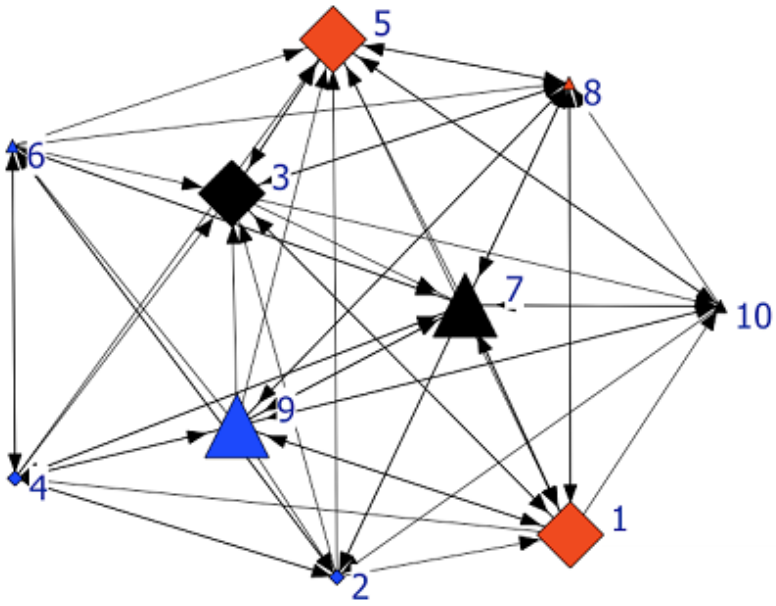
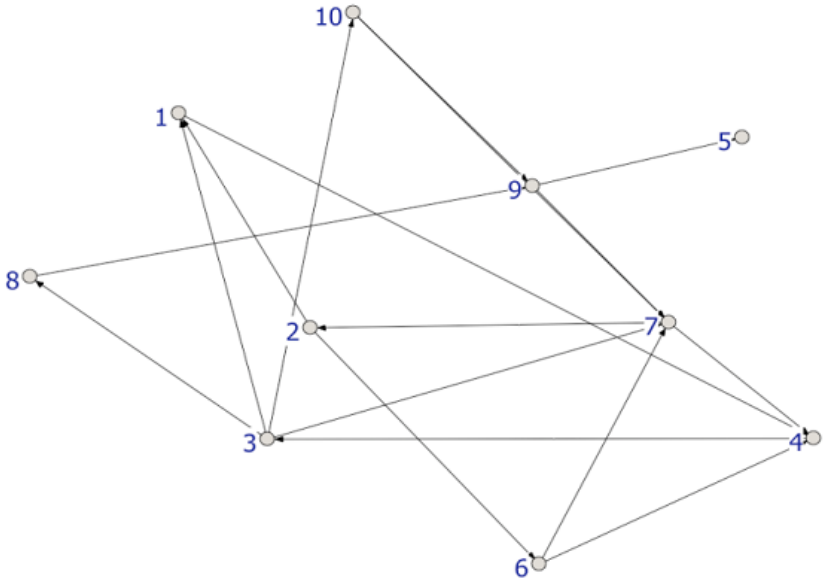
Organizational Network Analysis for Two Networks in the Washington State Department of Transportation

WA-RD 754.1 Shane Brown October 2010





Washington State Department of Transportation
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WSDOT Research Report

WA-RD 754.1

Research Report

Research Project T4120, Task 14

ORGANIZATIONAL NETWORK ANALYSIS FOR TWO NETWORKS IN THE WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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16. ABSTRACT

Organizational network analysis (ONA) consists of gathering data on information sharing and connectivity in a group, calculating network measures, creating network maps, and using this information to analyze and improve the functionality of the group. ONA was conducted for two functional groups in the WSDOT. The overall organizational health of these networks, as defined by network indicators, is positive, with a large percentage of individuals indicating others in their network were effective at providing information necessary to get their work done. Some individuals were over or under-connected in their networks. Both networks would benefit from identifying network functions and members more explicitly through a accessible and stable resource. Development of communities of practice in core strategic functions of both groups would facilitate productive interactions.

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EXECUTIVE SUMMARY

A significant amount of funding is used to gather and develop information and knowledge in support of business needs each year. This information is contained in documents and within the minds of employees. Preserving and promoting access to that that knowledge supports efficiency, productivity, cost management, workforce development, and succession planning. Organizational network analysis (ONA) is a tool used to analyze, understand, and improve the functionality and efficiency of information sharing in organizations. ONA consists of gathering data on who people get information from to accomplish their work and using this information to calculate network measures like connectivity, and to generate network maps that visually display collaboration among individuals. Measures and maps can be used to understand how groups of employees function and share work-related information. The inherent strength of this approach is that it provides an actual account of functionality, and not an assumed one. It is important to note that there isn't one network map that demonstrates the ideal. Rather, each network must evaluate the connections between individuals against expectations and use the network map and feedback to strengthen communication where connections are weak. Common issues uncovered using ONA are identifying individuals that:

- function as bottlenecks (i.e. impede connection between two groups and stand in the way of productivity)
- are inappropriately disconnected from their working groups.

Group issues can include lack of connectivity among individuals who share common expertise, resulting in the inability to share approaches to common problems.

Network measures indicate indegree (the number of individuals who go to a person for information), outdegree (the number of individuals an individual goes to for information), and

connectedness (the sum of indegree and outdegree). Indegree and outdegree can have ratings of ineffective, somewhat ineffective, somewhat effective, and effective. Network maps can show a multitude of network factors, including overall connectivity, network brokers, members who are central and non-central to the network.

Results

Network data was collected for two groups in the WSDOT using a validated network survey and network measures and maps were created for both groups. Network A consists of 60 people and four functional groups, and network B consists of 84 individuals and five functional groups.

Network A

Overall in this network, there are far more effective than ineffective ratings. However, several individuals were rated as ineffective in Network A, and one individual had substantially more outgoing ineffective ratings than all other network members. If three key members left Network A more than 20% of the connectivity would be lost.

Generally speaking, members of the leadership functional group are at the periphery of the network. The technical function appears to be more disconnected than other functions as evidenced by technical function members reporting that they have not worked on a project with others in their function. Finally, 26% of all possible connections exist within this network.

Network B

More than 11% of existing connections in this network are rated as ineffective, and more than 88% are rated as effective. One individual in Network B rated far more others in this network as ineffective than all other members of this network. The six most connected individuals represent about 18% of all network connections, but if these individuals left the

network, no network holes would result. Similar to Network A, technical function members are at the periphery of the network.

Internal consistency reliability analysis results indicate that the next survey can be much shorter due to the lack of new information from four existing survey questions. A shorter survey will facilitate increased response and completion rates.

General Findings

Both networks are broadly disseminated throughout the programs and offices of the agency and represent multiple levels of management and expertise. The connectedness of individuals was not always appropriate based on insights provided by network leaders. For example, there were individuals in both networks who felt they were peripheral who turned out to play a central role in network communication. Developing appropriate connectedness and strengthening both networks could be facilitated by identifying networks members and their functions more explicitly both through formal stable means, such as a webpage or SharePoint site, and through network channels when an agency action is initiated that requires individual's attention.

Data collected in both networks should be used to analyze and improve network efficiency through both individual and group actions. Individual actions could include personal interviews with effective and ineffective rated individuals to determine the reasoning for these ratings. Group actions could include developing communities of practice around key areas of expertise within each network. It is recommended that future research track one of these networks over time while making network changes, and use collected data to apply ONA to other WSDOT networks.

INTRODUCTION

Communication and information sharing are important for cultivating a productive organization. Individual and organizational innovation and creativity rely on productive and strategic information sharing among and across horizontal and vertical levels in organizations. Whether because of personal bias, internal structure, geographic separation, or any other reason, information sharing and transfer is not optimized in most organizations. This can cause loss of revenue, failure to be innovative, and potentially even loss of valuable knowledge. Organizational Network Analysis (ONA) is a tool that can be used to analyze existing information transfer structures, and can aid management and employees in making informed decisions to improve productivity.

ONA can answer many important questions about networks, such as how cohesive is the network? Do hierarchy, formal structure, or function group silos limit information sharing amongst employees? How well do employees know the expertise of others in the network, and how accessible is that expertise? Which employees function as bottlenecks, and which are acting as agents? Are some members of the network overly connected? Are some members not connected enough? Is there potential for dramatic knowledge loss and network fracturing if a small handful of people leave? Possessing the ability to answer these questions will greatly increase a manager's productivity when trying to create a more productive organization.

The goal of this project was to understand and improve information sharing and connectivity in two networks in the WSDOT. This goal will be fulfilled by the following objective: apply existing data collection and analysis tools and techniques to two existing networks in the Washington State Department of Transportation to investigate,

characterize, and provide suggestions for improving strategic collaborations and facilitation of information sharing in these networks. Additionally, this work can lead to an improved understanding of how ONA can be used at WSDOT to analyze and improve network efficiencies in these and other networks.

REVIEW OF PREVIOUS WORK

ONA allows for strategic and pointed decisions by employees and management on how to structure networks and associated information sharing to maximize productivity and use of existing resources. ONA can be used in a multitude of ways to examine networks. Parameters relevant to this study are to address network connectivity, knowledge retention, and connection of functional groups. In their book *The Hidden Power of Social Networks*, Rob Cross and Andrew Parker (2004) observe the following:

> *Even in small, contained groups, executives are often surprised by patterns of collaboration that are quite different from their beliefs and from the formal organization chart. […] Rather than leave the inner workings of a network to chance, executives can leverage the insights of a social network analysis to address critical disconnects or rigidities in networks and create a sense-and-respond capability deep within the organization. (p. 7).*

The overall health of a network can be greatly improved by making a few well-placed adjustments to the network after ONA has revealed deficiencies in existing networks and information sharing.

ONA can be beneficial to transportation agencies through effective knowledge sharing and retention. As more experienced employees move towards retirement, the potential for knowledge loss becomes greater. Employees who have been working in an

organization for decades have learned efficient and effective ways to solve problems and can often arrive at a solution more quickly than a new employee is able to. These skills save the employees, and therefore their organization, time and money on projects, and if those employees are allowed to retire without passing their expertise on to the younger generation, organizations have essentially lost not only time and money, but also a valuable resource. Cross, et al. state the importance of integrating these knowledgeable individuals in the organization, "Given the rapid turnover many companies experience today, it is important to find ways to help people become better connected so the organization can get the true benefit of their expertise more quickly" (2001, p. 112). ONA can allow firms to identify whether their more experienced employees have productive and meaningful connections with less experienced employees, or whether more formal means of information sharing should be established, such as a mentorship program or increased project collaboration.

Additionally, using ONA, firms can see how functional groups work together, and where relationships need to be fostered in order to promote more collaboration. According to Cross & Parker (2004), people rely on those they know and trust more than outside sources of information, so beneficial collaboration could occur between people who were already aware of the expertise of the others in the group. Wenger, et al. support the idea of collaboration by saying, "Having others who share your overall view of the domain and yet bring their individual perspectives on any given problem creates a social learning system that goes beyond the sum of its parts" (2002, p. 34). Collaboration, through communities of practice, or otherwise, can help an organization reach goals more quickly and effectively.

Network Analysis

Network analysis includes the calculation of network measures and development of network maps, and interpretation of both to understand and improve existing networks. Network measures exist to evaluate connectivity of groups and individuals within a network. Network measures relevant to this project are indegree, outdegree, permutations of indegree and outdegree (discussed in survey analysis in Research Approaches/Procedures Section below), and connectedness. These network measures are defined in Table 1 below. An actor is an individual that is part of the network being examined.

Table 1. Network measure descriptions. (Wasserman & Faust, 1994).

Network Measure	Definition	Importance
Indegree	The number of people who go to an actor for information	Indicator of an actors possession of information or resources
Outdegree	The number of people an actor goes to for information	Indicator of an actors knowledge of information or resources others possess
Connectedness	The summation of an actors Indegree and Outdegree	Indication of the ease with which and actor can communicate with other members of the network

Indegree is the number of people who *go to* an individual for information. As with other network measures, high indegree can be positive or negative. Examples of ineffective indegree are: a manager who has to provide approval for more employees than they can support as this can create a bottleneck in information flow, or individuals who receive information but do not have a function need for it or act on it in anyway. Leaders, however, may not understand the effect hierarchy has on a network since their days may be spent making quick decisions and they may not be aware that peripheral people may wait weeks for a response to a question (Cross & Parker, 2004). Cross & Parker find this to be especially true in professional services. "In many kinds of professional services

work, there is often not a single right answer but many plausible ones. Those in power often dictate the correct course of action and can quickly create networks that are overly reliant on them" (2004, p. 27). Indegree can be used to easily pinpoint those people who are most often sought out for information and who may be inadvertently acting as a bottleneck to the actors seeking information or decisions from them.

Conversely, Outdegree is the number of people and individual *goes to* for information. Outdegree can be used to indicate which people within the network know of the desirable proficiencies of others. Tom Allen of MIT indicated that engineers and scientists were roughly five times more likely to turn to a person for information than to an impersonal source, according to a decade's worth of studies on the subject (Cross & Parker, 2004). Furthermore, it has been found that even if a person containing the sought out knowledge on a subject works within the network, if the seeker does not have a direct relationship with that person, information transfer may not occur (Cross & Parker, 2004). One example in Cross & Parker's book describes a Research and Development company that had tried to promote collaboration by creating a virtual problem-solving space and using online resumes to pinpoint certain expertise. However, this organization still found that people relied on "those they knew and trusted, and not on a database of self-proclaimed experts" (p. 16). The individuals with a high Outdegree may be those most aware of the expertise of others. Outdegree can also indicate the individuals who may be too reliant on others for information. This reliance may be due to a person's relatively short tenure in their current job position, to their being a newly hired employee, or to some other reason. Awareness of these individuals is important in order to ensure, if their high Outdegree stems from less desirable reasons, that steps can be taken to create more

self-reliance in order that other individuals within the network are not overly burdened with requests for information.

Indegree and Outdegree can be combined into one single term, Connectedness. The criteria on which Indegree, Outdegree, and Connectedness are considered acceptable vary depending on the organization being analyzed. A small company might expect to see, on average, lower values for these terms of measurement than would a large national or international company, simply because a small company has fewer employees. For example, an actor in a company with 16 total employees could have a maximum connectedness value of 30, while an actor in a company with several thousand employees could easily have a connectedness value in the hundreds. Well-connected people generally fall into one of two categories, central connectors and bottlenecks. Cross & Parker (2004) point out that more connectivity is not always better.

> *In networks of any size, it is not possible for everyone to be connected to everyone else, nor is it desirable. An indiscriminate increase in connections can be a drag on productivity. A crucial benefit of network analysis often comes from discovering excessive relationships. This discovery can help managers develop ways to alleviate overburdened people and decrease time-consuming connections (pp. 8-9).*

When overly connected people are slowing the work of others it is crucial for organizations to take action to reduce their demand. This can be done through the formation of subgroups, where more people with the necessary expertise come into contact with one another, or through reallocating some of the more minor responsibilities of an overly connected person, allowing them to have more time to focus on their areas of expertise (Cross & Parker, 2004).

However, high connectivity does not always indicate a bottleneck. Highly connected people can be very beneficial to a network by making connections between groups that might not otherwise be made, or by providing quick feedback to those seeking information. It is important for executives to be aware of those members in order to ensure that gaps in the network will not be created if those individuals leave. These actors, sometimes referred to as central connectors, often have high levels of expertise in one or several areas, according to Cross & Thomas (2009), and therefore make day-to-day work possible for many others in the network. Losing a central connector can be extremely detrimental to a network. In order to reduce the impact of the departure of central connectors, "organizations need to develop the collaborative skills of everyone in the network and then help position emerging connectors in the center of the network by assigning them to critical and relevant projects" (Cross & Thomas, 2009, p. 172). Another action to take to ensure the retention of organizational memory held by the central connectors is to create informal pairings of centrally connected members with more peripheral members. Cross & Thomas use an example of a pharmaceutical company that needed scientists to work together to interpret data. The company paired junior scientists with central scientists, allowing the junior scientists to receive real-time feedback, as well as develop connections with others throughout the company. In this way companies can ensure that valuable knowledge is not lost and that the younger generation of employees is making important connections with employees who possess expertise.

Network maps can be created to visualize and examine the functionality of networks that complement the methods utilizing network measures. NetDraw is a

computer program that was used to create network maps. Network maps consist of nodes and lines. Nodes are used to represent people (actors), and lines are used to indicate the connections between the nodes, with arrows pointing out the direction of the communication. If an individual in a network map has eight arrows pointing towards them, they would have an indegree of eight.

Additionally, nodes can be labeled with names, colors, shapes and sizes to represent personal information, such as function, tenure, or region. Figure 1 displays a fictional network with ten employees who work in three different regions and perform two different functions. The nodes are shaded to represent the different regions, shaped to represent the functions, and sized to indicate the employee's tenure in the organization.

Network maps for individual employees can also be developed and their direct network, or egonet, can be analyzed to see to whom they are connected. These egonets generally contain the individual being studied, or ego, the members of the network who are directly connected to the ego, and the secondary members of the network who are indirectly connected to the ego. Figure 2 displays a sample egonet for person 40. There are 12 other individuals in his network who are either directly or secondarily connected to him.

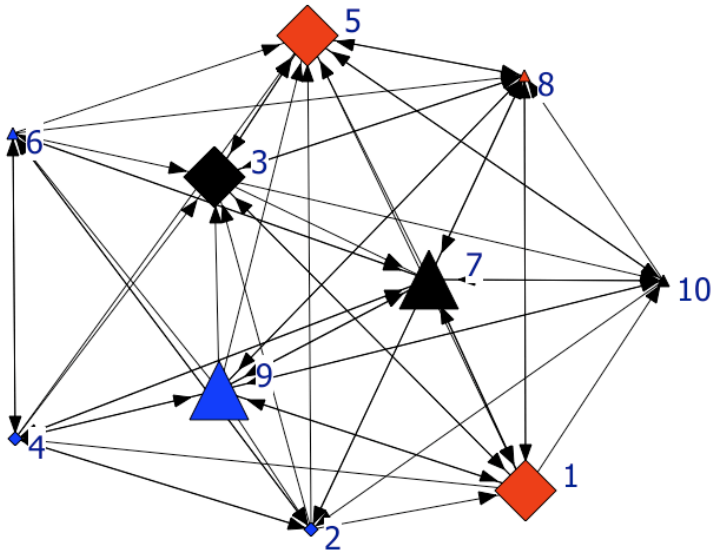

Figure 1. Using node size, shape, and color to represent information.

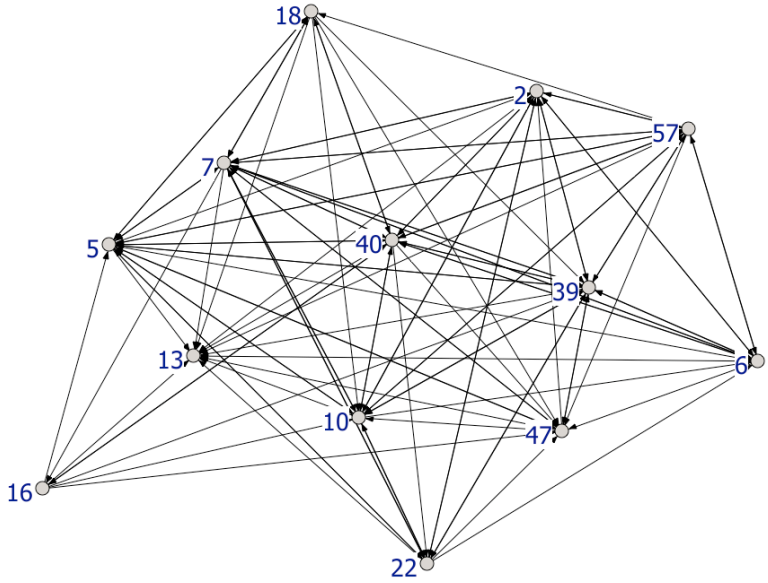

Figure 2. Egonet for person 40.

Network maps can also be created based on the strength of interaction between people, i.e. ineffective, somewhat ineffective, etc. Figure 3 and Figure 4 show how maps can vary depending on the connection strength being mapped. In the fictional network shown below, nodes are colored to represent their regions.

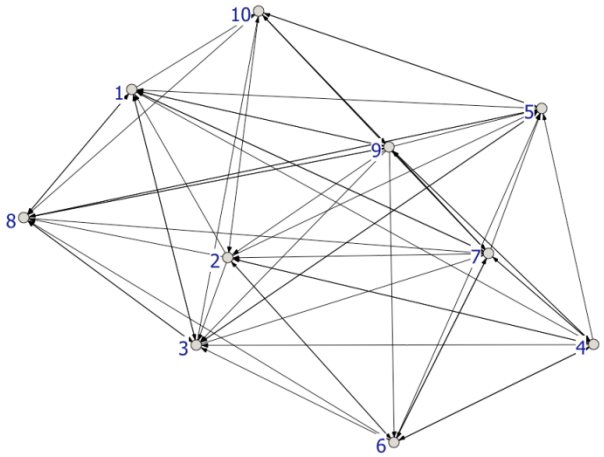

Figure 3. All connections within the network.

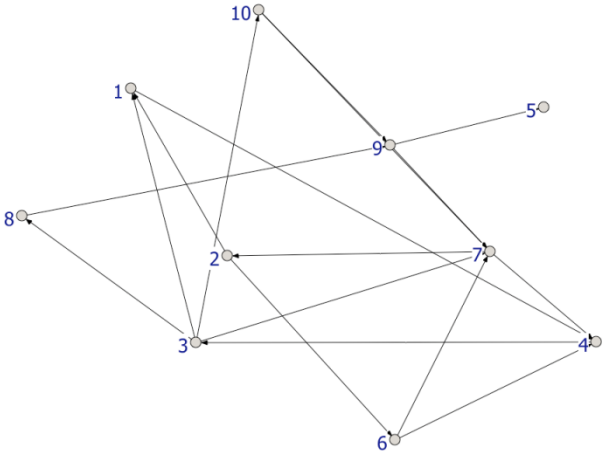

Figure 4. Only effective and somewhat effective connections within the network.

Another way that the maps can be manipulated is through the elimination of certain nodes and their corresponding connections. It is easy for people to become overly connected in an organization, and network maps can show the hole that would be created if these individuals left the company. For example, if person 1 was removed from the network map shown in Figure 5 below, the network would become completely separated into two distinct groups.

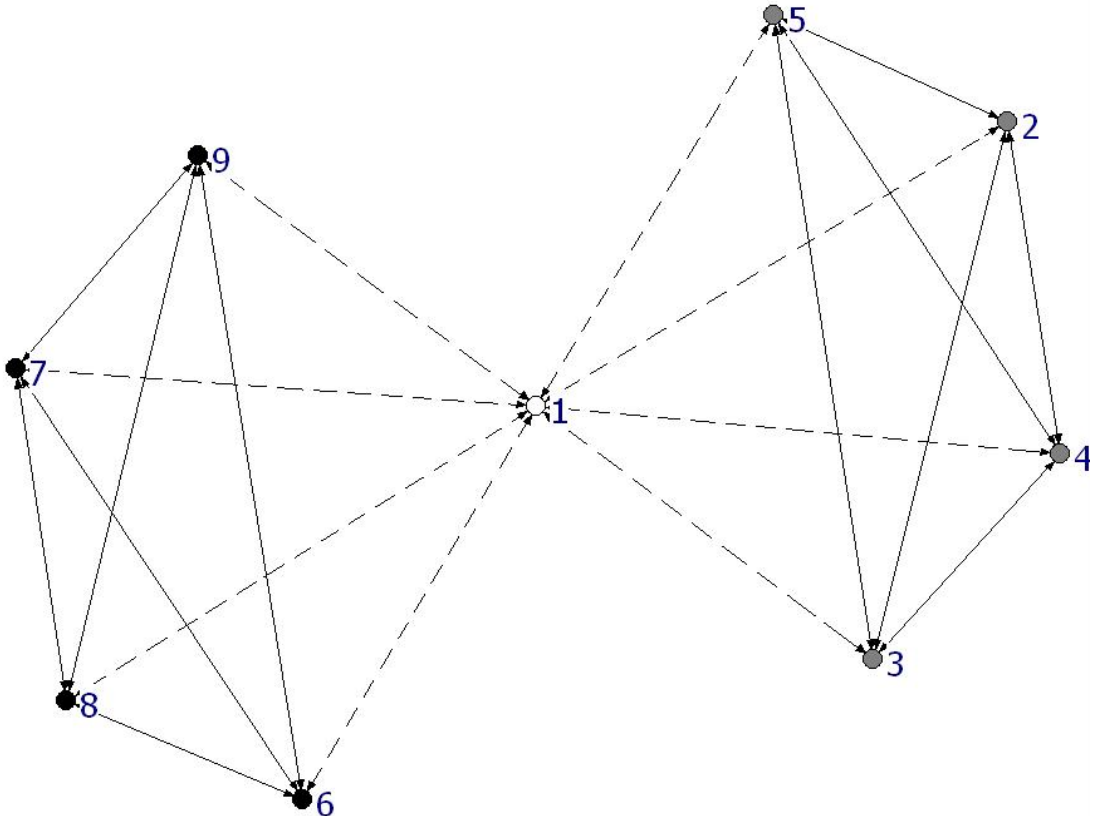

Figure 5. Fragmented network due to the removal of a highly connected employee.

Each network has its own set of challenges and difficult areas, so a generalized prescription for analysis cannot be proposed. Some networks are highly fragmented and have only a few members connecting the different areas, acting as brokers, while other networks are fairly well connected, but have a few members who are too highly connected, causing bottlenecks to occur. In the first example, creating more connections between the different areas would keep the network from becoming completely fragmented if the brokers left. In the second example, the best solution might be to delegate some of the highly connected members secondary responsibilities to others so that they can focus on the areas in which they have the most expertise. Each network must be subject to a detailed analysis in order to find the most effective solution for the

networks problems. However, the following case study provides a detailed look at an ONA for two networks within a state transportation agency.

RESEARCH APPROACH/PROCEDURES

ONA requires collection of a broad spectrum of data about individual network members and calculation of network measures and creation of network maps.

Data Collection

ONA data is collected using online survey instruments. Of utmost importance is that survey questions have been validated and proven reliable through extensive implementation and testing. Using unproven survey questions would lead to erroneous data. For this reason, the survey used to gather information necessary to conduct the organizational network analysis was a valid and reliable instrument developed at Network Roundtable at the University of Virginia under Rob Cross and Andrew Parker that has been used for thousands of individuals at hundreds of companies for ONA. At the recommendation of the Network Roundtable, the survey includes the following sections: All survey questions are included in Appendix A.

- Personal information, which includes Job Function, Tenure, Region, Age, and gender.
- Cultural values, which ask respondents to rate office environment values as they currently are within their work environment, and how they ideally should be. These values include such things as innovation and change, empowerment of employees to act, participation and open discussion, predictable performance outcomes, etc.

- Personal network, which asks respondents to list up to 15 people that they turn to for information to get their job done, and for each of these individuals to what degree they collaborate, the benefits to the respondent from this person. Also includes questions on the skills or expertise that are important for the respondent to be effective at their work.
- Energy network, which includes nine questions related to behaviors that energize networks on respondents' views of their interactions with the network as a whole.
- Bounded network, which asks respondents if they have worked with individuals from a pre-determined list and how effective interactions were with these individuals.

Network survey questions include open and bounded items. Bounded items are based upon a specific list of individuals that was developed in cooperation with WSDOT staff that were determined to be a part of the networks analyzed. Personal network questions were also included to address the concern that some individuals who are important to the work of the two networks may not have been included in the bounded network questions. In the survey, each respondent was asked to list up to 15 people to whom they turn for information related to their responsibilities in the network of interest. The respondents were further asked to identify whether the individuals within their personal networks collaborate with one another, or if they would be likely to collaborate with one another if the situation presented itself. By asking this question, ties can be made between people who may be part of the organizational network, but fail to respond to the survey or between people who are not part of the bounded network. The next

question in the personal network section asks the respondent to indicate the primary benefit they receive from each member of their personal network. This information further allows insight into the nature of the personal network relationships. Respondents were asked to list three skills or kinds of expertise that are important for them to be effective in their work, to rate themselves on their proficiency in that skill or expertise, and to indicate the extent each person in their personal network helps them with each skill or expertise.

The next section of the survey addresses energy in networks. The questions in this section ask about the respondents' own attitudes at work, and offer suggestions to help improve these attitudes. This section of the survey is geared towards offering immediate feedback to each employee to initiate a change in approach to dealing with networks. The energy section of the survey does not provide much immediate information for network analysis, however it can be useful for understanding each respondent's viewpoint.

The final, and most analytically useful, part of the survey is the bounded network section. The bounded network is the formally established network of employees being surveyed for the network analysis, as stated above. This network can be comprised of any portion of the employees within the organization with common interest, such as a group of people who are integral to a core process within the organization or those who all serve a critical function (Cross & Parker, 2004). When surveying a bounded network, each respondent is provided with a list of names for every other member of the network.

The first question in the bounded network section asks respondents to indicate the extent to which the other individuals in the bounded network are effective in providing them information that helps them learn, solve problems and do their work. The names of

each of the other individuals in the bounded network are listed, and for each name the respondent can choose either that they do not know the person or have not worked with them on any relevant projects, or that they are ineffective, somewhat ineffective, somewhat effective, or effective at providing information relative to their responsibilities in the network. Respondents must select an answer for each person in the bounded network. Four subsequent questions are then asked about the individuals the respondents indicated they knew, i.e. the individuals who were given an effectiveness rating. These questions asked if interactions with the individuals resulted in better quality of work, time saved, reduced project costs, and if the respondent receives clear direction from each individual. The responses to the bounded network questions, especially the first "information" question, act as the basis for the network maps, which graphically depict the relationships in the network.

Data Analysis

Network survey data was analyzed through the use of network analysis (UCI Net) and mapping software (Net Draw) that can calculate the network measures previously discussed and create network maps. All network maps were created using data from the summer of 2009 administration of the survey.

UCI Net was used to calculate each individual's Indegree, Outdegree, and Connectedness, and effectiveness ratings for Indegree and Outdegree. For example, if John had ten people that came to him for information on network tasks, and, of those people three responded effective, three somewhat effective, two responded somewhat ineffective, and two responded ineffective, John would have an indegree of 10, and effective indegree of 6, and an ineffective indegree of 4.

FINDINGS/DISCUSSION

The network analysis was conducted for two networks within the Washington State Department of Transportation; Network A was made up of 60 people and Network B consisted of 84 people. Each network contained individuals from several geographically separate offices. Some of the respondents were members of both Network A and Network B, but were asked to complete the survey twice, once for each network. Each network was analyzed separately; since the two networks represented largely independent groups in the WSDOT. The interaction between individuals within the two networks was not analyzed for this study. Networks A and B had completion rates of 58% and 72% respectively. Extensive efforts were made to maximize the response rate, including phone interviews to complete surveys.

The focus of the analysis discussed herein is on the personal and bounded network questions. Data from the cultural values and energy in networks sections of the survey is available upon request.

The responses to the last four questions of the survey, for both networks, asking about time saved, money saved on projects, quality of direction, and overall quality of work, were analyzed for reliability, and a Chronbach's alpha value of 0.848 resulted. Essentially, this means that if a respondent indicated that a particular person was generally effective, the respondent would also say that the person also generally saved them time, the person generally saved the money on projects, that they received clear direction from that person, and that the overall quality of their work was improved due to interactions with that person. This means that for future surveys, only one of the five questions would need to be asked, and the responses to that question could be

extrapolated for the other four questions. This also means that analysis of the networks could validly be conducted based on the responses to any one of those questions. For the case study in this paper, the responses to the effectiveness question were used for analysis.

Network A

Network A was composed of 60 individuals and had four function groups, Advisory, Core Team, Leadership Team, and Technical. Network values were calculated for all members of the network and are shown in Appendix B.

On the following network maps, the functions are represented by the shapes circle, square, triangle, and diamond, respectively. They will also be colored in varying shades of gray to aid in differentiation. In order to preserve the privacy of the individuals within the network, numbers have been assigned to each individual. In order to make the analysis simpler, the male pronoun will be used for every individual, regardless of his or her actual sex. Table 2 provides a more detailed description of each of the functions in Network A.

Table 2. Network A function descriptions.

Function	Description
Advisory	Develop, advise and/or set policy related to Network A activities for the department.
Core Team	Provide technical information on their area of expertise for Network A activities. Work together to gather information and develop recommendations to respond to legislative and policy requirements.
Leadership Team	Assist in the development of policy and procedures. Facilitate implementation of Network A activities within their areas of responsibility.
Technical	Provide technical information on their area of expertise for Network A activities on an as needed basis.

The first network map analyzed was the map representing all of the "ineffective" responses to the survey question, "How effective is each individual in providing you information to get your work done". As shown in Figure 6, individual 40, who is one of the directors within Network A, has 9 arrows pointing towards others, indicating that he views these others as ineffective. Additionally, he has 2 arrows pointing inward, indicating that there are 2 individuals who find him ineffective at providing information. One of the people who individual 40 found to be ineffective is person 22, who is a manager in Network A. An interesting observation of this map is that two directors in Network A find individual 22 to be ineffective, while individual 22 finds 4 other people in that function to be ineffective. The majority of the individuals in this network are not included on this map, indicating that most people found the others to be better than ineffective at providing information, which is a positive sign for the network. Additionally, person 29 has 4 incoming arrows, the most of any individual in Network A, with person 5, person 49, and person 58 each receiving 3 arrows indicating ineffective communication.

All the responses of "somewhat ineffective" to the same survey question were examined and are shown in Figure 7. Individual 40 has 16 outgoing ratings of somewhat ineffective, indicating that there are a number of people whom he finds to be somewhat ineffective at providing information. The average number of outgoing arrows for this connection level is 4. The people most often identified as somewhat ineffective in providing information are person 2 with 8 incoming arrows, persons 5, 6, and 49 with 7 incoming arrows, and person 55 with 6 incoming arrows. The average number of incoming arrows for this connection level is 3 arrows. In order to try to improve the

network, person 40 could be interviewed and asked why he rated the others as somewhat ineffective. According to the network map, Individual 40 is central to the network, meaning that the other individuals in the network somewhat revolve around him, and that he is an integral part of the network. His high level of centrality would indicate that some measures should be taken to ensure that others' communication with him would improve in the future. Another central individual in this map is person 55. Again, he has 6 incoming arrows, showing that others find him to be somewhat ineffective at providing information. Person 2, the program leader for Network A, is on the periphery of the map, which is surprising, since he is one of the more senior people in the network. However, since Figure 7 shows somewhat ineffective ratings , the peripheral position that individual 2 holds is not considered troubling.

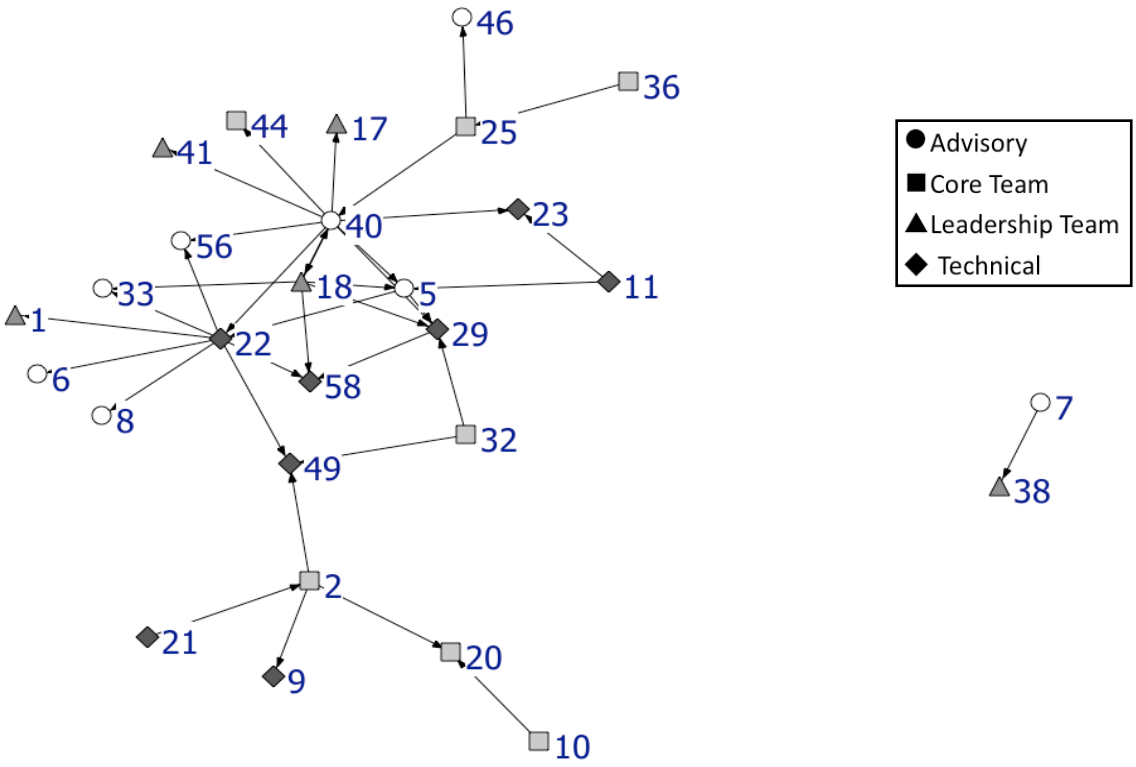

Figure 6. Network map showing responses of "Ineffective"

Figure 8 presents a map of all of the connections resulting from responses of "Somewhat effective" to the information question. This level of response had the highest number of connections (387 connections) of any of the answers, indicating that most people considered others to be somewhat effective in providing information ("effective" had 381 connections, "somewhat ineffective" had 117 connections, and "ineffective" had 37 connections). Having the greatest number of connections for this response level indicates that Network A is healthy in that most people indicate that they are able to get the information they need from others in a fairly effective manner.

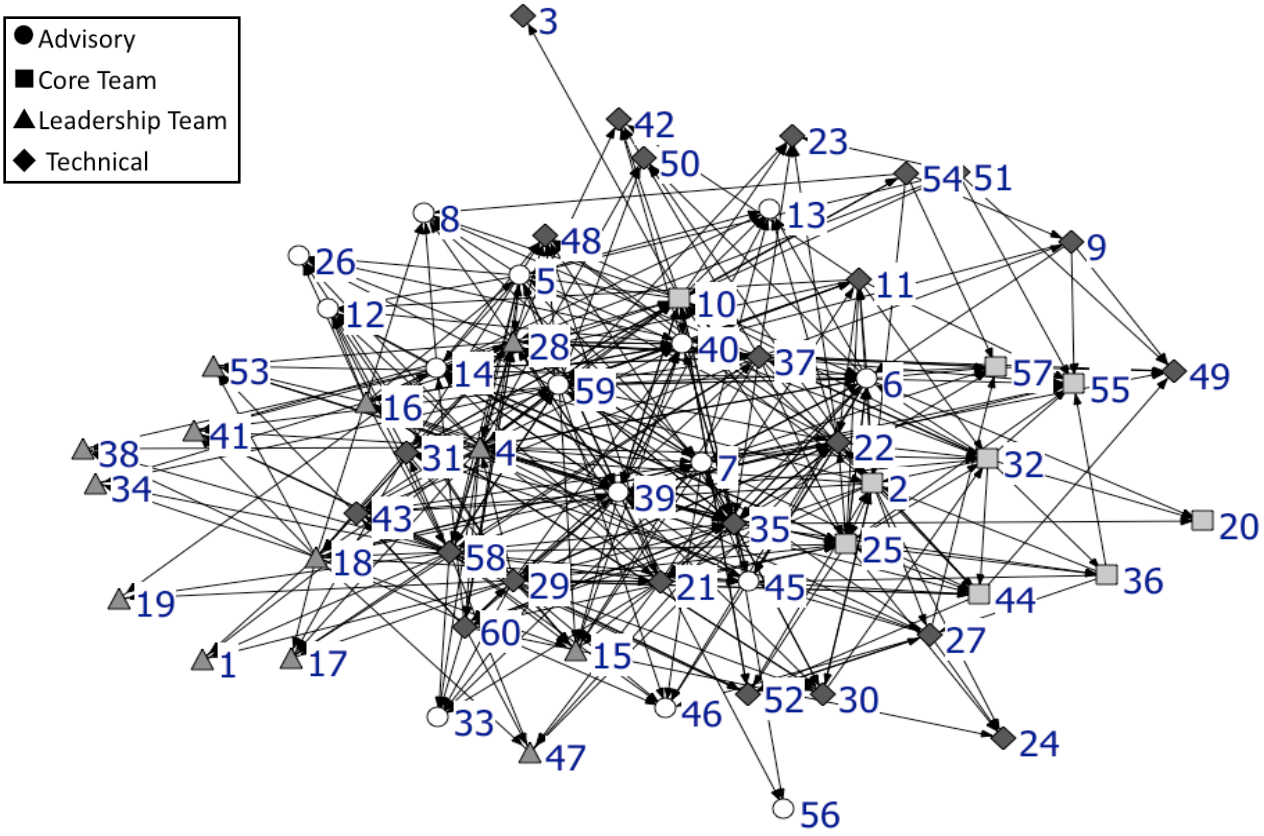

Figure 7. Network map showing responses of "Somewhat Ineffective".

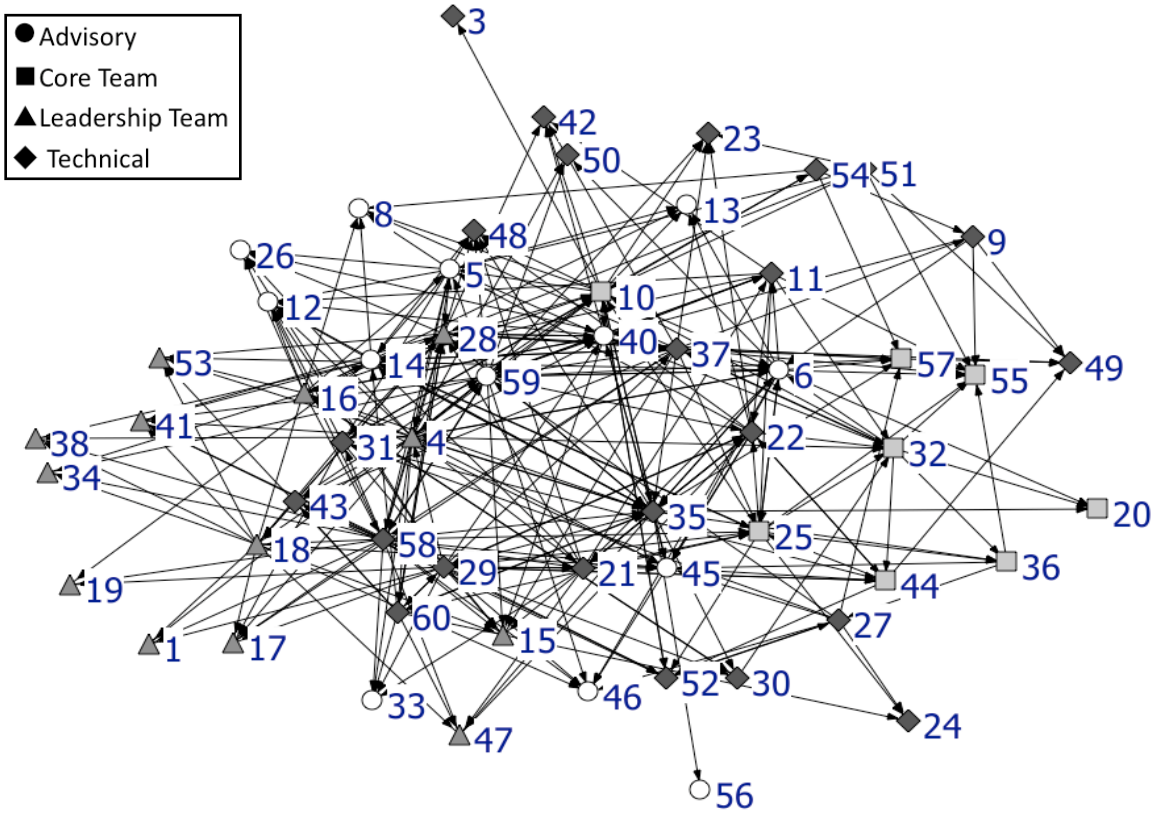

Figure 8. Network map showing responses of "Somewhat Effective".

Within this Network there appears to be vulnerability at the connection level of somewhat effective. If the three most connected people, (persons 2, 7, and 39) who represent approximately 5% of this network, were to be taken out of the network, because of retirement, layoffs, etc., a hole would be created in the network map, as shown in Figure 9. More than 20% of the total number of connections (78 of 387) in this map would be lost if these three people were no longer part of this network. An important note about those three people is that they are all part of the advisory function, and each one is a director within one of the departments of the agency. Having people so high up in the agency being the most connected could potentially lead to a bottleneck. If these individuals are responsible for approving too many decisions that could be handled by

lower ranking individuals, they may not have time to handle the bigger issues that require their expertise.

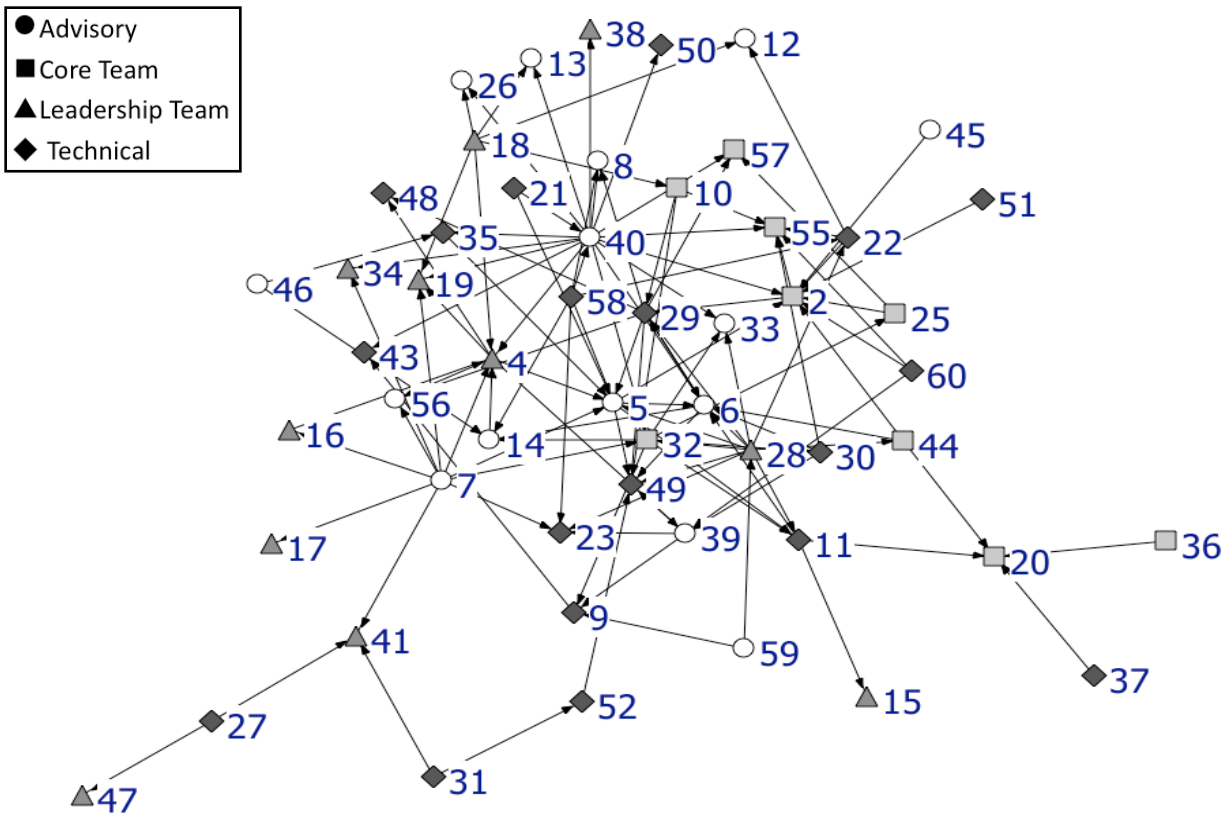

Figure 9. Network map showing the hole left by removing the three most connected members of Network A.

The map in Figure 10 indicates the responses of "Effective" to the information question. There are still a good number of connections, 381, for this response level, which indicates that there are many individuals who both find others effective and are found to be effective in providing others with information. The fact that the number of connections for the "somewhat effective" and "effective" responses is much higher than for the "somewhat ineffective" and "ineffective" responses indicates that network A as a whole tends to have positive information sharing. Individual 57 has 32 connections pointing away from him, indicating that he finds many others to be effective in providing

information, however only 9 people found him to be effective. In the time which passed between when the survey was distributed to Network A and when the analysis of the results took place, person 57 was relocated to another position, so the lack of effective information provided by him is no longer an issue for the network. Person 2, who is the program leader for Network A, was found to be effective at providing information by 11 other people, while he found 23 people to be effective. His numbers are above the average of 7 connections in and 10 connections out.

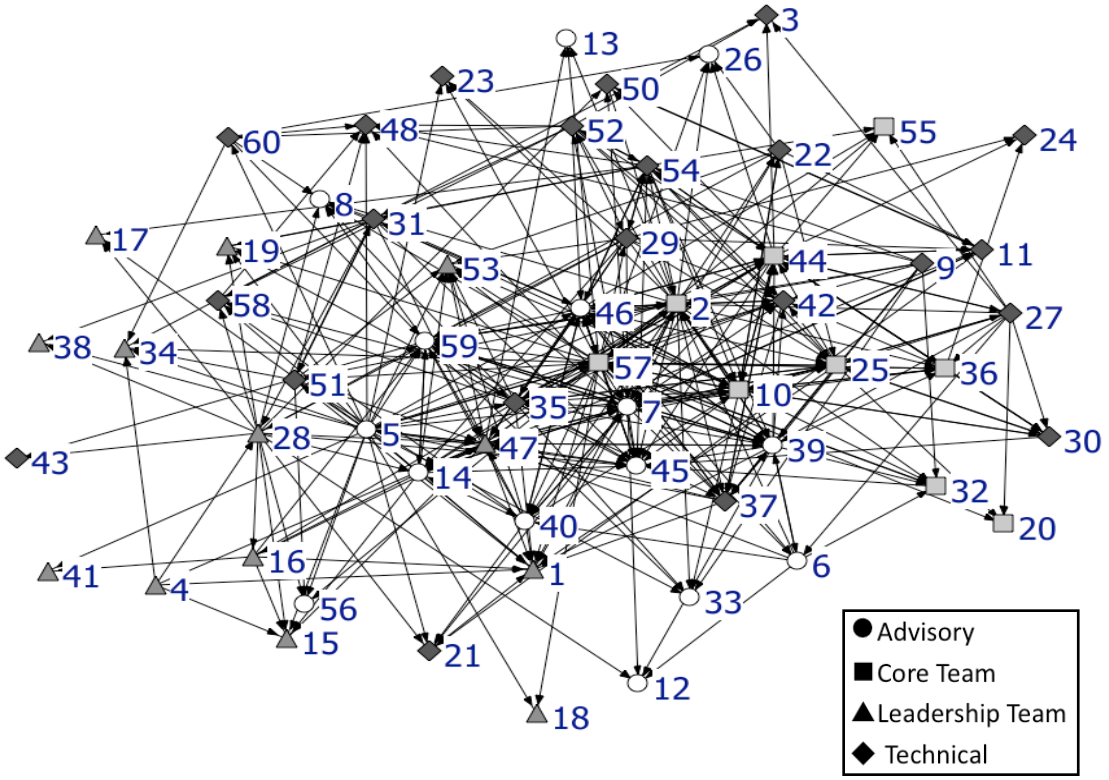

Figure 10. Network map showing responses of "Effective".

An interesting thing about Figure 10 is that most of the members of the leadership function are peripheral to the network. This indicates that they are not centrally connected to the other members of the network and are therefore not sought out as much for information, nor do they seek others out, which might seem surprising, since they are in

fact the leaders of the department. However, their time is spread more broadly than just Network A, so the peripheral position is not alarming.

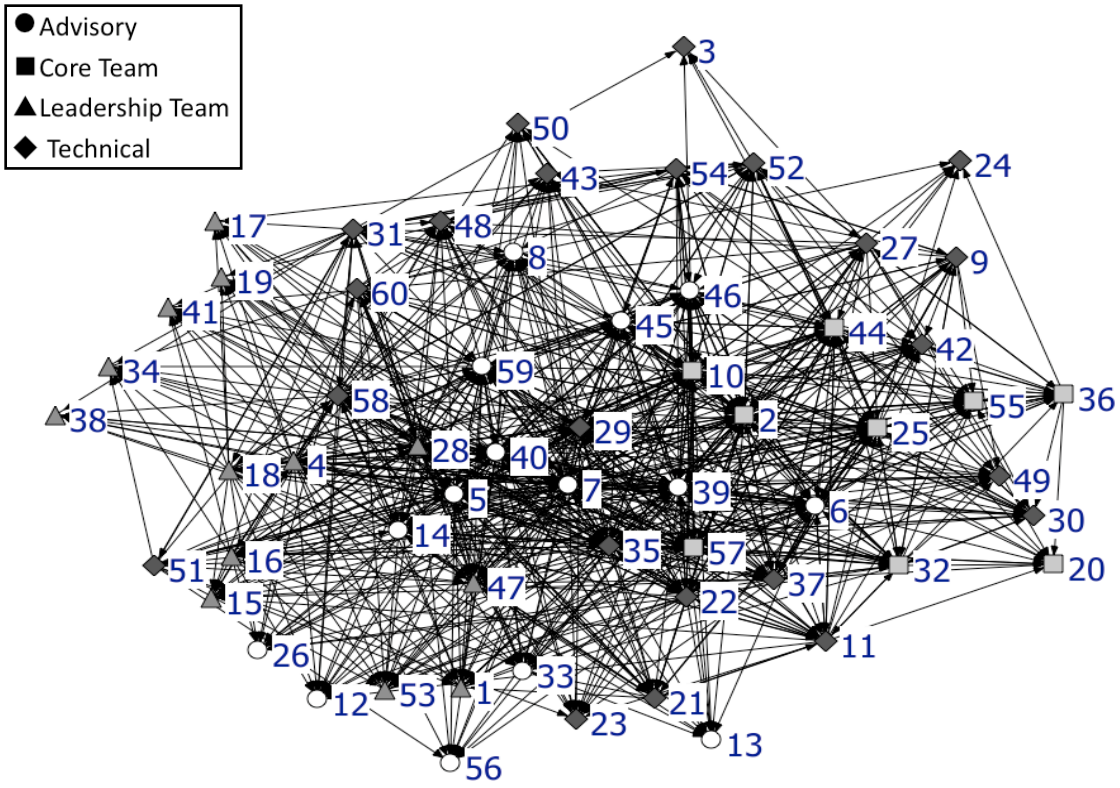

Figure 11. Network map showing all connections for Network A.

The Network map displaying all of the connections for Network A is shown in Figure 11. This map shows 922 of the possible 3540 connections between the various members of the network. In other words, approximately 26% of the possible connections for the network actually exist, according to the responses to the survey. However, not every member of the network completed the survey, so the number of actual connections could be higher. Every member of the network is connected to at least one other member of the network, so there are no individuals completely excluded from communication.

Also of interest are the maps showing where communication does *not* occur. Figure 12 displays the responses of "I do not know this person" for the information

question. Every line on the map indicates where a person does not know another person, or knows them but has not worked with them on an issue relating to Network A. Compared to Figure11, Figure 12 shows a large number of connections (1438 vs. 922). This indicates that people within Network A are more likely to not have worked with others or to not know others than they are to know them.

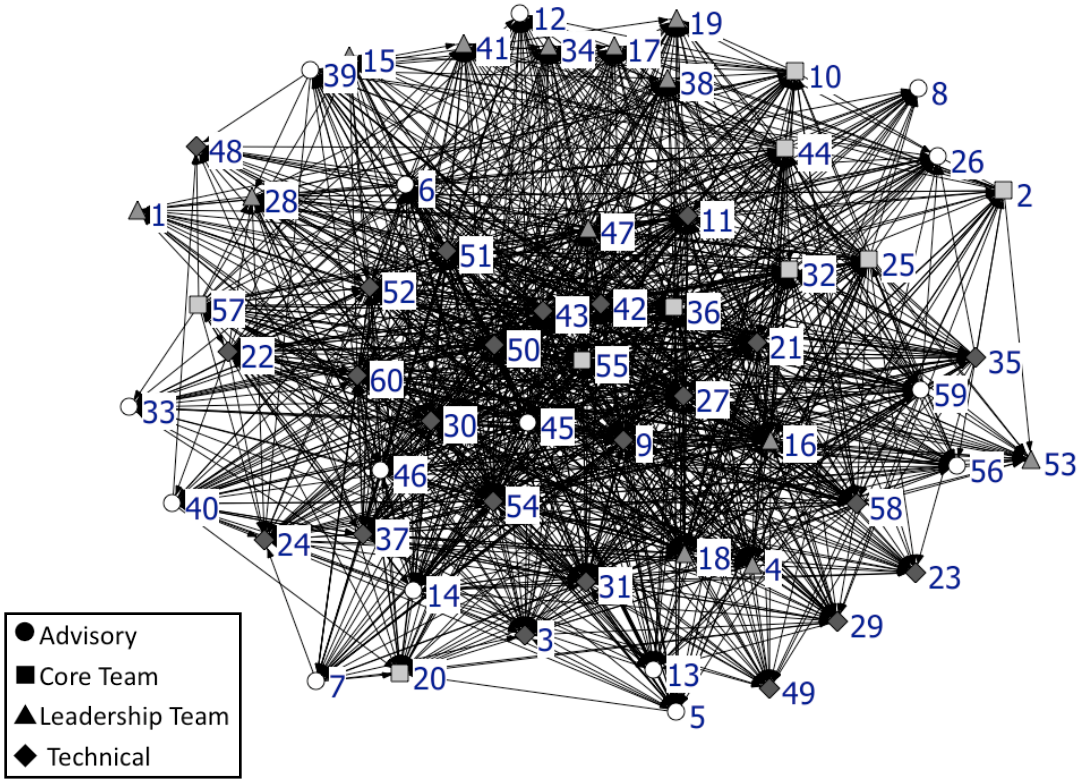

Figure 12. Network map showing which individuals do *not* know others.

The individuals who reported that they had not worked with other individuals in the network for the different functions are displayed in Figures 13-16 below. The lines on these maps represent when people do *not* know each other. Thus, the more lines on the map, the less communication that is occurring. The technical function, especially, has a large number of lines between the different individuals. This is true for both Network A and Network B. Some possible reasons for this are that the individuals in the technical

function perform more specialized duties, and therefore are not as reliant on each other, and this could be exacerbated by the fact that, like every other function, the individuals in the technical function are located all around the state, so face-to-face contact is somewhat impeded.

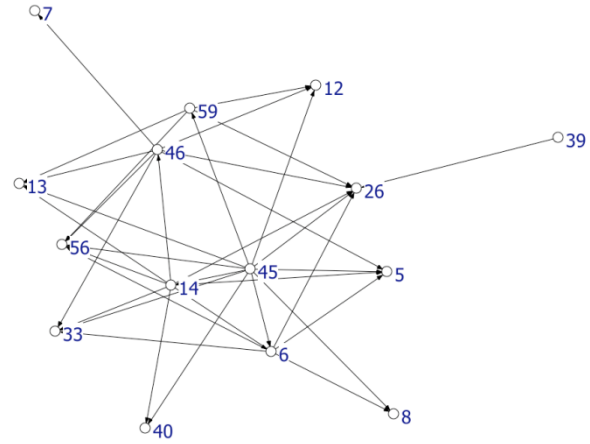

Figure 13. Advisory function.

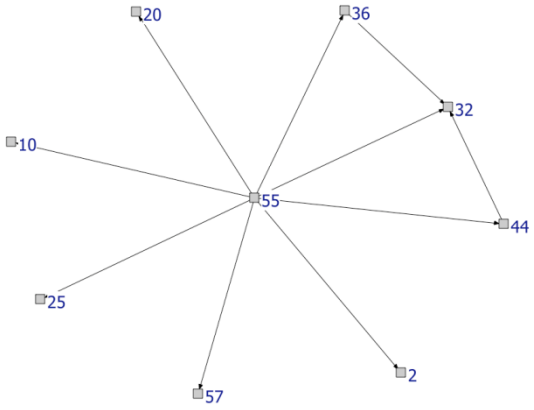

Figure 14. Core Team function.

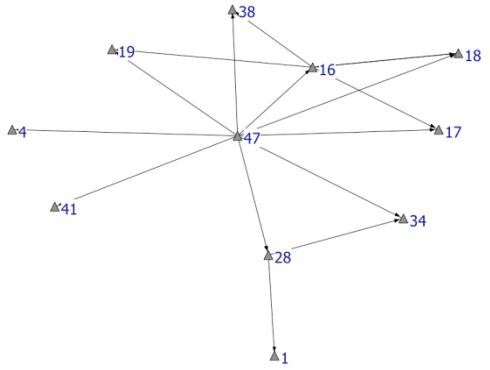

Figure 15. Leadership Team function.

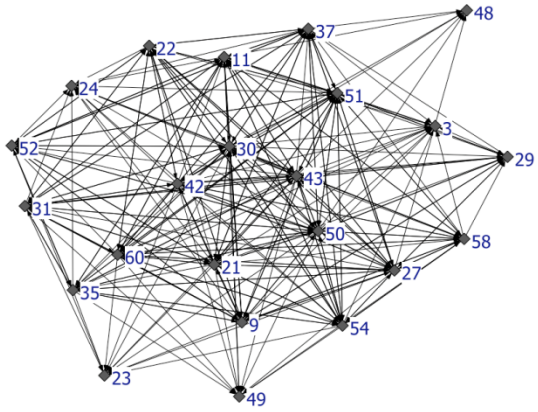

Figure 16. Technical function.

Figure16 illustrates the lack of connection that exists between each of the four different function groups in Network A. As in Figures 12-16, the lines on Figure 17 represent where individuals do not know others or have not worked with others on projects related to Network A. This is another area where improvement could be made.

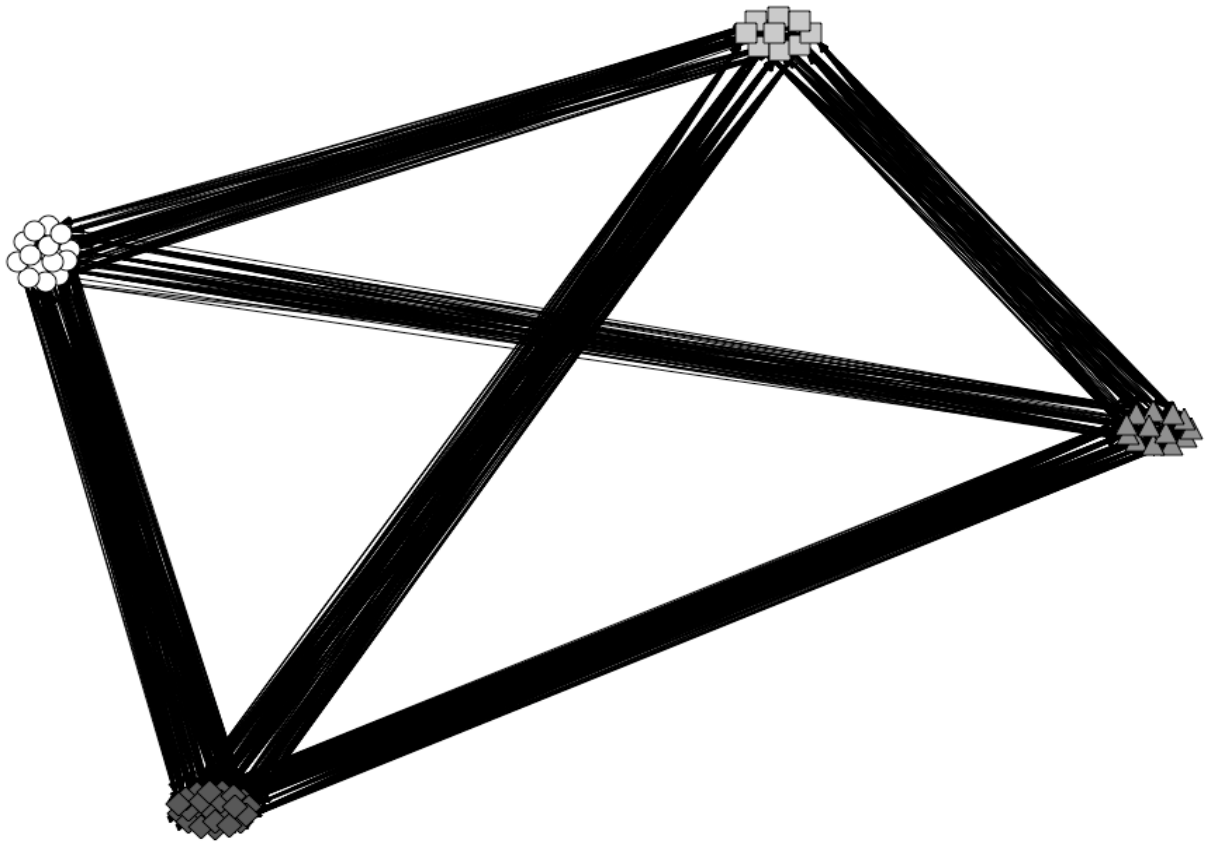

Figure 17. Network map showing lack of connection between functions in Network A.

The effective and ineffective connectivity of each individual was calculated. Essentially this represents how many times an individual listed another person as either somewhat effective or effective or as somewhat ineffective or ineffective versus how many times the individual was listed in either of those categories. Appendix B contains a complete table of all individuals Indegree, Outdegree, Connectedness, and the effective and ineffective connectedness values. Two interesting findings from the tabulated data are from person 5 and person 40. Person 5 has equal numbers of effective and ineffective Indegree ratings, but has 36 effective Outdegree ratings. Essentially this means that while other people in the network tend to find person 5 a neutrally effective source of

information, person 5 finds over half of the other people to be either somewhat effective or effective at providing information. Person 40 has a generally effective rating for Indegree, but has a majority of ineffective Outdegree ratings, indicating that while people in the network tend to find him effective at providing information, person 40 generally does not find others to be effective sources of information. The findings for person 40 could be particularly important as it could indicate that he may be frustrated that others in his network do not seem to provide information as effectively as he does. Investigating the reasoning for these ratings in an interview could provide insight into this person's view of the network. Other helpful actions to address this problem could be to identify the kind of information that person 40 tends to seek out and then to identify which individuals in the network are most likely to possess that information and to ensure that person 40 is aware of those individuals.

Network B

A similar analysis was conducted for Network B, which is composed of 84 individuals in 5 function groups. The functions for Network B are Government-to-Government Relations, represented by the circle, Policy and Procedure represented by the square, Project Development represented by the upward pointing triangle, Technical represented by the diamond, and Liaison/Coordinator represented by the downward pointing triangle. The functions are also colored in varying shades of gray to aid in differentiation. Network maps were created for Network B, and each one was analyzed in a similar manner to Network A. Table 3 provides a more detailed description of each function in Network B.

Table 3. Network B function descriptions.

Function	Description
Government to Government Relations	Involved in government to government relationship building and maintenance including negotiations, policy development and problem solving.
Policy & Procedures	Involved in procedure development, policy development and problem solving for Network B activities as it relates to the their area of expertise. Provide technical advice on this subject within the department.
Technical	Provide technical information on their area of expertise for Network B activities on an as needed basis.
Liaison/Coordinator	Develop, collate, and guide Network B policy and procedures within the department. Serve as the experts on Network B process and procedures within the department. Serve as a liaison.
Project Development	Assist in development and funding of transportation projects that occur.

The first network map, shown in Figure 18, represents all of the responses of "ineffective" to the survey question of how effective is each individual in providing information. Person 10 is very central to this network map with 9 incoming and 12 outgoing ratings of ineffective, only 1 of which is mutual. The average number of outgoing ineffective ratings for Network B is less than 1, so person 10 stands out as identifying ineffective communication. Person 10 holds a fairly central role in Network B and is connected to almost 80% of the network, so it makes sense that if ineffective communication was occurring that he would be able to identify it. Interviewing person 10 and asking why he rated each individual as ineffective at providing information could obtain valuable information for network improvement. Person 5 has the second highest number of ineffective ratings for Network B, with 6 incoming arrows, half of which are from others within his function. He did not identify any others as ineffective at providing information. It could be beneficial to know why the other people in the network see Person 5 as ineffective at providing information. There are a total of 44 connections for

the response of “ineffective” in Network B, totaling less than 1% of the total possible connections for the network, and over 3% of the existing connections. Combined with the “somewhat ineffective” ratings discussed in the next paragraph, over 11% of the existing connections for Network B are some degree of ineffective.

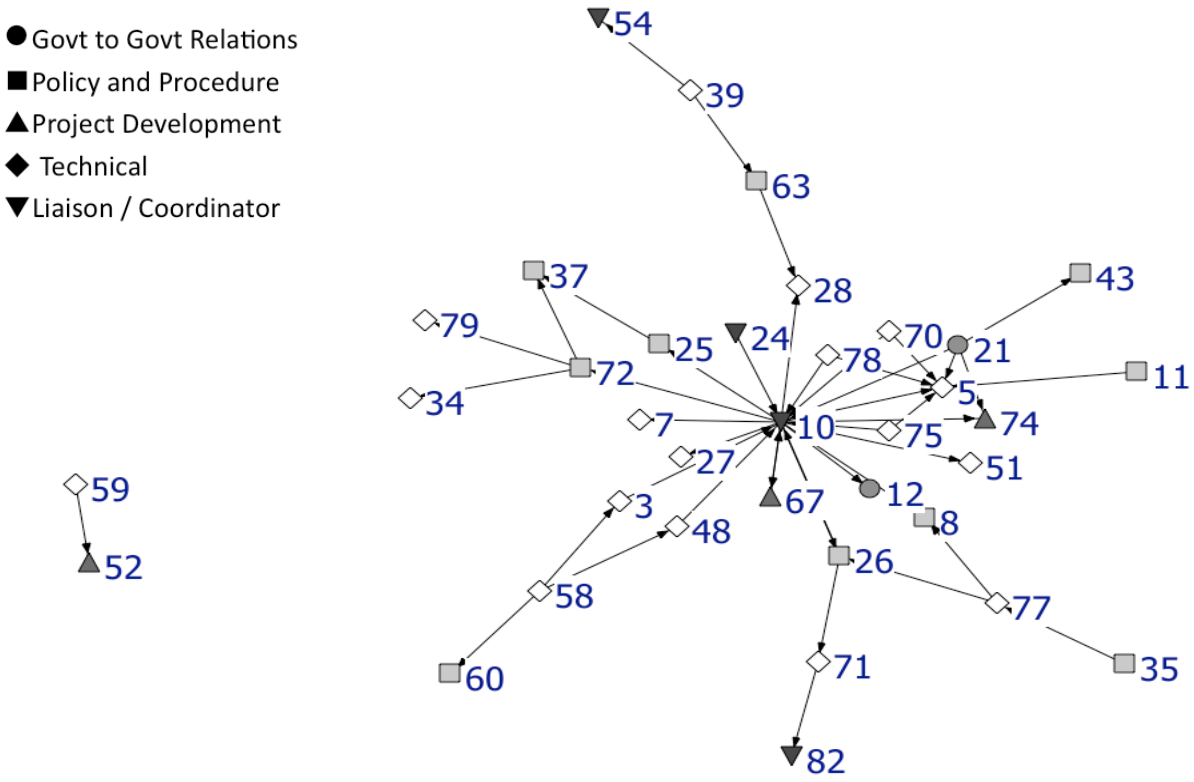

Figure 18. Network map showing responses of "Ineffective".

The next network map analyzed presents the responses of “Somewhat Ineffective” (Figure 19). The key observations from this map are that person 10 is again the most connected individual with 10 outgoing and 6 incoming arrows. Persons 11, and 28 are also fairly well connected with a total of 13 and 14 connections, respectively. Thirty-one of the members of the Technical function are represented on the map (exactly half of all people on the map), either being identified as somewhat ineffective, or identifying others

as somewhat ineffective.

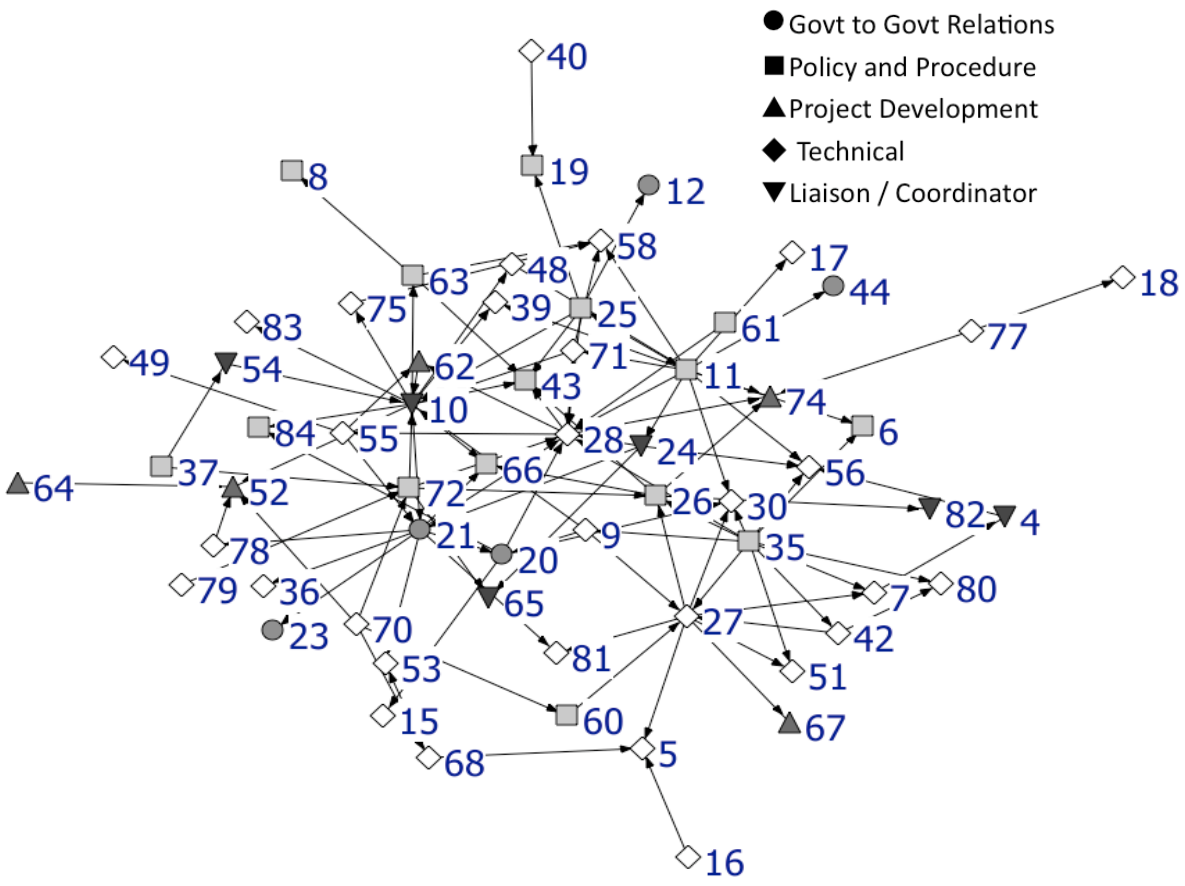

Figure 19. Network map showing responses of "Somewhat Ineffective".

The next network map, shown in Figure 20, representing responses of “Somewhat Effective” gives more useful information. The first thing to be noted is that person 33 is not included in the map. He neither indicated anyone as somewhat effective nor was he indicated by anyone else as somewhat effective at providing information. This indicates that all of his connections are either more effective or less effective than the “somewhat effective” level. Three individuals, person 15, person 29 and person 69 are all extremely peripheral on the map, which indicates that even though they are connected to others in the network at this effectiveness level, they are not central to the network information

flow. Additionally, each of those individuals is only connected to one other person in the network. Person 35, on the other hand, is very central to the network with 36 connections indicating that he finds others and is found by others to be somewhat effective at providing information. Person 11 is equally as connected on this map, which is to be expected as that individual holds a very central role in Network B. It is important to note that there are 457 connections at the somewhat effective level, more than at both of the ineffective levels combined, indicating that in general, people in Network B tend to find each other more effective than ineffective. The connections at the somewhat effective level represent approximately 34% of the total number of existing connections for Network B, but only represent roughly 6.5% of the total number of possible connections for the network.

The network map shown in Figure 21 indicates all of the responses of "Effective" for Network B. This map includes everyone in the network, which indicates that the network is healthy. Persons 10 and 72, both of whom hold high positions in the network, are central on this map, having 17 and 16 incoming arrows respectively, which would indicate that they are performing their duties well. They are not the most highly connected people on the map, however. Persons 54 and 60 both have 26 incoming effective ratings, indicating that they are the most effective at providing information for the network of all individuals in Network B. In total there are 728 connections at this effectiveness level, representing over 54% of all existing connections for the network, but still only slightly over 10% of the total possible connections.

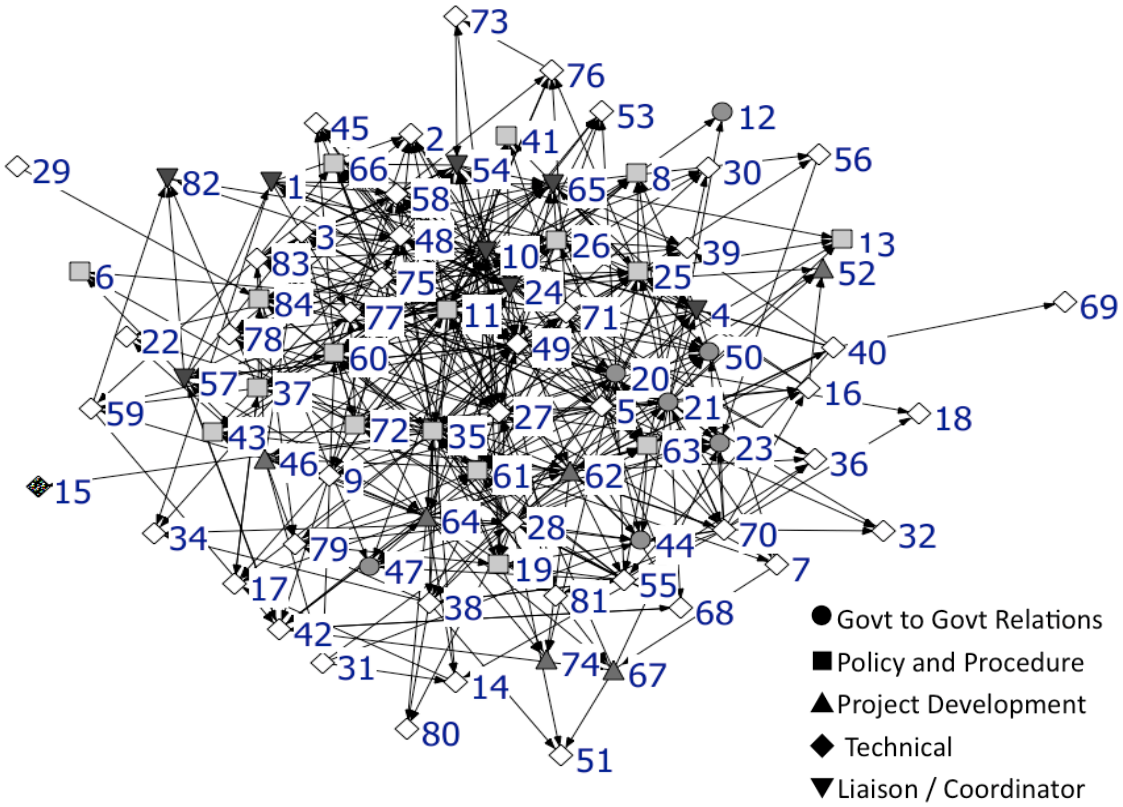

Figure 20. Network map showing responses of "Somewhat Effective".

This map represents the most positive response to the survey question, with over half of the total connections for the network occur at the effective level. Combining the "somewhat effective" and "effective" responses results in over 88% of the connections in the network. An interesting observation is that all of the Project Development function members are on the periphery of the map, possibly meaning that these people in particular should be more connected to others in the network.

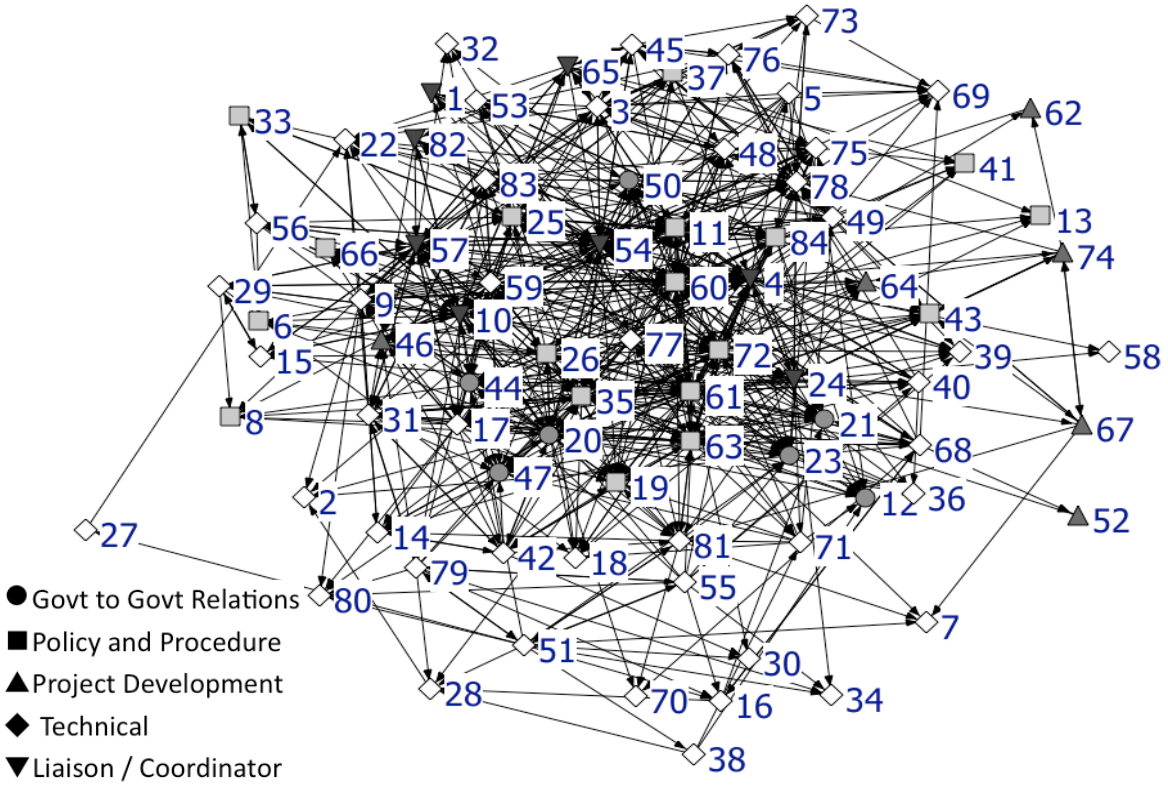

Figure 21. Network map showing responses of "Effective".

Figure 22 displays all of the connections between every member of Network B. Every member of the network is connected to at least 3 other individuals, indicating that no one is left entirely unconnected. The fact that the lines are so dense in the middle of the map indicates that a large number of connections exist between the members of the network who are most central. The most connected individuals in the network are persons 10, 11, 35, 54, 60 and 61, but they are not all the most central people. This indicates that though they represent the people with the highest number of connections, they are not the most sought after people, possibly because of being overly connected. Figure 23 shows the same map with the 6 most connected people, approximately 7% of the network members, removed. These 6 people correspond to about 18% of all existing connections in the network. While there are definitely fewer connections across the center of the map,

there does not appear to be any large holes in the network. This lack of holes is a good indication that the network is healthy, and that information has routes to people other than through the most connected individuals.

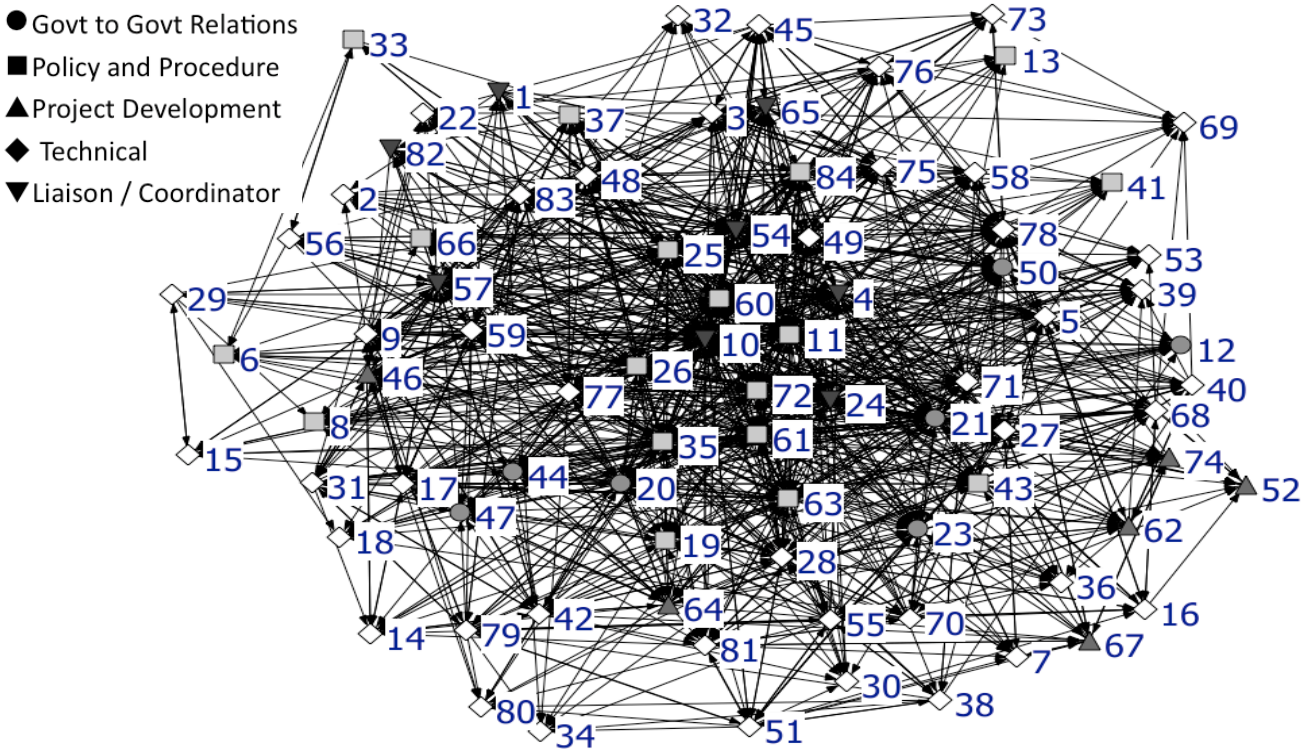

Figure 22. Network map showing all connections for Network B.

An additional positive aspect of Network B is that no one individual is connected only to the most connected people. In other words, when the most connected individuals are removed from the network, no one is left without any means of getting information. One negative observation for the network, though, is that all of the individuals in the Technical function are periphery to the network. It may not actually be a problem, but it is something that would need to be brought to the attention of the network members, nonetheless.

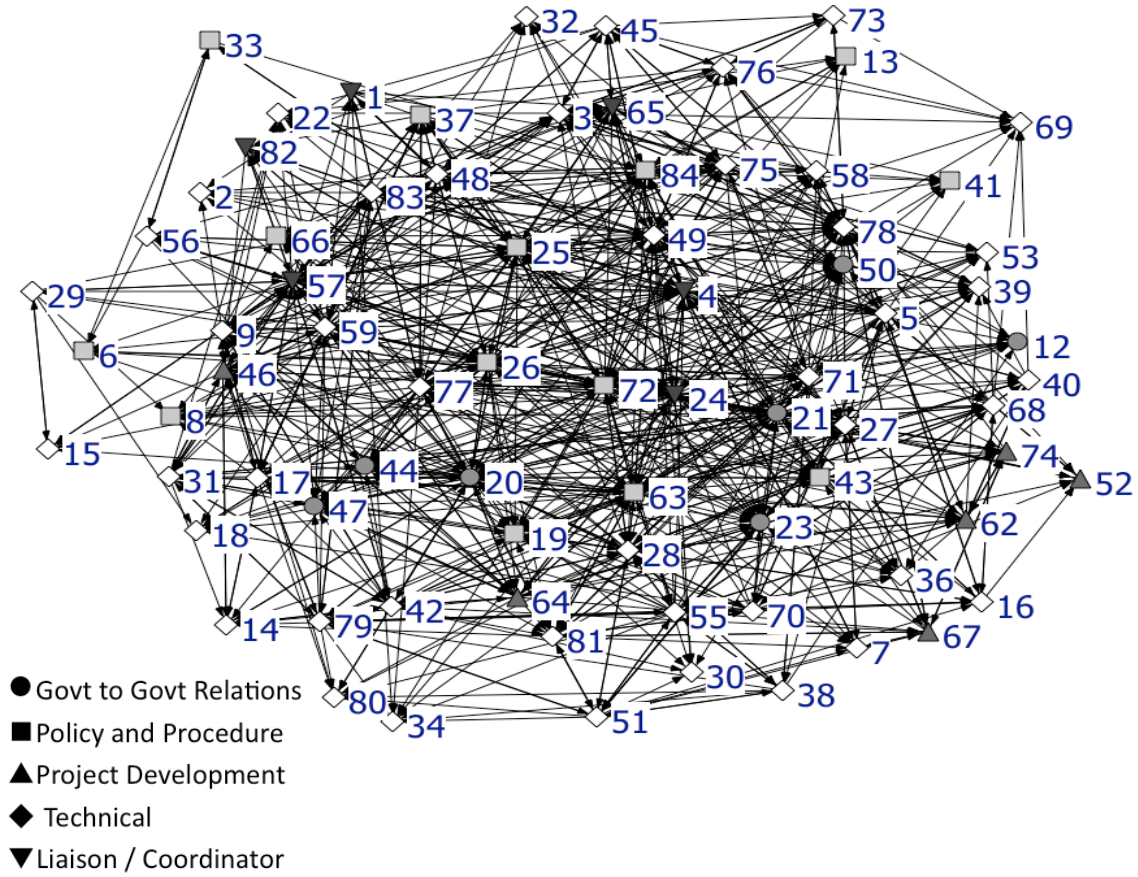

Figure 23. Network map showing the hole left by removing the 6 most connected people in Network B.

The next map created for Network B displays all of the connections that do not exist between people. The lines on Figure 24 represent answers of "I do not know this person" to the survey question asking about the effectiveness of information flow. Not surprisingly, the majority of the central people on this map are members of the Technical function. While it cannot be expected that every person within a network know every other person in the network, the density of the lines is worth consideration and examination. Figures 25 through 28 show which individuals in each of the different functions do not know the others or have not worked with the others on network related

projects. There is no map created for the Government-to-Government Relations function because every member of that function knew every other member of the function.

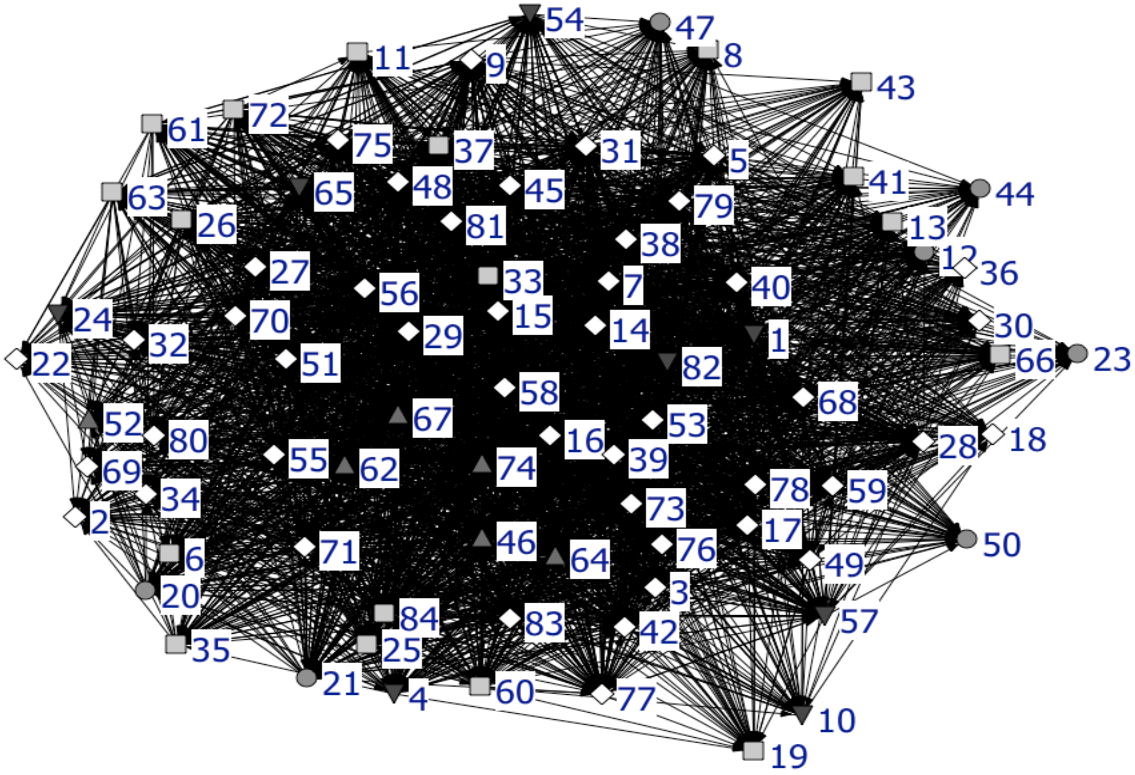

Figure 24. Network map showing which individuals do *not* know others.

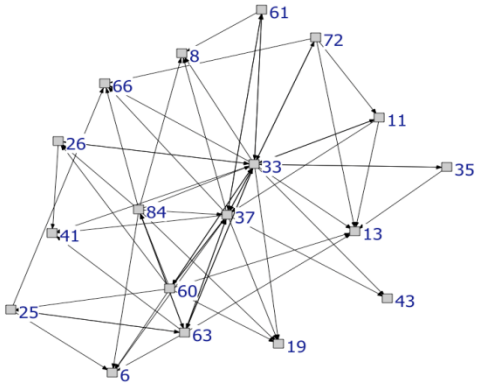

Figure 25. Policy and Procedure function.

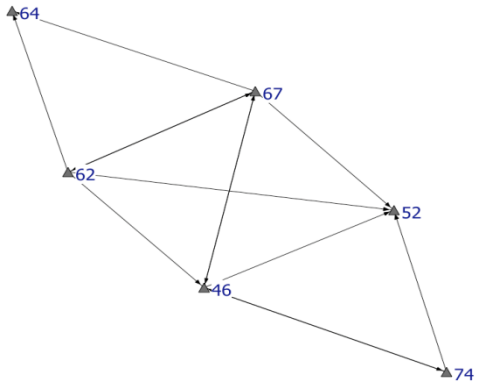

Figure 26. Project Development function.

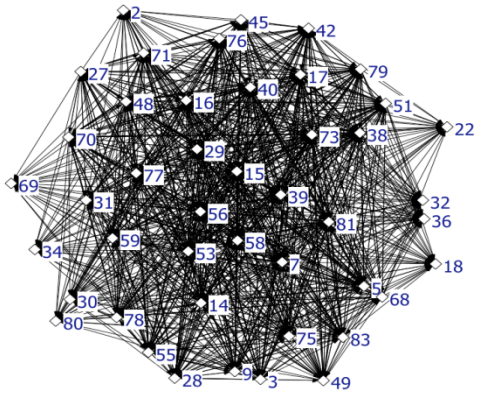

Figure 27. Technical function.

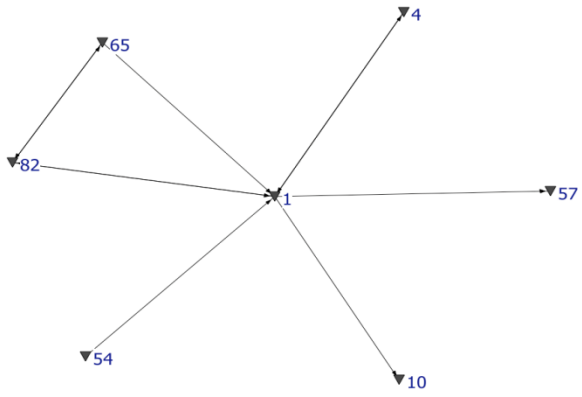

Figure 28. Liaison/Coordinator function.

The function with the fewest connections is the Technical function. This might be due to the fact that the technical people are mostly self-reliant, and do not need to communicate with others in their function, but some investigation into why there are so few connections would still be beneficial. Whether or not these individuals need to seek out information from other people in their specific function, it is important for them to be aware of who other technical people are, in case the occasion ever did arise that they needed information. One especially interesting observation is that person 1, in the Liaison/Coordinator function, is completely unknown by half of his network. Figure 29 illustrates the lack of connection between each of the functions in Network B. Again, the largest number of connections is between the Technical function and each of the other functions (almost 60% of all connections).

As with Network A, the individual numerical results for every person in Network B have been tabulated and can be found in Appendix C. One interesting effective/ineffective rating anomaly is that person 5 has 2 effective Indegree ratings and 9 ineffective Indegree ratings, but has 29 effective Outdegree ratings and 0 ineffective Outdegree ratings. In other words, person 5 tends to find others effective at providing information, but is generally found to be ineffective himself at providing information to others. In general, the people in Network B tend to have mutual effective/ineffective opinions of each other's ability to provide information.

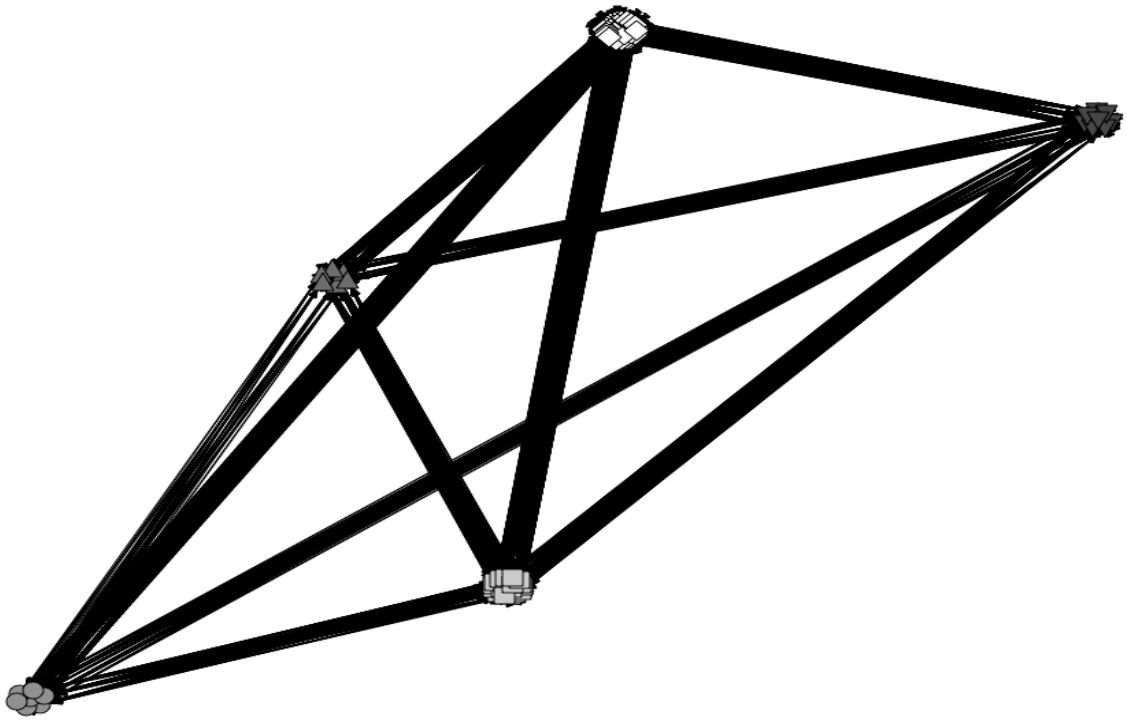

Figure 29. Network map showing lack of connection between functions in Network B.

To summarize the results from the case study, further information from Person 40 in Network A and Person 10 in Network B could help the networks identify why others are ineffective at providing information. For both networks, the majority of the communication has been labeled as either “somewhat effective” or “effective”. In Network A, the top 5% most connected people represent 20% of the network connections, and their removal could prove to be very detrimental to the network, so steps should be taken to ensure they stay in the network, and that information can be transferred between network individuals apart from them. In both networks the members of the Technical function are poorly connected to both others in their function and other members of the networks in general. It should be determined if this lack of connection and centrality is actually a problem, or if it is acceptable because of the duties the

members of this function perform. According to the numbers, both networks have far fewer than the possible number of connections that could exist in the two networks, however both networks had non-respondent members, and new connections are made as employees tenure increases, so the number of mission connections is not a completely reliable indication of the health of either of the networks.

CONCLUSIONS

The most challenging aspect of ONA is determining what a healthy organization looks like in terms of network measures and maps. Evidence collected from this study indicates that there is strong potential for substantial reduction in overall connectivity if a few key employees were to leave the networks, that some employees lie at the peripheries of the network and would probably be better situated more central to the network, and that there is broad variation in the ingoing and outgoing effectiveness ratings of employees. Although there are no clear measures of a healthy network for comparison purposes, each of these issues is potentially problematic on its own. Because all networks are unique in size, connectivity, expertise of participants, geographical distribution, and other factors, it is difficult to determine "one-size-fits all" connectivity and other network measures. The best way to understand and improve the connectivity and information transfer is through multiple longitudinal surveys and analyses. This approach allows for "snapshots" of the network for comparison of the health of the network over time.

RECOMMENDATIONS/APPLICATIONS/IMPLEMENTATION

Substantial information was obtained through this investigation on both the survey process and on the functionality of both networks. The most substantial barrier to

survey implementation was the length of the survey. Based on feedback from multiple individuals the time to complete the survey was more than one hour. This duration is too long to expect a high respondent rate from individuals. Two steps can be taken to address this concern. First, as mentioned previously, the statistical analysis of the five bounded network questions revealed that these questions did not contain information independent of the other questions. Therefore, in future implementations, only one of these five questions will be included on the survey. It is expected that this will reduce the survey time by about 30 minutes. Additionally, it was found that several respondents only completed the first portion of the survey. This is unfortunate because the most important information for the analysis if organizational networks was in the later portion of the survey. In future implementations bounded network questions will be included at the beginning of the survey. It is also recommended that future surveys include questions about the common information resources used by respondents that are in addition to the individuals listed in the bounded network section. This information will highlight other non-human resources that are important for individuals to get their work done on a daily basis. Finally, as noted previously, it is recommended that key individuals in the network be interviewed to help understand and explain their connectivity and role in the network. This personalized information is critical to not only understanding their role, but to designing and implementing changes to the networks.

Certain characteristics of both networks were revealed through the analysis. Both of these networks are broadly disseminated throughout the programs and offices of the agency and represent multiple levels of management and technical expertise. Some network members work on the network subject on a daily basis, others are only engaged

intermittently. Both networks have strong connections to external partners but these external connections were not included in the survey. There were individuals in both networks who felt they were peripheral who turned out to play a central role in network communications.

Several improvements are recommended for both networks. Both networks would benefit from identifying network functions and members more explicitly. It is suggested that the functions and members of each function be summarized and made available through a stable resource (such as a SharePoint site or web page) and that this information also be communicated to intermittent members when an agency action is initiated that will require their attention. Network functions/expectations should be reviewed for individuals who thought they would be peripheral but were found to be central. For example, the following questions could be investigated: Is the communication necessary or are they receiving similar information from multiple sources? Are they perceived as a decision-maker and is that role appropriate or can the decision be made elsewhere? Recommendations for specific individuals and groups in each network are summarized below.

Recommendations for Climate Change Network

Since the survey, the Climate Change Network has evolved into a Transportation Sustainability Network. The observations and recommendations described herein still apply to the new network.

It is expected that Core Team members would be fairly well connected but the degree of connectedness varied substantially. In some cases, this work is one of several duties. Improvements suggested include clarification of their role within the department

and expectations within the network and formalizing their community of practice to promote knowledge and workload sharing and problem solving.

Involvement of Leadership Team members was highly variable. This should be considered when communicating agency positions so that the message is effectively getting to all Leadership Team members. Individuals 28 and 4 had the highest connectedness amongst the Leadership Team members. A review of their egonets by WSDOT staff may identify opportunities for streamlining communication.

Staff involved with the Technical and Advisory functions of the Climate Change Network may be involved only sporadically. This survey suggests that a notice to network participants may be beneficial when their participation in a Climate Change activity is needed so that network members can understand their role and expectations that will support project development, decision-making, or implementation They should also be aware of the other network members participating in the activity and the expectation for communication with these members.

An information repository is available for network members that could facilitate productive interactions among network members but is underutilized. Training on SharePoint is needed to improve use of the resource. Expectations about use of the SharePoint site should be clarified.

Recommendations for Tribal Network

Individual 35 is potentially over connected in this network and begs the question whether some of this communication could be handled differently or whether Leadership involvement is needed. Thirty people identified this individual as a contact and he/she identified 57 people that he contacts for Tribal issues.

One individual questioned the need to take the network survey as he/she did not believe they were part of the network . However, the survey responses showed he/she had a fairly high level of connectedness with 21 people coming to him/her for information and outwardly connecting with 27 people. This suggests an opportunity to increase awareness about roles within the network, especially those that seem sporadic.

It is expected that Tribal Liaisons would be fairly well connected but the degree of connectedness varied substantially. In some cases, this work is one of several duties. For three individuals, it is a primary duty. Improvements suggested include: clarification of their role within the department and expectations within the network; formalizing their community of practice to promote knowledge and workload sharing and problem solving. Since the survey, the duties of one tribal liaison have been expanded. Communities of Practice may be beneficial for other functions within the network as well.

Staff involved with the Technical and Policy & Procedures functions of the Tribal Network may be involved only when a project with Tribal interests is active in their area or when policy and procedures are being updates. This survey suggests that a notice to network participants may be beneficial when an activity involving Tribal issues is activated so that network members can understand their role and expectations that will support project development, decision-making, or implementation They should also be aware of the other network members participating in the activity and the expectation for communication with these members.

An information repository should be developed for network members so they can access the most current resources.

Overall Recommendations and Future Research

In light of the lack of standard measures for a healthy network, it is recommended that one of these networks be selected for network improvements and longitudinal analysis. Findings from this study could serve as the foundation for such efforts. Additionally, the ability to implement a shorter survey, as discussed above, would increase participation in future surveys. Results from this future study would initiate an understanding of how to improve network function within the unique social and contextual features of the WSDOT.

One well-documented potential implementation is communities of practice. In their book Cultivating Communities of Practice, Wenger, et al. define communities of practice as "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (2002, p. 4). These communities of practice help employees group together around common areas of work, and foster productive collaboration. In his earlier book, Communities of Practice, Wenger states, "Communities of practice are the locus of 'real work'. Their practices are where the formal rests on the informal, where the visible counts on the invisible, where the official meets the everyday" (1998, p. 243). Areas of expertise could be identified in the network and communities of practice initiated.

In order to prove the value of ONA, it is recommended that measures of efficiency be determined and implemented to assess the effectiveness of interventions and resulting network changes. These measures would serve essentially as data to calculate the return on investment for both the cost of research projects like this, but the cost of developing and implementing interventions.

Future ONA work at WSDOT should prove to be very effective in improving the efficiencies of networks analyzed and collecting evidence for the value of ONA in refining networks to better achieve intended objectives.

REFERENCES

Cross, R., & Parker, A. (2004). The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations. Boston: Harvard Business School Publishing.

Cross, R., & Thomas, R. J. (2009). Driving Results Through Social Networks: How Top Organizations Leverage Networks for Performance and Growth. San Francisco: Jossey-Bass.

Cross, R., Parker, A., Prusak, L., & Borgatti, S. P. (2001). Knowing What We Know: Supporting Knowledge Creation and Sharing in Social Networks. Organizational Dynamics , 30 (2), 100-120.

Knoke, D., & Yang, S. (2008). Social Network Analysis. Thousand Oaks, Ca: SAGE Publications.

Wasserman, S., & Faust, K. (1994). Social Network Analysis: Methods and Applications. New York: Cambridge University Press.

Wenger, E. (1998). Communities of Practice. Cambridge, United Kingdom: Cambridge University Press.

Wenger, E., McDermott, R., & Snyder, W. M. (2002). Cultivating Communities of Practice. Boston, MA, United States of America: Harvard Business School Publishing.

APPENDIX A - COMPLETE LIST OF SURVEY QUESTIONS

Personal Information Section

What is your function within the network?

How long have you worked in your functional group?

How long have you worked at the organization?

Cultural Values Section

Please assess the extent to which each characteristic below is and should be valued currently within your network

Participation, open discussion

Empowerment of employees to act

Assessing employee concerns and ideas

Human relations, teamwork, cohesion

Flexibility, decentralization

Expansion, growth, and development

Innovation and change

Creative problem solving processes

Control, centralization

Formality, structure and routines

Stability, continuity, order

Predictable performance outcomes

Task focus, accomplishment, goal achievement

Direction, objective setting, goal clarity

Efficiency, productivity, profitability

Outcome excellence, quality

Personal Network Section

Please indicate up to 15 people you turn to for information to get your work done in your network.

To what degree do these people either currently collaborate on projects or would be likely to collaborate when the opportunity arose?

Please indicate at least one of the primary benefits that you currently receive from each person

Please indicate up to 3 skills or kinds of expertise that are important for you to be effective in your work.

Please rate your ability for the skills or expertise

To what extent do you learn by seeking each person below out for information or advice regarding your skills or expertise?

Energy Networks

I strike and effective balance between tapping people in my network to get work done and connecting with these people on a personal level

I maintain an appropriate balance between what I ask for and what I contribute to those in my network.

I consistently follow through on the commitments I make to people in my network

I am committed (and show this commitment) to principles or goals that are larger than my own self interest

In meetings and one-on-one conversations I effectively engage others in realistic possibilities that capture their imaginations and hearts

I fully focus my attention in meetings and one-on-one conversations and show my interest in others and their ideas.

I create room for others to be a meaningful part of conversations or make sure they see how their efforts will contribute to an evolving plan in the future.

When I must disagree with someone's plan or a course of action I do so in a way that focuses attention on the issue at hand and not the individual contributing the idea.

I maintain an effective balance between pushing toward a goal and welcoming new ideas that improve on a project or process for getting to a goal.

Bounded Network Section

Please indicate the extent to which the other people in the network are effective in providing you with information that helps you to learn, solve problems, and do your work.

The quality of my work within this network is better as a result of interactions with this individual

I save time on my projects within this network as a result of interaction with this individual

I have made decisions on my projects within this network that have reduced project costs as a result of interaction with this individual.

I receive clear direction of work tasks I need to accomplish within this network as a result of interaction with this individual

APPENDIX B - TABLE OF RESULTS FOR NETWORK A

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
1	20	20	19	1	0	0	0	3.5	Leadership Team
2	69	27	18	9	42	37	5	3.5	Core Team
3	5	5	5	0	0	0	0	3.5	Technical
4	44	12	7	5	32	27	5	3.0	Leadership Team
5	63	20	10	10	43	36	6	3.0	Advisory
6	46	22	14	8	24	21	3	3.0	Advisory
7	69	21	21	0	48	37	11	4.0	Advisory
8	20	20	16	4	0	0	0	3.5	Advisory
9	20	6	2	4	14	13	1	2.5	Technical
10	61	26	25	1	35	30	4	3.5	Core Team
11	31	14	11	3	17	12	5	3.0	Technical
12	16	16	14	2	0	0	0	3.5	Advisory
13	12	12	10	2	0	0	0	3.0	Advisory
14	44	21	17	4	23	22	1	3.5	Advisory
15	17	17	16	1	0	0	0	3.5	Leadership Team
16	29	7	6	1	22	20	1	3.0	Leadership Team
17	11	11	9	2	0	0	0	3.0	Leadership Team
18	33	8	7	1	25	14	11	3.5	Leadership Team
19	13	13	9	4	0	0	0	3.0	Leadership Team
20	12	12	6	6	0	0	0	3.0	Core Team
21	25	13	13	0	12	8	3	3.0	Technical
22	44	14	10	4	30	20	10	3.0	Technical
23	15	15	9	6	0	0	0	3.0	Technical
24	7	7	7	0	0	0	0	3.5	Technical
25	46	23	21	2	23	19	4	3.5	Core Team
26	14	14	12	2	0	0	0	3.0	Advisory
27	26	6	6	0	20	18	2	3.5	Technical
28	56	15	14	1	41	31	10	3.5	Leadership Team
29	60	17	9	8	43	35	8	2.5	Technical
30	22	12	11	1	10	7	3	3.5	Technical

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
31	30	8	8	0	22	20	2	3.0	Technical
32	35	15	12	3	20	12	8	3.5	Core Team
33	18	18	13	5	0	0	0	3.0	Advisory
34	12	12	10	2	0	0	0	3.0	Leadership Team
35	57	21	19	2	36	35	1	3.5	Technical
36	22	10	10	0	12	10	2	3.5	Core Team
37	41	14	14	0	27	26	1	3.5	Technical
38	9	9	7	2	0	0	0	3.0	Leadership Team
39	66	27	24	3	39	36	3	3.5	Advisory
40	64	21	17	4	43	18	25	3.5	Advisory
41	13	13	9	4	0	0	0	3.0	Leadership Team
42	19	18	18	0	1	1	0	3.5	Technical
43	14	14	12	2	0	0	0	3.0	Technical
44	48	23	21	2	25	22	3	3.5	Core Team
45	34	27	27	0	7	6	1	3.5	Advisory
46	40	22	21	1	18	16	2	3.5	Advisory
47	34	23	22	1	11	11	0	3.5	Leadership Team
48	19	19	17	2	0	0	0	3.0	Technical
49	16	16	6	10	0	0	0	2.5	Technical
50	11	9	8	1	2	2	0	3.5	Technical
51	20	3	3	0	17	15	1	3.5	Technical
52	26	10	9	1	16	15	1	3.0	Technical
53	18	18	18	0	0	0	0	3.5	Leadership Team
54	26	8	8	0	18	18	0	3.5	Technical
55	21	21	15	6	0	0	0	3.0	Core Team
56	11	11	6	5	0	0	0	3.0	Advisory
57	53	20	17	3	33	33	0	3.5	Core Team
58	44	15	12	3	29	23	6	3.0	Technical
59	51	23	23	0	28	26	2	3.5	Advisory
60	27	8	8	0	19	16	3	3.0	Technical

APPENDIX C - TABLE OF RESULTS FOR NETWORK B

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
1	18	7	7	0	11	11	0	3.5	Liaison/ Coordinator
2	13	13	13	0	0	0	0	3.5	Technical
3	37	21	20	1	16	15	1	4.0	Technical
4	61	22	21	1	39	37	1	4.0	Liaison/ Coordinator
5	40	11	2	9	29	29	0	2.5	Technical
6	12	12	10	2	0	0	0	3.5	Policy and Procedures
7	13	10	7	3	3	2	1	3.5	Technical
8	17	17	14	3	0	0	0	3.5	Policy and Procedures
9	40	20	19	1	20	17	3	4.0	Technical
10	102	40	25	15	62	39	22	3.0	Liaison/ Coordinator
11	84	32	31	1	52	38	13	3.5	Policy and Procedures
12	15	15	13	2	0	0	0	3.5	Gov to Gov Relations
13	8	8	8	0	0	0	0	3.5	Policy and Procedures
14	16	12	12	0	4	4	0	3.5	Technical
15	11	8	7	1	3	3	0	3.5	Technical
16	15	8	8	0	7	6	1	3.0	Technical
17	32	15	14	1	17	17	0	4.0	Technical
18	13	13	12	1	0	0	0	3.5	Technical
19	26	26	24	2	0	0	0	3.5	Policy and Procedures
20	65	22	20	2	43	39	4	3.5	Gov to Gov Relations
21	56	21	18	3	35	22	12	3.5	Gov to Gov Relations
22	15	15	15	0	0	0	0	4.0	Technical
23	26	26	25	1	0	0	0	3.5	Gov to Gov Relations
24	65	16	15	1	49	43	5	3.5	Liaison/ Coordinator
25	55	24	22	2	31	24	6	3.5	Policy and Procedures

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
26	58	17	12	5	41	35	6	3.0	Policy and Procedures
27	38	16	11	5	22	15	7	3.0	Technical
28	48	21	10	11	27	22	5	3.0	Technical
29	12	5	5	0	7	7	0	4.0	Technical
30	11	11	7	4	0	0	0	3.5	Technical
31	28	11	11	0	17	17	0	4.0	Technical
32	7	7	7	0	0	0	0	3.0	Technical
33	8	3	3	0	5	5	0	3.5	Policy and Procedures
34	9	9	8	1	0	0	0	3.0	Technical
35	87	30	30	0	57	45	12	3.5	Policy and Procedures
36	14	14	13	1	0	0	0	3.5	Technical
37	26	10	8	2	16	14	2	3.5	Policy and Procedures
38	15	7	7	0	8	8	0	3.0	Technical
39	22	20	18	2	2	0	2	3.5	Technical
40	21	6	6	0	15	14	1	4.0	Technical
41	12	12	12	0	0	0	0	3.5	Policy and Procedures
42	31	12	11	1	19	17	2	4.0	Technical
43	24	24	18	6	0	0	0	3.0	Policy and Procedures
44	26	26	25	1	0	0	0	3.5	Gov to Gov Relations
45	25	11	11	0	14	14	0	4.0	Technical
46	32	17	17	0	15	15	0	4.0	Project Development
47	23	23	23	0	0	0	0	3.5	Gov to Gov Relations
48	34	19	17	2	15	13	2	3.5	Technical
49	52	24	23	1	28	28	0	4.0	Technical
50	22	22	22	0	0	0	0	3.5	Gov to Gov Relations
51	22	9	6	3	13	13	0	3.0	Technical
52	11	11	9	2	0	5	0	3.0	Technical
53	17	11	6	5	6	0	0	3.0	Project Development

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
54	75	38	36	2	37	36	1	4.0	Liaison/ Coordinator
55	31	7	6	1	24	21	3	3.0	Technical
56	20	11	7	4	9	9	0	3.5	Technical
57	57	25	25	0	32	32	0	4.0	Liaison/ Coordinator
58	21	15	11	4	6	3	3	3.5	Technical
59	45	13	13	0	32	31	1	4.0	Technical
60	67	37	35	2	30	29	1	4.0	Policy and Procedures
61	70	24	24	0	46	44	1	3.5	Policy and Procedures
62	22	11	9	2	11	10	1	3.0	Project Development
63	64	26	24	2	38	34	4	3.5	Policy and Procedures
64	36	13	13	0	23	22	1	4.0	Project Development
65	36	17	15	2	19	19	0	3.5	Liaison/ Coordinator
66	19	19	16	3	0	0	0	3.5	Policy and Procedures
67	18	9	7	2	9	8	1	3.0	Project Development
68	29	11	10	1	18	16	2	3.5	Technical
69	10	10	10	0	0	0	0	4.0	Technical
70	25	6	6	0	19	13	6	4.0	Technical
71	37	12	9	3	25	21	4	3.0	Technical
72	65	27	23	4	38	30	7	3.5	Policy and Procedures
73	12	6	6	0	6	6	0	4.0	Technical
74	20	13	7	6	7	6	0	3.0	Project Development
75	41	14	13	1	27	24	3	4.0	Technical
76	24	12	12	0	12	12	0	4.0	Technical
77	54	15	14	1	39	34	4	3.5	Technical
78	47	26	25	1	21	18	3	4.0	Technical
79	25	9	8	1	16	15	1	2.5	Technical
80	11	11	9	2	0	0	0	3.5	Technical
81	28	16	14	2	12	12	0	3.5	Technical

ID	Connectedness	Indegree	Effective Indegree	Ineffective Indegree	Outdegree	Effective Outdegree	Ineffective Outdegree	Overall Effectiveness	Function
82	18	11	9	2	7	7	0	3.5	Liaison/ Coordinator
83	36	16	15	1	20	20	0	3.5	Technical
84	39	18	16	2	21	20	0	3.5	Policy and Procedures