) structural, (2) trust and reciprocity, and (3) resources (Glanville & Bienenstock, 2009). In terms of social structure, some social network researchers often focus on macro-network characteristics that are enablers of social capital, such as density and the prevalence of structural holes and bridges. On the one hand, social cohesion benefits individuals and communities, such as social support and integration (Crossley et al., 2015; Glanville & Bienenstock, 2009; Putnam, 2000).[1] On the other, social circles that are too dense and "inward" often lack critical ties, or "bridges," often between "brokers," to other social circles that can offer access to valuable resources. The idea of focusing upon ties as an indication of brokerage potential first found popular application through Mark Granovetter's (1973, 1983) work on "weak ties," which found that people were more likely to obtain jobs through weak rather than strong ties because the former functioned as bridges that tied densely knit clusters of people together. Burt (1992) later expanded Granovetter's argument and took a more strategic and competitive approach than Granovetter. He deemphasized the type of tie and focused instead on the "gaps" in networks, which he called "structural holes." Burt believes that actors whose ties span these gaps enjoy a competitive advantage over those who do not because bridging ties provide them with an opportunity to broker the flow of various resources that pass through a network. While the notions of "weak ties" and "structural holes" have their limitations,[2] social network research generally accepts that individuals and social networks should seek to balance local, dense networks, often built upon strong ties, with

[1] This aspect is what Putnam (2000) refers to as "bonding capital," whereas "bridging capital" refers to capital acquired from ties across groups and communities (Crossley et al., 2015).
[2] For instance, "weak ties" can be hard to define and measure, whereas Burt's competitive perspective is problematic in the sense that there would be no brokers if everyone adopted a strategy to put themselves into structural holes (Kadushin, 2012).

bridging social ties into other social circles, which can offer benefits such as access to new information and resources (Borgatti & Halgin, 2011; Everton, 2012; Glanville & Bienenstock, 2009; Kadushin, 2012; Lin, 2001).

The second aspect of social capital that Glanville and Bienenstock (2009) identify, trust and reciprocity, has received moderate attention from social network researchers. Defining "reciprocity" as a norm that requires a return in kind of some good and "trust" as an expectation of goodwill and acceptance of risk or vulnerability (Glanville & Bienenstock, 2009, p. 1512), they argue that, taken together, the two concepts capture the extent to which people are willing to invest in personal relations. They contend that social capital cannot exist without some level of trust or reciprocity, although they recognize that the two could be antecedents and/or outcomes of social capital. This perspective is related to the large body of literature on network exchange theory, which postulates that one's bargaining power "is a function of the extent to which they are vulnerable to exclusion from communications and other exchanges within the network" (Monge & Contractor, 2003, p. 209). A central aspect of this research is that individuals form relations based on a cost-benefit analysis regarding their "investments" with others in a network. Scholars who take such a perspective consider different types and levels of reciprocity as precursors to varying degrees of trust. For instance, Glanville and Bienenstock (2009) describe how a simple *quid pro quo* between two people may lead to some level of trust, but exchanges involving a larger group in which individuals receive "indirect" benefits and resources may lead to greater generalized trust within communities.

The third perspective on social capital emphasizes the importance of resources that social networks can offer (Glanville & Bienenstock, 2009). The main idea is that having access to others with high levels of various resources (e.g., money, technology, and information) is advantageous. At a macro-network level, the "flow model" of social networks assumes both material and non-material goods move across networks through social actors and ties, suggesting that network characteristics (e.g., path distance, "small world" typologies, multiplexity) affect resource availability in a network. Specifically, nodes far[3] from others tend to receive resources later than more central nodes, whereas

[3] Distance is measured in terms of "steps" in a path between two nodes.

actors embedded in dense parts of a network typically receive the same items repeatedly from their highly interconnected associates. Multiple ties or flows (i.e., multiplexity) can also enhance (or inhibit in some cases) relations and build trust among connected actors (Borgatti & Halgin, 2011; Kadushin, 2012).

A related perspective focuses on social capital as a collection of resources within individuals' personal (i.e., "ego") networks, which are thought to become accessible because of the history of personal relationships (Crossley et al., 2015; Van Der Gaag & Snijders, 2005). Scholars who view social capital from this viewpoint have spent considerable time developing approaches to quantitatively capture the concept. One, for example, is what is known as a "name generator." It seeks to collect detailed information about an individual's "ego" network. It assumes that individuals located in structurally advantageous positions within their networks, such as structural holes, can access and control important resources. Another approach focuses on individuals' "indirect" access to resources through connections to people who maintain specific social positions (e.g., occupations, roles). It assumes that certain positions control relevant resources (Crossley et al., 2015) and uses a "position generator" to identify those positions (Lin, 2001; Lin & Dumin, 1986). A third approach also looks at "indirect" access to resources, but it seeks to capture associations between specific relations and resources rather than focusing on social positions. It uses a "resource generator" to survey whether individuals know others with access to key resources (or possess access themselves) (Van Der Gaag & Snijders, 2005). While these approaches highlight different perspectives on social capital, they all attempt to capture individuals' potential to acquire available resources.

C. SOCIAL CAPITAL AND MULTILEVEL NETWORKS

An important aspect of social capital pertains to one's level of analysis. Kadushin (2012) describes two levels of networks pertaining to social capital: community or groups and individual. Putnam (2000), for example, tends to focus on the macro level and argues that communities in the U.S. have experienced a decline in social capital over time as measured by various indicators of political participation, voluntary organization membership, and generalized levels of trust, to name a few (Kadushin, 2012). Similarly,

Glanville and Bienenstock (2009) claim that social capital is an emergent collective characteristic of communities, and when viewed structurally, dense macro social networks lead to greater social support among members. Others have examined social capital at an organizational level (Leana & Pil, 2006), and as previously described, scholars have also offered many insights into individual-level social capital (Burt, 1992; Crossley et al., 2015; Granovetter, 1973, 1983; Lin, 2001; Lin & Dumin, 1986; Van Der Gaag & Snijders, 2005). However, there are also micro-macro level dynamics regarding social capital. For instance, individuals with limited access to social capital but are members of "high" social capital groups or communities can benefit from them. Similarly, micro-level social capital constitutes the distribution of social capital at the macro-level, such as reciprocity and trust among individuals has implications for community-level social capital (Glanville & Bienenstock, 2009; Kadushin, 2012). All this research suggests that the analysis of social capital within informal networks requires a framework that considers several perspectives on the concept and simultaneously accounts for multiple network levels.

The notion of multilevel social networks is a perspective that permeates social network research, as well as organizational and other social systems research (Goldstein, 1999; Lazega & Snijders, 2016; Lusher et al., 2013; McKelvey, 2002; Monge & Contractor, 2003; Robins, 2015; Sawyer, 2005; Snijders et al., 2010). Because individuals are embedded in unique social environments, it is unlikely that a single theory or law explains all social network dynamics. Instead, social network research emphasizes that social structures are a consequence of various social processes—how individuals form ties—that occur among social actors (Lusher et al., 2013; Monge & Contractor, 2003; Robins, 2015; Snijders et al., 2010). Informal social ties, such as communication and friendships, form between individuals in response to social environments. For instance, a mid-level employee at an organization may offer useful information to another who has provided him with information in the past about a new technology or website related to his professional interests, thereby forming a reciprocal information-sharing relationship. Yet, dependencies involving several actors and ties may create relatively complex local structures beyond the simple pairs of individuals (i.e., dyads). In the case of the information-sharing colleagues, for example, the probability that either one golfs

with their CEO is low. However, if one of the employees establishes a personal relationship with one of the CEO's close confidants and "golf buddies," then his chances of also establishing a tie with the CEO (i.e., triadic closure) increase substantially (Lusher et al., 2013).

Consequently, social network researchers have outlined many foundational ideas about social processes at multiple network levels (Kadushin, 2012; Lusher et al., 2013; Monge & Contractor, 2003; Robins, 2015; Snijders et al., 2010). The central idea is that many local, and often nested,[4] system effects combine into a complex set of social processes that undergird social systems (Lusher et al., 2013). While many social networks, for example, exhibit underlying social processes, such as preferential attachment (Barabási, 2016),[5] many other plausible mechanisms can help researchers explain social network structures and dynamics, including social exchange, co-evolution (Choi et al., 2001; Monge & Contractor, 2003; Porter, 2006; Robins, 2015), multiplexity, social selection (i.e., homophily) (McPherson et al., 2001), and social influence (e.g., diffusion) (Valente & Vega Yon, 2020). In other words, various social processes can be at play simultaneously and occur at different network levels, a phenomenon that has become more apparent in social network research over the last two decades (Borgatti et al., 2013; Lusher et al., 2013; Robins, 2015; Snijders et al., 2010).

A useful perspective is Monge and Contractor's (2003) multitheoretical, multilevel (MTML) framework. Their framework is *multitheoretical* in the sense that it argues that researchers should draw from a variety of network theories to explain emergent social network patterns. Specifically, they argue that researchers should consider multilevel social processes, such as brokerage, reciprocity, and triadic closure, that may serve as forces driving a social network's emergence and dynamics, often simultaneously. Other relations and individual attributes can contribute to tie formation, too. Their framework is *multilevel*[6] in the sense that it enables researchers to explicitly account for mechanisms at different social network levels, including those pertaining to the actor level (e.g., brokerage), various structural levels within a network (e.g., dyad,

[4] For instance, reciprocity between two individuals can be nested inside a triad.
[5] This is a process by which well-connected individuals continue to acquire additional connections.
[6] This is not necessarily the same as "multilevel" network analysis in which researchers analyze associations between individuals and collectives, such as organizations, thereby linking together micro and macro-levels through a meso-level. See Lazega and Snijders (2016).

triad, subgroup, global), and across social networks (e.g., multiplex relations). While little existing social network research applies this framework explicitly, the domain's most widely used models, specifically exponential random graph models (ERGMs) and stochastic actor-oriented models (SAOMs), incorporate the multilevel, social network perspective and enable researchers to test several theories simultaneously (Lusher et al., 2013; Snijders et al., 2010). In fact, Lusher et al. (2013), who have offered the most extensive overview of ERGMs to date, describe how the MTML framework aligns with this model class. Taken together, the MTML framework and ERGMs facilitate the analysis of social tendencies within social networks, like NAVSPECWARCOM's blue network, and enhance assessments about how to draw value from networks.

D. MULTILEVEL HYPOTHESES: SOCIAL TENDENCIES WITH NAVSPECWARCOM'S BLUE NETWORK

Following the MTML framework, several prominent theoretical mechanisms about social capital offer direction about the type of social processes that may help drive the blue network's dynamics at the individual, dyad, triad, and other levels. Granovetter's (1973) well-known notion of a "forbidden triad" captures the role that strong ties can play in the emergence of new relations at a triad level. It suggests strong ties among two pairs of actors in a triad are likely to lead to network "closure." For instance, if employee A in a triad maintains an enduring relationship with individual B, and the latter regularly interacts with actor C, it follows that individuals A and C will end up forming a tie eventually (Everton, 2012). Put simply, individuals are likely to form ties with "a friend of a friend." This process can lead to dense, local substructures that can amplify and transmit information efficiently (Kadushin, 2012), which can be beneficial for acquiring social capital. However, from a structural perspective on social capital, such benefits may be intensified when individuals form ties with other personnel with whom they share multiple contacts; that is, when they are a "friend of *friends*." Thus, the first hypothesis that such "higher-order" closure at a cluster level in which many triangles may appear will occur within NAVSPECWARCOM's blue network (*cluster hypothesis*). Figure 1 depicts such closure.

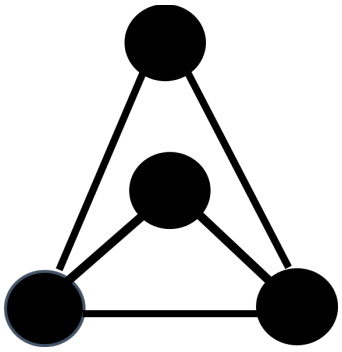


Figure 1. Cluster Hypothesis

As professionals who seek to support the command's objectives, it is highly likely that blue network personnel will seek out as many relationships as possible within the blue network. The reasons for doing so can vary and can include attempting to access new information and resources (Monge & Contractor, 2003), enhancing their promotability and mobility (Burt, 1992; Podolny & Baron, 1997), fostering innovation (Molina-Morales & Martinez-Fernandez, 2010; Obstfeld, 2005), enhancing job performance (Kratzer et al., 2005), and generating efficiency in achieving organization goals (Biancani et al., 2014). However, individuals often gravitate toward others who maintain many social ties and who may already possess high levels of attractive skills, information, and resources (Barabási, 2002, 2016; Barabási & Bonabeau, 2003; Capra, 1996; Kadushin, 2012; Robins, 2015; Root, 2020). One can expect, therefore, some form of this "preferential attachment" in the blue network in which "the rich get richer" whereby well-connected individuals, or "hubs," attract others to form ties with them (Barabási, 2016; Robins, 2015). The famous "80/20 Rule" (i.e., Pareto Principle), in which 20% of nodes maintain approximately 80% of the relations, reflects the essence behind this commonly observed process (Barabási, 2016; Capra, 1996). Therefore, the second hypothesis is that hubs will emerge in the blue network (*hubs hypothesis*). Figure 2 shows the pattern for the hubs hypothesis.

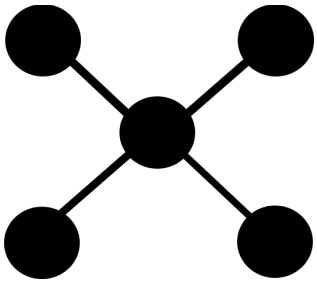


Figure 2. Hubs Hypothesis

Blue network personnel often come into close "social distances" of one another whereby only a few other members separate them from anyone else in the network, ultimately leading to a network that exhibits "small world" characteristics (Travers & Milgram, 1969; Watts, 1999, 1999, 2003).[7] While the presence of hubs can lead a network to possess such traits (Capra, 1996), another way by which individuals can increase connectivity to access information and resources is through multiplex relations. For example, personnel who wish to locate and communicate with technical experts (e.g., AI professionals) can begin by reaching out to others who attended the same graduate institution (e.g., NPS) as they did or with whom they developed close personal ties during combat deployments. When several ties (e.g., friendship and colleagues) exist between personnel, it offers the benefit of creating multiple avenues for information flows that can enhance relations and strengthen trust between the individuals, which are important factors for leveraging social capital (Borgatti & Halgin, 2011; Glanville & Bienenstock, 2009; Kadushin, 2012). Thus, the next hypothesis is that one type of relationship (e.g., colleague and personal) will tend to be entrained (i.e., coupled with) with another (*multiplexity hypothesis*). Figure 3 depicts the multiplexity hypothesis.

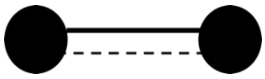


Figure 3. Multiplexity Hypothesis

[7] This is analogous to the well-known "Kevin Bacon Game." See, https://oracleofbacon.org/.

III. DATA, METHODS, AND MODELS

A. DATA COLLECTION

To investigate NAVSPECWARCOM's blue network from a social capital perspective, this analysis leveraged social network questionnaires that captured multiplex data among personnel as well as to non-NAVSPECWARCOM individuals who can offer access to resources and skills. In terms of the former, this analysis utilized a complete roster (n=85) questionnaire in which personnel were asked about their relations to other blue network members.[8] It sought information about those with whom respondents communicated about official business, which respondents considered colleagues, and with whom they had close personal ties. Personnel had three options about *communication* ties that attempted to capture the frequency they communicated with others in the blue network regarding official, NAVSPECWARCOMM business: *weekly or more*, *monthly or less*, and *no communication*. The *colleagues'* relation indicated a connection between two individuals who worked closely with each other at another institution in the past (other than current organization) or during a previous deployment, whereas *personal* relations captured individuals who associate with one another outside of work regardless of means (e.g., in-person or social media friends). All relations are treated as undirected connections due to missing data.[9] Taken together, the three relations (i.e., communication, colleagues, and personal) form NAVSPECWARCOM's blue network (aka, "aggregate network"), whereby personnel can exchange information, and potentially leverage capital injected into the network from other personnel, including resources that may originate from outside of the command, such as the private sector and academia.

This analysis administered a second questionnaire that captured data about personnel's access to non-NAVSPECWARCOM individuals (e.g., private sector and academia) who could offer capital to support the command reaching its objectives.

[8] The command provided the list of the 85 members of the network, which served as this study's "population."
[9] The response rate was 55% (47 out of 85 personnel responded to the questionnaire). Part of the challenge was contacting personnel who did not have access to their .mil accounts.

Following Van Der Gaag and Snijders (2005) work on "Resource Generators," this paper outlined sixty-seven resource items that the command thought were desirable to meet their objectives of maintaining a force that can operate effectively in the "future operating environment" (e.g., Mandarin speakers, AI professionals, and Silicon Valley) (United States Special Operations Command (USSOCOM), 2019). To supplement this list, this research drew from items reflected in several U.S. Government publications, such as SOF Operating Concept 2030 (2019), the National Defense Strategy (2018), and the National Strategy for Critical and Emerging Technology (United States Government, 2020). It is important to note that personnel were not asked to identify specific individuals outside of the command who may have access to key resources; rather, the purpose was to assess if NAVSPECWARCOM has access to key items through extant ties with "outsiders," as well as to give the command a sense of the extent to which it can meet its objectives of remaining competitive through social capital.[10] Finally, respondents were asked to indicate how often they communicated with their command (e.g., weekly, monthly, and quarterly).

B. SOCIAL NETWORK ANALYSIS (SNA) AND EXPONENTIAL RADOM GRAPH MODELS (ERGMS)

Our analysis draws on both descriptive statistics and social network models to examine how the blue network functions and formed in terms of social capital. It begins by estimating several commonly used statistics to describe the *aggregate*[11] blue network's structural characteristics, which can help illustrate global networks patterns, as well as help identify the network's potential strengths and vulnerabilities regarding the flow of information and resources. *Average degree* helps gauge the network's interconnectedness. It is calculated as the sum of ties in a network divided by the number of actors (Everton, 2012). For instance, the average degree of a friendship network

[10] This research adhered to the Naval Postgraduate School's (NPS) Institutional Review Board (IRB) protocols.
[11] The "aggregate" blue network consist of all relations captured in this analysis; that is, it is a combination of communication, colleague, and personal ties. Like individual ties, this network is treated as a non-directed, binary (i.e., a tie exists or it does not and there are no weights) network.

consisting of 100 links among 50 individuals is 2 (100/50), which indicates that, on average, each individual has two friends.[12]

For estimating network spread, we use *degree* and *betweenness centralization*, *diameter*, and *average path length*. *Centralization* is the standard measure of network spread and is based on the variation in actor centrality within the network (i.e., each actor's score is compared to the highest score). More variation yields higher scores, while less yields lower ones.[13] Many forms of centrality exist, and thus many centralization indices do too, so one must be explicit about how centralization is measured and interpreted. *Betweenness centralization* implies the distribution of brokers throughout a network, while *degree centralization* highlights whether a few individuals maintain relatively more connections than others. Both can provide context about the distribution of potential influence over the flow of information in networks (Borgatti & Halgin, 2011). *Diameter* equals the longest shortest path (geodesic) between all connected pairs of nodes, while *average path length* equals the average length of all geodesics between all connected pairs of nodes. Larger diameters and average path lengths indicate greater spread, while shorter lengths indicate relatively shorter distances between network members. Finally, *reciprocity* indicates the proportion of node pairs that share a tie also reciprocate their ties, and size equals the number of actors in a network.

While this paper offers descriptive insights into the aggregate network, it only focuses on testing hypotheses regarding social processes in NAVSPECWARCOM's *communication* network. It focuses on this network for multiple reasons. First, the communication network reflects *extant* and *regular* interactions among personnel in their *current* or *most recent* positions, whereas colleague ties were established during previous deployments/positions and thus *may* not serve as useful for understanding how to accomplish objectives today. Second, this network consists of interactions related to *official, NAVSPECWARCOM business*, whereas personal ties do not necessarily have to

[12] While average degree can be misleading when social networks are locally dense and globally sparse, it offers a useful glance into global interconnectedness.

[13] The index ranges from 0.0 to 1.0 and attempts to capture the extent to which a network is "dominated" by a single actor, several individuals, or nobody. An index of 1.0 indicates a centralized network in which a single actor scores highly in a selected centrality measure when others do not. The assumption is that relatively central individuals are likely to maintain some form of relative advantage over others. An index of 0.0 implies a decentralized network in which all actors are relatively equal in terms of their centrality scores, suggesting no single actor possesses unique structural advantages over other actors. Certainly, what it means to "dominate" a network depends on the centrality measure on which the index is calculated.

do with official business, though they could facilitate it. Nonetheless, while this analysis attempts to explain how personnel communicate currently, it will consider colleague and personal ties as potential drivers of communication tie formation (i.e., multiplexity hypothesis).

To test the hypotheses outlined above, this paper turns to ERGMs (also known as p* models) to model social processes underlying NAVSPECWARCOM's *communication* network. ERGMs offer researchers a means to examine various multilevel social processes that help give rise to a network's observed patterns at the macro level (Lusher et al., 2013; Monge & Contractor, 2003; Robins, 2015). They assume that observed social networks are built upon local patterns of ties, often called micro-configurations, that are a function of local social processes, such that "actors in the network form connections in response to other ties in their social environment" (Lusher et al., 2013, p. 1). ERGMs are analogous to logistic regression models, except they include important modifications to account for the dependencies between observations (Leifeld & Cranmer, 2018; Lusher et al., 2013).

The basic approach for estimating an ERGM is to hypothesize what social processes give rise to a particular network's global properties and then build a model that takes these and other factors into account. Local processes are operationalized in terms of the various micro-configurations found within a network (e.g., edges, stars, open and closed triads, etc.), while exogenous factors, such as gender, rank, and location, are modeled to capture various social selection processes, such as homophily or status (Lawrence & Shah, 2020; Lazarsfeld & Merton, 1954; McPherson et al., 2001). For example, analysts may hypothesize that actors who share a particular attribute are more likely to form ties with one another than those who do not; or they may test whether actors who score high in terms of a particular attribute (e.g., age or rank) are more (or less) likely to form ties than those who do not. Other social relations can serve as exogenous factors, too. For instance, two friends will likely communicate with one another. The key is to build a model that accounts for both endogenous and exogenous processes because what lies behind tie formation is not always clear.

Estimating an ERGM is essentially a two-step process. The first step is to build a model that includes a mix of micro-configurations and attributes that yield fitted

parameter values and allow the model to converge. A t-ratio for each parameter value is calculated by taking the difference between the actual count of a micro-configuration (e.g., triads) and the average count of the micro-configuration from a large sample of networks that are simulated using the parameter estimates and then dividing this difference by the simulation standard error (Lusher et al., 2013). When the absolute value of all of the t-ratios in the model are less than 0.10, the model is considered to have converged, and when a parameter's absolute value is greater than twice the size of the estimated standard error, it is considered statistically significant (Wang et al., 2013). The goal "is to find a small set of configurations which capture the properties we are interested in and which yield reasonable parameter values that converge" (Borgatti et al., 2013, p. 142). The next step is to see if the fitted parameters adequately account for the remaining micro-configurations that were not included in the model. If not, the ERGM needs to be re-estimated with a different set of parameters, and the process starts anew.

C. OPERATIONALIZING THE MODEL

This analysis focuses on reporting the results of a single model that consists of micro-configurations that reflect multilevel tendencies outlined in the hypothesis section.[14] The *edges* effect is the most basic one and controls for the tendency for ties to form. It is similar to a constant term, and it is not interpreted on its own. To test the cluster hypothesis, the model includes a geometrically weighted edgewise shared partners, or *GWESP* effect, whereby personnel who share multiple contacts ultimately communicate with one another directly (i.e., *Multiple Shared Contacts* in Table 1). The model includes a geometrically weighted degree, or *gwdegree* effect, to test the hubs hypothesis whereby the network exhibits a tendency for well-connected personnel to emerge (i.e., *Hub Formation* in Table 1). To test the multiplexity hypothesis, this analysis includes two *edgecov* effects: one for the effect of *colleagues* ties on communication ties and one for the effect of *personal* ties on communication ties. In other words, these help

[14] We ran several models but chose to report on the model with the best AIC and BIC scores. Also, this paper designed and ran ERGMs in the R package, ERGM (Handcock et al., 2021). Hence, our effects reflect their terminology for all variables.

answer if either tie affects the formation of regular communication among personnel.[15] Table 1 depicts the variables, a graphical representation of each one, related hypotheses, and an interpretation of each effect.

Endogenous Effects (Term)	Graph Representation	Hypothesis	Interpretation
Edges			The tendency for regular communication ties to form.
Multiple Shared Contacts (GWESP)		Cluster	Individuals who share multiple contacts in the communication network will communicate directly (higher-order closure).
Hub Formation (gwdegree)		Hubs	Well-connected individuals in the communication network will emerge.
Exogenous Effects			
Personal Network (edgecov)		Multiplexity	Tendency for those with personal ties to form regular communication ties.
Colleague Network (edgecov)		Multiplexity	Tendency for colleagues to form regular communication ties.
Same Gender			Tendency for individuals with same gender to establish regular communication relations.
Same Type Institution			Tendency for individuals at the same type of institution to form regular communication ties.
Same Rank			Tendency for individuals with the same rank to form regular communication ties.
Comms			Tendency for individuals who communicate with the command to the same extent (e.g., weekly, monthly, quarterly, and annually) to form regular communicate ties.
Response			Did individuals who regularly communicate respond to the questionnaire?

Table 1. Model Configurations

Finally, this analysis includes several actor covariates to control for various forms of homophily and individuals' communication activity through formal channels. The *Same Gender* covariate controls for the propensity of individuals of the same gender to communicate regularly. *Same Type Institution* controls for the role that shared institution (e.g., USN Academia, Joint Academia, Civ. Academia, Industry, and Research LNOs) has on communication patterns, whereas *Same Rank* controls for homophily based on individuals' formal Navy rank (e.g., Commander). The *Weekly Comms*, *Monthly Comms*, *Quarterly Comms*, and *Annual Comms* account for individuals' propensity to

[15] It is important to note that this analysis does not analyze longitudinal data, which means one cannot argue that one type of tie *causes* another to form, but rather there is a tendency for them to couple.

communicate with their command. Finally, *Response* controls for whether an individual responded to the questionnaires.

IV. ANALYSIS AND RESULTS

A. DESCRIPTIVE ANALYSIS – GLOBAL PATTERNS

Figure 4[16] depicts each network, and Table 2 outlines the results for the seven social network statistics. While the table reflects descriptive statistics for *each* network, this section will focus interpretation primarily on the aggregate blue network consisting of all three types of ties. Beginning with *average degree*, personnel maintain almost twelve contacts on average (avg. degree = 11.765), which means that each individual could reach out to a dozen other members of the blue network to attain information and resources. On the one hand, personnel know many others (9.341) through previous deployments/institutions (i.e., colleagues), which suggests they can utilize ties they have established in the past to pursue the command's objectives. On the other hand, network members maintain many extant contacts they can leverage for capital now (communication network's avg. degree = 7.318).

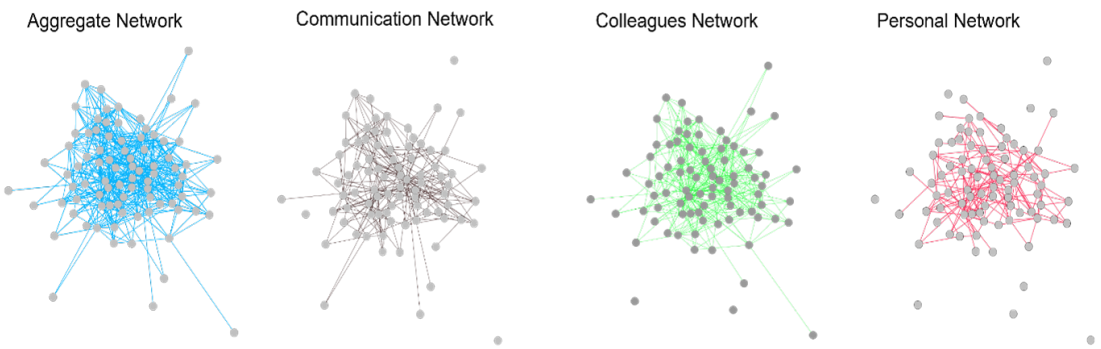


Figure 4. Visualization of Various Networks

The measures of spread offer different insights into the network. Degree centralization (0.454) suggests a handful of individuals (i.e., potential "hubs") are relatively way more connected than others and can be valuable for gathering key information and resources. In particular, the relatively high degree centralization for the communication network (0.447) suggests the command can identify and utilize a handful

[16] Note the gray nodes (n =85) represent blue network personnel.

of communication hubs. However, the aggregate and communication networks are not necessarily built around or fully dependent upon such individuals structurally or in terms of information and resources, which will be explored further and tested in the modeling results section. In terms of *betweenness centralization*, the aggregate network appears to be decentralized (0.193) and maintains many potential brokers, though the results indicate there could be some "standout" brokers who communicate regularly with others (communication network's betweenness centralization = 0.316).

Network	Size	AvgDeg.	DegCent	BetCent	Diameter	AvgPath	Reciprocity
Aggregate	85	11.765	0.454	0.193	4	2.104	0.235
Colleagues	85	9.341	0.264	0.106	4	2.254	0.137
Personal	85	3.929	0.098	0.111	7	3.316	0.105
Communication	85	7.318	0.447	0.316	5	2.357	0.305

Table 2. Network Descriptive Statistics

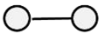
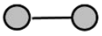
The *diameter* (4) and *average path* (2.104) length results, along with the visuals in Figure 4, suggest the aggregate blue network is relatively "tightly knit" in this sense that personnel do not have to "go far" to locate one another. In fact, the aggregate network's average path length indicates that, in most cases, personnel can contact other members of the network through a single intermediary.[17] When considered along with some of the other statistics, such that each person has approximately twelve ties on average (i.e., average degree), this is a positive trend for NAVSPECWARCOM because information and resources, at least theoretically, do not have to travel far in order to reach personnel across the network. Finally, *reciprocity* (0.235) suggests that about a quarter of all pairs in the aggregate network reciprocate and mutually consider one another as either a friend, colleague, and or communicate regularly.

[17] It is important to note that only 47 individuals responded, which suggests the network is likely even more compact that what is shown here.

B. ERGM RESULTS – COMMUNICATION PATTERNS

As described in the methods section, ERGMs enable the analysis of several multilevel factors that may underly a network's global properties, which in this case is NAVSPECWARCOM's communication network. This analysis considered endogenous—or purely structural effects—on the likelihood personnel would communicate regularly, such as those pertaining to the cluster and hubs hypotheses. To capture exogenous effects—or external factors besides the communication network itself—on the network, the model included independent variables for the role that colleagues and personal relations had on the formation of communication ties among personnel, as well as attributes to control for homophilous effects, such as same gender, rank, and institution type. Also, it accounted for network members' level of communication activity (e.g., weekly and monthly communications with command).

Table 3 depicts the model's results. Odds ratios (OR) are provided in the text for many estimates to support interpretation. At the cluster level, *the positive and statistically significant estimate (Est. = 0.557, $p<0.01$) for Multiple Shared Contacts provides support for the clustering hypothesis*. This result suggests the communication network demonstrates a tendency of clustering whereby individuals with multiple shared contacts establish direct and frequent communication. In fact, when holding all other variables constant, personnel who communicate regularly with the same blue network contacts are nearly two times (OR = 1.75) more likely to form a direct tie than those who do not share multiple contacts. When "closure" like this occurs, it offers the benefit that information and resources can transmit efficiently across a network (Kadushin, 2012).

Communication Tie Formation – NSW Blue Network			
	Representation	Communication Ties	Odds Ratio
Edges		-5.316(0.395)***	
Multiple Shared Contacts		0.557(0.118)***	1.75
Hub Formation		0.131(0.570)	
Personal Network		4.061(0.278)***	58.03
Colleague Network		3.228(0.188)***	25.23
Same Gender		-0.351(0.253)	
Same Type Institution		0.724(0.173)***	2.06
Same Rank		-0.382(0.207)*	
Weekly Comms		0.926(0.677)	
Monthly Comms		0.704(0.684)	
Quarterly Comms		0.740(0.703)	
Annual Comms		0.964(0.800)	
Response		-0.340(0.680)	
AIC		969.575	
BIC		1,049.919	

*p<0.1; **p<0.05; ***p<0.01

Table 3. ERGM Results

At the individual level, while leadership can obtain information and resources from well-connected personnel (who could serve as potential information brokers, too), the *Hub Formation* results, which is positive but statistically insignificant, indicates there is not a tendency for communication hubs to emerge. *This outcome does not provide support for the hubs hypotheses* and suggests it is *unlikely* that the blue network is dominated by a handful of individuals (Est. = 0.131). On the one hand, decentralized networks offer flexibility and adaptability when compared to centralized, hub and spoke networks. As individuals leave the network and move into other positions, the network has the benefit of maintaining most of its structural patterns and functionality. On the other hand, this form can pose challenges for coordinating efforts to meet the network's

objectives, whereby most individuals maintain well-connected and diffuse networks (Cunningham et al., 2016; Everton & Cunningham, 2015).

In terms of exogenous effects, the *Personal Network* estimate is positive and statistically significant (Est. = 4.06, p<0.01), *which provides support for the multiplexity hypothesis*. This result suggests those in relationships outside of work tend to communicate on a regular basis (i.e., weekly or monthly) about official, NAVSPECWARCOM business. In fact, when holding all other variables constant, individuals who maintain a relationship outside of work are fifty-eight times more likely to communicate about official business than those who do not (OR = 58.03). Interestingly, the *Colleague Network provides support for the multiplexity hypothesis, too*. The results (Est. = 3.22, p<0.01) suggest that personnel who worked closely with one another during a previous deployment or institution continue to communicate regularly about work-related matters. The results show that colleagues are twenty-five times (OR = 25.23) more likely to communicate than those who did not serve together in the past.

In terms of the effects of individuals' attributes on communication patterns, only the *Same Type of Institution* variable is positive and statistically significant (Est. = 0.724, p<0.01). Individuals who are deployed to the same type of institution, such as USN Academic Institutions, are twice as likely to communicate than those who are not at the same type of institution (OR = 2.06). The negative and statistically significant result for *Same Rank* (Est. = -0.382, p<0.1) indicates that individuals tend to communicate with others who are ranked differently than them in the command, whereas there is little evidence that having the *Same Gender* or similar communication patterns with the command (i.e., *Weekly Comms*, *Monthly Comms*, *Quarterly Comms*, and *Annual Comms*) affects the formation of communication ties among blue network personnel.

C. ACCESS TO RESOURCES FROM MEMBERS AND EXTERNALLY

This analysis now turns to a description of NAVSPECWARCOM's access to specific skills, knowledge, or expertise through its members and/or external individuals

from domains like the private sector and academia. [18] Based on available data, tables 4-6 depict the percentage of respondents (n=47) who claimed they have access to one of the sixty-seven items outlined in the questionnaire. The columns titled, "Acquaintance," "Colleague," "Friend," and "Yourself," indicate the nature of one's access to an item (see Appendix for definitions). For instance, sixty percent of respondents (28/47) stated they have access to an individual outside of the command who *can leverage artificial intelligence for practical use*. Of the respondents, thirty percent (16/47) said they had an *acquaintance* with such expertise. To support interpretation, the items have been placed into quartiles whereby the "Top Items" or top tier items (Table 4) are those to which the network has the greatest amount of access through non-blue network members, whereas "Second Tier Items" (Table 5) are those to which they have relatively less access (i.e., fifty percent of the items remain below this group). The final group, or "Third Tier" (Table 6), depicts the items to which NAVSPECWARCOM has the least amount of access among the items outlined in this study.

Top Items - Do you know anyone outside of NSW who...

	Item	Percent	Acquaintance	Colleague	Friend	Yourself
1	is an expert in unmanned systems, such as unmanned aerial vehicles (UAVs) and underwater drones?	64	36	40	23	13
2	you consider well-connected to Silicon Valley or another technology-focused hub that can benefit NSW?	62	36	40	34	26
3	can leverage artificial intelligence for practical use?	60	30	45	23	19
4	is an expert on artificial intelligence?	57	34	36	21	4
5	is an expert in machine learning?	57	34	38	19	2
6	is a data scientist?	57	28	43	21	13
7	has established an innovation program, project, or center?	55	26	40	17	26
8	is an acquisition professional?	55	23	34	21	4
9	is involved in research and technology development activities?	55	34	43	23	30
10	is an expert in robotics?	51	26	32	13	2
11	is an expert on AI man-machine integration?	49	23	32	13	4
12	is an expert in deep learning?	49	26	32	23	0
13	develops new analytic tools that NSW can use in the real-world?	49	23	36	17	6
14	is an expert in strategic competition, including great power competition?	49	21	32	13	0
15	provides skills and knowledge in wargaming and/or experimentation?	49	30	23	13	2
16	is an expert about underwater operations?	47	21	21	23	19
17	professionally researches ethics in decision making and warfare?	47	19	23	11	9
18	is an expert on weapons of mass destruction (WMD) or counter-proliferation (CWMD)?	47	23	34	15	2

Table 4. Top Items – NAVSPECWARCOM Access

Table 4 indicates items to which the command has the greatest amount of access through outsiders and blue network personnel, most of which are technology-based

[18] Our analysis attempted to conduct Mokken scaling analysis (Van Der Gaag & Snijders, 2005); however, it appears our response rate contributed to a data set that violated some fundamental assumptions of the approach. Hence, we limit ourselves to descriptive analysis in this paper.

resources. Nearly half of the respondents indicated they know people outside of the blue network with the following skills, knowledge, and expertise: knowledge in wargaming and/or experimentation (49%), strategic competition (e.g., GPC), analytic tool development capabilities (49%), expertise in deep learning (49%) or AI man-machine integration (49%). More than half of respondents claimed they know people with access to other key items, such as expertise in robotics (51%), involvement in research and technology development activities (55%), acquisition (55%), innovation programs and center (55%), data scientists (57%), AI and/or machine learning expertise (57%), tech hubs like Silicon Valley (62%), and expertise in unmanned systems (64%). Just as importantly, NAVSPECWARCOM has direct access to several key items via blue network personnel (i.e., "Yourself" column) who responded to the questionnaire, including research and technology development activities (30%), Silicon Valley and/or other tech-based hubs (26%), innovation programs/centers (26%), AI skills for practical purposes (19%), underwater operations (19%), data science (13%), and unmanned systems (13%), to name a few.

Table 5 indicates "Second Tier" items to which respondents have acquaintances, colleagues, or friends who can offer relevant resources and expertise, including open source data analysis (45%), violent extremist organizations (45%), emerging threats (45%), irregular warfare concepts (45%), Mandarin (43%), Chinese foreign policy (43%), CYBERCOM-related security challenges (43%), decision making and critical thinking (43%), Chinese culture (40%), and INDOPACOM-related security challenges (36%), to name a few. However, it shows the command is highly reliant on outsiders for many of these resources and lacks many "in-house" skills. For instance, less than five percent of the respondents have requisite skills and expertise in open source data analysis (2%), Mandarin (0%), Chinese foreign policy (0%), CYBERCOM-related security challenges (2%) and cyber operations (2%), Chinese culture (2%), and INDOPACOM-related security challenges (2%), as well as other topics such as maritime domain (2%), social media and security-related issues (0%), economies (0%), and Arabic (0%).

Second Tier Items - Do you know anyone outside of NSW who...

	Item	Percent	Acquaintance	Colleague	Friend	Yourself
1	is an expert in open source data analysis?	45	21	28	9	2
2	professionally researches violent extremist organizations (VEOs)?	45	19	26	13	9
3	professionally researches emerging threats?	45	19	23	13	19
4	professionally researches irregular warfare concepts and activities (e.g., UW, COIN, CT)?	45	21	30	9	13
5	is fluent in Mandarin?	43	30	11	17	0
6	is an expert on Chinese foreign policy?	43	30	13	6	0
7	can offer expertise about CYBERCOM-related security challenges?	43	21	26	15	2
8	professionally researches decision making and critical thinking?	43	17	21	4	11
9	is a cultural specialist of China?	40	26	17	13	2
10	professionally researches competition in the maritime domain?	40	23	21	15	2
11	is an expert in cyber operations through combined real-world experience and research?	40	21	30	13	2
12	knows organizations that specialize in training and education that may benefit NSW in great power competition?	40	21	23	9	26
13	is an expert in social media and security related issues (e.g., radicalization)?	38	13	19	11	2
14	is an economist?	38	17	23	15	0
15	is fluent in Arabic?	36	21	23	21	0
16	can offer expertise about CENTCOM-related security challenges?	36	21	26	17	17
17	can offer expertise about INDOPACOM-related security challenges?	36	17	23	13	2

Table 5. Second Tier Items – NAVSPECWARCOM Access

Table 6 reflects the "Third Tier" items to which NAVSPECWARCOM has relatively little access through its members (≤ 17%) or via external sources (≤ 34%). In terms of the latter, some notable items pertaining to GPC and SOF 2020 include Russian culture (32%) and language (30%), Farsi (28%), North Korean domestic politics and government (28%), Russian foreign policy (26%), North Korean foreign policy (26%), Russian domestic politics and government (23%), foreign media (e.g., Chinese media) (21%), Iranian foreign policy (21%), and Iranian domestic politics and government (19%). Other items to which the command has little access that can pertain to GPC include items such as NATO expertise (30%), Illicit finance expertise (28%), trafficking-related topics (e.g., drugs and humans) (28%), climate change and/or environmental-related security issues (e.g., water resources and conflict) (26%), and trade (21%), to name a few.

Third Tier Items - Do you know anyone outside of NSW who...						
	Item	Percent	Acquaintance	Colleague	Friend	Yourself
1	can offer expertise about AFRICOM-related security challenges?	34	13	17	9	17
2	professionally researches information operations and related activities and effects?	34	13	23	4	2
3	is a cultural specialist of Russia?	32	21	6	11	2
4	is an expert on Chinese domestic politics and government?	32	26	9	0	0
5	can offer expertise about SOUTHCOM-related security challenges?	32	13	19	11	9
6	is an expert on technologies that avoid detection and disruption of networks?	32	11	26	9	4
7	is fluent in Russian?	30	19	9	11	2
8	is an expert on NATO?	30	13	13	9	0
9	can offer expertise about EUCOM-related security challenges?	30	15	19	9	4
10	is an expert in vocal recognition and/or natural language processing (NLP)?	28	17	15	11	2
11	is an expert on additive manufacturing?	28	11	17	11	0
12	is fluent in Farsi?	28	15	11	13	0
13	professionally researches complexity sciences?	28	6	17	4	2
14	is an expert on North Korean domestic politics and government?	28	19	6	6	0
15	is a expert on disease or epidemiology?	28	9	17	9	2
16	is an expert on illicit finance?	28	11	9	19	0
17	is an expert on trafficking related issues (e.g., drugs and human)?	28	9	17	23	2
18	is an expert on national infrastructure	26	13	13	6	4
19	is an expert on Russian foreign policy?	26	17	6	6	0
20	is an expert on North Korean foreign policy?	26	17	6	6	0
21	is an expert on climate change and/or environmental related security issues (e.g., water resources and conflict)?	26	15	4	17	2
22	is an expert on biometric and digital signature tracking?	23	13	15	9	2
23	is an expert on Russian domestic politics and government?	23	19	4	4	0
24	is a cognitive psychologist who specializes in foreign relations or national security issues?	21	6	11	6	0
25	is an expert on foreign media (e.g., Chinese media)?	21	13	11	6	0
26	is an expert on Iranian foreign policy?	21	6	15	4	0
27	can offer expertise about SPACECOM-related security challenges?	21	9	13	4	2
28	offers support in the preservation of force and family?	21	11	9	9	9
29	is an trade expert?	21	15	4	4	0
30	is an expert on Iranian domestic politics and government?	19	6	13	2	0
31	is an expert on immigration and migration issues?	17	6	4	13	0
32	is an expert on radicalization?	17	15	13	6	0

Table 6. Third Tier Items – NAVSPECWARCOM Access

In summary, the areas in which NAVSPECWARCOM is in its most advantageous position[19] to leverage capital through its network's members and via external contacts are the following:

- Research and technology development activities.
- Silicon Valley or other technology-focused hubs.
- Innovation programs, projects, and centers.
- Artificial intelligence for practical use.
- Underwater operations.
- Unmanned systems (e.g., UAVs).
- Data science.

[19] Items were selected if ≥10% of respondents considered themselves to be experts *and* if they were "top tier" items in terms of access via non-NAVSPECWARCOM individuals.

However, the areas in which the command is in its most disadvantageous position[20] in which it lacks *both* internal and external access to items are the following:

- Foreign media (e.g., Chinese media).
- China (domestic politics and government).
- Russia (language and culture, domestic politics and government, and foreign policy).
- North Korea (domestic politics and government, and foreign policy).
- Iran (Farsi, domestic politics and government, and foreign policy).
- Trade.
- Complexity Sciences.
- Natural Language Processing (NLP).
- Information Operations.
- SPACECOM-related security challenges.
- Biometrics and digital signature tracking.
- Additive manufacturing.
- Cognitive psychology with emphasis on foreign relations or national security issues.
- Potential convergence issues (NATO, climate change/environmental-related conflict, illicit finance, epidemiology, trafficking, immigration/migration, and radicalization).

[20] These are items to which few (2%) or no respondents claimed they could provide *and* they fell into the "third tier" category.

V. DISCUSSION

NAVSPECWARCOM's blue network consists of multiple relations among its personnel, as well as connects with external networks, such as those in the private sector and academia. Consequently, this analysis considered how the network formed and the extent to which it leverages inputs from the "outside," which, in the case of social capital, are resources, skills, and knowledge that can help it meet its objective of preparing for future operating environments. To the extent that it could capture pertinent data, this study combined three approaches to social capital to assess NAVSPECWARCOM's blue network. It applied descriptive SNA statistics to describe the aggregate structure (i.e., communication, colleague, and personal ties), as well as leveraged ERGMs to test hypotheses about communication patterns among personnel. Finally, it identified the resources, skills, and knowledge to which blue network personnel can gain access on behalf of the command.

In terms of underlying social patterns among personnel, this paper's modeling approach produced several useful insights. One is that personnel tend to form communication clusters that can permit information and resources to transmit efficiently across them, especially in a decentralized form. The results indicated that hubs do not dominate the network, which suggests the command can rely on *many* individuals to gain access to capital within the structure rather than depend on a few well-connected individuals. In general, it appears that personnel are well-connected with many other blue network members with whom they can share information and resources. However, only 79% of the respondents communicate with their command on a weekly or monthly basis, which indicates that while capital *could* flow among personnel in an informal manner, it may not always reach the command level in a formal, systematic way.

Additionally, this analysis found that both personal and colleague relations substantially contribute to regular communication patterns among personnel. As extant literature demonstrates, understanding informal relations like these can offer valuable insight into an organization and its ability to acquire capital (Eisenberg et al., 2015; Krackhardt & Hanson, 1993; Kratzer et al., 2005; Molina-Morales & Martinez-Fernandez, 2010; Obstfeld, 2005; Romzek et al., 2012). While it is possible that

NAVSPECWARCOM collects and stores information about who served with whom (i.e., colleagues), it is likely unaware of the role that personal ties, which can include friendships that take place outside of official business, play in the formation of communication interactions that it can leverage for capital and meet its objectives. Similarly, this analysis found that being co-located at the same type of institution can improve the chances that individuals will communicate.

While the blue network may possess advantageous structural properties, the type of capital to which it may have access varies depending on the topic. Based on the available data, the blue network is relatively strong in areas pertaining to technology-based activities, such as innovation, AI, unmanned systems, and access to technology hubs like Silicon Valley. Even if individuals are located within the same clusters of the social network, its interconnected and compact structure (i.e., short average path lengths) should permit the command to locate individuals easily in order to leverage such capital. However, the blue network lacks potential access to capital in many key substantive areas pertaining to GPC for which it should account in the future, including issues pertaining to shifting geopolitical, socio-economic (e.g., instability and shifting demographics), and technological (e.g., biometrics) trends, as well as the convergence of "future trends" (e.g., extremism, nation-states, changing battlefield) (Mattis, 2018; United States Special Operations Command (USSOCOM), 2019).

VI. RECOMMENDATIONS

Based on these findings, the analysis concludes with several recommendations for the command to consider as they see fit. These recommendations can be placed within two main categories: namely, *practices* and *information collection and storage procedures*.

A. PRACTICES

Maintain entrepreneurial mentality but improve formal communication: The informal network must serve the formal structure. The informal, blue network is well-connected, in part, because network members maintain an entrepreneurial mentality, which is reflected in the type of resources to which the command has the greatest access as well (i.e., technology-based resources). This pattern is a positive for the command; however, the command should consider improving *formal* reporting practices that transmit information pertaining to expertise and resources back to the command more systematically, such as more frequent SITREPS from personnel stationed at each institution (e.g., NPS). A key aspect of this is addressing how the command can connect with personnel when they are located at an affiliated institution Specifically, many personnel do not have access to their ".mil" accounts at certain institutions, therefore making communication with the command substantially more difficult.

Facilitate the creation of "short-cuts" among institutions: Much like Granovetter's (1973, 1983) notion of "weak ties" that connect otherwise disparate social circles, NAVSPECWARCOM should enable personnel to connect institutions (e.g., USN Academic and Industry) working on similar topics and potential areas of convergence. Many military-aligned academic institutions, for example, are looking for opportunities to collaborate on research projects and publications but do not know how or have the means to approach one another. NAVSPECWARCOM's personnel can foster these relations through extant blue network connections among personnel located at various institutions, which can help guide research toward topics relevant to the "future operating

environment," potentially produce returns on such research, and broaden the blue network's knowledge base. The command can utilize in-person relations, working groups, and symposia, as well as take advantage of the COVID-19 environment in which teleconferences have become more frequent and accepted (e.g., Zoom).

Task personnel to target gaps and specific resources: The command should assess and validate what it considers foundational resources and expertise to which it requires access. The data provided by this study's questionnaires is a useful place to start in its efforts to direct personnel to fill key resource and expertise gaps, many of which pertain to GPC and other substantive areas. Specifically, leadership can utilize extant network data to understand informal ties among personnel, as well as guide personnel to seek out resources, knowledge, and skills based on their current network positions.

Establish contacts <u>now</u> in key areas: While "trust" ties can enhance one's access to social capital (Glanville & Bienenstock, 2009; Krackhardt & Hanson, 1993), the formation of strong relations with "outsiders" may take longer than the duration of an individual's deployment at an institution (e.g., eighteen months at NPS). One response is to formalize transition processes (i.e., "hand-offs" among personnel) at each institution, preventing incoming personnel from having to learn about the institution, program, and/or subject matter experts from scratch. For instance, the command can assign students leaving NPS to incoming personnel and exchange information with them in a more formal manner.

B. INFORMATION COLLECTION AND STORAGE

Collect Blue Network and Resource Data: NAVSPECWARCOM should consider systematically collecting information about relationships among blue network personnel and their external contacts, much like it did for this study. Some data is relatively straightforward to capture, such as communication ties and personnel who worked closely at previous deployments (e.g., colleagues), whereas other data is a bit more intrusive and may have to be voluntary (e.g., personal ties). While this analysis leveraged

questionnaires, the command could consider analyzing email exchanges (i.e., not content but who emails whom) to understand regular communication among personnel. Regardless of the approach, it is important to consider multiple types of relations because some ties, like "personal" and "colleagues" in this study, may help explain the formation of others (e.g., communication). By collecting both network and resource data regularly, the command can understand more effectively its informal blue network and its ability to acquire capital even as personnel move from one position to another.

Leverage information system for storage: Capturing these data requires that the command store and manage them somewhere, too. The command might consider utilizing a database to structure and store data in an accessible and searchable manner. While it is beyond this paper's scope to recommend a specific system, the data can include blue network members' external contacts and their expertise (e.g., business cards of those in AI), as well as information about the blue network itself (e.g., colleagues). This approach can benefit the command further if taken in conjunction with improving formal reporting processes from personnel, such as establishing more frequent SITREPs protocols from individuals at each institution and addressing challenges posed by ".mil" access.

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APPENDIX A: QUESTIONNAIRE

A. INTRODUCTION

This appendix provides the information outlined in the questionnaires that attempted to capture network data among personnel identified by the command as “blue network” members, as well as resources to which they have access via individuals outside of the network (e.g., academia and private industry). The questionnaires were built in Excel and are not all elements are depicted here. This appendix is simply designed to give readers a sense of the items sought for this analysis.

B. BACKGROUND AND INSTRUCTIONS

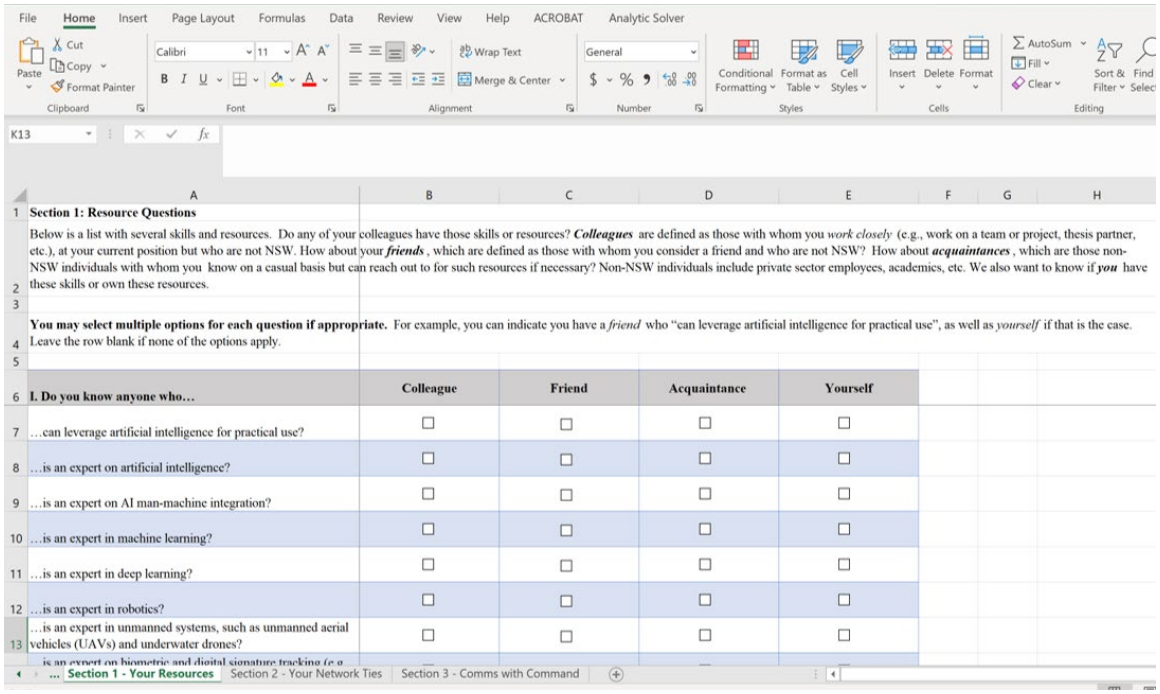
This questionnaire’s purpose is to map and support NAVSPECWARCOM’s ability to understand NSW’s “Blue Network,” which is comprised of personnel serving in positions across the private sector, attending graduate degree programs, and representing NSW at other CONUS-based institutions. The goal is to examine the network and its access to resources from a macro-perspective, not to critique your personal network. It should take you approximately 15-20 minutes to complete

The first section ("Your Resources") contains questions pertaining to your access to skills and resources outside of NSW that may benefit NAVSPECWARCOM and inform decision-making about how best to leverage the network to maintain a competitive edge with global adversaries. Section two’s (i.e., "Your Network Ties") items concern your connections with other NSW personnel who make up the “Blue Network.” Finally, section three (i.e., "Comms with Command") asks you how often you communicate with your command while deployed to your current position.

Please fill out all three sections of this questionnaire, save this workbook, and return it to the email provided to you. We ask that you save your file in its current format and title it with the following format, "NAVSPECWARCOM_Last Name_First." Be sure to double-check that you saved your responses properly before submitting.

C. YOUR RESOURCES

Below is a list with several skills and resources. Do any of your colleagues have those skills or resources? ***Colleagues*** are defined as those with whom you *work closely* (e.g., work on a team or project, thesis partner, etc.), at your current position but who are not NSW. How about your ***friends***, which are defined as those with whom you consider a friend and who are not NSW? How about ***acquaintances***, which are those non-NSW individuals with whom you know on a casual basis but can reach out to for such resources if necessary? Non-NSW individuals include private sector employees, academics, etc. We also want to know if ***you*** have these skills or own these resources. **You may select multiple options for each question if appropriate.** For example, you can indicate you have a *friend* who "can leverage artificial intelligence for practical use", as well as *yourself* if that is the case. Leave the row blank if none of the options apply.



Section 1: Resource Questions

Below is a list with several skills and resources. Do any of your colleagues have those skills or resources? ***Colleagues*** are defined as those with whom you *work closely* (e.g., work on a team or project, thesis partner, etc.), at your current position but who are not NSW. How about your ***friends***, which are defined as those with whom you consider a friend and who are not NSW? How about ***acquaintances***, which are those non-NSW individuals with whom you know on a casual basis but can reach out to for such resources if necessary? Non-NSW individuals include private sector employees, academics, etc. We also want to know if ***you*** have these skills or own these resources.

You may select multiple options for each question if appropriate. For example, you can indicate you have a *friend* who "can leverage artificial intelligence for practical use", as well as *yourself* if that is the case. Leave the row blank if none of the options apply.

I. Do you know anyone who…	Colleague	Friend	Acquaintance	Yourself
…can leverage artificial intelligence for practical use?	☐	☐	☐	☐
…is an expert on artificial intelligence?	☐	☐	☐	☐
…is an expert on AI man-machine integration?	☐	☐	☐	☐
…is an expert in machine learning?	☐	☐	☐	☐
…is an expert in deep learning?	☐	☐	☐	☐
…is an expert in robotics?	☐	☐	☐	☐
…is an expert in unmanned systems, such as unmanned aerial vehicles (UAVs) and underwater drones?	☐	☐	☐	☐

Figure 5. Questionnaire Section 1: Your Resources

D. YOUR NETWORK TIES

How often do you communicate with each person via phone, email, social media, in-person, or otherwise for ***work-related purposes***? If you communicate with one of the following individuals nearly every week, then select the option under the *"Weekly"* column. If you communicate with one of the following people on a monthly, quarterly, or annual basis, then select the *"Monthly or Less"* option. If you do not communicate with an individual in your current position, then select the *"I don't communicate with this person"* option.

We are interested in other ***personal relationships*** too. If you have worked closely with an individual below at another institution or during a previous deployment, please select the *"Colleague"* option. If you associate with the person outside of work (e.g. friend) regardless of means (e.g., in-person or via social media), please select the *"Personal"* option.

You may select multiple options if appropriate. For example, you may communicate with an individual weekly as well as maintain a personal relationship with that person. Another example is when you don't communicate with an individual anymore but you've worked with them in the past (i.e., colleague).[21]

E. COMMUNICATION WITH COMMAND

In your current position, how often do you communicate with your command via phone, email, social media, in-person, or otherwise for ***official, work-related*** matters?

[21] The section of the questionnaire is not depicted to avoid showing personnel's names.

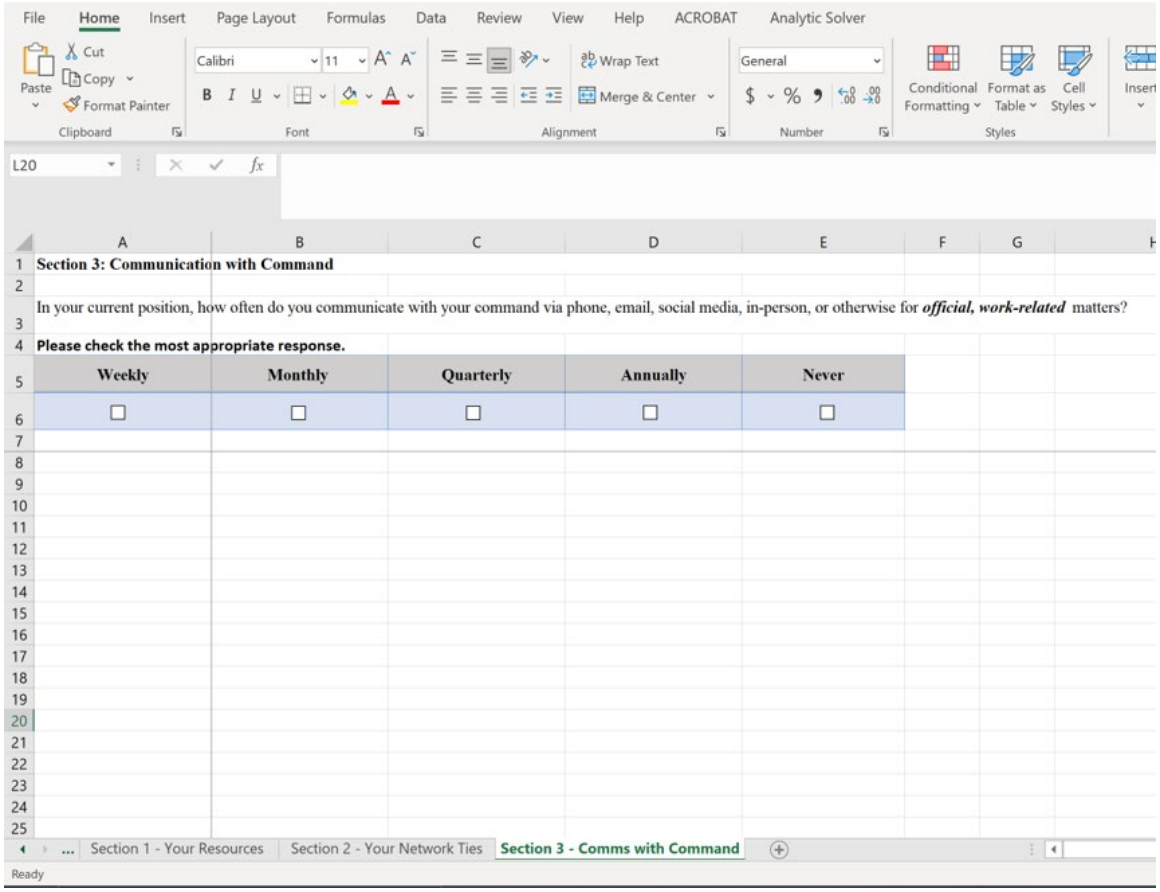


Figure 6. Questionnaire Section 3: Communication with Command

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