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UNTANGLING THE ROOTS OF ORGANIZATIONAL STRUCTURE THROUGH NETWORK ANALYSIS

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THESIS

UNTANGLING THE ROOTS OF ORGANIZATIONAL STRUCTURE THROUGH NETWORK ANALYSIS

by

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June 2019

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13. ABSTRACT (maximum 200 words)

Social network analysis (SNA) serves as a valuable tool when modeling complex, abstract interactions amongst business groups, criminal organizations, and terror networks, by exploiting spatial, relational, and temporal data to provide a tangible representation of organizational structure and interaction. By refocusing SNA on Air Force Special Operations (AFSOC) organizations, this tool will provide leaders with the ability to visualize their organization's underlying interactions, work flow, and deficiencies and enable them to leverage scale and expertise to develop a more effective organization. Already utilized in the corporate sector, SNA proved useful in identifying the need to develop efficiently integrated working groups within companies to increase their efficiency.

By conducting an online survey and calling upon organizational design theories, this thesis will evaluate the underlying organizational network of a military organization modeled after operations groups within AFSOC that control several war-fighting units that support and conduct varying global air missions in support of special operations. This analysis provides actionable insights for organizational leadership to potentially produce measurable impacts and find opportunities to better align their organization's structure for more effective communication.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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LIST OF ACRONYMS AND ABBREVIATIONS

ACC	Air Combat Command
AFI	Air Force Instruction
AFPD	Air Force Policy Directive
AFSOC	Air Force Special Operations Command
ARD	average reciprocal distance
CC	commander
CCE	commander's executive officer
CORE	Common Operational Research Environment
CRS	Creative Research Systems
DNA	dynamic network analysis
DOT	training
IRB	institutional review board
M-form	multidivisional form
MICT	Management Internal Control Toolset
NAF	numbered air force
NPS	Naval Postgraduate School
ONA	organizational network analysis
ORA	Organizational Risk Analyzer
RA	resource advisor
SE	safety
SECAF	Secretary of the Air Force
SNA	social network analysis
SOG	special operations group
SOS	special operations squadron
SOSS	special operations support squadron
SOW	special operations wing
Stan Eval	standards and evaluations
TQM	total quality management
U-form	unitary form
WPS	weapons squadron

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I. INTRODUCTION

Social network analysis (SNA) has proved to be a valuable tool for modeling complex, abstract interactions amongst members of business groups, criminal organizations and terrorist networks by exploiting spatial, relational, and temporal data to provide a tangible representation of organizational structure and interaction. Focusing SNA on Air Force Special Operations organizations can provide leaders with the ability to visualize their organization's underlying interactions, workflow and deficiencies and enable them to leverage scale and expertise to develop a more effective system (Cross & Thomas, 2009). Already implemented in many other business arenas, SNA further emphasized the need for work forces to integrate more in order to become more effective (Cross & Thomas, 2009). This thesis does not attempt to measure an organization's effectiveness. Instead, it intends to highlight network analysis and managerial-theory-defined areas of potential improvement within a military organization, utilizing network analysis concepts to compare the organizational design to a member identified workflow.

A. RESEARCH QUESTIONS

1. Is a hierarchy the best organizational design for a special operations flying group?

2. Can SNA be used as a tool to maximize a military unit's organizational structure?

3. Will SNA expose hidden potential for improvement in an operational military organization and provide actionable data?

B. RESEARCH IMPORTANCE

In 2018, the Air Force's Air Combat Command (ACC) announced plans to execute a radical change in warfighting that involved a profound transformation of the traditional Air Force Wing design (SECAF, 2017). This redesign was intended to "flatten the decision-making structure within wings to encourage faster, decentralized decision-making" by bringing squadron commanders under direct report to the Wing Commander, effectively eliminating an entire traditional organizational layer (Losey, 2018). This move followed the Air Force Chief of Staff's push to revitalize squadrons as the backbone of the force, challenging the ways organizations within the Air Force accomplish tasks as a result of recent constraints and operational demands (Brissett, 2017). As a guideline, Air Force Chief of Staff, General Goldfein, stated that the revitalization effort should not be a "top down change," inferring a bottom-up drive (Brissett, 2017). Championing the General's vision, ACC took action, implementing a solution that challenges the sacred institution of the military hierarchy.

With this in mind, this thesis focuses on a high-tempo, operational military organization modeled on organizations within the Air Force Special Operations Command (AFSOC). These organizations have been supporting non-stop conflict operations for the past two decades, and their mission sets cover a wide range of different areas in support of special operations around the globe (1st Special Operations Group, 2017). Like other military organizations, AFSOC subunits are built upon hierarchical structures governed by Air Force doctrine, instructions, and directives (SECAF, 2011; SECAF, 2017; SECAF, 2018b). As rigid as a hierarchy can be, the nature of AFSOC subunit operations places them in a complex systems category (Stacey, 1995). As such, they will renew themselves overtime through direct restructuring and slow, undirected, adaptive change driven by the dynamics of the environment in which they operate (Stacey, 1995). The group-level organizations within AFSOC are large in size, yet manageable, with enough mission diversity and globally separated operations to make network analysis a valuable pursuit in determining what shifts have occurred in its non-stop activity that may justify changes in its overall design.

If this thesis establishes the validity of SNA as applied to a military operational organization, then it can be a valuable tool for a force seeking innovative ideas to more effectively handle a persistently-limited resource, high-demand environment. It will better prepare these organization for the contingencies they face by highlighting deficiencies and identifying ways to overcome challenges seamlessly.

C. RESEARCH SCOPE

The conceptual basis for this research is organizational design. The discipline of organizational design is an ever-expanding universe of theories, debates and models. In the exploration of our research, it will draw on organizational design concepts from Henry Mintzberg, Jay Galbraith, Peter Senge, and Richard Daft to include communication concepts from Everett Rogers and Rekha Agarwala-Rogers. These principles will then be applied to a military organization. These organizational models will then be aligned with SNA results.

SNA is a "set of methodological techniques that aim to describe and explore the patterns apparent in the social relationships that individuals and groups form with each other" (Scott, 2017, p. 2). SNA applied to an organization may be referred to as organizational network analysis (ONA). The techniques of Rob Cross, Stephen Borgatti, Kathleen Carley, and others offer deep insight into the theory and application of SNA, extracting abstract relational data and forming it into a tangible model.

Lastly, the methodology of this thesis requires a thorough understanding of research methods using human subjects and surveys. Thus, it addresses the benefits and potential pitfalls of survey research and its applications.

D. RESEARCH APPROACH

The aforementioned organizational design and SNA theories and core principles will be applied to the military hierarchy. To accomplish this comparison, this thesis created and administered a survey to the members of a 1400-person military organization (1st Special Operations Group, 2017). It will act as the vehicle to produce the quantitative data necessary to evaluate the dynamic military hierarchy. These data will be used in conjunction with network analysis and organizational design theories to visually depict and assess the organization.

E. OUTLINE

After the introduction in Chapter I, the reader can expect the thesis to flow in the following direction.

Chapter II covers an in-depth discussion of organizational design theory starting with the base theories established by Mintzberg. It also highlights the uniqueness of the military hierarchy and the ways in which this organizational type may be managed.

Chapter III begins with the foundation of social network analysis. It covers the details of network analysis and how SNA metrics measure an organization and its individuals. It also discusses how leaders and managers can influence an organization to be more effective.

Chapter IV discusses this thesis's methodology and approach. It provides the basis for selection of this thesis's research methods and covers the difficulties and benefits of survey research. It also makes mention of the alternative approaches research of this type can follow.

Chapter V draws in the survey data collected and the theories discussed in Chapters II and III to analyze an operational Air Force Group. It takes this analysis and provides a situational assessment, discussing potential scenarios that could explain the findings and providing methods for managing them.

Chapter VI concludes the thesis with a summary of the findings. Additionally, it provides recommendations for the way forward for military organizations to implement network analysis in their evaluation process.

II. ORGANIZATIONAL DESIGN

This chapter will use organizational theory to evaluate both the formal and informal characteristics of the military hierarchy and apply the organizational models of Henry Mintzberg to the features of the current military structure. In doing so, this chapter's goal is to evaluate the feasibility of alternate organizational structures in the Air Force command structure.

A. HIERARCHY

1. Formal Hierarchies

In its most basic form, a hierarchy is an organizational structure that relies on vertical communication and a "condition of relational power in which a dominant polity possesses the right to make residual decision while the other party - the subordinate member - lacks this right" (Cooley, 2005, p. 5). The hierarchy is historically the most dominant form of organizational structure for military organizations. It offers centralized decision-making that focuses responsibility and goal setting on those at the top and relieves subordinates of independent thinking. According to Alexander Cooley in his book, *Logics of Hierarchy: The Organization of Empires, States, and Military Occupations* (2005), there are two forms of hierarchy commonly employed: the "unitary form" (U-form) and the "multidivisional form" (M-form) (p. 5).

a. U-Form Hierarchy

Cooley defines the U-form as a hierarchy that "organizes its periphery according to distinct administrative functions (such as sales, manufacturing, and finance), which require integration and coordination by the center for the whole range of products produced by the firm" (Cooley, 2005, p. 5). This form of hierarchy closely resembles the traditional United States Air Force Wing structure.

Air Force Instruction 38–101: Air Force Organization (2017) describes a "standard wing" (Figure 1) as an organization that "generates and employs combat capability" with one commander who "concentrates on the wing's primary mission and delegates authority to subordinates so they can accomplish their responsibilities" (p. 26). These subordinates are typically composed of "four dependent groups (operations, maintenance, mission support and medical) with related functions and disciplines aligned under the appropriate group" (SECAF, 2017, p. 26).

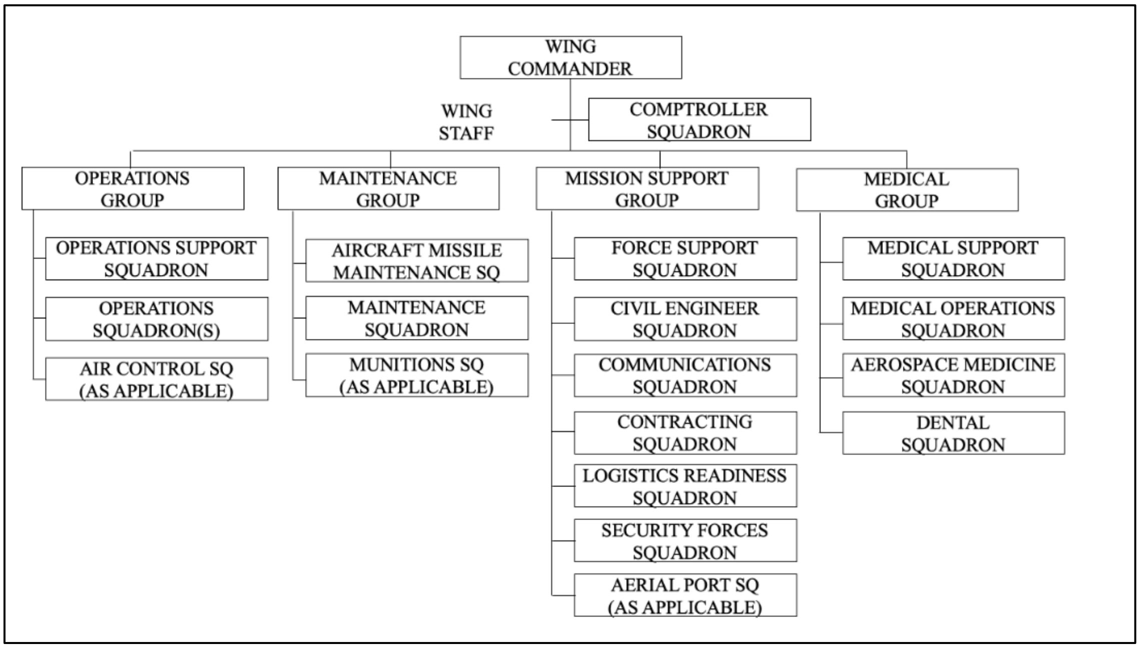

Figure 1. United States Air Force Wing Structure. Source: SECAF (2017).

There are several parallels to be drawn with Cooley's U-Form position descriptions and the Air Force wing structure. As the "chief executive" of the organization, the wing commander determines "the major operating and strategic decisions" and transmits them to the "managers of the functional division" (Cooley, 2005, p. 21). These divisions, known as "groups" in the Air Force, are distinguished by the administrative function that they serve in the wing as a whole. Under this structure, each group is expected to execute its designed responsibilities and communicate laterally with other groups when interaction is required. In the context of Cooley's description, group commanders act as "divisional managers," who "must maintain extensive horizontal ties with each other, as well as the executive [wing commander], as they continuously coordinate and sequence their activities during the planning and production process" (Cooley, 2005, p. 21). These groups are usually further divided into squadrons that have more specific objectives that relate to the group's mission.

The U-form of the hierarchy is effective because it "organizes the firm along functional lines as each operating division corresponds to a different function of the firm's operations" (Cooley, 2005, p. 21). When conflicts arise between two or more functional lines, the wing commander at the top of the hierarchy is called in to resolve the dispute. This role, which Goold and Campbell (2002) describe as "parenting" in their book *Designing Effective Organizations*, is "unavoidable…in organizations with complex interdependencies between units" (p. 341–342). While the Air Force prefers to organize wings as U-form hierarchies, the larger structure of the service as a whole more multidivisional.

b. M-Form Hierarchy

The command-level above the wing is known as Numbered Air Force (NAF) and is commanded by a NAF commander (typically a general officer). It directly oversees several wings and is "focused on ensuring the readiness of assigned forces" (SECAF, 2017). Due to the fact that each wing is tasked with performing a similar operation from a different location, this structure represents Cooley's M-form of hierarchy. Cooley describes the M-form as an organization that "governs its subordinate divisions according to product or geography, as each division is relatively autonomous and encapsulates a wide range of functions so that it can produce its particular product" (Cooley, 2005, p. 5).

The autonomous nature of each wing enables the NAF-level command to serve more of a support role in ensuring that each wing is capable of executing its mission. The NAF does not perform any of the primary roles or responsibilities for the subordinate wings and is only there to facilitate results for the independent wing commanders. Cooley expands upon this structure:

> Under this schema, the divisional heads [wing commanders] are responsible for the routine functions of finance, accounting, and manufacturing in their respective divisions and have little or no contact with their counterparts in

> other divisions. Furthermore, each division operates as a financially autonomous unit … (Cooley, 2005, p. 22)

The M-form of hierarchy is effective for the Air Force when suborganizations are independent, geographically separated, and do not rely on lateral communication. Goold and Campbell (2002) refer to these characteristics as “autonomy needs” (p. 56). They explain that “when a unit is integrated into a larger organization, it can be hard to develop and maintain” without the freedom to maintain its “special ways of managing” (p. 56–57). This style of hierarchy traditionally exists between two U-form organizations and is often smaller and efficiently designed to facilitate vertical communication and suborganization support. While the U-form and M-form of hierarchy make up the formal design of the military structure, they often exist separately from the informal structure.

2. Informal Hierarchies

In their book, *Communication in Organizations* (1976), Everett M. Rogers and Rekha Agarwala-Rogers examine the informal structures inside an organization. These hierarchies are primarily composed of abstract elements like interpersonal relationships and are important to their organizations because they act as “the ‘threads’ that hold a system together” (p. 127).

Informal hierarchies rarely resemble the formal hierarchy in which they exist. They are difficult to identify and even harder to analyze. In *Communication in Organization* (1976) Rogers and Agarwala-Rogers list the three methods for discovering and analyzing informal networks in an organization:

> 1. Identifying cliques within the total system, and determining how these structural subgroupings affect communication behavior in the organization;
>
> 2. Identifying certain specialized communication roles such as liaisons, bridges, and isolates (thus allowing communication research to proceed far beyond the relatively simpler issue of opinion leadership); and
>
> 3. Measuring various structural indexes (like communication integration or connectedness, and system openness) for individuals, cliques or entire systems. (p. 125)

These three methods outline the formal construct for using SNA to evaluate organizational structure in this thesis. This section will identify and discuss two informal hierarchies in the Air Force: qualifications and communication.

a. Qualification Hierarchy

Military hierarchies are no strangers to informal communication networks and structures. Unofficial tiers based on qualification, reputation, and experience exist outside of formal designators such as rank and direct reporting elements. This is due in large part to the unique mission focus of the Air Force. In a flying unit, aircraft qualifications serve as their own form of hierarchy that are not depicted on the organizational chart. These tiers of job qualification are a function of experience and merit in the aircraft and remain independent of rank or authority in the formal hierarchy.

An example can be seen with the traditional career progression of a pilot. When a pilot is new to an aircraft, regardless of rank or designated authority, he/she often joins as a co-pilot, which is the lowest ranking position in the aircraft. Co-pilots are subservient to all aircraft commanders regardless of rank or hierarchy position outside of the aircraft. Aircraft commanders occupy the next tier of career progress, but remain below other qualifications such as flight lead, instructor, and evaluator. This situation is unique because crew qualification, which weigh heavily in determining a pilot’s status and authority outside of the airplane, is based on performance in the aircraft and not in his/her designated position within the formal hierarchy. What results is a complex matrix of authority and prestige unrelated to the formal military structure designated by commanders. This informal hierarchy is essential to the operation of the organization and often carries more weight than the formal hierarchy itself.

b. Communication Hierarchy

Another example of an informal hierarchy within a military organization is communication. Due to the high turnover-rate of personnel in the military, experience and seniority outweigh rank and position. Unlike civilian or non-military government organizations, the military leans heavily on job seniority to ensure efficiency in the face of high turnover. This phenomenon leads to the employment of long-term civilians in military positions to ensure continuity in the face of deployments and short-term assignments. What results are bottlenecks in communication and power that flow heavily through long-tenured personnel instead of through official avenues mandated by the hierarchy. In *New Directions for Organizational Theory*, Jeffrey Pfeffer (1997) describes these communication substructures as "social control" (p. 136). He explains that social control is used to "develop informal influence and power to achieve what one wants and needs for task accomplishment as well as individual benefit" (p. 136). While the communication hierarchy in the Air Force as a result of longevity is generally unavoidable, the informal hierarchies that emerge produce structures in which low-ranking members wield a disproportionate amount of power.

This thesis will examine the informal nature of communication and workflow within a military organization by using SNA in an effort to understand its optimum design. Rogers and Agarwala-Rogers (1976) discuss the benefits of this analysis when they state, "communication inquiry in organizations make manifest otherwise static structural variables; network analysis permits an understanding of the dynamics of organizational structure as it determines the flows of messages between units and across hierarchical positions" (p. 123). With this concept in mind, this paper will explore alternate methods of organizational design in order to determine if the hierarchy is the best fit for an Air Force military organization.

B. APPLICATIONS

In his work, *Organization Design: Fashion or Fit?* (1981), Henry Mintzberg states that "a great many problems in organizational design stem from the assumption that organizations are all alike; mere collections of component parts to which elements of structure can be added and deleted at will" (p. 1). Mintzberg's statement summarizes the military's continuous struggle to maintain a sound hierarchical structure in the face of an ever-changing force. This challenge is also prevalent in the corporate world where "a strong ground-swell of opinion has built up that blames many of the ills of large companies on oppressive corporate hierarchies" (Goold & Campbell, 2002, p. 335). This section will explore design configuration alternatives offered by Mintzberg and discuss how each model currently or potentially fits into the current military hierarchy.

1. Mintzberg Design Models

Mintzberg's article proposes four relevant configurations for organizational design: simple structure, machine bureaucracy, professional bureaucracy, and adhocracy (Mintzberg, 1981, p. 2). Each is composed of the same consistent elements that are applied in different methods or quantities to facilitate success. These are strategic apex, operating core, technology structure, and support staff (p. 4). This section will briefly describe each configuration and discuss how and why each is catered to a different style of organization.

a. Simple Structure

Mintzberg's simple structure (Figure 2) consists of two of the four core elements previously described: strategic apex (top) and operating core (bottom). This configuration involves direct supervision from the boss to the working element and has no technology structure or support staff. Most simple structure organizations are in the early stages of development and often expand out of this configuration with growth (Mintzberg, 1981, p. 6).

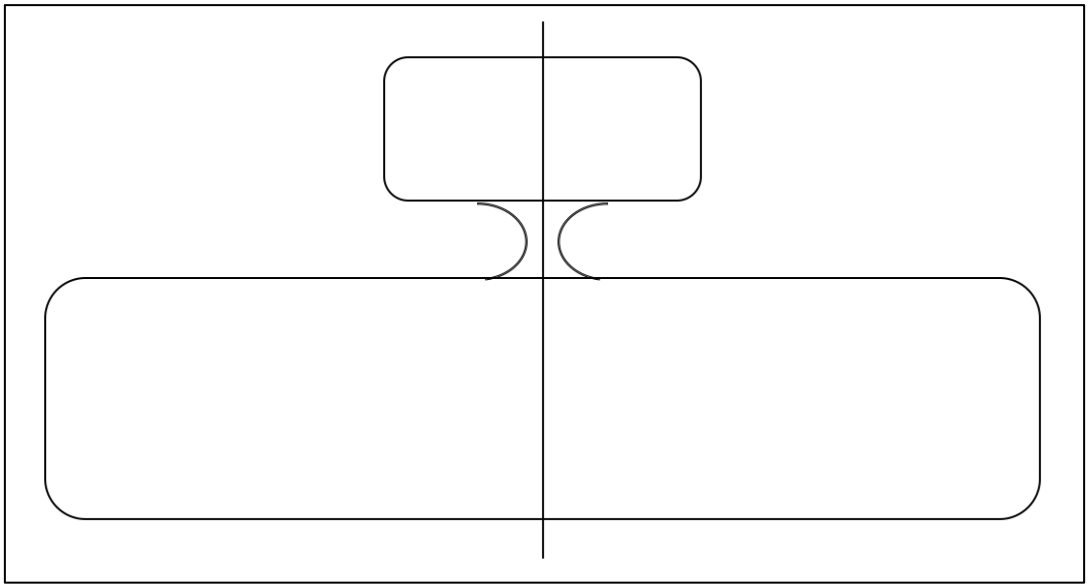

Figure 2. Mintzberg's Simple Structure. Source: Mintzberg (1981).

b. Machine Bureaucracy

The machine bureaucracy (Figure 3) is a configuration that focuses largely on standardization and contains all four of the core elements. The strategic apex (top) sets the vision for the machine bureaucracy and uses a large technology structure and support staff (left and right middle) to assist the operating core (bottom) to standardize outputs. It seeks to maximize core tasks through centralized control, repetition, and by limiting the environment in which the bureaucracy operates (Mintzberg, 1981, p. 7).

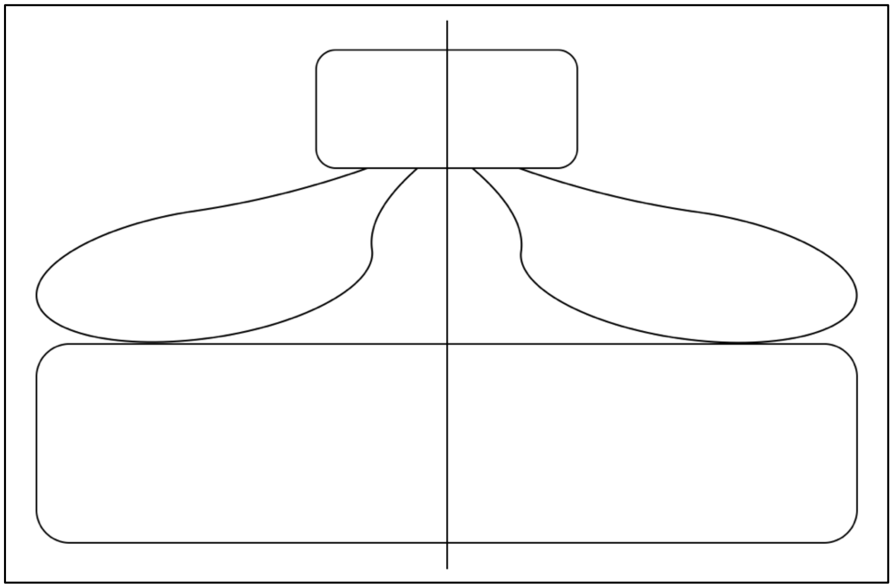

Figure 3. Mintzberg’s Machine Bureaucracy. Source: Mintzberg (1981).

c. Professional Bureaucracy

The professional bureaucracy configuration (Figure 4) relies on the “standardization of skills through its employees” in the form of “highly trained professionals in its operating core and considerable support staff to back them up” (Mintzberg, 1981, p. 4). This model contains all four core elements but has a smaller strategic apex (top), a limited technology structure (left middle), a large support staff (right middle), and a flat operating core (bottom) (Mintzberg, 1981, p. 7).

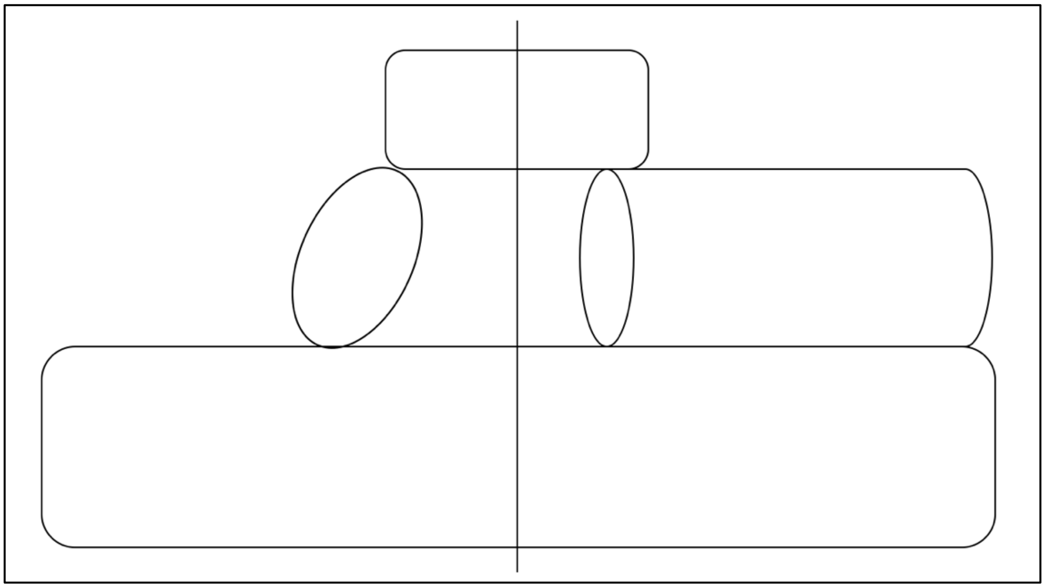

Figure 4. Mintzberg’s Professional Bureaucracy. Source: Mintzberg (1981).

d. Adhocracy

The most complex configuration is the adhocracy (Figure 5). This model is a conglomeration of the previous organizational types as it involves interconnected support from all four core elements. Adhocracies rely on mutual adjustment between autonomous teams of experts to achieve success. The adhocracy model consists of separate but equal groups that provide achieve a specific goal while simultaneously supporting other teams and offering feedback. This configuration is difficult to achieve but highly flexible in a dynamic environment (Mintzberg, 1981, p. 10).

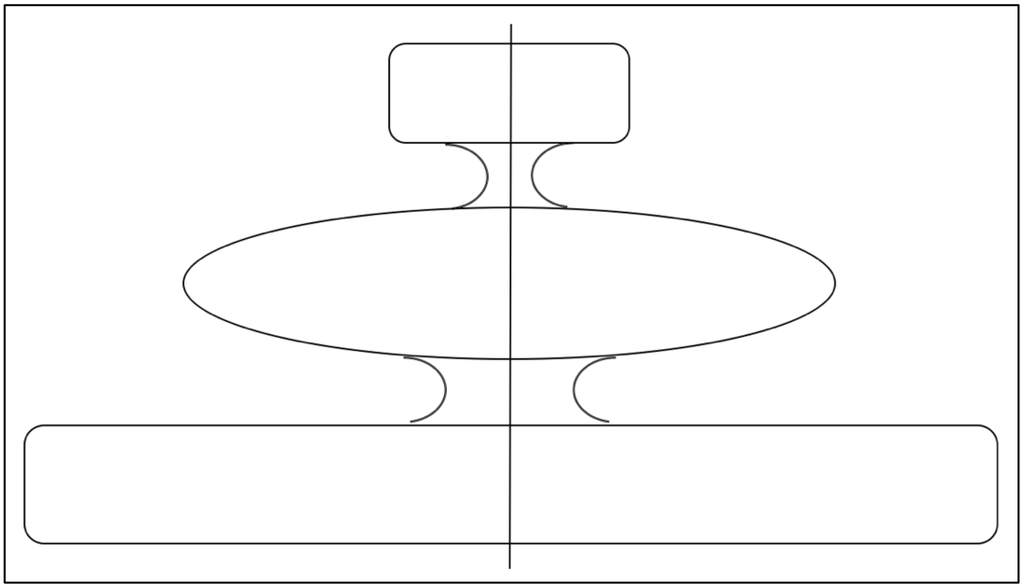

Figure 5. Mintzberg's Adhocracy. Source: Mintzberg (1981).

2. Military Application of Mintzberg

a. Simple Structure

The military hierarchy is, in theory, a simple structure. Mintzberg describes the use of a simple structure as an organization in which "coordination is achieved at the strategic apex by direct supervision--the chief executive officer gives the orders" (Mintzberg, 1981, p. 4). While this description appears on the surface to describe the principles behind a U-form hierarchy, the simple structure also maintains several characteristics that do not fit the mold for a military organization. Unlike a standard Air Force wing, Mintzberg's simple structure is often "young and small" and must be "flexible because it operates in a dynamic environment" (Mintzberg, 1981, p. 5). The Air Force is neither young nor small; however, it does focus a significant amount of energy towards flexibility in dynamic environments. Traditionally, a simple structure has very little technology or support staff. This is not the case with the military, which has large quantities of both and thus has assumed the characteristics of a machine bureaucracy.

b. Machine Bureaucracy

Mintzberg describes the need for a machine bureaucracy "when coordination depends on the standardization of work" (Mintzberg, 1981, p. 4). While this description is also apt for elements of the military like skills training and aircraft maintenance, the organizational structure described in the machine bureaucracy is far from ideal. This configuration is focused on standardization above all else and has a large technology structure and support staff underneath the strategic apex to support the consistent outputs of the operating core.

With regards to the military, the largest flaw of this configuration is its relationship to stability. Mintzberg states, "because machine bureaucracies depend on stability to function, they tend not only to seek out stable environments in which to function but also to stabilize then environments they find themselves in" (Mintzberg, 1981, p. 7). While this inability to adapt to a dynamic environment may work for a factory assembly line, it is far from ideal in the ever-changing world of 21st century warfare. In addition, while the machine bureaucracy excels at creating standardized outputs from an operating core, it fails to produce the independent thought, analysis, and creativity required to solve the complex problems created in the same dynamic environment.

c. Professional Bureaucracy

In many respects, an Air Force Wing is a collection of professional bureaucracies organized into a large simple structure. Due to the fact that each suborganization is responsible for mastering a different set of skills (flying an airplane, protecting an access gate, controlling air traffic, etc.), this configuration lends itself nicely to the overall success of the hierarchy. In standardization, however, Mintzberg (1981) finds weakness:

> Standardization is the great strength as well as the great weakness of professional bureaucracy. That is what enables the professionals to perfect their skills and so achieve a great efficiency and effectiveness. But the same standardization raises problems of adaptability. This is not a structure to innovate but one to perfect what is already known. (p. 8)

This revelation once again shows that even a configuration that emphasizes skills struggles to succeed in a dynamic environment. While the expanded support staff allows the operating core to focus on skill standardization, the bureaucratic nature of the configuration restricts innovation.

d. Adhocracy

Unlike the rest of the configurations, adhocracy does not fit into any facet of the military hierarchy. The spirit behind adhocracy is that of autonomy, creativity, and mutual adjustment among teams of experts. This description has no place in either the U-form or M-form hierarchy described by Cooley and is unlikely to ever be approved as new organizational structure by a wing commander. It is, however, applicable in the Air Force's most dynamic environments.

In Air Force Special Operations Command, teams deploy to austere locations in the form of the "hard crews" that make up the necessary positions to operate an aircraft. Leadership forms these crews with members who have experience in different disciplines to ensure that once all of the teams are in place, they can mutually support each other while simultaneously performing their own independent missions. The downside of this structure is that when one crew is away on a mission, all of the experience and support they provide is unavailable until they return. In this respect, the adhocracy appears as a matter of necessity when the Air Force is operating in its most dynamic environment.

C. SUMMARY

The Air Force is looking to re-evaluate its traditional organizational structures and challenge the paradigm that the military hierarchy is the most effective method of conducting 21st Century warfare. To explore the roadmap that would affect these changes, this chapter has explored the nature of the formal and informal military hierarchy and compared their characteristics to four of Henry Mintzberg's organizational configurations. This effort has shown that while structurally simple on the surface, the traditional Air Force wing is a complex system comprised of multiple dynamic sub-structures. This revelation justifies the further exploration into Air Force organizational design through Social Network Analysis which will be discussed in the following chapter.

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III. SOCIAL AND ORGANIZATIONAL NETWORK ANALYSIS

Technological advancements in data collection and computing have provided everyday organizations with usable tools for gaining quantifiable data to evaluate. The sociological basis of exploration for social network analysis (SNA) and organizational network analysis (ONA) date back to the late 1800s, and are methods of evaluation that use relationship data to understand the dynamics of a group of individuals (Simmel, 1950; Prell, 2012). Analyzing these relationships can identify system capacities and resource flows as they apply to the organizational structure that governs them. In this context, resources refer to any exchange that creates a continuing relationship whether it is an exchange of funds, information, tangible supplies, or intangible trust.

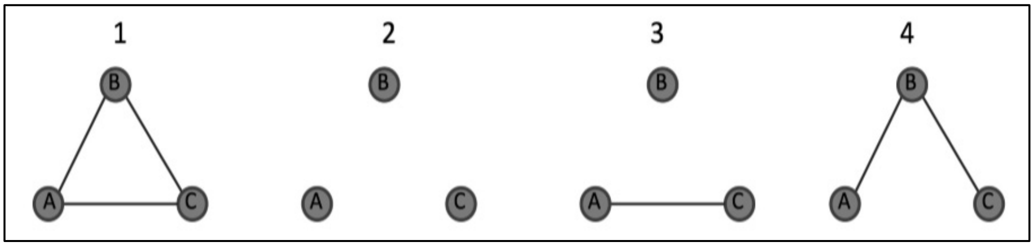
The basic foundation of SNA theory is that among any number of loosely associated people there exists an underlying social phenomenon that links individuals within the group together, forming a social structure. As one of the theoretical precursors to SNA, Georg Simmel used a study of secret societies to demonstrate that assessing interaction patterns led to a stronger understanding of social behavior (Simmel, 1950). Since that time, scientists have capitalized on Simmel's research and advanced SNA to create new research tools and apply new theories to different areas (Barabasi, 2003).

To understand SNA, the reader must first grasp the base concept of SNA used in this thesis. A network is identified by any group of individuals connected by some defined relationship. Thus, all organizations are networks, from loosely bound social circles to formalized institutional hierarchies (Nohria & Eccles, 1992). Two entities in any organization may form ties based on commonalities, differences, or simply because their organizational role requires them to interact (Collins, 2004). These organizational relationships form the communication and work flow on which organizations rely.

One principle of SNA is that all entities operating within the network do so interdependently. They are influenced by their interactions with others. As time passes, these interdependent relationships adapt to changes in the environment that may create new, and sometimes unintended, workflow formations that differ from the organization's intended design (Cunningham, Everton, & Murphy, 2016; Sterman, 2000). Such adaptations can be detrimental or beneficial to an organization. Fortunately, SNA can help an organization's decisionmakers interpret and thus manage these underlying, often invisible changes (Stacey, 1995). This chapter will discuss the basis of network analysis and how it can be used to analyze an organization for potential process improvement or organization redesign.

A. NETWORK CHARACTERISTICS

Wasserman and Faust (1994) refer to a network's connected individuals or groups as actors and the connections between them as ties. The former can also be referred to as nodes and the latter as edges or arcs (Cunningham et al., 2016, p. 10). See Figure 6 for a visual depiction. Actors may represent individuals, groups of people, or even nonhuman objects (Cunningham et al., 2016, via Childress, 2012, p. 30). While actor attributes significantly aid in understanding a network, the analysis primarily focuses on the ties between actors, which "can vary in terms of type, direction, and strength" (Cunningham et al., 2016, p. 10). The types of ties can be based on relationships generated from friendships, group affiliations, financial transactions, and even work-related roles defined by organizational designs such as hierarchies (Wasserman & Faust, 1994). Mark Granovetter (1973) defined the strength of a tie as the degree to which at least two actors relate by "amount of time, emotional intensity, intimacy, and reciprocal services" (p. 1361). Tie strength can reflect a level of trust or solidarity among actors and can be applied to real world situations. Krackhardt (1992) discovered that employees of a tech firm made final decisions relying more on the opinion of those with whom they held stronger ties, while Granovetter (1973) found that job seekers had more success relying on weaker over stronger ties because information flow had a greater distribution and reach through weaker ties.



Actors or nodes are labeled A, B, and C. Ties are the lines, or links, between them.

Figure 6. Ties and Actors. Source: Cunningham et al. (2016, p. 11).

Actor attributes are important as they provide nonrelational data of actors, such as "attitudes, roles, affiliations, and behavior," which may add context to the ties that two or more sets of actors share (Cunningham et al., 2016, p. 14). For example, attributes may help explain the strength or weakness of a tie between two actors. They may also help determine the extent of resource distribution throughout an organization. Combined, relational and attribute data helps characterize a network overall.

When dyads (two actors tied together) and triads (three actors tied together) are connected to other dyads and triads, they form a larger network as displayed in Figure 7. These larger network displays, also called sociograms, can help visually identify important bridges and brokers within the network. These elements control information flow throughout a network simply by their relational position. Brokers are actors that connect gaps between smaller networks, or subgroups, within the larger framework, and the bridges are the ties between them. As an example, Figure 7 shows actors 3, 2, 4, 10, and 16 (circled) as brokers with the ties between them being bridges. In this instance, actor 3 has the largest brokerage influence connecting all the other actors' networks (Cunningham et al., 2016, p. 11–12).

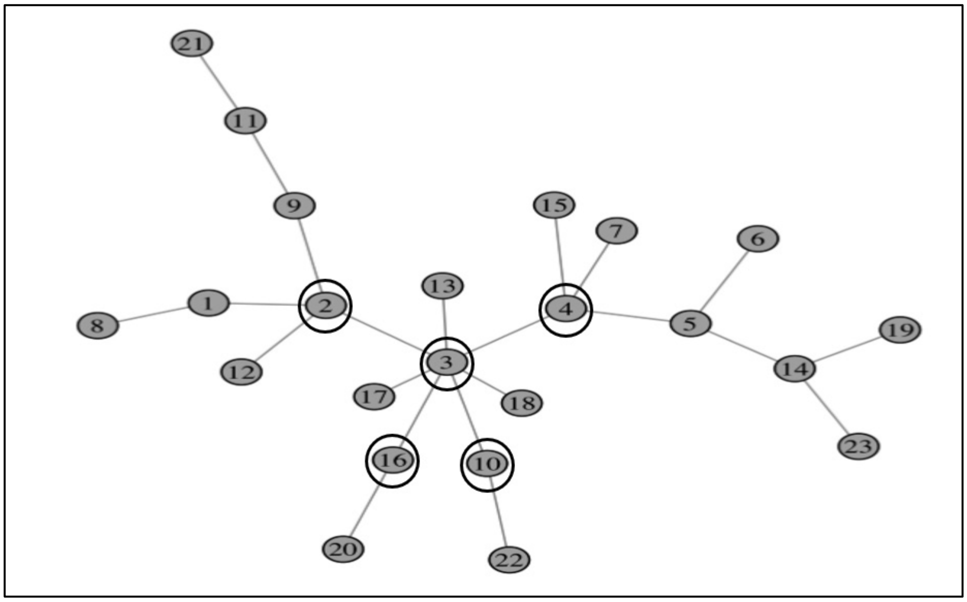


Figure 7. Brokers in a Network. Source: Cunningham et al. (2016, p. 12).

Ties in a network may be directed or undirected. In a directed network, the direction of ties defines the path by which resources flow through two or more actors. Consider, for example, a network where actor A provides a resource to actor B. This relationship would be depicted with an arrow originating at actor A and terminating at actor B, rather than just identifying that actor A and B know each other with an undirected tie, such as the ones connecting actors in Figure 7. Figure 8's diagram shows directed ties with arrows. Actors connected directly or indirectly by following the direction of the ties is called a strong component, while actors connected directly or indirectly ignoring the direction of the ties is called a weak component (Cunningham et al., 2016, p. 13). Components are one type of subgroup. Cliques are another. A clique is a subgroup that contains three or more actors where each actor is tied to every other actor. Subgroup analysis can visually display the diversity or density of particular subsets. Various subgroup measures can be found in Table 1, Appendix A.

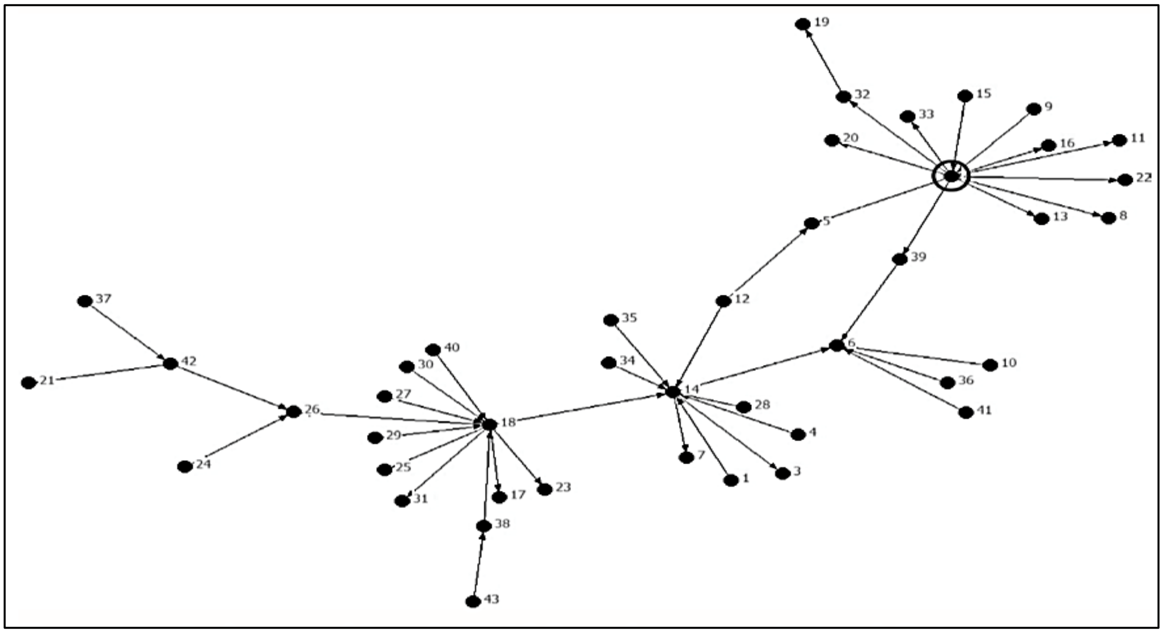


Figure 8. Context in Analysis. Source: Cunningham et al. (2016, p. 46).

A network's overall topography provides network characteristics for categorization and comparison. These characteristics generally cover network structure defined by size (number of actors), density (proportion of ties), cohesion (proportion of connected pairs), and level of centralization (Cunningham et al., 2016, p. 13). Network-to-network comparisons benefit analysis, evaluation, and predictive decisions by comparing previously analyzed networks. This is useful when attempting to see how an organization compares to either poor performing or successful organizations with similar metrics. It may also be used to evaluate how changes to the system impact measures of interest. Names and definitions for some of these measures can be found in Table 1, Appendix A.

Of actor-level SNA measures, centrality is one of the most utilized metrics (Bavelas, 1948; Cook and Emerson, 1978; Borgatti, Everett & Johnson, 2013). Centrality measures vary in their assumptions and can be applied across a spectrum of different networks (Cunningham et al., 2016, p. 141). For instance, degree centrality equals the number of an actor's ties and can be interpreted as a measure of the popularity (Freeman, 1979). This measure is dependent on the size of the network and therefore needs to be normalized for cross-network comparisons (Cunningham et al., 2016, p. 147). A variation of degree centrality is eigenvector centrality. Like degree centrality it takes into account the number of an actor's ties, but it weights this count by the degree centrality of the other actors (alters) to which the actor has ties. It is sometimes used a measure of network status or power. Measuring centrality can also be done by taking account of the path between actors (Freeman, 1979). For example, betweenness centrality captures the extent to which each actor lies on the shortest path between all pairs of actors in a network. It is often seen as capturing the brokerage potential of actors. See Table 2 for some of the most commonly used centrality measures (Cunningham et al., 2016).

Of note, a high centrality score does not necessarily guarantee that an actor within a network is of most importance. It is essential for analysts to understand what type of network they are analyzing and the environment in which it operates, as well as what traits are important to that situation. For proper analysis, the context of the metrics, or the situation and environment the network's entities find themselves in, must be taken into account (Cunningham et al., 2016; Kurtz & Snowden, 2003). As an example, the role or responsibility of an actor within a network can provide the context needed to associate appropriate centrality metrics. The network displayed in Figure 8 shows how a certain actor (actor 2 circled), seems central to the network by the sheer number of connections the actor holds. The direction of the relationships, represented by arrow direction, for this actor indicate that they are potentially subordinate to the others in that group

B. NETWORK ANALYSIS ASSUMPTIONS

The assumptions underlying social network analysis are as equally as important as the context in which the network operates (Azarian, 2005; Knoke and Yang, 2007; Wasserman and Faust, 1994). The first assumption is that the ties between actors are the paths through which resources flow. Second, the actions and decisions of actors within the network are interdependent, meaning that decisions made by one actor or another impacts the entire network to varying degrees. Third, in addition to being directly or indirectly guided by the actions of others in the network, an actor's position in the network also influences their choices and how they act or interact. Fourth, these interactions develop observable patterns over time, and the repeated interactions of these actors evolve into new, sometimes unexpected subgroups within the structure of the network (Clayton and Davies, 2006; White, 2008). Typically, these subgroups form tight bonds over time, driven by the values shared between actors of the organization or network (Chaves, 1997). Examples of organizations that exemplify these assumptions can be found in studies by Doug McAdam (1986), John Meyer (1977), and Mark Chaves (1997).

These assumptions and the situational context help analysts define the boundary of a network. The boundary contains a group of actors based on certain parameters. Throughout the evolution of social network analysis, practitioners developed several theories guiding boundary decisions and group inclusion. When deciding on group selection, practitioners believe that the actors within a network should have significant exclusivity from the world as a whole, and that the identified group membership is unique and constrained enough that the number of members is of a reasonable size to study and of which to draw conclusions (Erickson, 1981). Some practitioners believe that the actors included in a network should be driven by the members themselves, as only they can define the ones they interact with and who belongs (Laumann, Marsden, and Prensky, 1983; Knoke and Yang, 2007). This member-driven approach to defining the boundary is referred to as the realist or emic approach (Laumann et al., 1983). The approach of the analyst defining the boundary and group inclusion based on their research is known as the nominalist or etic approach (Laumann et al., 1983). Regardless of approach, analysts can further refine these boundaries by focusing on specific actor attributes or specific relational ties when applying their network analysis (Cunningham et al., 2016).

C. APPLYING NETWORK ANALYSIS

> Network analysis helped me quickly get a sense of what I had stepped into. Being new to the organization and the people I was supposed to be managing, it would have taken me at least six months to make the rounds to get a sense of what was going on. Even then, I would still only get some people's perspectives and opinions and have things wrong by other accounts. The network analysis taught me a lot about the inner workings of this group, and most importantly showed me some splits in the network that we really had to address quickly. – A global manufacturing organization's Research & Design Director. (Cross & Parker, 2004, p. 15)

The difference between 100-meter gold and silver medalists is eight-hundredths of a second (International Olympic Committee, 2019). For individuals and organizations, staying atop the competition leaves little room for inefficiency in operation. This requires refining operations at the margins to maintain an edge over your opponent. With the benefits that come from being the top provider and the potential to find areas of refinement in all organizations, leaders worldwide urgently seek operational improvements and organizational redesign that provide actionable insights, resilience, and adaptability (Cross & Thomas, 2009). To accomplish this, they work to understand an organization's focus, information flow, and other potential points of leverage (Cross & Thomas, 2009). With this data, a leader can drive impactful innovation, collaboration, growth, strategic alignment, and improved knowledge sharing across their organization (Cross & Thomas, 2009).

It is not uncommon for industry leaders to boast about improving their organization's effectiveness by instituting new communication and collaborative practices. All too often, however, these individuals put technology at the forefront of collaboration to increase the speed and amount of information that flows throughout leading to an undesired result that may end up being more detrimental to an organization's overall performance (Cross & Thomas, 2009). Understanding how employees interact in order to complete their work provides a better perspective for managers to make process improvement decisions (Cross & Parker, 2004; Apte, 2006). To fulfill this need, there are many process analytic tools geared toward operational improvement such as total quality management (TQM) and Lean Six Sigma (Cross & Thomas, 2009; Apte, 2006). Yet, the often-discounted method of network analysis strengthens these processes and, in many cases, should precede them to create a better product in a shorter period of time by more accurately identifying potential causes of inefficiency (Cross & Thomas, 2009). Understanding the underlying networks within these processes provide leaders with the information necessary to drive value through their organization (Cross & Thomas, 2009, p. ix).

The information provided by analyzing the underlying network gives decision-makers the ability to increase strategic alignment, organizational adaptability, and ultimately mission execution; all aspects vital to the survival of a business (Cross & Thomas, 2009; Cross & Parker, 2004). With an accurate depiction of a network, a leader can take targeted action that addresses disconnects, overloads, and rigidities in the system that developed as a result of organizational design and leadership decisions that lag behind the changing environment in which it operates (Cross & Parker, 2004). With this information, a leader and manager can create integrated structures that are more resilient to changes. "This is not trivial. Most executives [tell] you that effective collaboration is critical to [an] organization's strategic success" (Cross & Parker, 2004, p. 7). Research supports this statement, reinforcing that collaboration and connectivity in well-managed networks impact performance, learning, and innovation (Monge & Contractor, 2001; Cross, Borgatti, & Parker, 2002). Success is about the appropriate level of connectivity, being able to connect the right people at the right time. In fact, an "indiscriminate increase in connections can be a drag on connectivity," and collaboration comes at a cost (Cross & Parker, 2004, p. 8; Hansen, Podolny, & Pfeffer, 2001). Leaders need to understand the "true" flow of resources through their network and how this flow affects the organization as a whole in order to quickly adjust to a dynamic environment and prepare their organizations for future challenges (Cross & Thomas, 2009). Network analysis helps illuminate this truth.

1. Analyzing the Organizational Network

> The network results definitely showed that we are hierarchical in decision making and that we can put a real cost to that in ways that have finally captured the attention of our leaders. Before, I think they thought we were grousing and they of course did not want to give up control of things and neither would I, probably, if I were in their shoes. But this has forced the conversation to the forefront. (Cross & Thomas, 2009, p. 83)

Place an organization chart in front of most employees, and they will tell you that it does not "really" depict how work is accomplished. Network analysis diagrams support the simplicity of formal organization charts, helping to reveal the true connectivity of an organization's separate aspects (Cross & Parker, 2004). In Section A, this chapter covered the basics of SNA to include the central aspects of a network and some basic metrics.

Leaders can use these measures to address their organization's needs. Building the network diagram and subsequent metrics requires collecting the appropriate data.

Collecting network data can be done several different ways and, like other research designs, requires an understanding of what information is needed and what aspects of an organization needs to be mapped. This requires asking the right questions or making the right observations. These details will be covered later in Chapter IV. One method of data collection is direct observation (Cross & Parker, 2004). Like many other process analytic techniques, observing and researching how tasks are completed provides detailed insight into the process. Analysis can begin by creating job process diagrams (Apte, 2006). These illustrate workflow based on desired outcomes governed by job manuals and regulations. Unfortunately, creating process diagrams can be time consuming and observation can interfere with the process as a whole (Apte, 2006). To avoid this interference, analysts can use techniques like nametag badging to create a trackable identification number that is tied to a specific individual or role. These badges track the interactions one individual has with others throughout the work cycle (Cross & Parker, 2004). While this provides good workflow data by adding the duration of interaction and distance traveled, it still lacks the type of exchange that occurred, which can only be gained from the individual being tracked and those they interacted with.

Information exchange can be collected in many ways, one of which is email tracking (Cross & Parker, 2004). While this comes with privacy concerns, official emails provide the type of information exchanged, frequency, and the hierarchical relationship between the two entities. Unfortunately, this covers only the type of information exchange that occurs via email, which is generally classified as less urgent. This data excludes face-to-face and telephone facilitated communications, which tends to carry a greater weight in both the personal sense and sense of urgency. This style of communication typically is associated with a stronger, closer bond between the two actors.

To capture as much of this data as possible, in the shortest amount of time, with the least impact on operations, analysts can design a survey that captures the process, its directivity, the type of information exchanged within it, the duration of work performed, and the degree of importance of the exchange (Cross & Parker, 2004). When this is done correctly, the true workflow can be diagramed. Surveys come with pitfalls of their own, and administering them properly takes careful consideration. The specific aspects of survey data collection are covered in the methodology chapter of this thesis; it is the methodology leveraged for our data collection. Of course, collecting information from one individual or role within an organization only provides a one-sided view of the process. Establishing a boundary for data collection that encompasses all the roles and responsibilities desired for the analysis is important. This provides the minimum two-way exchange necessary to capture all perspectives.

Once this data is collected, the interactions and collaborations can be mapped onto a visual diagram called a sociogram. Additionally, network analysis programs provide measurable metrics that can help identify key actors critical to the process and those that reside on the periphery of the organization (Cross & Parker, 2004). Sometimes the network importance of these individuals, or lack thereof, surprises leaders. Understanding the context, or specific role of each entity, will help define the reason for an individual's degree of importance in the network. The centrality of an individual in a group can be either good or bad depending on the context of their operations. An individual or group less central to the organization and on the periphery may be there by design or it could be a key administrator who that has become too separated from day-to-day operations (Cross & Parker, 2004). Some roles that require high levels of specified expertise are best served on the periphery of an organization so that they can maintain their knowledge and provide it to the group through the right connections. This helps ensure their vital knowledge is dispersed throughout the organization. In the situation where an individual should be more central, but the analysis reveals that they have been seemingly separated from the day-to-day, could be a result of higher authorities outside the network boundary demanding more of their time. These are examples of context importance, and aligning the sociogram with the organization chart helps provide that context.

The formal organization chart and associated sociogram in Figure 9, taken from Rob Cross and Andrew Parker's *The Hidden Power of Social Networks* (2004), illustrates the aforementioned points. Cole, as a lower member of the Exploration branch, holds a critical information flow position. It appears this member may be overburdened with work.

If the group has become disproportionately reliant on Cole, based on his position in the company, then he may be identified as a bottleneck of information (Cross & Parker, 2004). In any process the bottleneck is the slowest performing function that drives the performance of the rest of the organization or sub-organization (Apte, 2006). Poorly timed decisions, role and responsibility changes, or less interaction in decision-making venues, could have created this bottleneck (Cross & Thomas, 2009). Meanwhile, it appears that Senior Vice President Jones is only tied to Cole and Williams in the Exploration branch. This may align with the current strategy of the organization if exploration is the prime focus. As the senior vice president, it may be expected that he should be tied into all the branches particularly with the branch leads. Additionally, the Production Stock branch is only connected to the group as a whole through Cole, which due to his overwhelmed performance may hinder that branch's progress. With additional context, knowing that the branch was recently moved to a different floor means less chance meetings are occurring, which reduces the informal exchange that may keep them more closely tied to the organization's overall innerworkings (Cross & Parker, 2004). Furthermore, the Drilling branch may require specified expertise or little need for collaboration, putting Miller and Sen on the periphery.

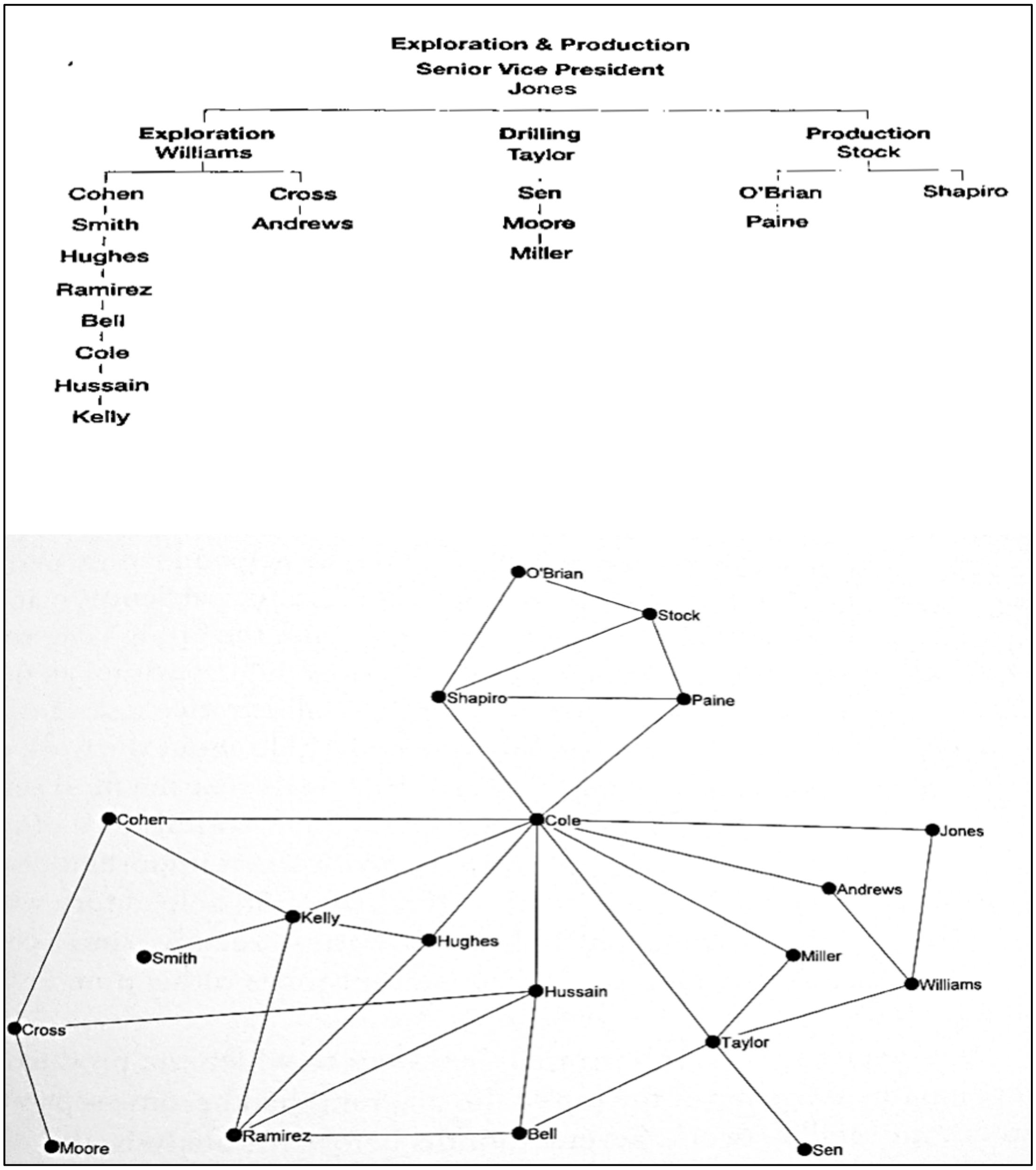


Figure 9. Formal/Informal Diagrams. Source: Cross and Parker (2004, p. 5).

These important members or groups in an organization typically have a thorough understanding of how the organization as a whole operates, with many direct information connections throughout (Cross & Thomas, 2009). Members of an organization end up in central positions within an organization for several reasons. They become central as a result of their role, the decisions they make, resources they control, their expertise, the people they attract, or the information they have access to (Cross & Thomas, 2009).

Being central to the network may not always be a good thing. In this case, Cole (Figure 9) holds a high degree centrality and is a boundary spanner, an individual ideally occupying a fulcrum position, connecting two or more groups together and facilitating the flow of information (Cross & Prusak, 2002; Conway, 1997).[1] Due to a boundary spanner's position and role, it is important that they have a high degree of continuity (Anheier, 1999). It seems like Cole is an "unsung hero," a member of the organization doing way more than his superiors anticipated (Cross & Parker, 2004). Cole may be a selfless employee supporting in any way he can, regardless of recognition, but by the looks of the formal organization chart, his role does not appear to support his position as a boundary spanner in this organization. Typically, a boundary spanner is an individual in a position of leadership or in a role that brings two or more organizations together with the potential of spurring innovation and knowledge distribution (Thompson, 1967). Cole's centrality could be a result of a role change driven by leadership decisions. His new responsibilities may overwhelm his capacity unbeknownst to managers, making him an unintended bottleneck, undiscovered until network analysis was conducted. If he were to leave the organization, it would take time for the group to regain the coordination, he alone, controlled. As illustrated in this example, the network analysis drew out evidence to support organizational adjustments for process improvement and resiliency (Cross & Parker, 2004).

Managers, supervisors, and leaders are not the only ones in the organization who can benefit from this information. The sociogram provides a visual tool for all employees to understand how the organization works as a whole, and how they fit into the larger picture. It will give them a better sense of who in the organization, knows and does what (Cross & Thomas, 2009). They may also be able to see avenues of improvement from their perspective because of this knowledge.

[1] A metric measuring a node's boundary spanner potential will be used in Chapter V.

This knowledge may change an individual's role and interaction within the organization. To this note, it is important to understand that the networks are not static, especially as work has become more short-term and mobile (Castells, 2000). This is why it is important to map them periodically over time for true assessments of changes in the organization and its subsequent ability to adapt. As the network changes, different roles may find themselves in the bottleneck position, particularly after a significant role change, as an individual takes on new tasks, but the organization and its members still rely on their previous role and relationship (Cross & Parker, 2004). Modeling these relationships over time can lead to useful simulations for predicting the effects of large shifts, for instance in the workforce if high-year tenure employees leave in mass (Cross & Parker, 2004; Stacey, 1995). Once an organization can model and understand its underlying network, it will then be able to adjust its organizational structure and further develop a more effective network.

2. Developing Effective Networks

Leaders and managers can influence a network to produce desired results in many ways. In order to do this, they need to understand which characteristics of the network drive the value they desire. Leaders come to this conclusion by understanding the core product or value their organization supports. Next, they identify the relationships necessary to support that strategic objective. Once the network analysis is complete, the resultant network needs to be compared to the ideal network and identify points where excessive connectivity exists and points where connectivity does not exist but should (Cross & Thomas, 2009).

Leaders can control these aspects through such means as regulation, reorganization, technology, communication forums, orientation practices, job rotations, and mentoring (Cross & Parker, 2004). Managers need to carefully consider the methods they use. For instance, regulations and contractual agreements can both increase or decrease connectivity depending on how prescriptive it is on collaboration (Cross & Parker, 2004). When it comes to increasing connectivity, managers cannot mandate relationships; however, they can increase the likelihood of them developing (Cross & Parker, 2004). This is based on the premise that network patterns result from intentional behavior and not personal characteristics (Cross & Parker, 2004). These intentional behaviors can then be taught and leaders can control some aspects of an organization that promote connectivity. For example, a leader or manager can control the structure of interaction by changing aspects like the physical proximity of offices or roles and the timing of meetings and who must attend them (Cross & Parker, 2004).

Promoting this connectivity and maintaining beneficial relationships means aligning the organization's "design, control system, technology, and human resource practices," which can also be impacted by the organization's cultural values and leadership behavior which can either support or deter the network (Cross & Parker, 2004, p. 116). For effective networks, leaders should work to promote strong, flexible, supporting structures that share in the decision-making responsibilities and draw in the necessary aspects of the periphery (Cross & Parker, 2004). Much of this also depends on organizational structure and what aspects of formal structure the leader should invest in (Cross & Parker, 2004).

3. Analyzing Structure

> By now we should have reduced costs and created a more nimble company without a focus on hierarchy or fiefdoms. But it's tough to ensure that this is really happening. Most of us in this room have thousands of people we are accountable for stretched across the globe. It's impossible to manage or even know what's going on in the depths of the organization. I mean, each of us can fool ourselves into thinking we're smart and running a tight ship. But really the best we can do is create a context and hope that things emerge in a positive way, and this is tough because you can't really see the impact your decisions have on people. So [sic] you just kind of hope what you want to happen is happening and then sound confident when telling others. Executive Vice President, Commercial Lending. (Cross & Thomas, 2009, p. 3)

Networks exist within any organizational structure. As discussed in Chapter II, the general form of a hierarchy orchestrates its resource flow vertically through regulation. A hierarchical network operates in some degree within the bounds of the hierarchy, but has elements of individual, yet interdependent, choices on how to handle their portion of the resources (Perri 6, Freeman, Goodwin, & Peck, 2006). This individual element of interorganizational relationships establishes the basis for utilizing network analysis in uncovering underlying drivers of organizations. Understanding these underlying drivers will help an organization's leaders manage their units more effectively by developing refined pathways for resources and ensuring those pathways integrate with key decision makers in the timeliest fashion (Perri 6 et al., 2006; Cross & Thomas, 2009).

In analyzing a hierarchy, managers want to know what aspects of the analysis will differ from the organization's original structural design. Following causal theory, regardless of the internal actors' or any external environments' impacts, the originally expected resource flow will continue as designed (Perri 6 et al., 2006). In contrast, contingency theory states that a single network type will emerge, predictably, in response to the environment and conditions (Perri 6 et al., 2006). Different still are economic models that show that networks will form as a result of transaction costs where decisions are based on the most efficient way to accomplish a given task (Williamson, 1985). Within sociology, the institutional form in which the network operates drives the reasons for network shifts modified as a result of past experiences, thus leading to future expectations and effects (Perri 6 et al., 2006). All of these dynamic system theories, along with several others similar in nature, intend to capture the ways organizational networks perform and a manager's desire to control it.

Mintzberg's studies claim that organizational structure "materially affects strengths and weaknesses in performance" (Perri 6 et al., 2006, p. 71, from Mintzberg 1983). An organization's structure affects its inter-organizational relationships, subsequent performance, and process evolutions (Perri 6 et al., 2006). The extent of the affects is difficult to determine because performance varies across different structural types, serving different purposes in different environments (Perri 6 et al., 2006). Network analysis encompasses these variations and helps identify organizational affects and process shifts, providing opportunities to correct or accommodate them based on an organization's needs.

"In general, institutions, ideas, interests, social structure and styles of governance and power are all crucial influences upon the formation, development, destruction, current form, and changing type of inter-organizational relations" (John, 1998, quoted in Perri 6 et al., 2006, p. 81). A hierarchy's structure is designed to distribute the workload among its members that characteristically share long-term, repeated interactions (Stinchcombe, 2001). Successful hierarchies rely on individuals or groups working within capacity, with good information flow, aligned incentives, and continuity (Anheier, 1999). One missing, yet important, part of any organization, is trust (Bradach & Eccles, 1989). The workload balance and subsequent reliance on others requires developing some degree of trust in working relationships. While more flexible, less bureaucratic organizations tend to outperform hierarchies, the opposite is true in environments of low trust (Powley & Nissen, 2012). This may be due to the fact that hierarchies attempt to control trustworthiness through a rules and roles system, establishing trust-based authorities and punitive actions when trust is broken (Perri 6 et al., 2006).

A hierarchy establishes these authorities and regulations to make it more resilient, but its rigid, chain-of-command driven, hierarchical structure can affect collaboration and constrain information flow (Cross & Parker, 2004). As typically seen in hierarchical organizations, information flow is slow, particularly on the return message. This means that individuals on the periphery rarely if at all receive timely information. Network analysis captures this through systematic feedback and identifies the ways in which a hierarchy affects the aspects it relies upon to be successful: capacity utilization, information flow, alignment, and continuity (Cross & Parker, 2004). While useful at identifying organizational shortfalls, the process of network analysis also has limitations. It is to that topic that we now turn.

4. Limitations of Network Analysis

As stated earlier, network analysis is not an all-encompassing solution and should accompany other techniques for full organizational analysis. Proper analysis requires the right tools utilized by trained individuals. These individuals should work alongside members of the organization through pre- and post-analysis meetings to host brainstorming sessions, covering organizational concerns and gathering organizational context for proper analysis (Cross & Parker, 2004). The analysis experts are there to design the data collection devices with input from an organization's members, avoiding research collection traps. Network analysis purveyors need to execute cautiously due to the ethical impacts of the findings and management's reception of them. Mangers need to take caution not to take from analysis what is not there. One story from Rob Cross and Andrew Parker illustrates this point:

> We had created [and presented] a network diagram of connections that did not exist but should exist for the group to be successful. Not hearing us indicate that these were nonexistent relationships, the manager immediately began recounting events and happenings that had created that specific network. During a five-minute monologue, he recalled interactions from a ropes course to prior work lives to current projects that he was sure had generated the network pattern in front of him. (Cross & Parker, 2004, p. 140)

This exemplifies the importance of presenting the findings accurately and communicating them clearly with a complete overlay of the context in which the organization operates. A manager reacting in this way is a prime example of the sensitivity of this information and should be used only to generate constructive conversation on how to improve organizational processes, not solely as justification for an individual's impact or for work force reduction measures (Cross & Parker, 2004).

D. SUMMARY

The basis of SNA developed from the study of people's interactions and personal networks over 100 years ago. Since then, it has developed into a useful tool for leadership teams to analyze their formal organizations and make improvements as needed. Increases in computer processing power over the last 25 years has made this type of data analysis more available to everyday corporations. Companies around the world have taken advantage of SNA's ability to illustrate the member-defined resource flows of an organization. Combined with metrics such as centrality and brokerage, organizations are able to highlight key formations in a network's structure and identify information bottlenecks, underutilized human resources, areas of redundant effort, overloaded points, and areas that lack connectivity. By evaluating these measures in the context unique to the organization, its leadership team can make focused impacts on the organization's workflow in a short period of time. It is this type of impact businesses need to help successfully implement change, and it can be done proactively at the micro and macro level.

Just like civilian corporations, military organizations can and should benefit from the availability of the tools utilized in SNA. Their hierarchical structure, dynamic operating environment, and need to lean operations make them an ideal candidate for SNA. The next couple of chapters discuss the methodology used in analyzing a military organization.

IV. METHODOLOGY AND RESEARCH DESIGN

This chapter presents the basis for this study's research methodology and research subject focal point. It expands the discussion on methodology used to apply social network analysis (SNA) in examining an organization's structure and design, as well as collecting research via a survey. It then discusses the responses of the surveys.

A. BASIS FOR SELECTION

1. Basis for Selection of Methodologies

The discipline of organizational design is an ever-expanding universe of theories, debates, and models. Organizational design theory explores the tendency of organizations to adapt to changing environments and explains shifts in information flow to accommodate the evolution of new demands (Sterman, 2000). Over time, these shifts form new procedural paths within an organization, gradually and subtly building substructures that may drastically diverge from an organization's original design and intent (Perri 6 et al., 2006). These unmanaged, adaptive structures may be detrimental or beneficial to an organization, but unrecognized, an organization's leaders and managers cannot correct an unintended deficiency or maximize a potentially beneficial discovery. Many organizations, including both business corporations and military units, have recognized these shifts and subsequently altered their processes to accommodate them. To recognize and manage these unintended organizational developments, this thesis will consider the works of Jay Galbraith and Richard Daft and call upon Henry Mintzberg's organizational design principles, which provide considerable flexibility in discussing the dynamics of the "simple structure" of the military hierarchy.

Due to the evolution in computing power, organizations can now use modern, dynamic tools such as SNA to conduct multi-level analysis on nearly any given data set. SNA is one such tool and lies at the heart of this thesis's analysis of the military hierarchy. In the civilian world, social and organizational network analysis have been utilized to improve "innovation, sales effectiveness, connectivity, lateral collaboration, talent management, leadership development, feedback, and strategic organizational alignment"

(Cross & Thomas, 2009, p. xi). Because of SNA's unique ability to provide a tangible representation of otherwise abstract relationships (communication, workflow, etc.), it presents an opportunity to determine areas for which a military organization can achieve greater performance.

While a combination of direct observation, official record, and process-participant input generates a more exact and preferred method for retrieving data within an organization, it is typically time consuming and resource demanding (Apte, 2006). The use of surveys provides a low-cost and alternative method for gathering quantitative network data from afar. Given these considerations in a time and access constrained environment, this study implemented a self-administered questionnaire (online survey) to maximize data collection effectiveness to conduct social network analysis.

2. Basis for Selection of Survey Subject

Understanding the aforementioned theories, tools, measures, and level of analysis establishes a strong foundation to determine how beneficial this application can be to a military organization. As an application, the focus will be on the hierarchical status of U.S. Air Force special operations units, particularly at the group level, based on its hierarchical-like design and likeliness to adapt to the high-operations tempo, global distribution, and organizational growth that they have constantly and consistently sustained since September 11, 2001 (military.com, 2019). Due to this study's limitations, a full analysis of a specific unit could not be completed. However, this thesis applied organizational design theories and SNA to an organization modeled on special operations groups within AFSOC to demonstrate the potential of beneficial application.

The authors selected to survey the 1 SOG to build the base of the model due to its size and uniqueness in physical proximity to higher chains-of-command both inside and outside of its direct supervisory chain, placing it at the hub of the Air Force Special Operations operational community (1st SOW Public Affairs (1 SOW PA), 2019). The organization's size of roughly 1,400 people, 11 squadrons, and over 100 suborganizations all conducting a diverse range of complex missions, made the 1 SOG desirable for analysis (1 SOW PA, 2019). Additionally, it met Cross and Parker's (2004) preferred subject requirements for SNA survey as an organization characterized by its "cross function, hierarchical, and physical boundaries" (p. 145). Aside from its physical proximity to higher levels of command, the 1 SOG shares similar characteristics to other special operations flying groups within AFSOC, enabling it to represent a model for special operations groups (SOGs) as a whole.

B. SURVEY METHODOLOGY

Managing Networks of the Twenty-First Century Organizations discusses theories, such as transaction cost and organization competency, which explain why individuals within subunits adaptively shift workflow from its designed purpose (Perri 6 et al., 2006). Its authors propose that people within organizations, whether negatively or positively driven, will seek the information needed to execute their job and improve effectiveness from whatever source is associated with the lowest cost or effort. This individually-driven change may or may not align with efforts of the overall organization and often occurs without approval from higher levels of authority (Perri 6 et al., 2006). To gather these characteristic values of a network, data must be collected from individuals working within the network's subunits. Though not necessarily the best method of data collection, the use of an anonymous online survey provides this study's best chance to successfully map the interactions described above.

1. Survey Design

In Cross and Parker's *The Hidden Power of Social Networks* (2004) the authors assert that SNA should either be conducted through a "personal (egocentric) or group (bounded)" approach (p. 143). While the egocentric approach looks at the interactions between individuals and their immediate neighbors (alters), the bounded approach explores critical functions in an organization through a pre-selected group of individuals. It is the latter approach adopted here. It uses individual responses to 50 questions (Appendix B) that were designed in such a way to enable a bounded SNA.

The survey asked respondents to indicate their organization and office, their tenure in the office, the number of individuals in their office, and list the top six organizations with which they interact (for the full set of questions, see Appendix B)[2] Once a participant selected an organization with which they interacted, follow-up questions identified additional information concerning the interaction, such as its origin, type and frequency, as well as whether it was mandated by regulations. Such information helps expand upon the nature of network relationships and contextualizing the links that tie an organization together. For instance, the responses to frequency and type of interaction can help identify whether two entities interact and gauge the closeness and level of formality of their interaction. As described by Cross and Parker (2004), "the key is to pick relationships that address challenges or strategic imperatives of the group and that are actionable once you find areas to target for improvement" (p. 149). Analysis may uncover situations where two entities, based on function, unexpectedly have frequent and informal communication that upon further review could uncover opportunities for time saving measures to be implemented through a standardized process; a situation not uncommonly overlooked by parties directly involved.

a. Reliability

In Martin Abbot and Jennifer McKinney's book, *Understanding and Applying Research Design* (2013), the authors assert that "research needs to be focused on reliability and validity" (p. 36) and define reliability as the "extent of which measures produce the same result each time it's used," emphasizing the notion of consistency (p. 45). In order to ensure the reliability of the survey used here, we placed special emphasis on eliminating biases and limiting the amount of free-form answers available to the survey subjects. We further enhanced reliability through the review processes established by both the Naval Postgraduate School (NPS) Institutional Review Board (IRB) and Air Force Survey Office. These processes helped identify and remove opinion-based answers and focused the subject's attention on pre-selected options.

[2] The questions were derived from Cross and Parker's *The Hidden Power of Social Networks* (2004), Abbot and McKinney's *Understanding and Applying Research Design* (2013), Gibbons and Zolin's *Studying Relationships in Project Management Through Social Network Analysis* (2015), the 1st SOW PA's 1st Special Operations Group Fact Sheet (2019), Wade Vagias's (2006*) Likert-type scale response anchors*, and conversations with Dr. Susan Hocevar of the Naval Postgraduate School's (NPS) Graduate School of Business and Public Policy (2018).

Because of the anonymous and organizational task focus of this study, the issues of inter-rater and retest reliability were a primary concern when designing the survey. Abbot and McKinney define inter-rater reliability as the "extent to which there is agreement between two or more expert judges classifying the presence of some measure" (p. 82). Our survey addresses this type of reliability, exercising consistency and variance reduction by collecting the responses of multiple experts responding to inter- and intraorganizational relationships from varying aspects of the interaction. If two expert judges from the same organizational function express differing opinions on a measure, their responses are evaluated for consistency among similar functions in other organizations and then a deliberate assessment is made that either averages their responses or selects the most accurate response based on beta-testing. The thesis conducted beta-testing by administering the survey to 12, NPS master's degree students with prior AFSOC experience.

Retest reliability is the "extent to which the responses of a measure correlate highly with the same measure administered at another time or similar form of the measure" (Abbott & McKinney, 2013, p. 82). This study ensured this factor in the survey through the elimination of opinion-based answers and a forced-design template with minimal free-form input. While the survey may be altered in the future to seek different results, the current version maintains a high retest reliability due to the universal nature of the questions that are unlikely to become obsolete.

b. Validity

Abbot and McKinney (2013) describe survey validity as a measure of accuracy. Issues of validity often plague survey research as they are vulnerable to the moods and biases of the survey respondents. The authors detail this problem when they assert that often "attitude measures get confused with behavior measures, and attitude responses tend to be generalized as behavior responses" (p. 46). In their work on the subject, they break down three measures of validity that need to be addressed during this research: face, content, and predictive (p. 81).

Achieving face validity is the foremost concern for any survey research as it involves whether or not the survey actually achieves what it sets out to measure (Abbot & McKinney, 2013). We addressed this issue through careful question selection and non-member, expert beta-testing. Phrasing each question clearly and concisely with limited selection options has enhanced this study's chance of achieving face validity.

Content validity is the concern that the research process fails to adequately include all possible domains in the response section (Abbot & McKinney, 2013). To avoid any issues with content validity, our survey carefully mapped out all potential sub-organizations using research subject documents and allowed sections for respondents to add additional organizations or interactions that were not already captured by the survey itself (1 SOW PA, 2019; SECAF, 2017).

Predictive validity is the ability for a research survey to "provide predictions that can later be confirmed by examining the behavior or content from the same individuals" (Abbot & McKinney, 2013, p. 81). While this survey's predictive validity can only truly be tested by further applications of the study, its standardized nature will provide a valid template on which to base predictions.

2. Survey Ethics

Anytime human subject research is conducted, the ethical implications of the study must be considered to ensure any unforeseen negative outcomes of the study are mitigated. To ensure this study was conducted in the most ethical manner possible, both authors completed Human Research training from the Collaborative Institutional Training Initiative Program. In addition, all survey questions were vetted and refined through the processes of the NPS IRB and Air Force Survey Office. The two primary ethical concerns for any survey-based research are achieving informed consent and beneficence (Abbott & McKinney, 2013).

Informed consent "allows subjects to base their voluntary participation on a clear understanding of what a proposed study will do, any possible risks associated with the study, how their data will be handled, and if there are resources available for any adverse effects" (Abbott & McKinney, 2013, p. 57). The survey conducted for this study addresses all previously mentioned informed consent liabilities with a disclaimer on the initiation page of the survey.

Beneficence is the obligation of researchers to ensure that no harm (physical, psychological, social, legal, etc.) comes to the participant of the study (Abbott & McKinney, 2013). This study ensures beneficence through the anonymity of participation and limited release of results. While its results are releasable contingent on specified consent by a survey respondent and regulation governing its application, this study's intent and use is purely academic and will lead to no retribution. Additionally, it will present all actual results and analysis of this survey in an anonymous method that further disguises survey responses by assigning an alphabetic label to suborganizations in place of each unit's numeric label. Furthermore, individual responses have no direct name correlation, and displayed results are an aggregate of responses identified as a generic organizational function within a special operations group.

C. SURVEY RESPONSE DATA

The 1 SOG survey was conducted during a seven-week period from February through April, 2019. With permission from the 1 SOG Commander, the authors distributed the 1 SOG survey to the entire 1 SOG organization using an official distribution list from the Air Force Network Global Address List. Approximately, three weeks after the initial email advertising the survey was sent, the authors sent an additional reminder email requesting voluntary participation prior to the close of the survey window. In accordance with the aforementioned survey ethics guidelines, the authors did not initiate any further contact with the survey pool. Air Force regulatory restrictions limited survey participation only to military (non-civilian or contractor) members of the unit (SECAF, 2018a). Due to the continuous fluctuation of personnel, the respondent pool is estimated to have been approximately 1,400 individuals (1 SOW PA, 2019). Of those participants, an unknown number (estimated in the hundreds) were likely unavailable to take the survey due to deployment, temporary duty status, or personal leave.

Of the available subjects, the survey garnered 82 total responses. These can be broken down into 46 partial responses (participants did not fill out the survey in its entirety) and 36 full responses. In addition, the authors sent a separate, but similar, survey to 12 Naval Postgraduate School students with previous AFSOC experience (several former members of the 1 SOG) who provided insight into 18 other Air Force special operations functions. NPS respondents were encouraged to answer the survey multiple times if they held more than one position in a SOG in which they had gained expert knowledge. Their voluntary participation served as a beta-test to validate survey questions and responses, generating additional input from various experiences in other AFSOC SOGs, helping to formulate a better overall model, improve its accuracy, and resolve conflicting information.

The combined 100 SOG and NPS responses resulted in enough data to map 172 organizations and 305 ties between them. A tie between two organizations was "drawn" if one or more survey respondents indicated that they interacted with another organization. In other words, if respondent A belongs to organization X, and he or she indicates that they interact in some manner with organization Y, then a tie was assumed to exist between organizations X and Y. The type of interaction (e.g., frequency, informal, mandated) was also recorded.

Simple sample size evaluations of the population surveyed in this study does not provide a true measure of data validity. The simple sample size calculation of a 1,400-person survey, with a confidence level of 95% and interval of six, yields a 224-person sample size (Creative Research Systems (CRS), 2012). The results from this short and voluntary method of data collection do not provide enough information to accurately model the entire 1 SOG as a network. The 305 relations do, however, offer more than enough information to validate the use of SNA as a tool for the purposes of this study.

This study analyzes a particular type of organization; therefore, the model's validity should be valued on the number of organizational functions that responded. Of the roughly 190 primary functions within the 1 SOG, the survey captured 132. Held to the same sample size standards as before, 111 responses would make for a valid sample to model the organization (CRS, 2012). Further validating the responses requires that a significant number of personnel that perform the function within the organization fill out the requested data. For instance, if 20 people work in the SOG Standardization and Evaluation (Stan Eval) office, by the same sample size standards nearly all of them would need to provide data to ensure a 95% confidence level was achieved in measuring the relationships. While this study mapped more than 111 organizational functions, in most cases it was unable to achieve a response rate representative of every individual responsible for any given organizational function within the 1 SOG.[3] Regardless, this thesis's primary purpose is to illustrate the utility of using SNA to evaluate military hierarchies such as the 1 SOG. That the results presented later are highly suggestive and potentially informative suggests that a survey with a higher response rate would prove of even higher value.

D. RESEARCH GOALS AND DATA ANALYSIS

This study's goals are to answer the following three foundational research questions (first discussed in Chapter I):

1. Is a hierarchy the best organizational design for a special operations flying group?

2. Can SNA be used as a tool to maximize a military unit's organizational structure?

3. Will SNA expose hidden potential for improvement in an operational military organization and provide actionable data?

To ensure these are met, the quantitative results from the survey and beta-testing, in conjunction with Air Force organizational design documents will be analyzed using SNA and then compared with Henry Mintzberg's organizational design theories discussed in Chapter II.

1. Data Analysis

The research study survey provides unique insight into the network of communication and workflow a SOG. Utilizing some of the tools discussed in Chapter III

[3] This study's survey data resided on NPS's survey link run by LimeSurvey.org, on NPS servers. Where held, the authors password protected survey response data per NPS IRB approval and deleted the information once aggregated and analyzed for ethical integrity. All data in the forthcoming analysis was logged and then anonymized to protect against the identification of individual unit respondents.

and listed in Appendix A, a thorough SNA will be conducted to highlight key areas that support or potentially impede the organization as a whole. Measurements such as betweenness and degree centrality, centralization, and network density will enable us to determine if sub-units communicate in a manner consistent with Henry Mintzberg's (1981) simple structure or if they circumvent their organizational design. If the analyzed relational data display notable deviations from the expected organizational structure based on basic design documents, Mintzberg's principles will be examined to asses if a better structure may be applicable.

2. Hypothesis and Expected Results

Knowledge of organizational and systems theory paired with SNA/ONA tools allow this thesis to conduct an in-depth study of organizational processes and structure. It will help determine the usefulness of this tool, applied to an operational, military organization, during a time when the force is seeking innovative ideas to more effectively handle a persistently-limited resource, high demand environment. As such, this study's hypothesis and expected results are as follows:

1. The current M-form hierarchy is suitable; however, an adaptation of the U-form hierarchy may produce better communication and workflow.
2. SNA can be a valuable tool for military organizations to refine their structure and maximize capabilities.
3. SNA will both expose hidden potential and provide actionable data for military organizations.

V. ANALYSIS

This chapter analyzes the compiled survey data using SNA and organizational design principals. In particular, communication within the SOG hierarchy will be examined to determine if SNA is a tool that can provide actionable data on the formal and informal relationships that exist within an organization. The hierarchy in this thesis is defined as the organizational structure of the military unit as defined by organizational theory and military doctrine (Mintzberg, 1981, SECAF, 2015b). It is not defined in terms of SNA measures of centralization; in fact, a military "hierarchy" could turn out to be relatively decentralized. Nevertheless, the organizational theories of how hierarchies work is evaluated in terms of the organizational measures and traits SNA associates with elements of an organization's network.

The information contained within this chapter reflect a model of a SOG based on several inputs including survey data collected from the 1 SOG. The validity of the model is strong, but it is only a model. It does not directly reflect the answers provided by the 1 SOG survey or the actual 1 SOG as an organization. Readers should caution themselves against assuming or asserting context to perceived similarities between what is captured in this survey and actual operational units (Cross, 2004).

A. NETWORK ANALYSIS

1. SOG Evaluation

Once all survey data was compiled and anonymized to model a SOG, the authors analyzed it using Organizational Risk Analyzer (ORA), version 2.3.6 (Carley, 2011). In addition, all sociograms depicted in this chapter were generated by the same software. To clearly display the network, most sociograms in this study color the nodes based on unit affiliation, size the nodes based on importance in the military hierarchy, and label the nodes by the unit name and function. The color of the tie between nodes represents the unit that sourced the link. The entire SOG-modeled network can be seen in Figure 10, which displays all compiled data representing both the formal and informal communication relationships of the entire SOG network. Characteristic of a typical SNA network visualization, this image is devoid of a formal organizational design structure.

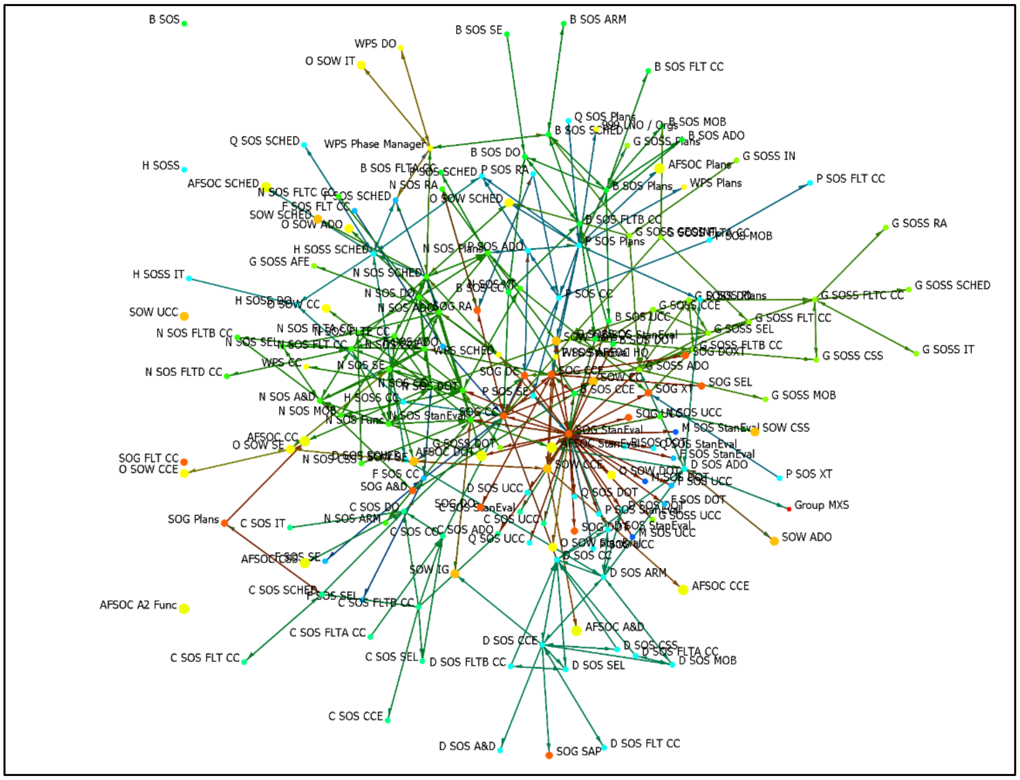


Figure 10. SOG Communication Network

Table 1 lists the measures and associated definitions used in this analysis. Their importance to the analysis will be discussed as applicable throughout this chapter. These measures, along with several other SNA metrics, can also be found in Appendix A.

Table 1. Measures and Algorithms Used in SOG Analysis.

SNA Measure or Algorithm	Definition
Degree Centrality	**The number of a function's (organization's) ties**
Betweenness Centrality (Freeman, 1979)	**The degree to which a function (organization) lies on the shortest path between two other functions**
Eigenvector Centrality (Bonacich, 1972)	**The number of a function's (organization's) ties, weighted by the degree centrality of its neighbors**
In-degree Centrality (Wasserman & Faust, 1994)	**The number of a function's (organization's) incoming ties**
Out-degree Centrality (Wasserman & Faust, 1994)	**The number of a function's (organization's) outgoing ties**
Hub Centrality (Kleinberg, 1998)	**Eigenvector centrality of out-degree; a high scoring "hub" points to many "authorities" or nodes with incoming ties.**
Authority Centrality (Kleinberg, 1998)	**Eigenvector centrality of in-degree; a scoring "authority" points to many "hubs" or nodes with outgoing ties**
Boundary Spanner, Potential (Cormen, Leiserson, Rivest, & Stein, 2001)	**Betweenness centrality divided by degree centrality**

SNA Measure or Algorithm	Definition
Clique Count (Wasserman & Faust, 1994)	**Number of distinct cliques to which a node belongs. Used in ORA only (Carley, 2011).**
Clique (Wasserman & Faust, 1994)	**A group of three or more functions (organizations) where all have to ties to one another**
Density	**Total number of observed ties in a network divided by the total possible number of ties in that network, range 0 – 1.**
Centralization	**Standard measure of centralization uses the variation in actor centrality within the network to measure the level of centralization.**
Variance	**Indicated how centralized a function (organization) is as the average of the squared differences between each actor's centrality score.**
Standard Deviation	**The square root of variance, indicates how centralized a function (organization) is.**

a. Forming Networks from Survey Responses

To gather network data, survey participants identified their organizational role and nominated other organizational roles with which they interacted most often. Next, they answered questions about the interaction such as how often the interaction occurred, what means were used to interact, whether the interaction was mandated by regulation and whether the interaction was characterized by a request of their role, by their role, or both. More specific survey questions and possible answers to them are found in Appendix B.

The responses generated the three primary networks used in this analysis. These networks based relationships on frequency of interaction, regulation requirements, and formality of communication. Brief descriptions of these networks are covered in this chapter, and further network details are presented in Appendix C. The following scenario will demonstrate how the networks were formed.

Figure 11 shows the sphere of influence of the P SOS Plans office. At least one individual fulfilling the role of the plans office for the P SOS completed the survey, entering in the identity of that organizational responsibility into the network. From that office, 13 other organizational roles and responsibilities were identified as being an important relationship for P SOS Plans to do its job. One of those relationships was to N SOS Plans (circled in black). The network relationships (the ties between nodes) displayed in Figure 11 represent the frequency of interaction between organizational functions. These relationships were generated from the question about how often the two roles interact. The weight of "7" shown in Figure 11 (yellow box) means the interaction occurred two to three times per week. The answer of "two to three times per week" was one of eight responses the survey participant could have provided to this question about this relationship. The other relationships were generated likewise with varying degrees of weight. A lower value was given to less frequent interactions, placing those organizational relationships further from the P SOS Plans node. ORA can generate a similar display such as the SOG Stan Eval sphere of influence from the same frequency of interaction network as before, seen in Figure 12.

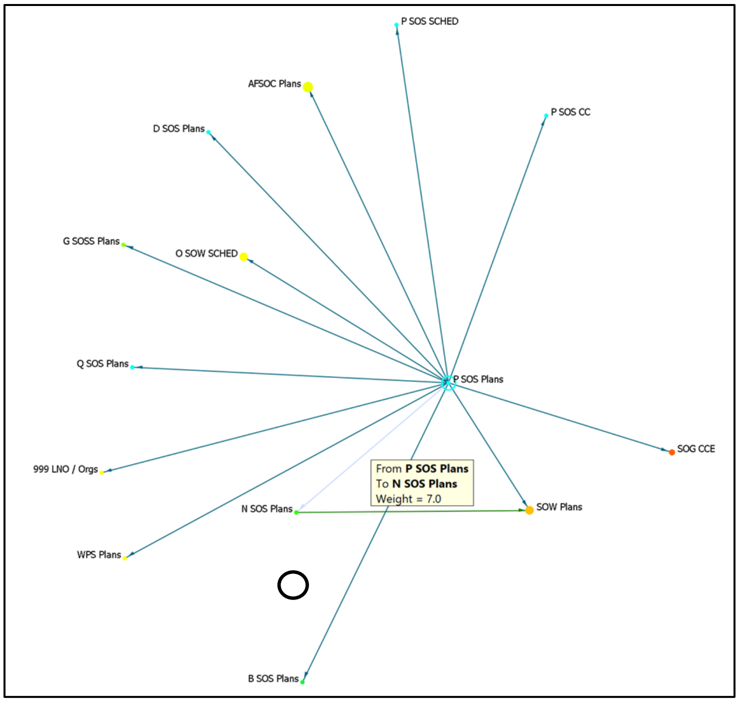


Figure 11. P SOS Plans Sphere of Influence

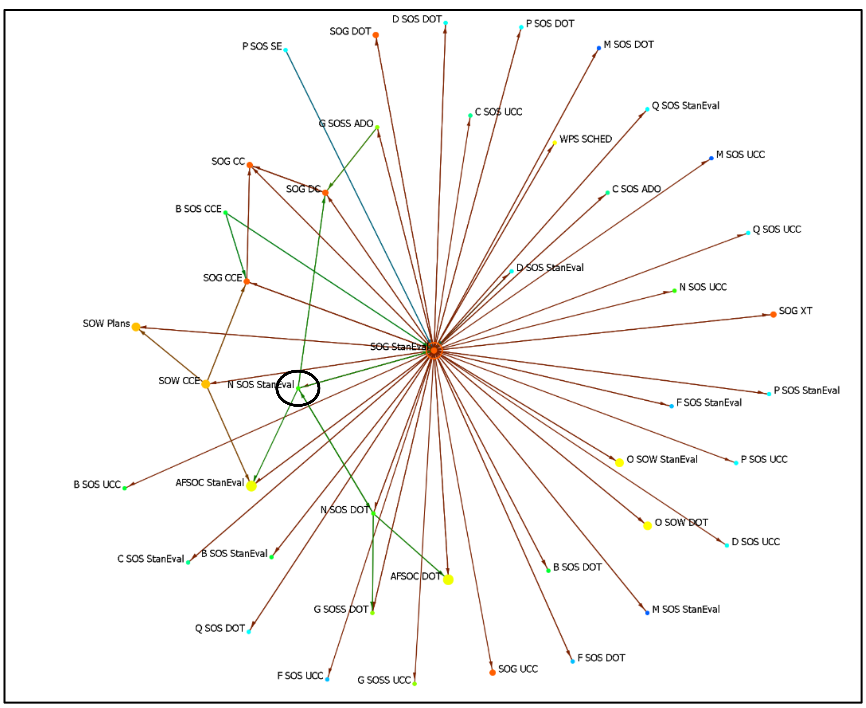


Figure 12. SOG Stan Eval Sphere of Influence

Like the P SOS Plans survey participant, SOG Stan Eval nominated the other functions seen in Figure 12. Additionally, members from N SOS Stan Eval (circled in black) also responded to the survey. The response from that office generated a SNA relationship that includes both side's perspectives, resulting in a stronger, closer tie with directional arrows on both ends. The analysis also included the other relationships that N SOS Stan Eval and SOG Stan Eval share, as seen by the tie between N SOS Stan Eval and N SOS DOT.

The network continues to combine these relationships, making connections through commonalities in survey response. Figure 13 shows the combination of the P SOS Plans and SOG Stan Eval from Figures 11 and 12. While SOG Stan Eval and P SOS Plans did not have a direct link, Figure 13 highlights the organizational functions that tie them, seen in the center of the figure. They both provide inputs to SOW Plans and SOG CCE. The distances between nodes is still representative of the weights assigned to the frequency of interaction. The closer the nodes, the more frequently those roles interact. The tie between N SOS Plans and SOW Plans, highlighted in the yellow box holds a weight of interaction that occurs less frequently than N SOS Plans and P SOS Plans as seen in Figure 11. Just as Figure 13 combines these relations, the rest of the network is built similarly, on the same type of interaction, until the entire network is created as illustrated by Figure 14 (same network as Figure 10). This examples only shows one type of relationship. The other relational networks will be explored later in the chapter.

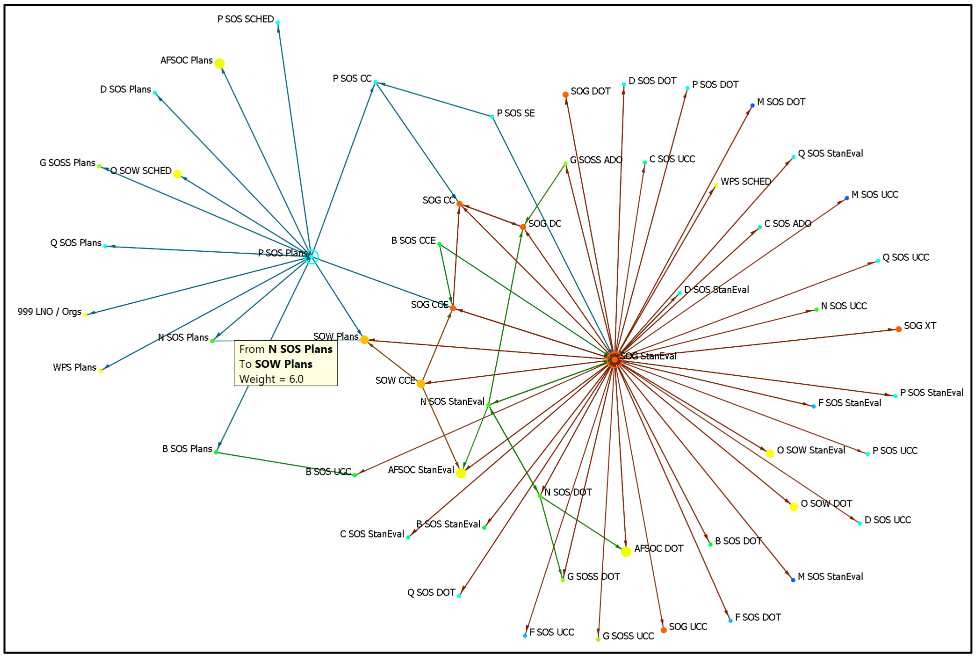


Figure 13. P SOS Plans and SOG Stan Eval Network

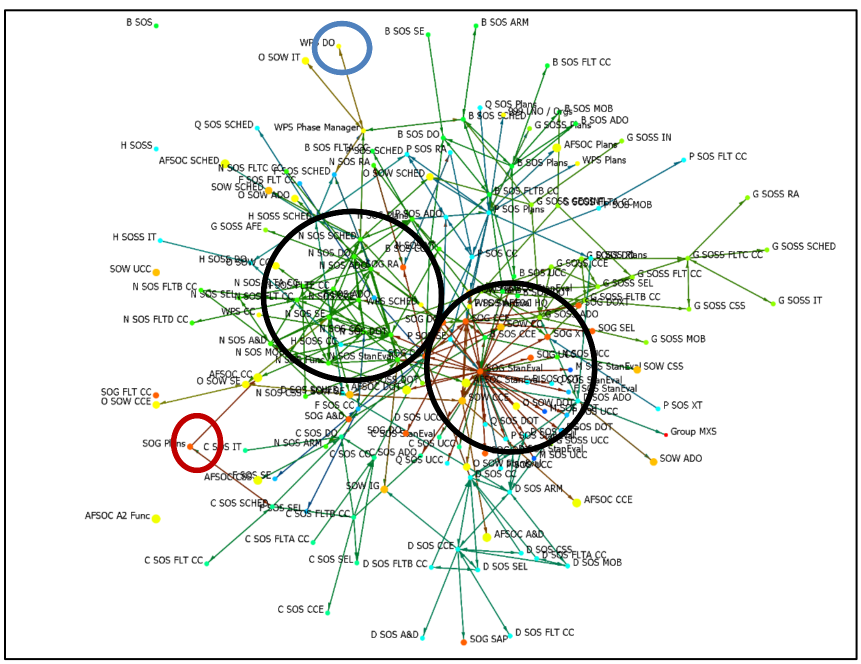


Figure 14. SOG Communication Network: Nodes Circled

Algorithms that generate network sociograms attempt to locate nodes that are either tied to one another or share ties to several of the same nodes close to one another. Nodes that are not tied to one another and share few or no ties to other nodes tend to be placed at a distance from one another. Thus, nodes with numerous ties can be found both in the center or on the periphery, as can nodes with very few ties. That said, it is not uncommon to find nodes with numerous ties located toward the center of sociogram and those with few ties located on the periphery. The communication network displayed in Figure 14 includes all types of ties (daily, weekly, and monthly frequency; mandated communication by regulation, etc.), as well as several nodes located not part of the SOG (e.g., yellow nodes indicate AFSOC organizations). All organizations outside of the SOG, such as the AFSOC nodes, were nominated by an individual within a SOG organization and did not actually participate in the survey. Nodes without any ties are referred to as isolates and were removed for analysis measures (Cunningham et al., 2016).

The network has 172 actors (166 without isolates) and 305 ties. Network density (0.01) and degree centralization (0.034) are low, suggesting there are much fewer ties than possible and the network is decentralized (not dominated by one or a few nodes). The low variance (0.000025) and standard deviation (0.005) support these conclusions as well. However, the top two highest scoring functions in degree centrality, SOG Stan Eval (0.038) and SOG CC (0.020), were the only two outside of three standard deviations from the mean. This sets SOG Stan Eval and SOG CC clearly above the rest, and suggests that the organization is possibly more centralized around SOG Stan Eval and the SOG CC. As nearly all information is expected to flow to the SOG CC, that function retains the highest ratio of in-degree centrality (0.036 on a scale of 0 to 1). While these measures point the organization toward the higher-levels, the low centralization value is explained by the communication and interaction filtering that occurs in each step up the chain of command (example: lower ranking officer and enlisted personnel rarely speak directly with the SOG commander, they typically communicate solely with their peers and direct supervisors).

In terms of centrality, SOG Stan Eval ranks the highest in betweenness, eigenvector, out-degree, and total degree centrality. The values of these measures for each network can be found in Appendix A. For this example, though, the measures do not matter as much as the reason why SOG Stan Eval takes the top spot in each category, which occurred because SOG Stan Eval has the most ties. Networks generate initial ties when one actor nominates another. If all actors only nominate six other actors, and one actor appears as the number one in all categories, then it is a true representation of that actor's centrality based on others votes. However, if "actor A" makes 24 undirected nominations (while all the other actors only nominate six), "actor A" will have the highest centrality based on the sheer number of self-nominations. SOG Stan Eval's degree centrality was more than six standard deviations from the mean and could be considered an outlier in this regard.

This is a reason why the direction of the communication matters and could validate an in- or out-degree of centrality for SOG Stan Eval. This situation highlights one drawback of this study's research method in the data collection process; the survey design allowed for more than six responses from multiple individuals who held the same organizational role. This issue could be minimized by eliminating some of the responses, but to build as many functions as possible in a SOG for analysis, all were kept. Aside from the skewed data, if more evenly spread responses provided this result, it would not have been surprising considering SOG Stan Eval's role in the organization. This is explained by the fact that SOG Stan Eval exists outside of the direct chain of command in the hierarchy, but as an essential support element that aids all levels of the organization focused on upholding the standards of flying for all squadrons with that mission within a SOG, a primary focus of the organization (SECAF, 2010).

In Figure 14, the orange SOG staff and the dark green N Special Operations Squadron (SOS) are both circled in black. These organizations lie at the very center of the network. This could reflect the fact that the SOG staff and the N SOS exhibited the highest participation rates in the survey, but they may simply be because they are truly located at the center of the network. In every network, after all, some nodes will be located at the center and some will be located on the periphery.

b. Peripheral Elements

Units that exist on the periphery provide the analysis with a metric that highlights units or offices with very few interactions. This is not necessarily a negative, however, as a contextual comparison is necessary to reveal whether a peripheral function is appropriate. Since this is an analysis of a SOG, analysts should expect minimal connections to organizations (such as higher headquarters) outside of that SOG. Figure 14 illustrates this with most of the wing and command functions residing on the periphery. Additionally, detailed squadron functions should not be central to the operations of an entire group since their function is solely designed to support the squadron. Other experts emphasize that functions relying on expertise should be on the periphery with minimal connections, reflecting opportunities for those functions to improve their expertise for future dissemination through the organization without the distraction of the daily organizational operations (Cross, 2004). A weapons squadron (WPS) provides a good example of this, and one such element is circled in blue in Figure 14.

With such information, a commander (armed with the context of his own unit's status) can deduce which of his units are most essential, or should be, to the group's everyday mission. On occasion, some of the peripheral functions may shift to a more central position and vice versa. For example, SOG Plans (circled in red on the bottom left of the sociogram in Figure 14) lies on the edge of the network currently, but could become more central to the SOG as more functions interact with plans while gearing up for its annual multi-force exercise. Armed with manning and deployment information, a commander can reallocate essential personal to SOG Plans from more peripheral nodes during those times, and then return them for majority of the year. To assist in this endeavor, sociograms can vary the node size based on an organizational function's manpower strength. The decision to temporarily shift manpower to the SOG Plans function in this situation may be intuitive, but to snapshot an entire organization as large as a SOG with SNA tools would drive a more expedited, constructive manpower sourcing conversation.

c. Boundary Spanners

As mentioned in Chapter III and earlier in this chapter, boundary spanners are generally key elements in a network. Typical boundary spanners are individuals in leadership positions, who distribute information in and out of an organization (Thompson, 1967). However, this is not always the case, such as when the boundary spanner brings two or more organizations together. Sometimes, leaders tend to be those that interact on behalf of the organization outside of its boundaries. When analyzing boundary spanners within an organization, leaders and managers should take note. Successful boundary spanners tend to have a higher degree of continuity, therefore regular manpower turnover in these positions could prove detrimental (Anheier, 1999). When boundary spanner functions exhibit high levels of centrality, they have a significant degree of leverage and influence throughout (Cross, 2004). These are the individuals that typically dominate the informal communication hierarchies defined in *Communication in Organization* by Rogers and Agarwala-Rogers (1976) back in Chapter 2. In this case, managers and leaders need to ensure these functions have adequate resources because this combination tends to encounter capacity-demand imbalances (Cross, 2004). Shifts in process flows that impact these positions could have far reaching impacts.

Figure 15 depicts the SOG based the frequency of interaction responses, narrowing it down to those that occur on a weekly or more basis. This sociogram highlights each unit's boundary spanners applying an attribute-based layout (grouping the units together) and sizing the nodes by their boundary spanner, potential score where larger nodes indicating a higher potential for being a boundary spanner in the network. The figure shows the various organizational functions assuming a boundary spanner role as assigned by the ORA program's boundary spanner potential measure, a measure given by each node's position and centrality in the network. Some of these functions hold leadership positions, like the SOG CC, and others do not. The SOG CC also scores high in terms of degree of centrality and therefore has a significant set of resources in his support structure. Hierarchies, such as the SOG, are designed to distribute transaction costs across the organization and alleviate the burden of boundary spanning agents (Stinchcombe, 2001). Non-leadership functions are boundary spanners due to their specific role and responsibility, like GEOINT (circled in black), due to their nature as an information distribution center within a support squadron, SOSS.

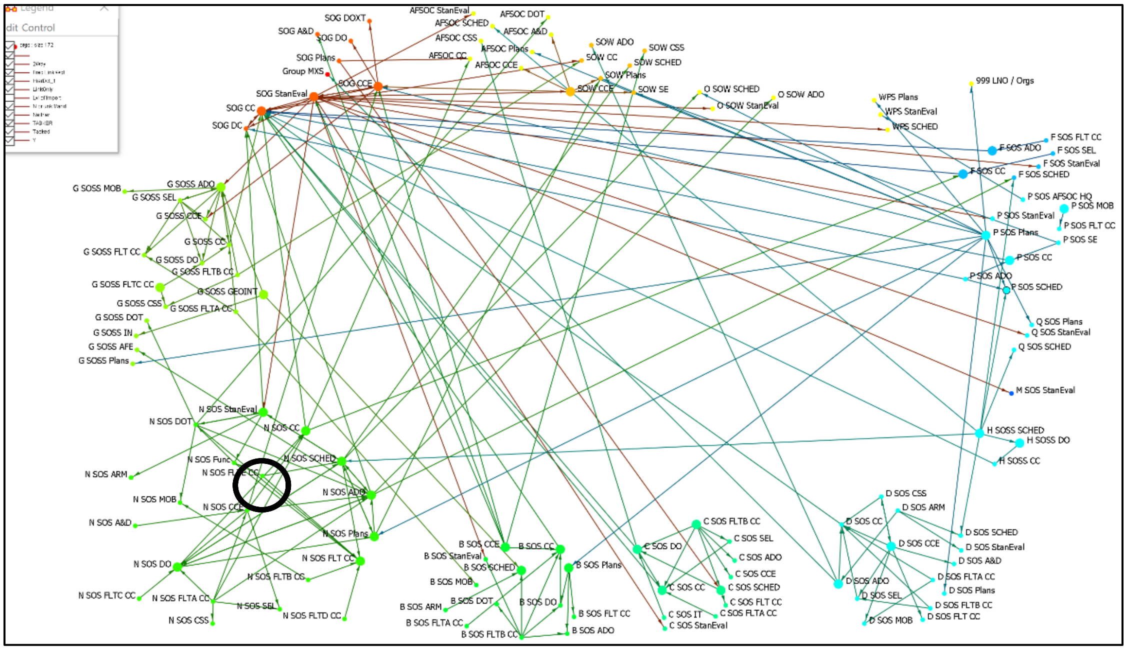


Figure 15. SOG Network: Boundary Spanners

d. Additional Network Measures

In addition to the fact that the network's density (0.01) and centralization (0.034) are both low, the network is also characterized by a high level of cohesion (0.909) and betweenness centralization (0.042). The lower betweenness centralization value also indicates a more decentralized organization, and the high level of cohesiveness (being able to connect to other functions directly and indirectly) in a network with a low density suggests a structural flow of information that connects separate portions of the network, much like a hierarchy.

Earlier the chapter discussed SOG Stan Eval highly centrality scores could reflect its numerous survey responses. Nevertheless, one would still expect the Stan Eval role would be very central for an organization focused on flying aircraft. For these units, Stan Eval "validate(s) aircrew readiness and the effectiveness of unit flying" for the commander, which includes maintaining aircrew qualifications (SECAF, 2010, p. 7). Since, the SOG modeled has eight flying squadrons, Stan Eval would be a significantly interactive function within the organization. It just may not be the most central as some measures suggest.

Analyzing the same function at the squadron level may be more representative of the centrality the Stan Eval role has in the SOG. The volume of N SOS Stan Eval interaction data was more consistent with the volume of data collected from other functions within the organization. While not occupying a top spot, it measured within the top 10 of each centrality measure considered here, obtaining its highest rank in terms of betweenness centrality, which is often interpreted as capturing brokerage potential within a network. This can be visually seen later in Figures 12 and 13, as N SOS Stan Eval is an active function within its unit and bridges directly to the next level in the hierarchy, SOG Stan Eval.

Aside from SOG Stan Eval, other functions scored high in terms of various metrics. As previously stated, the SOG CC (0.036) scored highest in terms of in-degree centrality. As the leader of the organization, it is not surprising that the SOG CC has the most inbound ties. The SOG CC also held the highest value in authority centrality (0.463) in both the frequency of interaction and formality of communication networks. Furthermore, particularly in the frequency of interaction network, the SOG CC holds one of the highest values in eigenvector centrality (0.296). Considered the king-of-cliques measure, this value represents an actor who is connected to other well-connected actors in the organization (Bonacich, 1987). Again, not unexpected for the role of the SOG CC as the leader of the group. The SOG CC rightfully holds the top spots in these measures of importance, but the value is low, showing a more decentralized control.

Interestingly, the N SOS DOT also ranks high in eigenvector centrality in several network variations. As the squadron training function, this suggests that training is tied to several other important functions within the unit and therefore an integral component with a significant workload. Many leaders and managers understand this function's role through experience and take it into consideration when making manpower decisions, but it demonstrates another way in which SNA can prove useful in managing organizations. The clique-count measure also supports this conclusion. It captures the number of cliques to which a function belongs; a clique, you will recall, is a subgroup of three nodes (functions) or more where each node is tied to every other node (Wasserman and Faust, 1994; Carley, 2011). N SOS DOT holds the highest clique count (13) in each of the SOG network variations, again displaying its level of importance in squadron operations. It is important to keep in mind that context matters when evaluating these roles. Even though other units have training (DOT) functions, it does not mean they utilize it in the exact same fashion, which may create variations in the measure across units. Although for an organization such as the SOG, regulations govern what responsibilities each function holds, closely standardizing their role throughout and suggesting that variations should be minimal. For more specific measures not discussed in this chapter see Appendix C - SNA Codebook and Additional Network Displays.

e. Compartmented Analysis

SNA can also parcel larger organizations into specified samples of units or entities. Figure 16 focuses in on three sub-units (SOG CC in orange, N SOS CC in dark green, and D SOS CC in teal) pulled from the larger organization and highlights their "sphere of influence" for both formal and informal monthly interactions. The Figure 16 sociogram is a top-down view of the frequency of interaction network involving the SOG with N SOS and D SOS. It can then be turned vertically (Figure 17) using an ORA hierarchy algorithm (Carley, 2011), which arranges nodes in terms of a hierarchy based on outgoing ties. For example, if a node has only outgoing ties, it will be located toward the top of the sociogram; if it only has incoming ties, it will be located toward the bottom. Figure 17 further emphasizes each person's position in the organization. This simplified example is essential to depicting how SNA can be manipulated into multiple sociograms that can then be further analyzed using organizational design principles for more detailed, specific decisions.

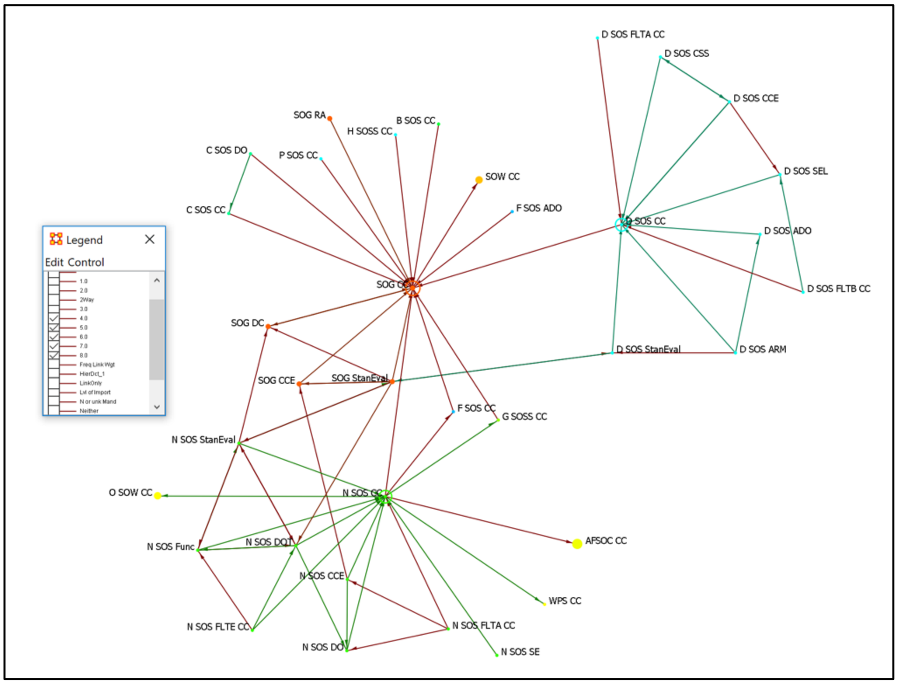


Figure 16. SOG Staff, N SOS, and D SOS Network

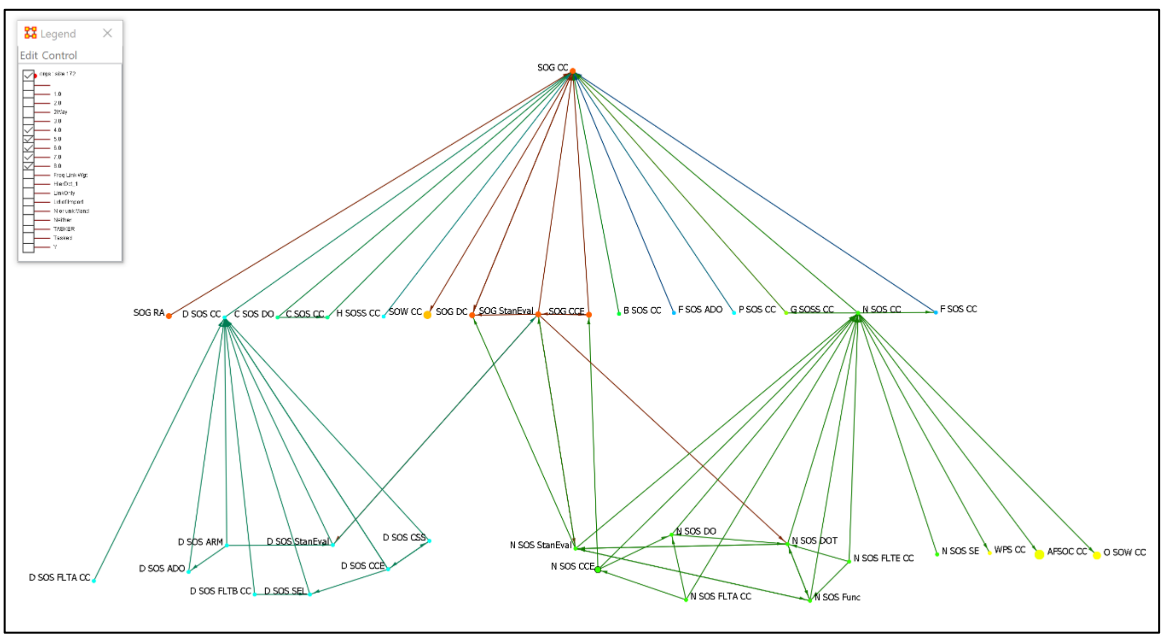


Figure 17. SOG Staff, N SOS, and D SOS Network 2

A direct comparison between these figures reveals some interesting findings in the way these two squadrons interact with their chain of command. In Figure 16, it is clear that the three most central nodes (SOG CC, N SOS CC, and D SOS CC) have relatively similar spheres of influences in which their subordinate organizations report through each commander, who then reports directly to the SOG commander. Figure 16 also displays formal and informal communication that happens within a month's timeframe. The main difference between N SOS and D SOS, however, is that sub-units within N SOS have formed several alternate links that connect to the SOG commander through the SOG staff on a more frequent basis. This, when compared with D SOS (an organization that filters all communication through the D SOS CC) highlights an example of breakdown in the simple structure of the hierarchy. Once the sociogram is turned vertically (Figure 17), it becomes apparent that those N SOS relationships that do not flow through the N SOS CC are a result of the N SOS Stan Eval communicating directly with the SOG Stan Eval office. This relationship still exists for D SOS but on a less frequent basis, which can be seen comparing Figure 16 to Figure 17 (the exact same network). The reason for the differences in the way these two squadrons interact is contextually driven, but regardless of the situation, it is an insight worth understanding. One possible explanation could be that the subordinate Stan Eval function in N SOS is less experienced requiring more frequent oversight by its senior counterpart. What is more important in this relationship (a characteristic that speaks to the health of the organization's design), is that this section of the organization is functioning as intended. While it appears both D and N SOS CC frequently communicate with their superior, the SOG CC, their responsibilities are fairly expansive. Delegating authority for the SOS Stan Eval component to directly manage the higher-level Stan Eval requirements with SOG Stan Eval, and allowing the SOG Stan Eval element to manage necessary information flow regarding that function to the SOG CC provides better time management to discuss the most pertinent topics SOG CC to SOS CC. While this is not an abnormal occurrence, it serves as a further example of how SNA can be a valuable tool to track communication in an organization.

2. The Network Hierarchy and Communication

The SOG hierarchy (Figure 18) shows the formal organizational structure of the group. Commanded by AFSOC and a SOW CC, the SOG CC maintains a small staff (labeled SOG RA, SOG SE, etc.) and directly oversees 11 squadrons. Designed in a fashion consistent with the classic Mintzberg (1981) simple structure (Figure 19), all communication is designed to flow upward from SOS sub-units, through the SOS CC, supported by the SOG Staff, leading ultimately to the SOG CC and then out of the organization.

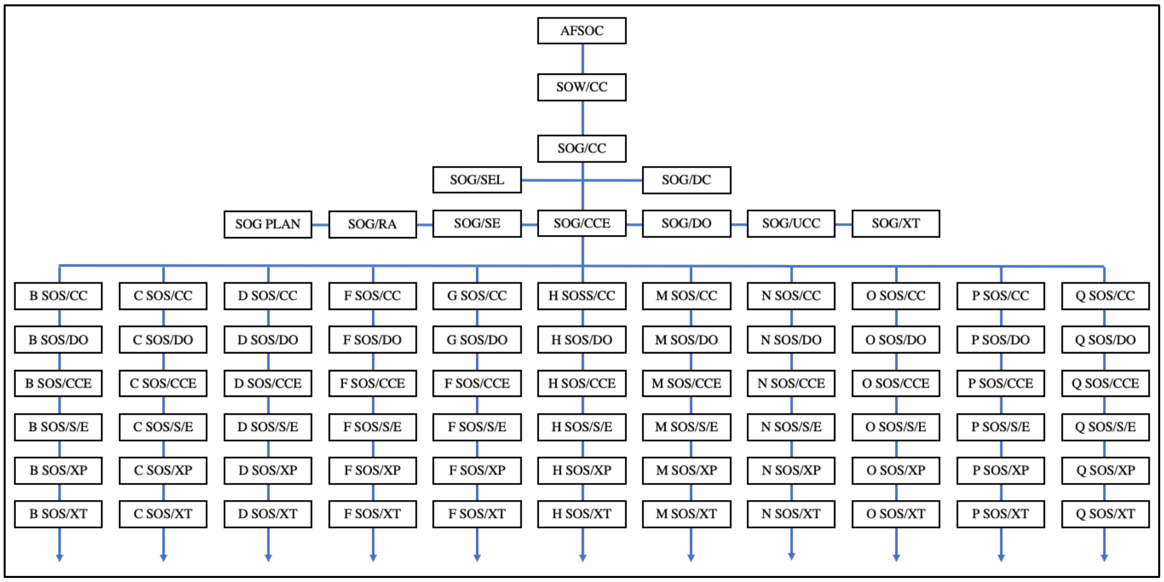


Figure 18. Anonymized SOG Hierarchy

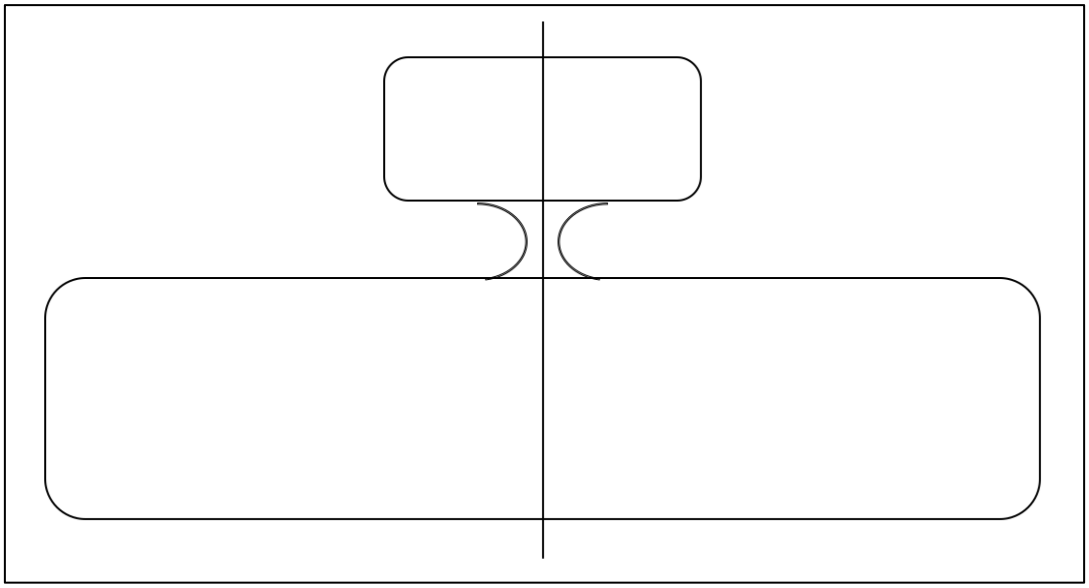


Figure 19. Mintzberg's Simple Structure. Source: Mintzberg (1981).

The hierarchy in Figure 18 closely resembles Mintzberg's structure in Figure 19 on paper, but does not communicate in a similar fashion once analyzed through SNA.

Figure 20 depicts all formal and informal interactions and is the same network as the beginning of the chapter (Figures 10 and 14), but visualized using ORA's hierarchy algorithm, which we discussed earlier. Visual analysis of the sociogram reveals the expected structural design of the hierarchy placing the SOG CC at the top of the network with subordinate units occupying lower levels. The sociogram deviates from the hierarchy, however, with the large amount of horizontal communication between dozens of sub-units inside of the organization. In addition, the same sub-units have dozens of links directly to the SOG Staff showing a high dependence on offices outside of the squadron organizations. If the SOG was a pure simple structure, the squadrons (or "operating core") would have little or no support functions between them and leadership (or the "strategic apex") (Mintzberg, 1981, p. 6).

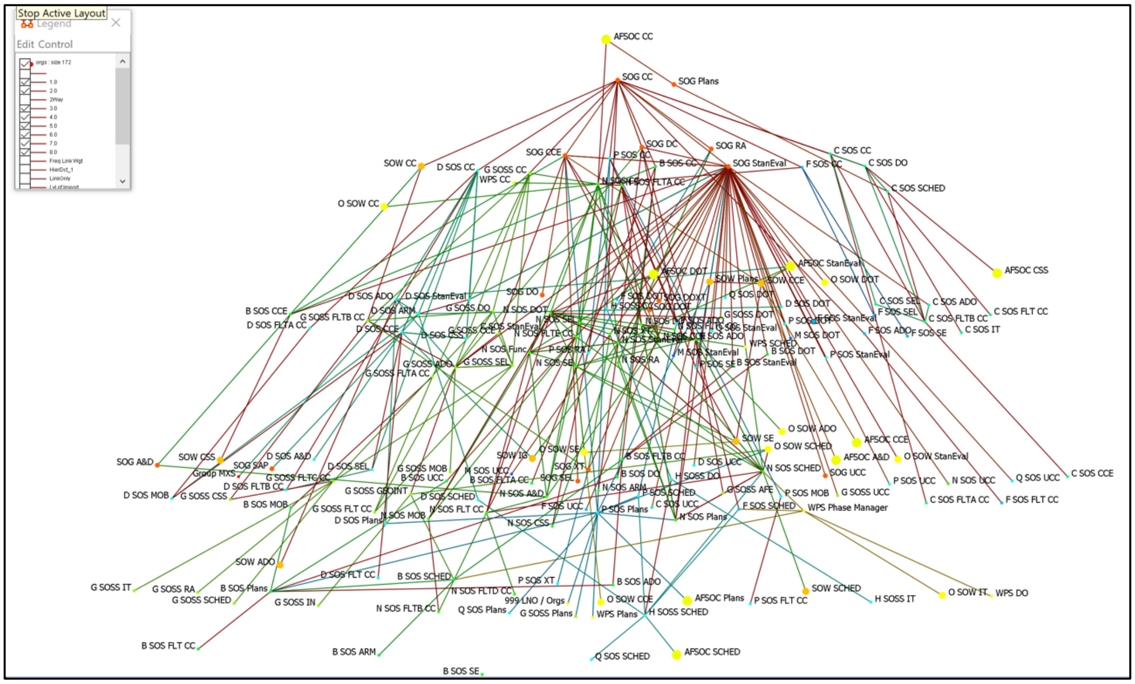


Figure 20. SOG Networked Hierarchy

In Figure 21, these examples of lateral communication (which occur in defiance of the simple structure nature of the hierarchy) are circled in black. This type of peer-to-peer communication and heavy reliance on outside support staff is more characteristic of Mintzberg's (1981) machine bureaucracy depicted in Figure 22. The visual confirmation of SOS dependence on the SOG staff is also backed up with the quantitative standard network report in ORA (Appendix C) that lists SOG Stan Eval, SOG CC, SOG CCE, and various SOS-level sub-units as having the highest betweenness centrality (a characteristic of "gatekeepers" that connect two groups) (Cunningham et al., 2016). If the SOG were acting in accordance with traditional simple structure principles, SOS CC positions should have the highest betweenness centrality scores. Instead, the survey and SNA reveal that the SOG depends heavily on informal and non-mandated communication to accomplish the day-to-day and week-to-week mission. A visual depiction of the informal and formal communication can be seen in Figure 23.

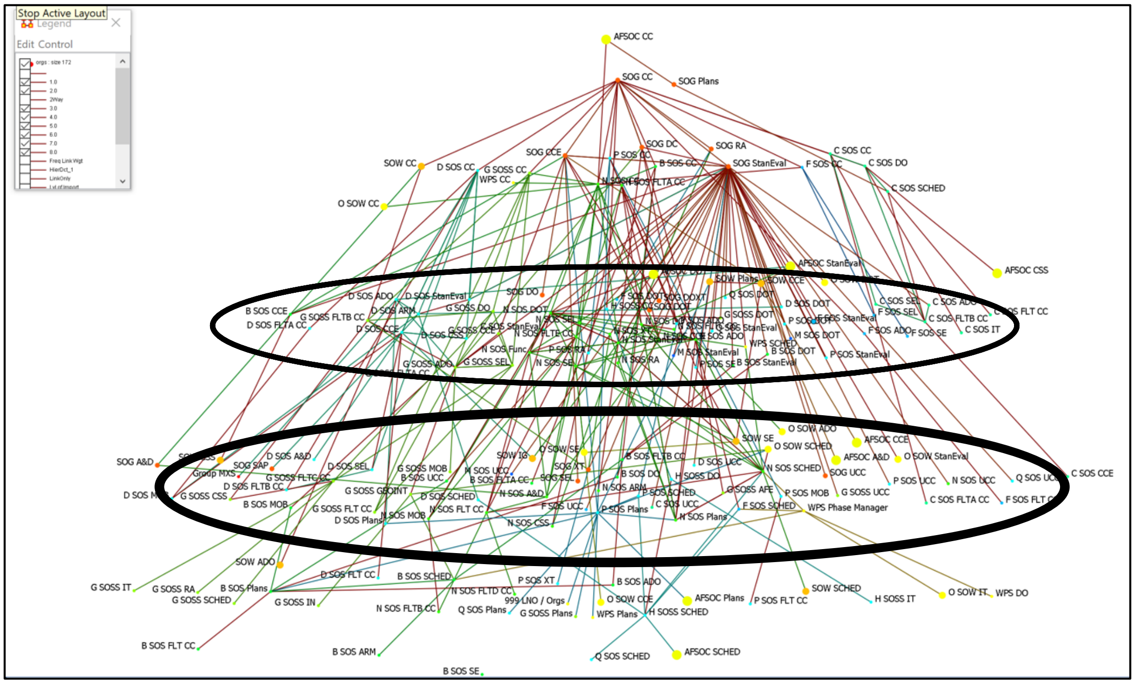


Figure 21. SOG Networked Hierarchy: Circled

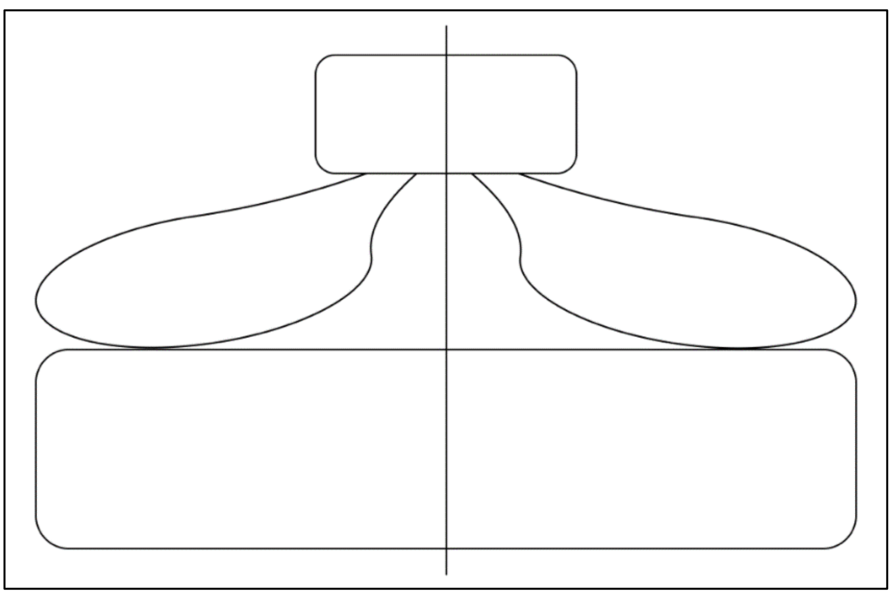


Figure 22. Mintzberg's Machine Bureaucracy. Source: Mintzberg (1981).

For visual ease of analysis, Figure 23 solely focuses on the SOG's relationship with two squadrons, N SOS and D SOS. In Figure 23, the top sociogram represents informal communication occurring between two squadrons and the chain of command. These interactions were created from survey responses regarding the means of communication. If the interactions utilized more formal means of communication (scheduled meetings, data sharing tools, and memorandums or official paperwork) then they were given a value of 1. The bottom sociogram represents more immediate communication with less formality (phone calls, email, and unplanned, face-to-face meetings). This communication was given a value of 4. This representation builds a better understanding of how certain organizational entities communicate. It also displays the urgency and closeness two entities have over others interacting with one another, particularly across hierarchical boundaries. Of note, most communication from subordinate, supporting elements of a unit occur by more formal means, while communication between command elements occurred less formally. Again, context is important. The manner of communication could be a product of leadership style or it may be established by regulation.

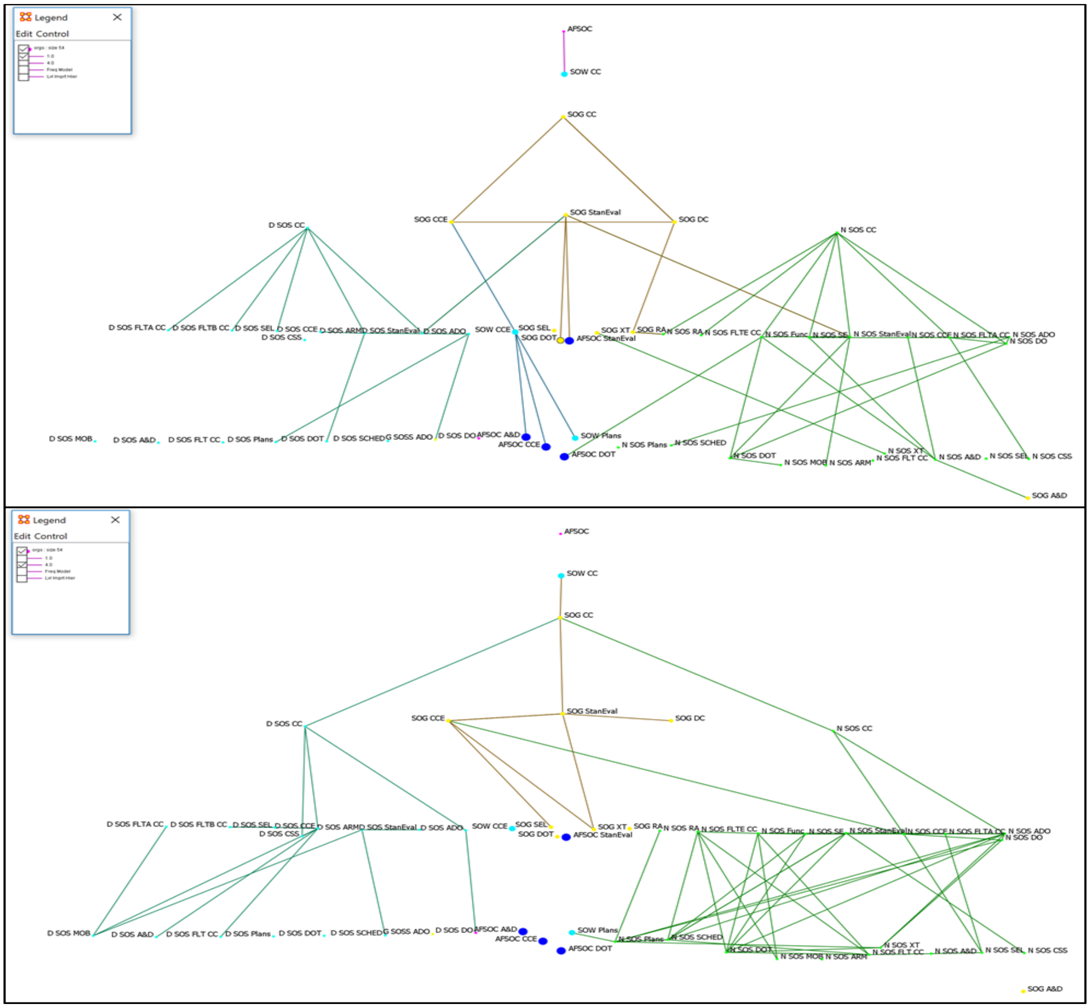


Figure 23. More (Top) vs. Less (Bottom) Formal Communication

One network attribute examined through the SOG SNA was the preponderance of mandated versus non-mandated communication within the organization. This characteristic is of particular interest to the Air Force, as certain formal communications are required by Air Force regulations. In light of the Air Force's push to reduce the number of regulations (and the requirements for formal communication described within), this study is able to extrapolate the difference between the mandated and non-mandated communication networks and run a correlation.

Figure 24 shows the SOG-mandated relationship network. This sociogram outlines the required interactions between all units and sub-units within the SOG based member-reported data on whether the interaction with the nominated organization was required by regulation or not (non-mandated). In addition, each link is characterized by a directional arrow that shows the nature of the relationship between two specific actors (tasker versus tasked). It is worth noting that the simple structure design of the SOG becomes less obvious when examining this network, as Air Force regulations make many subunits beholden to various group functions outside of their immediate chain of command. This varies from the traditional notion of a standard military hierarchy and the lack of clear authority is notably visualized in Figure 24. An example of this is N SOS CCE (N squadron commander's executive officers, circled in black) who is directly subordinate to N SOS CC yet continually tasked by an outside organization at a higher hierarchal level (SOG CCE).

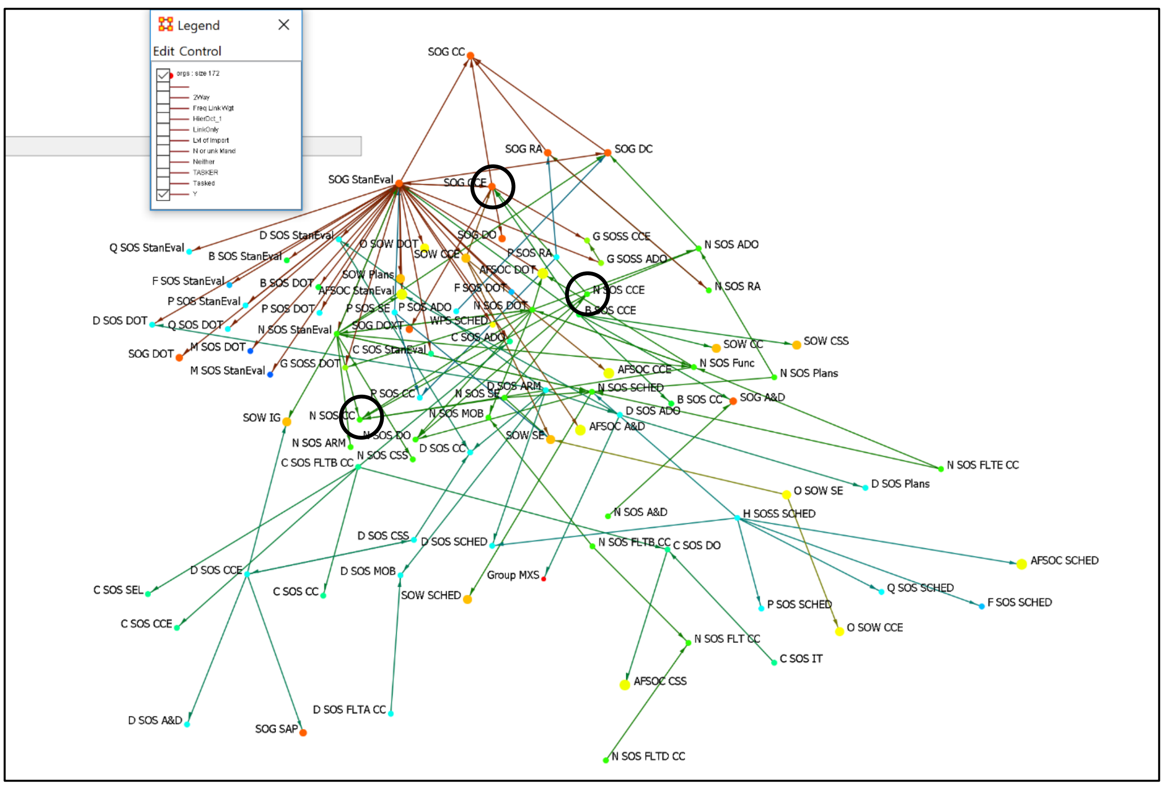


Figure 24. SOG Mandated Relationships

Figure 25 depicts the SOG non-mandated relationship network. In contrast to Figure 24, this sociogram shows all communication links described by SOG member-reported data that are not required by regulation. Both of these networks differ from Figures 10 and 17 which incorporate all SOG interactions as they have parsed out mandated and non-mandated communication. While a semblance of the hierarchy is still visible in this diagram, the lateral and free-form communication is much more representative of how the mission gets accomplished in the operations group. In this network, N SOS CCE (circled in black) sits at the very center of dozens of links and is connected with a dozen more relationships to squadron subunits. This stark contrast in network position could be a direct result of N SOS CCE's unique position of being subservient to two different bosses and thus having to generate twice the work of an office that is only tasked by one entity.

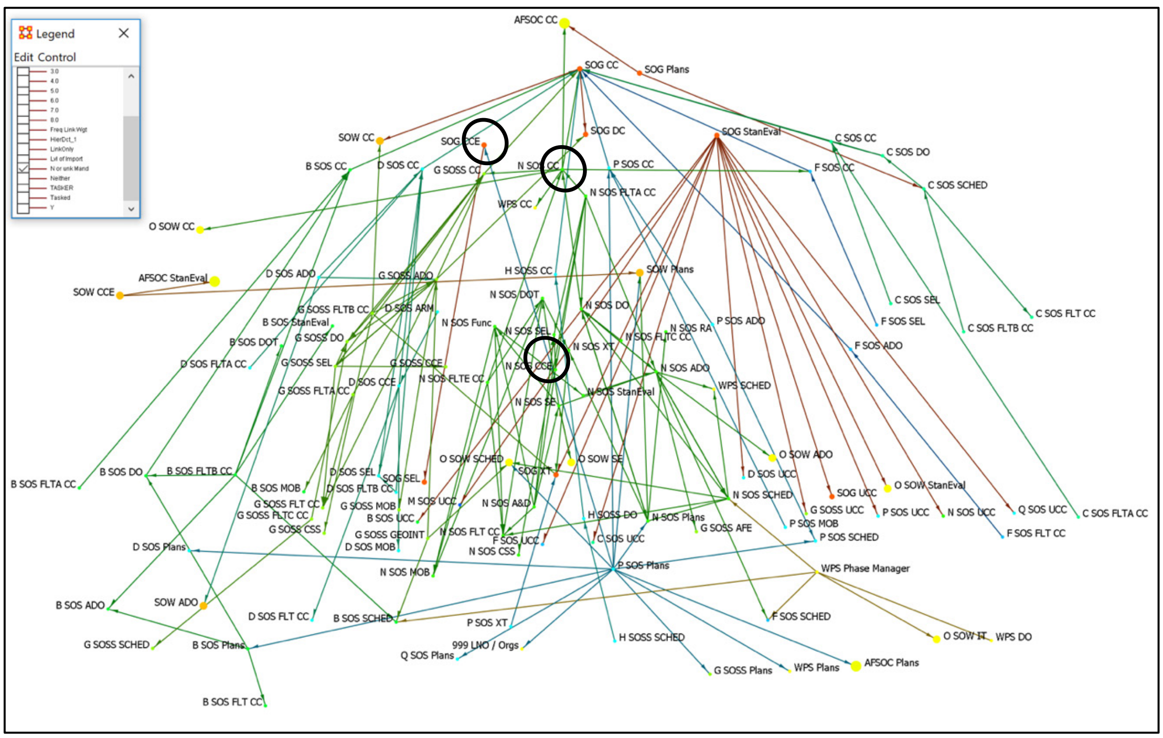


Figure 25. SOG Non-mandated Relationships

To further compare these two networks, we estimated the correlations between the formality of communication and whether the communication was mandated by regulation

(Appendix C). This showed a relatively strong correlation between formal and mandated communications (0.580) as well as between non-mandated and informal communications (0.615). This result demonstrates that more often than not for the study's model, the communication and relationships between units in a SOG follows a structurally ordered design within the hierarchy, aligning the style of communication with the method.

Lastly, SNA may help leaders and managers better understand what type of and how often interaction occurs outside the standard hierarchical, chain-of-command rules. To demonstrate, Figures 26 and 27 display a portion of the frequency of interaction network. Figure 26 shows daily interactions that go from the lower level squadrons direct to the command and wing level. Again, these functions could do this intentionally by design, but it highlights what roles within the organization rightfully have this type of interaction like plans and scheduling. In contrast to the timeframe, Figure 27 displays similar activities, but ones that occur less than every three months.

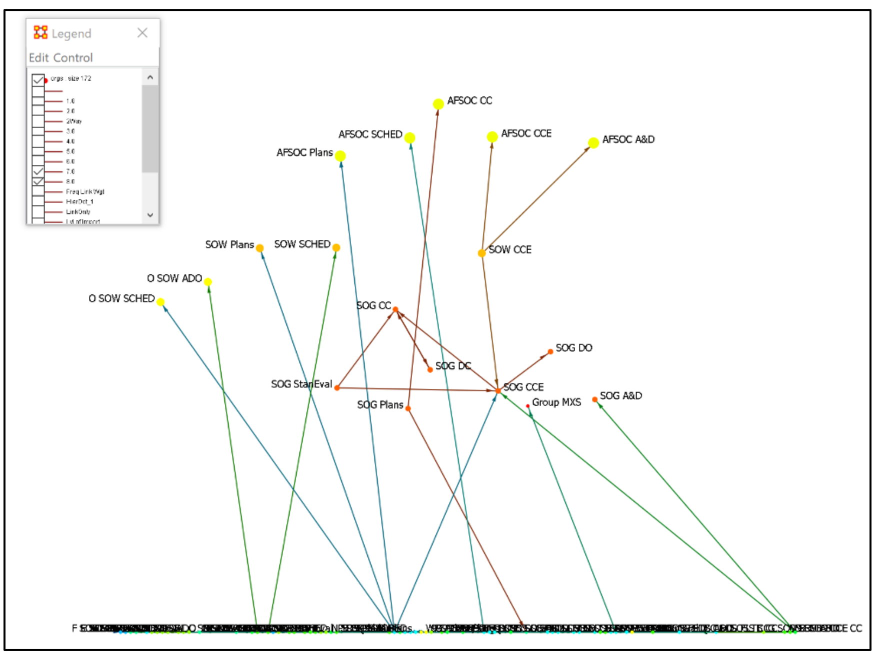


Figure 26. Interactions Bypassing the Hierarchy, Daily

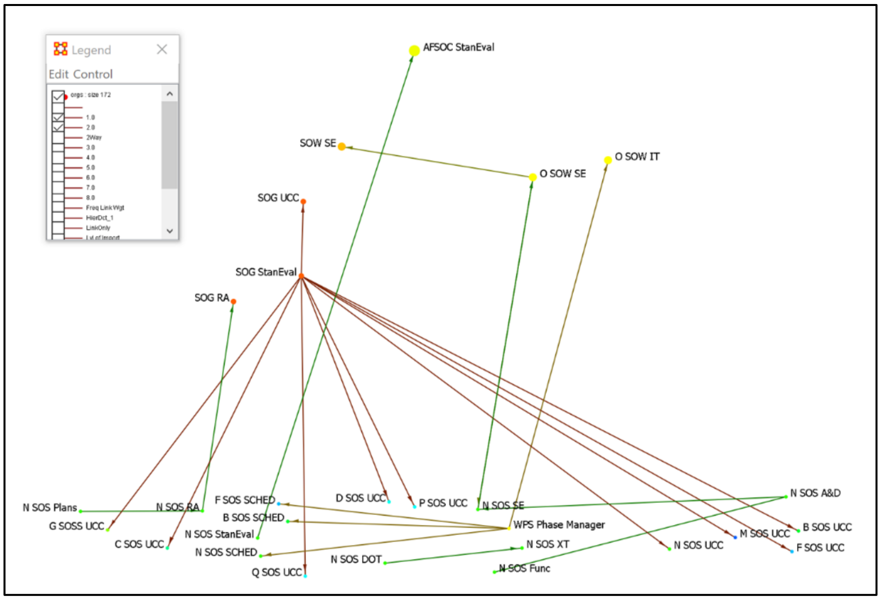


Figure 27. Interactions Bypassing the Hierarchy, Less than 3 Months

B. SUMMARY

This chapter discussed and analyzed the results of the SNA of the data, bringing multiple observations to light. First, mapping the formal and informal communication of an organization using SNA allows an analyst to determine which members of the organization are most central to its processes. Second, units and sub-units can be extracted from a larger network and examined vertically in the form of a hierarchy to allow for organizational design analysis. Finally, the mandated and non-mandated communication networks of an organization can be isolated, compared, and correlated to determine whether interactions happen inside or outside the intended bounds of the organizational structure. For more detailed information regarding the survey elements or SNA details, see Appendices B and C, respectively.

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VI. CONCLUSION

Beginning in Chapter II with a basic understanding of the organizational design principles set forth by Henry Mintzberg, this study focused on the military hierarchy and its formal and informal characteristics. As the most dominant organizational structure for the military, the simple design of the hierarchy has multiple variations including the M-form and U-form (Cooley, 2005, p. 5). Each variation is characterized by the method in which the organization interacts and communicates with authority. For organizational design, it is important to remember that while there may be similarities, no two organizations are alike (Mintzberg, 1981). Mintzberg simplifies them into four basic forms: the simple structure, the machine bureaucracy, the professional bureaucracy, and the adhocracy (p. 2). For the Air Force, like other military organizations, the simplicity of its structure only resides on the surface. The complexity of its organizational interactions requires more thorough analysis.

As discussed in Chapter III, SNA has the ability to explore and visualize the complex patterns of interaction between groups and individuals within any defined organization by displaying connections, or ties, between the individuals/groups, or actors, in a network. SNA provides analysts with tools to define these connections and the actors involved in various ways, as well as visual and quantitative methods for analyzing a network's overall topography and the roles that actors play within it. One such measure is degree centrality, which is the number of connections an actor has within an organization and measures the extent of its relative importance in an organization (Cunningham et al., 2016). Evaluation of these measures such as this consists of comparing the results of the analysis with the intended or desired impact of the individual. Inconsistencies can arise as the complex patterns of interaction within a network are interdependent and adjust or adapt according to changes in the operating environment (Cunningham et al., 2016; Sterman, 2000). SNA helps highlight these adaptations and potential inconsistencies.

Spurred by seemingly radical adjustments in traditional organizational design undertaken by some commands, military units may prove to be ideal candidates for SNA in the pursuit of flatter, more decentralized organizations, and Air Force special operations units were the focus of this research due to their consistently high-tempo operations and growing demand. The focus on combat operations tends to primarily bring reactive corrections to mostly unrecognizable organizational shifts driven by evolving environments. The group-level organization within Air Force special operations provides enough diversity in mission focus and global assignment to generate data substantial enough for analysis and conclusions, yet manageable for the resources of this study.

To accomplish this, we used a survey to gather data on typical Air Force special operations group functions. Survey responses characterized functions based on the level of authority they held by position, the number of people that performed that function, whether it directly or indirectly supported a flying mission, and the months of experience a respondent had executing that function. The survey also collected relational data about how various functions interacted with one another in terms of a number of different types of ties, such as communication based on regulations, frequency of communication, hierarchical position, and formal-informal communication.

A. ANSWERING RESEARCH QUESTIONS

1. Is a hierarchy the best organizational design for a special operations flying group?

Although the survey sample collected in this study is too small to draw definitive conclusions about the ideal organizational design for a special operations flying group, several findings open the door for additional exploration of this question. First, all sociograms generated in this study found significant evidence of lateral communication with a large technology support structure and support staff dependence, reflecting an organization more closely resembling Mintzberg's (1981) machine bureaucracy structure than a simple hierarchical one (p. 7). Additionally, a correlation between mandated and non-mandated communication found that the majority of communication does follow hierarchy guidelines. This may suggest that the SOG may be best suited to a hierarchy, but should perhaps explore restructuring into a U-form hierarchy where sub-units are more autonomous and less dependent on interactions that move vertically up the chain of command. Further research into this area may also help the Air Force improve communication through the deregulation of mandated actions and reporting (a pursuit they are already pursuing in earnest).

2. How could SNA be used as a diagnostic tool to evaluate a military organization's effectiveness?

This study has also shown that SNA can provide actionable data for commanders when evaluating their organization's effectiveness. Using SNA and organizational design theories along with application references, this study correlated several aspects of a SOG modeled from real-world responses that demonstrate the ability to measure and evaluate the organization's performance and level of centralization. The study also highlighted organizational functions that by role and responsibility should be characterized by certain SNA traits. The study discussed functions that were peripheral for justifiable reasons and those that act as boundary spanners by the nature of their duty. The study mentioned how leaders and managers should utilize this information to make manpower and process flow decisions to improve organization performance. These examples overflow into the next research question.

3. Will SNA expose hidden potential for improvement in an operational military organization and provide actionable data?

If this study has provided any concrete results, it is that SNA can provide tangible data from otherwise abstract relationships and useful ways to visualize and analyze the interactions of large organizations through metrics. The potential for this technology to provide improvements in military organizations and provide actionable data has yet to be seen, but remains a very distinct possibility. This study focused on traditional "day-to-day" operations within a special operations flying group. Modifications to this study could provide insight into communication during contingency operations or even focus on specific sub-groups (officers, senior non-commissioned officers, civilians, etc.) within the same organization.

B. IMPROVING THE METHOD

Although successfully providing a workable sample, this study was constrained by academic guidelines that may not apply if a similar study was undertaken by an active military organization. The time and resource constraints of this project limited data collection to an online survey. Therefore, improving this research would begin with a more robust method of survey deployment. Given the time and approval, several rounds of survey employment would help refine the questions asked and potentially increase the response rate. Mandating that each function within an organization complete a survey was outside the authority of this research, but could be within the authority of the command itself if a military organization decided to attempt a version of this study.

In fact, the military already employs several means of data collection (command climate surveys, the Management Internal Control Toolset (MICT) software, and Combined Unit Inspections) that could reap better results than this study could achieve. Still, if this method were employed by the military, care must still be given to the implementation of the surveys in order to ensure participants are free from retribution and rights are protected. Additionally, the military has its own survey restrictions it adheres to as well as collected-data release authorities.

Adding to the questions asked is another way this study can be improved. Being able to inject a member-initiated rating system on the quality of interaction would highlight areas of the process that members claim need improvement. While this can be done several ways, adding it to the evaluation of an organization through SNA tools visually distinguishes where in the overall process the complaint originates and more easily identifies how far the problem may reach.

C. POSSIBLE IMPLEMENTATION

With the data collection tools already utilized by the military, SNA could use this data for any number of specific organizational design questions or communication inquiries. As an example, the Air Force uses MICT to conduct inspections of a unit's program health (SECAF, 2018c). MICT is a computer-based inspection program that allows organizational members to report their program status up the chain-of-command to the Wing Inspector General (SECAF, 2018c). Modifications to the MICT program already in place could collect the data utilized to develop the networks seen in this study.

While completing MICT requirements, organizational functions could add number of office personnel to their responses and select organizations they interact with not governed by regulation. MICT is already designed to track interactions mandated by regulation. The program could further this purpose toward diagraming the organization by labeling ties between functions by the regulation that mandates them. Adding a communication type to this interaction would add additional value to the tool. It may quickly help identify data sharing techniques that inhibit the process or are beneficial and should be promoted for use in other areas. These details collected through a system already used by the inspector general could then be used to build an interactive map for leaders and managers to visualize their organization and make adjustments accordingly. Once MICT collects the data, it can generate time-stamped analysis that will allow a unit's leaders to visualize how the organization is adjusting over time and even to specific stimuli. For instance, if the command rewrites a major regulation governing training processes, the organization can take the sociograms generated before and after implementation for a full picture of what was impacted.

D. SUMMARY

For Air Force special operations units, using SNA can be a valuable tool for analyzing and improving organizational performance. The ability for SNA to provide member-driven data regarding the many facets of process flows throughout an organization can provide leaders, managers, and members in general, a better, more thorough understanding of the inner and outer workings of their units. Collecting this information over time can illuminate shifts in the evolution of an organization to proactively make organizational design decisions on process and manpower shifts for both functional responsibilities and roles held in the decision-making process.

This can mean drastic shifts in the traditional manner in which the Air Force (and military organizations as a whole) conducts business, moving away from rigid hierarchical structures to more fluid, flexible capabilities without sacrificing areas of needed oversight.

SNA is a valuable tool that military organizations can utilize to capture the Air Force Chief of Staff's initiatives and assist member-driven progress from the bottom up in a more resource constrained, high-demand environment.

APPENDIX A. NETWORK ANALYSIS METRICS

Table 2. Network Analysis Metrics. Source: Cunningham et al. (2016).

Size, Diameter, and Average Distance	
Size	The number of actors in a network
Geodesic	The shortest path between two actors
Average Distance	Average length of all the geodesics in a network
Diameter	Longest of all the geodesics that cross the network
Centralization Measures	
Centralization	Standard measure of centralization uses the variation in actor centrality within the network to measure the level of centralization.
Variance	Average of the squared differences between each actor's centrality score and the average centrality score
Standard Deviation	Standard deviation for a particular centrality measure is the square root of the variance
Interconnectedness Measures	
Density	Total number of observed ties in a network divided by the total possible number of ties in that network, range 0 – 1.
Average Degree	Sum of ties in a network divided by the number of actors in the network.
Fragmentation (Cohesion)	Ratio of all pairs of actors that are connected, directly or indirectly.

Breadth (Compactness)	Ratio of all pairs of actors that are connected, weighted by the average path distance between all pairs.
Global Clustering Coefficient	Sum of each actor's clustering coefficient divided by the number of actors within the network.
E-I Index	Ratio of ties a group has to nongroup members (external) and to group members (internal). The index is 1.0 for groups with external ties; -1.0 for a group with all internal ties; and 0.0 if there are an equal number of internal and external ties.
Centrality	
Degree Centrality **(Freeman, 1979)**	Count of an actor's ties.
Eigenvector Centrality **(Bonacich, 1972)**	Weights an actor's centrality by the degree centrality scores of its neighbors.
Closeness Centrality	The average geodesic distance from an actor to every other actor in the network, cannot be used with a disconnected network.
Average Reciprocal Distance (ARD) **(Borgatti, 2006)**	A measure of closeness by using the average geodesic distance from an actor to every other actor in the network, but can be used with a disconnected network.
Reach Centrality (Sade, 1989)	Number of actors each actor can reach in k steps or less.
Information Centrality **(Stephenson and Zelen, 1989)**	Counts all paths between two actors and assigns them weights based on their lengths.

Betweenness Centrality **(Freeman, 1979)**	How often each actor lies on the shortest path between all pairs of actors.
Flow Betweenness **(Freeman, Borgatti, and White, 1991)**	Assumes that actors will use all pathways between them in proportion to the length of the pathways.
Proximal Betweenness Centrality (Borgatti, 2006)	Estimates the proportion of all geodesics linking two actors that pass through a particular actor who is the second to last actor on the geodesic.
Fragmentation Centrality **(Borgatti, 2006)**	Estimates several "fragmentation" effects on a network if an actor is removed.
In-degree Centrality **(Wasserman and Faust, 1994)**	Count of direct incoming ties.
Out-degree Centrality **(Wasserman and Faust, 1994)**	Count of direct outgoing ties.
Input Domain (Lin, 1976)	Number of people chosen by someone directly or indirectly (can be restricted to actors within a certain number of steps).
Proximity Prestige **(Wasserman and Faust, 1994)**	Accounts for all actors within an actor's input domain but weights closer neighbors higher than distant neighbors.
Reach Centrality **(Sade, 1989)**	Number of actors each actor can reach (or be reached) in k steps or less.
Hubs and Authorities **(Kleinberg, 1999)**	A good hub is an actor that points to many good authorities, and a good authority is one that is pointed to by many good hubs.

Subgroup Algorithms	
Weak Components	Subgroups of actors who can reach one another either directly or indirectly.
Strong Components	Subgroups where each pair of actors is connected by a directed path and no other actor can be added without destroying its connectedness.
Cliques	Subset of three or more actors where each actor is directly connected to all other actors.
K-cores **(Wasserman and Faust, 1994)**	Maximum group of actors connected to some number (k) of other group members.
Factions	Compares an actual network with an idealized factional one, and then assesses the extent to which the former "fits" the latter.
Girvan-Newman **(2002)**	Subgroups defined as having more ties within and fewer ties between groups than expected. Focuses on edge betweenness.
Clauset, Newman, and Moore **(2004)**	Subgroups defined as having more ties within and fewer ties between groups than expected. An agglomerative method that treats each actor as a cluster unto itself.

APPENDIX B. SURVEY

This appendix covers the details of the survey used to collect SNA data. The details and decisions that led to choices within the survey are described in Chapter IV, Methodology. The survey was administered in accordance with the protocols of the Air Force Survey Office and NPS IRB, approval number NPS.2019.0012-IR-EP7-A expiring June 30th, 2019. For questions regarding this thesis's survey approval please contact the NPS IRB office, referencing the aforementioned approval number.

A. SURVEY EXPLANATION

Before voluntarily consenting and beginning, the survey participant had to read a consent statement informing them of the purpose, risks, and safeguards inherent to the survey. Abiding by Air Force survey rules and the approval of this research, the survey participant, also, had to acknowledge that they were military members, because civilian employees were prohibited from participating.

1. Survey Participant Identifiers

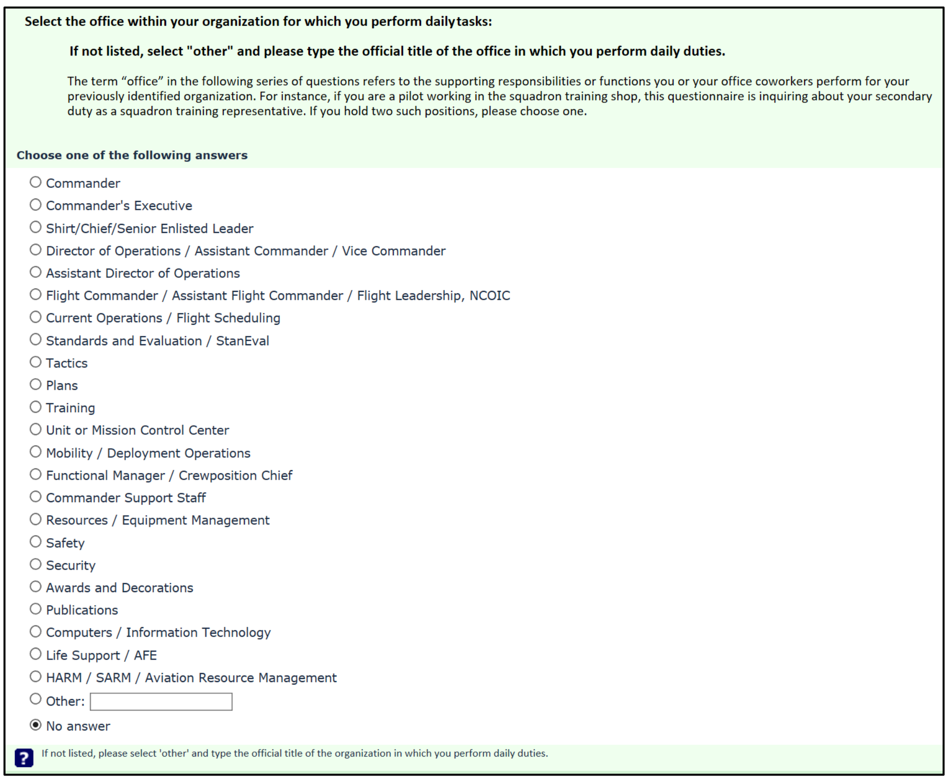
The first section of survey questions regarded descriptors of the function performed by the survey participant. Participants were informed to provide fact-based responses only. For the following series of questions, the term "office" refers to the primary responsibility or function performed by the participant, or the participant's office coworkers, that is necessary for the organization to support its mission. The survey participant identifier questions were:

1. Select the organization you belong to:

(a) The participant had to choose from a selection of organizations within the 1 SOG, before the next question in the survey was generated. If the choices listed did not meet the definition of the organization or the function for the participant, they could select a free form, user input option.

2. Select the office within your organization for which you perform daily tasks:

(a) The participant had to choose from a selection of generalized functions, common among organizations within the 1 SOG, before the next question in the survey was generated. If the choices listed did not meet the definition of the organization or the function for the participant, they could select a free form, user input option. An example can be seen in Figure 28.



Select the office within your organization for which you perform dailytasks:

If not listed, select "other" and please type the official title of the office in which you perform daily duties.

The term "office" in the following series of questions refers to the supporting responsibilities or functions you or your office coworkers perform for your previously identified organization. For instance, if you are a pilot working in the squadron training shop, this questionnaire is inquiring about your secondary duty as a squadron training representative. If you hold two such positions, please choose one.

Choose one of the following answers

- Commander
- Commander's Executive
- Shirt/Chief/Senior Enlisted Leader
- Director of Operations / Assistant Commander / Vice Commander
- Assistant Director of Operations
- Flight Commander / Assistant Flight Commander / Flight Leadership, NCOIC
- Current Operations / Flight Scheduling
- Standards and Evaluation / StanEval
- Tactics
- Plans
- Training
- Unit or Mission Control Center
- Mobility / Deployment Operations
- Functional Manager / Crewposition Chief
- Commander Support Staff
- Resources / Equipment Management
- Safety
- Security
- Awards and Decorations
- Publications
- Computers / Information Technology
- Life Support / AFE
- HARM / SARM / Aviation Resource Management
- Other:
- No answer

If not listed, please select 'other' and type the official title of the organization in which you perform daily duties.

Figure 28. Generalized Function Selection.

3. How long have you worked in this office or served this function?

(a) 0 - 3 months

(b) 4 - 6 months

(c) 7 - 12 months

(d) 13 - 24 months

(e) More than 2 years

(f) No answer

4. How many people work in this office and are responsible for the tasks it performs?

(a) 1

(b) 2 - 3

(c) 4 - 6

(d) 7 - 12

(e) 13 - 20

(f) Greater than 20

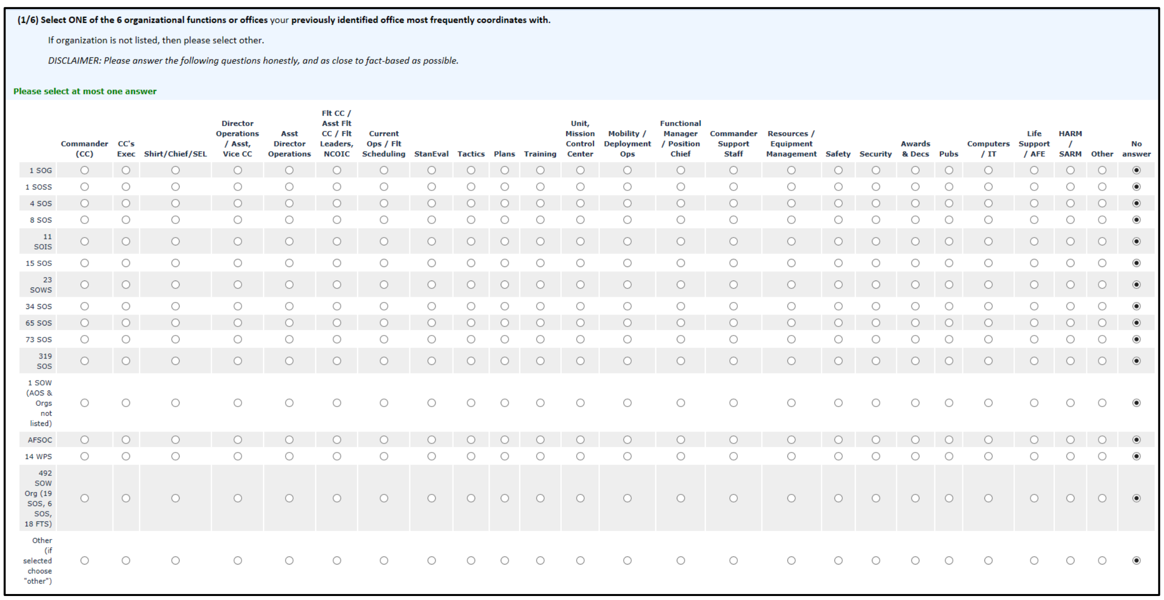
(g) No answer

2. Network Data

Once the participant's information was collected, the survey transitioned to collecting relationship data by asking questions regarding the participant's working network. The next six questions in the survey built upon one another to define the working relationship between the function of the participant and the function of the entity nominated by the participant at the beginning of this section. These six questions were repeated at most six times, in an attempt to get participants to nominate six other organizational functions they interact with. Participants were not required to fill out all six to complete the survey. However, as a limitation of the survey service used and the nature of the information requested, it was possible for participants to select multiple organizations and functions with each iteration. The six questions in each series were as follows:

5. Select ONE of the 6 organizational functions or offices your previously identified office most frequently coordinates with. (If organization is not listed, then please select other). Please select at most one answer.

(a) The participant had to choose from a selection of organizations to pair with generalized functions, common among suborganizations, before the next question in the survey was generated. An example of the selection matrix can be seen in Figure 29. If the choices listed in the matrix did not meet the definition of the organization or the function for the participant, they select a free form, user input option.


(1/6) Select ONE of the 6 organizational functions or offices your **previously identified office most frequently coordinates with.**

If organization is not listed, then please select other.

DISCLAIMER: Please answer the following questions honestly, and as close to fact-based as possible.

Please select at most one answer

	Commander (CC)	CC's Exec	Shirt/Chief/SEL	Director Operations / Asst, Vice CC	Asst Director Operations	Flt CC / Asst Flt CC / Flt Leaders, NCOIC	Current Ops / Flt Scheduling	StanEval	Tactics	Plans	Training	Unit, Mission Control Center	Mobility / Deployment Ops	Functional Manager / Position Chief	Commander Support Staff	Resources / Equipment Management	Safety	Security	Awards & Decs	Pubs	Computers / IT	Life Support / AFE	HARM / SARM	Other	No answer
1 SOG	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
1 SOSS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
4 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
8 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
11 SOIS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
15 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
23 SOWS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
34 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
65 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
73 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
319 SOS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
1 SOW (AOS & Orgs not listed)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
AFSOC	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
14 WPS	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
492 SOW Org (19 SOS, 6 SOS, 18 FTS)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉
Other (if selected choose "other")	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	◉

Figure 29. Office and Function Nomination Matrix

6. This interactive relationship is:

(a) A tasking of my office to take action on

(b) A request from my office for that office to complete

(c) Both, some tasks of my office and some requests from my office

(d) Neither

(e) No answer

7. The information exchange between these two offices is:

(a) An input from the other office needed for my office to perform its duties

(b) An output to the other office needed for that office to complete its tasks

(c) To update my office's status for situational awareness

(d) Do not know

(e) Two-way information flow for decision-making and course of action determination

(f) No answer

8. This coordination is:

(a) Required by regulation

(b) Not required by regulation

(c) Do not know

(d) No answer

9. How often does coordination of any kind occur between your office and this office?

(a) More than once a day

(b) Daily

(c) Once a week

(d) 2 - 3 times per week

(e) 2 - 3 times a month

(f) Once a month

(g) Quarterly (once every 3 months)

(h) Every 6 months

(i) Once a year

(j) No answer

10. How frequent are the following types of communication used for this coordination?

The next question allowed to participants to provide multiple responses to a matrix that related the following two lists and can be seen in Figure 30.

It related this list:

i) Often, primary means of coordination

ii) Often, not the primary means of coordination

iii) Sometimes

iv) Rarely

v) Never, but available

vi) Unavailable

With this list:

(a) Formal paperwork like memorandums/forms

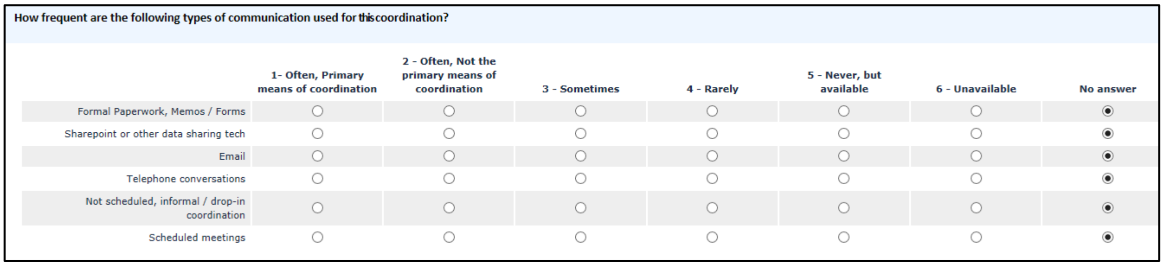
(b) SharePoint or other form of data sharing technology

(c) Email

(d) Telephone conversation

(e) Not scheduled, informal/drop-in coordination

(f) Scheduled meetings



How frequent are the following types of communication used for this coordination?

	1- Often, Primary means of coordination	2 - Often, Not the primary means of coordination	3 - Sometimes	4 - Rarely	5 - Never, but available	6 - Unavailable	No answer
Formal Paperwork, Memos / Forms	○	○	○	○	○	○	◉
Sharepoint or other data sharing tech	○	○	○	○	○	○	◉
Email	○	○	○	○	○	○	◉
Telephone conversations	○	○	○	○	○	○	◉
Not scheduled, informal / drop-in coordination	○	○	○	○	○	○	◉
Scheduled meetings	○	○	○	○	○	○	◉

Figure 30. Frequency and Type of Communication Used

Only the beta test participants were given two additional questions that were opinion based, and allowed them to rate the interaction. Those questions were:

11. This exchange is:

(a) Required and easily completed

(b) Required, but a burden to complete

(c) Required, but I often think it is an inefficient use of my time, could be done another way, and the work is often repeated

(d) Optional, I don't know what requirement it fulfills. There are other ways of getting what is needed

(e) No answer

12. What limitations, if any, exist in the interaction between your office/ function and the other you selected?

(a) This question was a free-form response.

The final two questions were opinion based and therefore restricted to the beta test group by approval. The intent of the final two questions was to add member-driven rating scales to the process flows within their organization to help highlight areas of improvement.

APPENDIX C. SNA CODEBOOK AND ADDITIONAL NETWORK DISPLAYS AND MEASURES

This appendix describes the details of SNA used to evaluate special operations groups. The SNA Codebook describes the actors involved, the attributes for each actor used, and the relational data created to build the Special Operations Group Network.

A. SOG NETWORK DATA BOUNDARIES AND SOURCES

The Special Operations Group Network is a 172-actor network each with five attributes and a maximum of 318 relationships each with four measures. Each actor represents an organizational function or responsibility within a special operations group (SOG).

The Special Operations Group Network is an aggregate network of organizational function data collected from individuals that work within the 1 SOG combined with former AFSOC officers with experience within a SOG. This data was collected via survey and is described in more detail in Chapter IV and Appendix B. Survey participants were able to nominate organizations outside of a SOG with an expectation that the majority of the top six given responses would be within the hierarchical control of a SOG or be a military organizational function. Due to the boundaries of the network and the surveyed group, attribute data may or may not be available for the organizations and functions nominated by respondents outside of a SOG. Of the 172 organizational responsibilities captured in the network, only 33 of them are outside of a SOG. Table 3 lists the actors alphabetically.

Table 3. List of Actors in the Special Operations Group Network

999 LNO / Orgs	D SOS DOT	H SOSS SCHED	P SOS SCHED
AFSOC A&D	D SOS FLT CC	M SOS DOT	P SOS SE
AFSOC A2 Func	D SOS FLTA CC	M SOS StanEval	P SOS StanEval
AFSOC CC	D SOS FLTB CC	M SOS UCC	P SOS UCC
AFSOC CCE	D SOS MOB	N SOS A&D	P SOS XT
AFSOC CSS	D SOS Plans	N SOS ADO	Q SOS DOT
AFSOC DOT	D SOS SCHED	N SOS ARM	Q SOS Plans
AFSOC Plans	D SOS SEL	N SOS CC	Q SOS SCHED
AFSOC SCHED	D SOS StanEval	N SOS CCE	Q SOS StanEval
AFSOC StanEval	D SOS UCC	N SOS CSS	Q SOS UCC
B SOS	F SOS ADO	N SOS DO	SOG A&D
B SOS ADO	F SOS CC	N SOS DOT	SOG CC
B SOS ARM	F SOS DOT	N SOS FLT CC	SOG CCE
B SOS CC	F SOS FLT CC	N SOS FLTA CC	SOG DC
B SOS CCE	F SOS SCHED	N SOS FLTB CC	SOG DO
B SOS DO	F SOS SE	N SOS FLTC CC	SOG DOT
B SOS DOT	F SOS SEL	N SOS FLTD CC	SOG DOXT
B SOS FLT CC	F SOS StanEval	N SOS FLTE CC	SOG FLT CC
B SOS FLTA CC	F SOS UCC	N SOS Func	SOG Plans
B SOS FLTB CC	G SOSS ADO	N SOS MOB	SOG RA
B SOS MOB	G SOSS AFE	N SOS Plans	SOG SAP
B SOS Plans	G SOSS CC	N SOS RA	SOG SEL
B SOS SCHED	G SOSS CCE	N SOS SCHED	SOG StanEval
B SOS SE	G SOSS CSS	N SOS SE	SOG UCC
B SOS StanEval	G SOSS DO	N SOS SEL	SOG XT
B SOS UCC	G SOSS DOT	N SOS StanEval	SOW ADO
C SOS ADO	G SOSS FLT CC	N SOS UCC	SOW CC
C SOS CC	G SOSS FLTA CC	N SOS XT	SOW CCE
C SOS CCE	G SOSS FLTB CC	O SOW ADO	SOW CSS
C SOS DO	G SOSS FLTC CC	O SOW CC	SOW IG
C SOS FLT CC	G SOSS GEOINT	O SOW CCE	SOW Plans
C SOS FLTA CC	G SOSS IN	O SOW DOT	SOW SCHED
C SOS FLTB CC	G SOSS IT	O SOW IT	SOW SE
C SOS IT	G SOSS MOB	O SOW SCHED	SOW UCC
C SOS SCHED	G SOSS Plans	O SOW SE	WPS CC
C SOS SEL	G SOSS RA	O SOW StanEval	WPS DO
C SOS StanEval	G SOSS SCHED	P SOS ADO	WPS Phase Manager
C SOS UCC	G SOSS SEL	P SOS AFSOC HQ	WPS Plans
D SOS A&D	G SOSS UCC	P SOS CC	WPS SCHED
D SOS ADO	Group MXS	P SOS DOT	WPS StanEval
D SOS ARM	H SOSS	P SOS FLT CC	
D SOS CC	H SOSS CC	P SOS MOB	
D SOS CCE	H SOSS DO	P SOS Plans	
D SOS CSS	H SOSS IT	P SOS RA	

1. Attribute Data

Most actors representing an organizational responsibility had the following attribute values:

1. **Hierarchical Level**. Each actor had a value assigned from one to four that represented the supervisory level their organization represented. Squadrons, designated by SOS or SOSS in the network, were at the lowest level of the hierarchy scale, and thus assigned a value of one. Proceeding up the supervisory chain, group-level organizations were assigned a two,

wing-level assigned a three, and command-level assigned a four. For more details concerning the levels of the typical military hierarchy, see Chapter II. This attribute is designed to visually display which entities hold regulatory authority over others by virtue of position in the network.

2. **Organizational Identification**. Each organizational function was given a numerical value associated with their parent organization. This attribute provided analysis based on organizational association. The values assigned to each organization can be seen in Table 4. P SOS and Q SOS were assigned the same value because they represent units with identical mission sets.

Table 4. Organizational Identification Values

Organization	Value
SOG	1
G SOSS	2
N SOS	3
B SOS	4
C SOS	5
D SOS	6
H SOSS	7
P & Q SOS	8
F SOS	9
M SOS	0
SOW	10
WPS	11
O SOW	12
AFSOC	13

3. **Flying Mission**. Based on a numeric value of one or two, this attribute simply defined each organization as a flying organization by denoting a value of two, meaning the members of the organization operate aircraft as their primary duty. A unit that does not primarily fly a single type of aircraft was assigned a one. This delineation provided a binary distinguisher for quick separation of the two types of suborganizations within the group.

4. **Experience Level**. The experience level attribute measured the entity's time in the organizational role selected by months. The survey choices were given the attribute values seen in Table 5.

Table 5. Experience Level Values

Survey Response	Attribute Value (mos.)
0-3 Months	3
4-6 Months	5
7-12 Months	10
13-24 Months	19
More than 2 years	27

5. **Office Size**. Each actor has a strength value that represents the number of individuals responsible for the function within the organization. The values assigned to each survey response can be seen in Table 6.

Table 6. Office Size Values

Survey Response (No. of People)	Attribute Value (No. of People)
1	1
2-3	3
4-6	5
7-12	10
13-20	17
Greater than 20	23

2. Relational data

All the relational data and network matrices created are organizational function-by-organizational function. The matrices created were as follows:

1. **Hierarchical Directed, one-mode**. The relationship data collected through this association provided the direction of interaction. Participants also responded to questions regarding information exchange that was either input, output, both, or for awareness only. These responses were combined to help define a member-initiated hierarchy by inquiring

whether the interaction could be defined and directed in a network in the following ways:

a. *A tasking of my office to take action on:* This relationship was treated as a one-way direction from the participant to the nominated office.

b. *A request from my office for that office to complete:* This response signaled a directed interaction from the nominated office to the participant.

c. *Both, some tasks of my office and some requests from my office*; *Neither*; and *No Answer*: These responses signaled two-way interactions or simple links between organizations and did not define a clear hierarchical relationship.

2. **Mandated Relationship Directed, one-mode.** This relational attribute defined each exchange as required by regulation. This provided analysts with the ability to create a network based on interactions that occurred regardless of whether they were required by any formal documentation. These responses were categorized the following way:

a. Required by regulation: Y

b. Not required by regulation, Do Not Know, and No Answer: N

3. **Frequency of Interaction Directed, one-mode.** This matrix defined relationships on the frequency of interaction. These interactions were weighted as seen in Table 7.

Table 7. Frequency of Interaction

Survey Response	Weight Applied
More than once a day	8
Daily	7
Once a week	5
2 – 3 times per week	6
2 – 3 times a month	4
Once a month	3
Quarterly (Once every 3 months)	2
Every 6 months	1

4. **Formality of Communication Directed, one-mode.** This relationship defined the closeness of two functions within the network based on responses to the types of communication used and frequency. To analyze these six responses, they were combined into two categories that defined the formality of communication.

a. *Formal paperwork*, *Data sharing technology*, and *Scheduled meetings* formed a more formal, less urgent style of communication by nature of the time and demand for the information contained within the exchange.

b. *Email*, *Telephone*, and *Not scheduled, informal, drop-in coordination* were labeled as less formal, yet more urgent in need. Additionally, this communicative relationship was treated as a closer, more comfortable exchange, giving it a higher value on the closeness of two organizaitons.

The member-defined frequency ratings of these type of interactions weighted the communication in favor of one of these two categories. Because of the higher value placed on the more informal type of communication in the network, these relationships were weighted as such:

c. *Formal communication* (paperwork, data sharing, etc.): 1

d. *More informal communication* (email, telephone, etc.): 4

B. MEASURES OF THE SOG NETWORK[4]

The ORA program calculated these measures from the networks described in section A.

1. Frequency of Interaction, Directed, One-mode Network

Actor Count: 172 (6 isolates); 304 ties; 5% of ties are reciprocal

Density / Diameter: 0.0011 / 38.0

Fragmentation: 0.024

Cohesion: 0.976

Degree Centralization: 0.034

Table 8. Top Scoring Organizational Functions by Measure – Frequency of Interaction Network

Rank	Betweenness Centrality		Eigenvector Centrality		In-degree Centrality	
1	SOG StanEval	0.042	SOG StanEval	0.485	SOG CC	0.036
2	N SOS StanEval	0.027	SOG CC	0.423	D SOS CC	0.022
3	N SOS Sched	0.016	SOG CCE	0.376	N SOS ADO	0.018
4	SOG CCE	0.010	N SOS ADO	0.349	N SOS Sched	0.018
5	N SOS Func	0.007	N SOS DOT	0.347	N SOS CC	0.017
6	N SOS DOT	0.006	N SOS CC	0.346	N SOS DO	0.016
7	N SOS DO	0.005	N SOS DO	0.301	N SOS Flt CC	0.016
8	G SOSS ADO	0.005	N SOS StanEval	0.300	G SOSS CC	0.014
9	N SOS CC	0.005	N SOS Sched	0.288	SOG DC	0.014
10	N SOS SE SOG CC N SOS Plans	0.004	N SOS CCE	0.266	SOG CCE	0.013

[4] All measures contained within section B were calculated by ORA (Carley, 2011).

Table 9. Top Scoring Organizational Functions by Measure – Frequency of Interaction Network 2

Rank	Authority Centrality		Out-degree Centrality		Clique Count	
1	SOG CC	0.463	SOG StanEval	0.066	N SOS DOT	13.0
2	N SOS ADO	0.420	P SOS Plans	0.033	SOG StanEval	12.0
3	N SOS CC	0.367	N SOS DOT	0.022	N SOS ADO	10.0
4	SOG CCE	0.338	D SOS CCE	0.022	N SOS CC	8.0
5	N SOS Sched	0.328	H SOSS Sched	0.020	N SOS SE	8.0
6	N SOS DO	0.319	N SOS StanEval	0.020	N SOS Func	8.0
7	N SOS StanEval	0.313	G SOSS ADO	0.019	N SOS CCE	7.0
8	SOG DC	0.289	N SOS Sched	0.019	N SOS StanEval	7.0
9	N SOS Flt CC	0.258	SOG CCE	0.017	D SOS CC	6.0
10	N SOS DOT	0.246	N SOS ADO	0.017	SOG CC G SOSS ADO N SOS Sched N SOS DO	5.0

2. Formality of Communication, Directed, One-mode Network

Actor Count: 172 (5 isolates); 305 ties; 5% of ties are reciprocal

Density / Diameter: 0.011 / 16.0

Fragmentation: 0.024

Cohesion: 0.976

Degree Centralization: 0.033

Table 10. Top Scoring Organizational Functions by Measure – Formality

Rank	Betweenness Centrality		Eigenvector Centrality		In-degree Centrality	
1	SOG StanEval	0.041	N SOS ADO	0.521	SOG CC	0.036
2	N SOS StanEval	0.026	N SOS DOT	0.511	N SOS Sched	0.020
3	N SOS Sched	0.019	N SOS Sched	0.430	N SOS ADO	0.017
4	N SOS DO	0.012	N SOS StanEval	0.390	N SOS Flt CC	0.017
5	SOG CCE	0.010	N SOS Func	0.380	SOG DC	0.016
6	N SOS DOT	0.007	N SOS SE	0.351	D SOS CC	0.016

7	G SOSS ADO	0.005	N SOS Flt E CC	0.327	G SOSS CC	0.014
8	N SOS CC	0.005	N SOS Flt CC	0.302	N SOS MOB	0.013
9	SOW CCE	0.005	SOG StanEval	0.272	B SOS CC	0.012
10	SOG CC N SOS Func	0.004	N SOS Plans	0.240	N SOS DO	0.012

Table 11. Top Scoring Organizational Functions by Measure – Formality of Communication Network 2

Rank	**Authority Centrality**		**Out-degree Centrality**		**Clique Count**	
1	SOG CC	0.505	SOG StanEval	0.064	N SOS DOT	13.0
2	SOG DC	0.429	D SOS CCE	0.027	SOG StanEval	12.0
3	N SOS Sched	0.366	N SOS DOT	0.022	N SOS ADO	10.0
4	N SOS ADO	0.358	G SOSS ADO	0.021	N SOS CC	8.0
5	SOG CCE	0.286	N SOS ADO	0.021	N SOS SE	8.0
6	N SOS Flt CC	0.280	N SOS CC	0.018	N SOS Func	8.0
7	N SOS DOT	0.263	N SOS Plans	0.018	N SOS CCE	7.0
8	N SOS MOB	0.242	N SOS Sched	0.017	N SOS StanEval	7.0
9	N SOS StanEval	0.241	N SOS StanEval	0.017	D SOS CC	6.0
10	N SOS DO	0.229	N SOS SE	0.017	SOG CC G SOSS ADO N SOS Sched N SOS DO	5.0

3. Hierarchical, Directed, One-mode Network

Actor Count: 172 (5 isolates); 501 ties; 73% of ties are reciprocal

Density / Diameter: 0.018 / 9.0

Fragmentation: 0.024

Cohesion: 0.976

Degree Centralization: 0.031

Table 12. Top Scoring Organizational Functions by Measure – Hierarchical Directed Network

Rank	Betweenness Centrality		Eigenvector Centrality		In-degree Centrality	
1	SOG StanEval	0.323	SOG StanEval	0.632	SOG StanEval	0.163
2	SOG CC	0.172	N SOS DOT	0.410	SOG CC	0.084
3	SOG CCE	0.148	N SOS StanEval	0.346	N SOS ADO	0.078
4	N SOS StanEval	0.106	N SOS CC	0.336	N SOS CC	0.072
5	P SOS Plans	0.101	N SOS ADO	0.317	P SOS Plans	0.072
6	G SOSS ADO	0.091	N SOS Func	0.267	N SOS Sched	0.066
7	N SOS CC	0.086	N SOS SE	0.257	N SOS StanEval	0.066
8	N SOS Sched	0.084	SOG CC	0.255	N SOS DOT	0.066
9	D SOS CC	0.058	N SOS Sched	0.249	SOG CCE	0.060
10	N SOS ADO C SOS DO	0.052	N SOS DO	0.234	N SOS Func D SOS CC	0.054

Table 13. Top Scoring Organizational Functions by Measure – Hierarchical Directed Network 2

Rank	Authority Centrality		Out-degree Centrality		Clique Count	
1	N SOS StanEval	0.397	SOG StanEval	0.253	N SOS DOT	13.0
2	N SOS DOT	0.395	N SOS ADO	0.078	SOG StanEval	12.0
3	N SOS ADO	0.335	P SOS Plans	0.078	N SOS ADO	10.0
4	N SOS CC	0.324	N SOS Sched	0.072	N SOS CC	8.0
5	N SOS SE	0.279	N SOS CC	0.072	N SOS SE	8.0
6	SOG CC	0.269	N SOS DOT	0.072	N SOS Func	8.0
7	N SOS DO	0.262	N SOS StanEval	0.066	N SOS CCE	7.0
8	N SOS Func	0.258	SOG CCE	0.060	N SOS StanEval	7.0
9	N SOS Sched	0.249	G SOSS ADO	0.060	D SOS CC	6.0
10	SOG DC	0.239	N SOS SE N SOS Func D SOS CCE	0.054	SOG CC G SOSS ADO N SOS Sched N SOS DO	5.0

4. Correlation Reports

The correlation reports run in ORA are calculated running 100 permutations with a random seed value of one. Figure 4 displays the correlation results of non-mandated communication being the dependent variable of the independent formality of communication. Figure 35 displays the correlation of mandated communication dependently against the formality of communication.

Table 14. Correlation of Formal and Informal Communications with Non-mandated Interaction

Correlation Results (Non-mandated Interaction)	
Network	**Correlations**
Informal Communication	0.417
Formal Communication	0.615

Table 15. Correlation of Formal and Informal Communications with Mandated Interaction

Correlation Results (Mandated Interaction)	
Network	**Correlations**
Informal Communication	0.580
Formal Communication	0.380

C. ADDITIONAL SOG NETWORK VISUALIZATIONS

These sociograms of the SOG Network demonstrate other ways in which ORA can present the organization.

Figure 31 displays the SOG organization as it relates to D and N squadrons, showing all frequency interactions. The color of the nodes denotes unit affiliation, the size denotes hierarchical level.

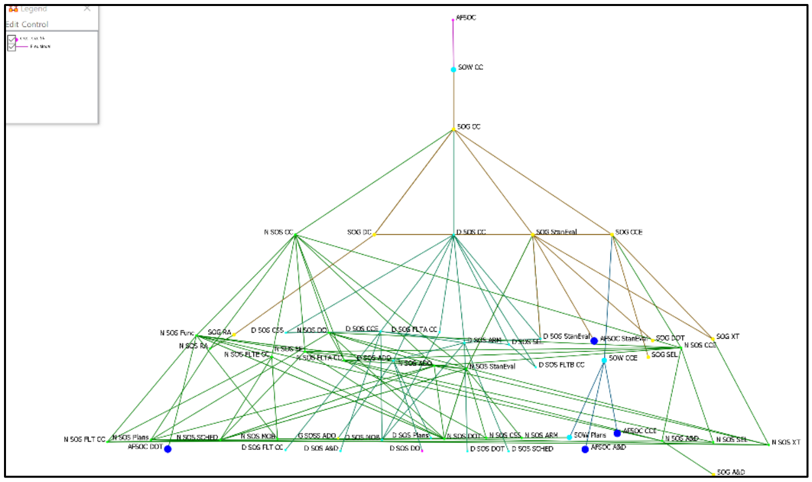


Figure 31. Additional D and N SOS Hierarchy

Figure 32 shows the network's mandated and informal interactions. The node size is based on the organizational function's authority measure, and the color is unit affiliation.

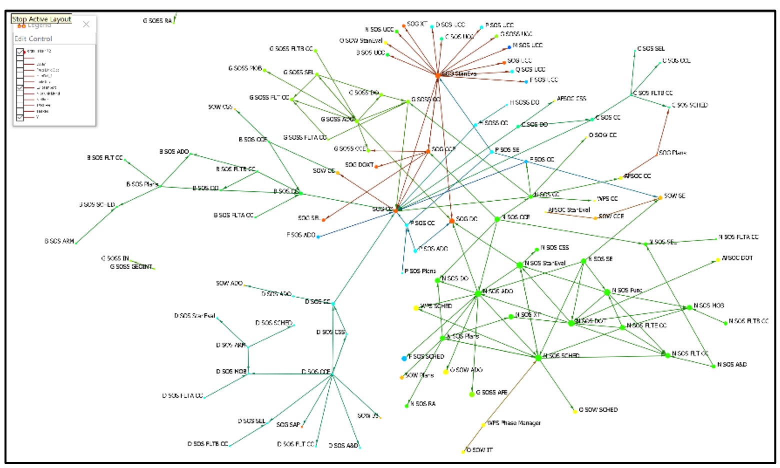


Figure 32. Mandated and Informal Interactions

Figure 33 illustrates the functions that interact less than every three months.

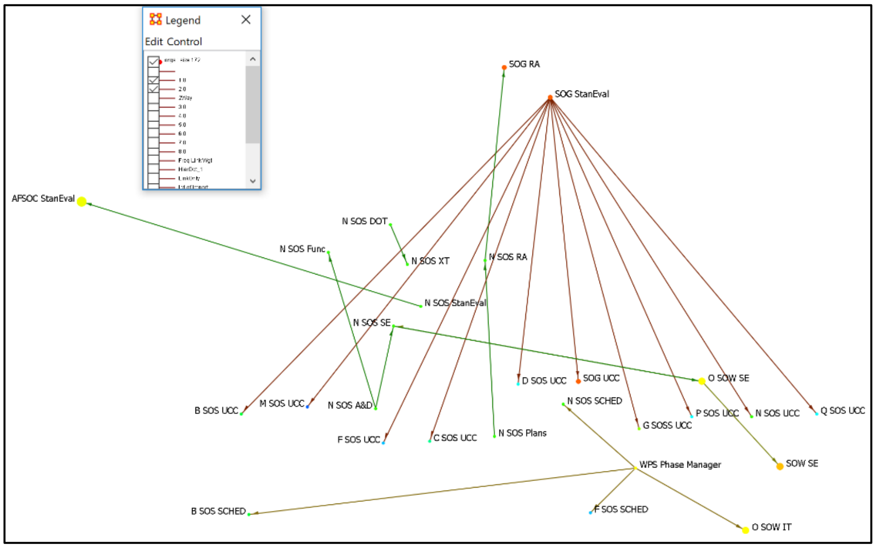


Figure 33. Frequency of Interaction – Less than Three Months

Figures 34, 35, and 36 all demonstrate ways in which the organization can be categorized for analysis.

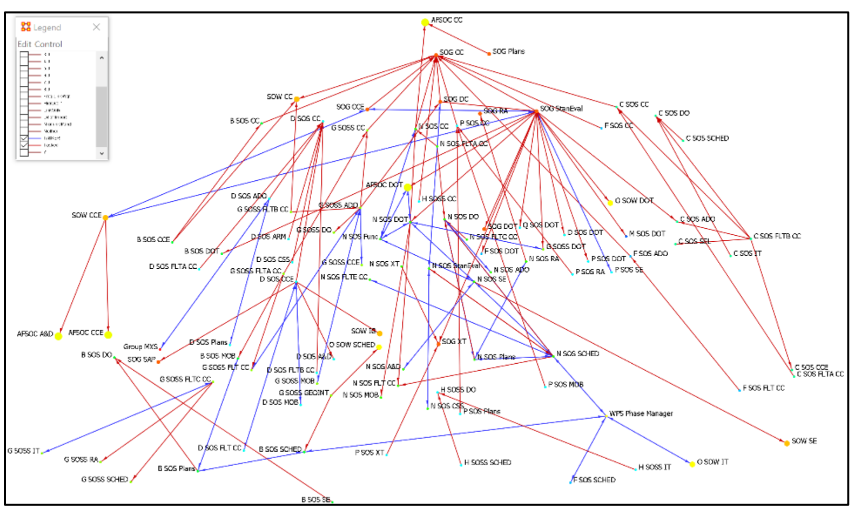


Figure 34. SOG Hierarchy Tasked (Red) versus Tasker (Blue) Relationships

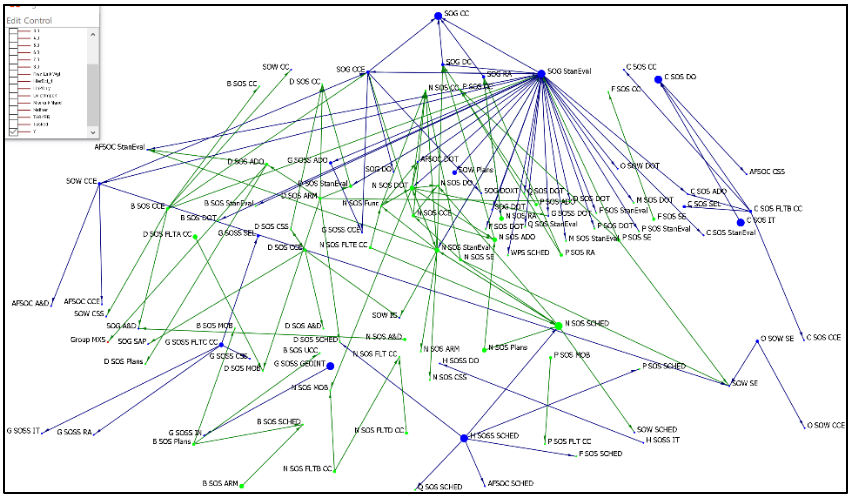


Figure 35. Mandated Interactions, Flying (Green) vs. Non-flying (Blue)

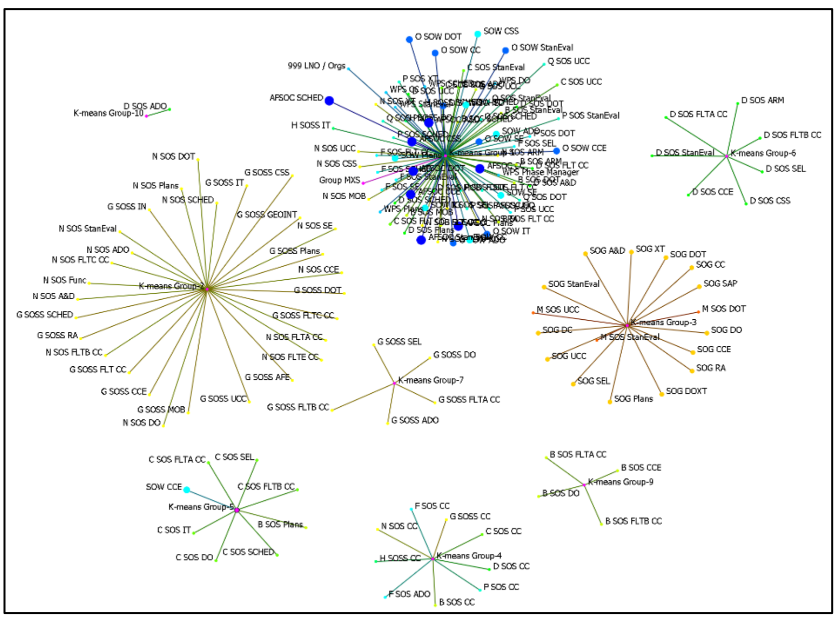


Figure 36. SOG Groupings

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