NATIONAL DIVERSITY ASSURANCE INITIATIVE

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ATIS

Alliance for Telecommunications Industry Solutions
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ATIS is a technical planning and standards development organization that is committed to rapidly developing and promoting technical and operations standards for the communications and related information technologies industry worldwide using a pragmatic, flexible and open approach. Over 1,100 participants from more than 350 communications companies are active in ATIS' 22 industry committees, and its Incubator Solutions Program.

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EXECUTIVE SUMMARY

The financial services and telecommunications sectors recognize the importance of ensuring continuity of critical operations in the event of a disaster. Both industries have led efforts focused on telecommunications resiliency and reliability of National Security/Emergency Preparedness (NS/EP) facilities since the aftermath of the September 11th terrorist attacks. Telecommunications diversity is a key component of resiliency. It provides multiple communication paths so there is no single point of failure for NS/EP services. Telecommunications diversity can be accomplished in several ways. Establishing multiple physically diverse circuit routes from a critical facility is promoted as a best practice by public and private sector organizations for ensuring resiliency of point-to-point telecommunication links. Financial services, as well as the Government Accountability Office, have raised concerns that telecommunication carriers cannot easily provide periodic information to assure that diversely engineered circuits remain physically separate over time. The National Diversity Assurance Initiative (NDAI), led by the ATIS CIO Council, evaluated the problem inherent in assuring physical diversity of NS/EP financial service circuits in a multi-carrier environment. For the purpose of this report, the context of *"NS/EP diversity, circuit diversity and diversity assurance"* is limited to the practice of ensuring there are multiple diverse physical circuit routes to a critical facility. The scope of the report does not consider other alternatives for achieving or assuring telecommunications diversity.

In April 2004, the President's National Security Telecommunications Advisory Committee (NSTAC) Financial Services Task Force concluded that customers cannot be assured at all times that their telecommunications circuits remain physically diverse. In parallel efforts, individual telecommunications carriers determined in regional initiatives that evaluating circuit diversity from a single carrier perspective, while feasible, was not an accurate reflection of how the telecommunications industry operates today. Based on these regional initiatives, it was apparent that a research effort was needed to evaluate physical circuit diversity assurance from a multi-carrier perspective. Prior to this Initiative, there was no industry analysis conducted to determine the level of effort or to quantify the costs involved in assessing and assuring diversity of telecommunications circuits in that environment. The objectives of the Initiative were to assess the diversity of a set of existing NS/EP circuits, establish diversity for those circuits found not to be diverse, and monitor a selected subset of circuits to assure that diversity is maintained over time. The NDAI team consisted of representatives from the Federal Reserve, AT&T, BellSouth, MCI, Qwest, SBC, Sprint, Verizon and ATIS. Working together, the team was able to create a trustworthy environment where the carriers and the Federal Reserve shared highly sensitive information and industry knowledge.

The team created a framework and processes to better understand what was required to develop a diversity assessment and assurance model. Circuit diversity was assessed manually for a subset of the Federal Reserve Bank's NS/EP circuit pairs. High-level conceptual and street-level maps for these circuits were created to explicitly show the physical routes of the circuit pairs. The Federal Reserve was able to use these maps to identify circuits as diverse or not diverse. The team discovered that conducting an end-to-end multi-carrier assessment of telecommunications circuits is a very labor and cost intensive process and can currently only be conducted in a manual fashion. Several factors contributed to this high level of effort and cost: complexity of the circuits and the systems (topology and architecture) used to access the circuit information, company structure (internal processes), disparate mapping processes in use by the carriers, and the lack of a common cross-industry circuit identifier to identify all of the circuit segments that comprise a diverse circuit pair. The team validated the assessment framework, fulfilled the Initiative goals, and developed valuable learnings that can be applied to any future efforts to address diversity assessment and assurance.

At the completion of the Assessment Phase, the team concluded that end-to-end multi-carrier circuit diversity assurance currently cannot be conducted in a scalable manner. The cost and level of manual effort required were comparable to the assessment step and demonstrated that an ongoing program for end-to-end multi-carrier circuit diversity assurance, as it exists today, cannot be offered as a widey available commercially viable product. Circuit route diversity, as defined by the scope of this Initiative, is widely promoted as a public and private sector best practice. The team concluded,

however, that it is not possible to guarantee that circuits are diverse and remain diverse over time unless manual assessment and periodic manual assurance are performed. Due to the high level of effort and cost involved in performing manual end-to-end circuit diversity assurance in today's multi-carrier environment, circuit route diversity assurance, may be justified for organizations with life safety missions and critical business needs. The team concluded that an automated system providing the capability to track circuits across multiple carriers would streamline the process for determining end-to-end diversity assessment and assurance. While the financial services sector considers the lack of diversity assurance for telecommunications services supporting its NS/EP functions a serious risk, practices using physical circuit route diversity in combination with other alternatives, such as geographic dispersion of operation centers, could mitigate the risk of a single event disrupting critical telecommunication functions. The telecommunications carriers believe that the marketplace to support the specialized requirements of NS/EP functions on a wide-scale basis is insufficient to recover costs from only the users of the service. The findings of this report support the need to develop and implement automated solutions that address diversity assessment and assurance if physical route diversity assurance is a requested carrier provided service. External funding for development and implementation must be made available before such development can proceed.

The team highly recommends that other industries with critical missions and circuits evaluate their current risks in regards to telecommunications continuity and take the necessary steps to mitigate those risks. In addition, the team developed recommendations that could be pursued as follow-on activities to this Initiative (detailed in the Recommendations section of this report).

First, the lessons learned from the Initiative provide information and terminology that could be used by organizations supporting critical NS/EP services to better understand the telecommunications infrastructure supporting their business needs in a multi-carrier environment. Second, the team recommends a follow-up effort to determine more accurately the requirements for providing an automated end-to-end diversity assurance solution in a multi-carrier environment. As a first step, a small-scale effort could be undertaken to leverage the findings of the Initiative to scope the objectives and requirements for providing an end-to-end diversity assurance solution in a multi-carrier environment. This scoping effort should include at least the creation of high-level requirements, cost estimates and the level of effort to develop and implement an automated circuit assurance solution. The telecommunications carriers believe that the scoping effort will need to be sponsored, by the Federal government. Without an automated circuit assurance solution, a real-time capability to identify, aggregate, and analyze circuit information for diversity concerns in a multi-carrier environment cannot be achieved. The results of the scoping effort could assist in quantifying the project scale and costs required to consider implementation of a diversity solution that could be used across different sectors. It is unclear whether circuit route diversity assurance in a multi-carrier environment is important in other critical sectors. An agency of the Federal government, perhaps the Department of Homeland Security (DHS), could provide insights regarding the level of urgency within other critical sectors for diversity assurance. The telecommunications carriers believe that external funding must be secured prior to the implementation of an automated solution.

BACKGROUND

The September 11, 2001, terrorist attacks highlighted the susceptibility of the telecommunications infrastructure to disruption. These attacks damaged telecommunications facilities, lines, and equipment and resulted in the loss of voice and data communication throughout lower Manhattan. As a result, critical U.S. financial institutions faced challenges as they restored business operations after the attacks. Through unparalleled efforts, the financial services industry and the telecommunications industry worked together to restore operations of the financial markets within five days after the attacks.

Telecommunications route diversity involves establishing different physical routes to ensure that facilities and circuits are diverse so that no single point in the communications path can cause all services to fail. Telecommunications route diversity has been a long standing best practice for business continuity from both private and public sectors. Assuring that circuits engineered to be diverse remain so, however, has been a major concern. In December 1997, NSTAC reported, "despite assurances about diverse networks from the carriers, a consistent concern among the financial services industry was the trustworthiness of their telecommunications diversity arrangements."[1] According to the U.S. Government Accountability Office, "This concern was validated following the September 11 attacks when firms that thought they had achieved redundancy in their communications systems learned that their network services were still disrupted. Other firms that had mapped out their communications lines to ensure that their lines flowed through physically diverse paths at the time those services were first acquired found that their service providers had rerouted some of those lines over time without their knowledge, eliminating that assurance of diversity in the process."[2]

Recognizing how highly dependent the financial services industry is on telecommunications, the Federal Reserve promoted several efforts to improve financial services resiliency. In November 2002, the Federal Reserve asked NSTAC to consider whether structural vulnerabilities or business practices within the telecommunications infrastructure posed a threat to the operation of the U.S. financial system or other elements of the critical infrastructure (such as power, transportation, etc.). Federal Reserve staff advised the NSTAC that unlike other key elements of the critical infrastructure, there are no alternatives or backup arrangements that public and private sector entities can implement to maintain critical communications services. It further advised the NSTAC that the financial system is so dependent on telecommunications that a widespread disruption of the telecommunications infrastructure that was not quickly recovered would bring the nation's wholesale financial system –- which processes trillions of dollars and securities transactions daily -- to a halt. Recognizing the national importance of the concerns raised by the Federal Reserve, NSTAC established a Financial Services Task Force to report on the ability of the telecommunications infrastructure to provide an appropriate level of service for national security level circuits in the financial system and other elements of the critical infrastructure.

In April 2003, the Federal Reserve Board developed, in conjunction with the Office of the Comptroller of the Currency and the Securities and Exchange Commission, an "Interagency Paper on Sound Practices to Strengthen the Resilience of the U.S. Financial System."[3] This interagency white paper identified business continuity objectives and sound practices aimed at strengthening the resilience of the U.S. financial system. The focus was to minimize the immediate systemic effects of a wide scale disruption of critical financial markets by ensuring that backup capabilities are resilient and robust. The paper promoted geographic separation of primary and backup operations centers to ensure that these are supported by separate utility infrastructures.

In response to the Federal Reserve's request, the NSTAC Financial Services Task Force published a report in April

[1] The President's National Security Telecommunications Advisory Committee (NSTAC), *Financial Services Risk Assessment Report,* December 1997.

[2] U.S. Government Accountability Office, *Potential Terrorist Attacks, Additional Actions Needed to Better Prepare Critical Financial Market Participants:* GAO-03-251, February 2003.

[3] Board of Governors of the Federal Reserve System, Office of the Comptroller of the Currency, and the Securites and Exchange Commission, *Interagecny Paper on Sound Practices to Strengthen the Resilience of the U.S. Financial System,* April 2003.

2004 that analyzed the dependencies of the financial services sector on the telecommunications industry and assessed the risks involved from a diversity perspective. As a result of its analysis, the Financial Services Task Force concluded: "Without a real-time process to guarantee that a circuit's path or route is static and stable, an [National Security and Emergency Preparedness] NS/EP[4] customer cannot be assured at all times that the diversity component of the resiliency plan retains its designed characteristics."[5] The report identifies additional measures that would improve the resiliency and reliability of critical NS/EP circuits. The report notes that development of a "diversity assurance" process (i.e., protocols for maintaining physical diversity of circuits within and across telecommunications carriers) is important, because differing definitions and interpretations of "diversity" among telecommunications providers and customers has led to uncertainty regarding maintenance of physical diversity for paired critical circuits.

In September 2004, the Payments Risk Committee, Assuring Telecommunications Continuity Task Force, published *Best Practices to Assure Telecommunications Continuity for Financial Institutions and the Payment and Settlements Utilities.*[6] These best practices and recommendations focus on what financial institutions and payment and settlement utilities should do in order to avoid telecommunication outages and to facilitate rapid recovery when outages occur.

In parallel with the activities conducted by the financial industry, the telecommunications industry began its own efforts to address the issue of circuit diversity assurance. In mid-2003, a working council of communications CIOs was established at the Alliance for Telecommunications Industry Solutions (ATIS) to formulate proactive positions as an industry interface with government and cross-industry interests on identified security matters. Building on the aforementioned studies that address critical financial services network issues, the CIO Council recognized the need to examine telecommunications circuit diversity. The CIO Council includes participation from AT&T, BellSouth, MCI, Qwest, SBC, Sprint, and Verizon.

Initially, individual carriers conducted their own regional initiatives to evaluate circuit diversity for their customers. The pilots only involved the respective carrier performing the pilot and were confined to one geographic area. During these initiatives, it became evident that evaluating circuit diversity from a single carrier perspective was not an accurate reflection of how the telecommunications industry operates today. Evaluation of the situation from a multi-carrier perspective was needed. Therefore, the CIO Council formed a working team consisting of participants from the member companies to develop a framework for a National Diversity Assurance Initiative.

From January to June 2004, the working team developed a Non-Disclosure Agreement (NDA), created a project framework, and sought participation from a financial institution. The NDA enabled all of the parties to work together and share and protect information. The framework outlined procedures and processes focused on identifying and rectifying circuit diversity concerns, and served as a work plan for activities that would be completed and identified ownership of deliverables. Lastly, the team worked to find an appropriate national financial institution, supported by multiple telecommunications service providers that would serve as an equal partner working to fulfill the goals of the NDAI. The ATIS CIO Council agreed on June 3, 2004, to form a partnership with the Federal Reserve on an in-depth assessment of circuit diversity assurance. The NDAI working team and the Federal Reserve together formed one team, known as NDAI, to research the feasibility of validating the existence of diversity on critical NS/EP circuits, and to identify methods to assure that the diversity is maintained on those circuits over time.

[4] Circuit(s) that qualify for TSP service under the Federal Reserve's Sponsorship Policy, December 2002.

[5] The President's National Security Telecommunications Advisory Committee (NSTAC), *Financial Services Task Force Report,* April 2004.

[6] The Payments Risk Committee – Assuring Telecommunications Continuity Task Force, *Best Practices to Assure Telecommunications Continuity for Financial Institutions and the Payment & Settlement Utilities,* September 2004.

INITIATIVE OBJECTIVE

The NDAI (Initiative), led by the ATIS CIO Council, was established to evaluate the problem inherent in assuring NS/EP circuit route diversity in a multi-carrier environment. In order to realize the goals of the Initiative, AT&T, BellSouth, MCI, Qwest, SBC, Sprint, and Verizon (carriers), the Federal Reserve, and ATIS worked as partners to scope the Initiative, assess the diversity of a subset of the existing circuits, establish diversity for those circuits that are not diverse, and monitor a selected subset of circuits to assure that diversity is maintained over time. All parties, working in partnership, agreed to evaluate and assess the viability and effectiveness of this process in responding to the Federal Reserve Board, Securities and Exchange Commission, and the Office of the Comptroller of the Currency white paper and the needs of the financial services sector, as expressed in the NSTAC Financial Services Task Force Final Report.

NDAI Team

The NDAI team consisted of representatives from AT&T, BellSouth, MCI, Qwest, SBC, Sprint, Verizon, the Federal Reserve, and ATIS. The Federal Reserve was represented by members from the Board of Governors, Wholesale Product Office at the Federal Reserve Bank of New York, and Federal Reserve Information Technology (FRIT). The ATIS CIO Council designated participants from within their respective companies. A minimum of two representatives from each carrier participated in the Initiative: a *Primary Point of Contact (POC)* and a *Technical Point of Contact (TOC)*. The POC served as the primary representative and acted on behalf of that carrier to assist in setting the direction of the Initiative, attended meetings, and interfaced with other parties throughout the Initiative. The TOC served as the technical representative who was responsible for receiving and delivering circuit information, participating in meetings, and assisting in the development of the deliverable. Due to the competitive and regulated nature of the telecommunications industry, it was necessary for a third party to integrate and manage the Initiative. ATIS served in the third party role and was responsible for providing project management, technical, legal, and administrative support. In this role, ATIS ensured that antitrust concerns were addressed and all parties were protected through a Non-Disclosure Agreement (NDA) and a Memorandum of Understanding (MOU). In order to engage a broader perspective of the financial services industry, a group of financial Subject Matter Experts (SME) from the ClearingHouse, Securities Industry Automation Corporation (SIAC), Payments Risk Committee, Depository Trust Clearing Corporation (DTCC), and SWIFT advised the Initiative activities and deliverables. See *Appendix A* for the list of NDAI team participants.

Initiative Scope

The intent of the Initiative was to explore and research the possibility of circuit route diversity assurance for critical NS/EP circuits across multiple service providers. Discussions of resiliency, reliability, and other elements or industry concerns of business continuity were outside the scope of this Initiative. [7]

Initiative Goals

At the onset of the Initiative, the Team set forth the following goals:

- Understand and define the capabilities of diversity assessment and assurance for the financial services sector.
- Understand the framework and processes that would be required to develop a diversity assessment and assurance model across multiple service providers.
- Identify and develop recommended requirements for providing diversity assessment and assurance.
- Assess framework and lessons learned.

[7] For the purpose of this Initiative, the context of *NS/EP diversity, circuit diversity and diversity assurance* is limited to the practice of ensuring there are multiple diverse physical circuit routes in a multi-carrier environment to an operations facility. The scope of the study did not assess the ability of other alternatives to achieve or assure telecommunications diversity.

Initiative Critical Success Factors

The NDAI Team also developed the following critical success factors to ensure that the Initiative fulfilled objectives:

Critical Success Factors	Measure
Clear definition of processes, and an understanding of the obstacles to overcome.	• Definition of a baseline understanding of diversity. • Definition and documentation of a process to assess diversity across carrier network. • Definition and documentation of a process to configure a diversity baseline. • Definition and documentation of a process to assure diversity for critical NS/EP circuits • Recommendations for resolution of barriers: – Clear statements of possibilities. – Clear statement of barriers and recommendations for overcoming those barriers.
Understanding of level of effort and cost and benefit of this capability.	• Basic requirements for diversity assurance that balances customer and carrier needs with business, regulatory, and legal requirements incumbent upon all participants. • Understanding of scalability.
Set of definitions for telecommunications diversity assurance applicable to this Initiative.	• Definitions of key telecommunications terms based on pilot learnings: – Items such as diversity, assurance, critical circuit. – Provide a common taxonomy.
Understanding if this process or the components developed within this Initiative can be applied outside of the "closed" enviroment.	• Assessment of "potential" applicability across financial industry NS/EP circuits. • Potential applicability across a broader population (i.e. other critical industry sectors).

Non-Disclosure Agreement

The NDAI team, along with respective legal counsel, developed an NDA to ensure that all parties followed guidelines to protect and share information in an appropriate manner. Due to the telecommunications regulatory and competitive environment and to address antitrust considerations (e.g., cost/pricing, circuit maps), an NDA was necessary. This document was signed by all parties involved in the Initiative and was adhered to throughout the project. The creation and institution of the NDA also created a trust environment among the team members that was vital in enabling the team to work collectively and collaboratively.

Initiative Framework – Memorandum of Understanding

The NDAI team developed a framework for the Initiative that defined the procedures and processes that all of the team members would follow throughout the Initiative, as well as assignment of deliverables to responsible parties. This framework became a contractually binding MOU and was signed by all parties involved. The schedule portion of the MOU defined and described the steps that would be necessary to execute in order to fulfill the Initiative's goals and critical success factors. The Initiative's four phase schedule included:

- ***Assessment Phase:*** Identification of sample critical NS/EP circuits by the Federal Reserve, the compilation of the "current" information for all circuit components by all involved Carriers, and the development of a composite "street level map" for the complete circuit. The Assessment Phase concluded with a joint analysis and agreement on work required to establish baseline diversity for the circuits.

- ***Baseline Phase:*** Evaluation of those circuits not deemed diverse from the Assessment Phase to determine if alternatives existed to diversify the circuits. If a viable option was found, the Federal Reserve made the determination on whether or not to proceed with the diversification effort.
- ***Assurance Phase:*** Consolidation of multi-carrier operational processes, agreed to by the Federal Reserve and the carriers, implemented on a defined cycle that will report and analyze any changes to the circuits such that any required steps are implemented to assure that diversity is maintained on the circuits.
- ***Deliverables Phase:*** Review of Initiative activities, assessment of the scalability and feasibility of wider deployment, and recommendations for next steps.

ASSESSMENT PHASE

The first phase, the Assessment Phase ("Assessment"), commenced upon the signing of the MOU. The objective of the Assessment was to map critical telecommunications circuit routes at the street level detail for a specified number of the Federal Reserve's bank customers and to identify potential diversity issues between the primary and secondary circuits. The *primary circuit* is typically used to transmit data during normal business operations. In the event the primary circuit fails, the *secondary circuit* is used to transmit data. Therefore it was essential that all routing was identified to determine the current state of diversity between the primary and secondary circuits. In order to accomplish this, it was necessary to map the circuits from both a high-level architectural perspective (including bank locations, central offices, points-of-presence [POPs], and all inter-connecting circuits) and a street-level perspective (the physical, geographic location of the circuits and the path they travel in street conduits, including central offices, bank locations, and POPs).

The first step in the Assessment was to determine the number of Federal Reserve circuits that would be included in the Assessment. The contractual agreement that the Federal Reserve currently has in place is with a single carrier, the "prime carrier," who is responsible for provisioning and maintaining the Federal Reserve's network for specific business applications. In the event that the prime carrier cannot provide connectivity to certain bank locations from its backbone network, services are contracted to other carriers.[8] Therefore sub-carriers and sub-sub-carrier relationships to the prime carrier exist in this multi-carrier environment. Based on the resources available and the time frame to complete the Assessment, it was determined that 10 customer banks, consisting of 20 total circuits (10 circuit pairs; each bank has a primary and secondary circuit) would be included in the Assessment. Four pairs of circuits included in the Initiative were previously engineered by the prime carrier to be diversely routed. The team agreed that for nine of the circuit pairs, street-level detail maps would be created from the bank location to the POP in each city where the customer circuit connects into the network backbone – this constitutes the "last mile" or "local loop" for the circuit. For one of the customer circuit pairs, the entire circuit (end-to-end) was assessed. This included street-level maps for last miles on both ends of the circuits as well as geographic depictions of the prime carrier's network backbone. Prior to conducting the Assessment, each carrier performed a cost estimate for completing the Assessment according to the steps detailed in the schedule portion of the MOU. The Federal Reserve agreed to fund the Assessment at the estimate provided by ATIS.

The prime carrier conducted research to obtain circuit identification numbers for the 20 Federal Reserve circuits and identified the sub-carriers that service was contracted to. The prime carrier sent this circuit identification to the sub-carriers. The prime carrier was also able to determine if the sub-carrier contracted service to another carrier (a sub-sub-carrier). In this instance, the sub-carrier would then have to obtain circuit identification number(s) for these circuits from their records and provide it to the respective sub-sub-carrier(s).

Once the sub-carriers and sub-sub-carriers received their respective circuit identification number(s), they were able to begin the processes involved to create street-level

[8] In certain circumstances, the prime carrier may elect to use another carrier for diversity purposes.

routing maps for their circuits. In order to obtain all of the necessary circuit information required to produce high-level and street-level detailed maps, the carriers had to reverse engineer their circuits. This required tracing the circuit from the circuit record detail through the carrier system multiplex, to the optical level, and ultimately to the SONET rings and their underlying cable assignments. This information was obtained by accessing multiple systems to determine the circuit hierarchy (DS0, DS1, DS3, to SONET) in order to get to the cable level detail (most systems do not automatically make this linkage). Different engineering groups and outside plant groups were involved in producing the circuit route maps; in some instances up to six different groups were involved. Not all circuit maps could be printed from a software program and therefore required some carriers to manually scan paper maps into a digital format. Lastly, manual circuit evaluation was required to ensure that all circuit information was included and accurate.

In order to evaluate the circuit pairs for potential diversity issues, all of the individual carriers' circuit information and maps had to be compiled to create one composite map for each bank location. Each of the carriers sent its circuit information to ATIS which was responsible for compiling the circuit data, creating high-level architectural maps, and using mapping software to create street-level composite maps. Piecing together the architectural layout of the circuit configuration from a high-level perspective was a very manual labor intensive effort that required significant analysis by both the carriers and ATIS. Upon completion of the circuit maps, ATIS and the carriers conducted working sessions to validate the accuracy of the maps and identified areas that highlighted potential diversity concerns.

In April 2005, the carriers and ATIS presented the high-level and street-level maps for 20 circuits to the Federal Reserve. The two-day session provided an opportunity for the prime carrier to present the layout of the circuit from an end-to-end perspective, and then the respective sub-carrier and sub-sub-carriers presented their segments of the circuits. Sample maps are provided in *Appendix B*. The presentation of these maps was an interactive session where the Federal Reserve was able to ask questions and initiate discussions pertaining to potential diversity issues. Throughout the entire process of obtaining and analyzing circuit information and compiling the high- level and street-level maps, all of the information was securely stored and protected to ensure that it was not compromised.

ASSESSMENT PHASE RESULTS

The NDAI team completed the Assessment Phase according to the steps and timeframes defined in the schedule portion of the MOU. The Assessment Phase was a valuable learning experience as lessons learned were developed from all parties involved. The compiled lessons learned are found in *Appendix D*. Below are highlights from the Assessment Phase.

Throughout the Assessment, it was evident that the NDA and contractual framework that were put in place were necessary in order to fulfill the objectives that were set forth. The agreements enabled the team to work effectively together and to protect circuit information appropriately. In addition, the strong personal relationships between the NDAI members -- some of which existed prior to and some of which were built during the process -- aided in executing the process. However, regardless of legal contracts, agreements, and relationships, the multi-carrier environment does increase the complexity of executing the processes involved.

At the completion of the Assessment Phase, the team concluded that circuit diversity assurance is not scalable in a manual mode. Upon receipt of circuit information of the ten circuit pairs from the Federal Reserve, prime carrier, sub-carrier, and sub-sub-carrier relationships were identified and circuit paths were determined. From the original 20 customer circuits, the team learned that the actual number of physical circuits from the carrier perspective totaled 68 circuit segments. The lack of a common identifier for each "circuit diversity group" made cross-carrier correlation a major challenge and consolidated map preparation was a labor-intensive manual effort, because of disparate mapping processes in use by the carriers. The level of effort to create street-level detail maps varied across the carriers. For example, in order to complete the necessary steps one carrier worked with teams in three geographic regions, used a total of twenty-four staff resources, and accessed four different systems. Another carrier localized to one geographic region used one primary staff resource with additional support from a team of engineers and accessed two different systems.

The systems that the Carriers had to access in order to obtain circuit information, the complexity of the circuits, and the company structure (internal processes) drove the costs for completing the Assessment Phase. In total, approximately 2,500 labor hours were required to perform the Assessment at a cost of approximately $209,000. The labor hours and cost reflect the time spent for all of the carriers and ATIS to execute the required steps of the Assessment as well as administrative, technical, and legal support. The street level maps that were created did provide useful information for the circuit paths between switching facilities. However, given the expense of providing street-level detail, the high-level circuit routing descriptions that identified circuit numbers, circuit type, and facility location provided an adequate representation of circuit diversity. The team has determined that manual circuit diversity assurance as explored in this Initiative, at this point , is too expensive to be considered commercially viable.

REVIEW AND ANALYSIS

At the conclusion of the Assessment Phase, the Federal Reserve indicated that the four circuit pairs that had been engineered as diverse remained diverse. There was significant interest from the team to determine if there was a specific cause or reason why those four circuits had not changed in that 12-month period. All impacted carriers investigated internally to determine if there was a notation, contractual agreement, or "do not change" marker that was identifiable on those circuit segments. The team determined that for two of the circuits there was no identifiable reason that these circuits did not change and it was simply happenstance.

The team determined that the other two circuits were flagged by the prime carrier and designated as *Special Customer Arrangements*. This flag, however, was not applied from the prime carrier to the sub-carriers that were responsible for circuit segments that comprise the end-to-end circuit. The prime carrier does believe this flag controlled changes in its network; however, the flag was not generated to sub-carriers when orders were placed and therefore it would not prevent a change in the sub-carrier's network. The team recognized that even with a flag in place, it is difficult to address diversity because the sub-carriers are only responsible for one of the circuits that comprise a diverse pair. The other segment of the diverse pair is typically owned and managed by another carrier and circuit location information regarding the circuit pair is not shared and analyzed. Subsequent to the pilot, Federal Reserve staff worked with the prime carrier to develop compensating measures to ensure that the sub-carriers recognize that these circuit segments should not be changed.

After complete review and analysis of the lessons learned from the Assessment Phase, the team believed that the value of executing an Assurance Phase would not provide any additional learnings, because an Assurance cycle would replicate most of the same steps that are required to perform the Assessment. Therefore, the team determined that an Assurance Phase was not necessary. The processes of the Assessment had been tested and validated and there was no perceived benefit in replicating it. The only difference in conducting an Assurance Phase from the Assessment Phase is that the steps would be performed at other points in time.

CIRCUIT DIVERSIFICATION

In parallel with the Review and Analysis of the Assessment Phase, the Federal Reserve evaluated those circuits that were not diverse, and agreed to explore diversification options for two pairs of circuits. During this process, the Federal Reserve worked with the prime carrier's account team and NDAI carrier participants involved with the diversification effort. This step in the Initiative will continue in the normal course of business between the Federal Reserve and the prime carrier.

APPROACHES TO DIVERSITY ASSURANCE

As the lessons learned were developed by the team at the conclusion of the Assessment Phase, it became evident that alternative approaches to diversity should be evaluated. The team did not believe that there were any regulatory constraints that would prevent the implementation of these approaches. Security must be addressed in all of these approaches, since it is critical that circuit information is protected from both a competitive and national security standpoint.

The team identified the following approaches that could potentially address circuit diversity assurance issues. Each of these approaches assumes that service is provided to a customer by multiple carriers. In order to assess and assure circuit diversity, carriers must collaborate in order to understand all of the circuit segments that comprise a circuit pair and individually ensure that no changes are made to diverse circuits over time. The approaches are grouped into two categories: *Business Relationships* and *Technological Capabilities.* Each approach could be implemented as a stand alone solution or in conjunction with others.

As a first step in considering any of the approaches, a risk assessment should be performed to clearly define business continuity requirements and define acceptable levels of risk for critical business functions and develop a functional definition of diversity. Service providers view telecommunications resiliency from an engineering risk perspective. Developing common terms of reference that bridge business and engineering risk is an important step for translating functional diversity requirements into engineered solutions. Common terms of reference would help develop a partnership between the carrier(s) and the customer that would be leveraged to help the carrier understand how the customer's functional view of diversity can be approached based on topology and engineering availability. The customer must be knowledgeable and able to articulate the risk it is willing to tolerate, and also translate this risk tolerance into terms that the provider understands. It is also important that the provider has knowledge of the customer's business continuity objectives so the provider can communicate how technical alternatives address business risk. This would create a partnership among the parties and commitment on both sides to ensure that technical diversity approaches satisfy functional requirements and mitigate potential risks.

Business Relationships

Dedicate Service to One Facilities-Based Carrier

A scenario where all telecommunications services are provided to the customer from one *facilities-based carrier* would give that carrier total control of the service provided and would also provide the customer with a single point of contact. In this situation, it would be much easier for the sole provider to establish diversity and assure that the diversity does not change over time. This would eliminate the need for sub and sub-sub-carriers, where information sharing is vital to establishing and assuring diversity. With one carrier, it would be possible to tag the primary circuit as "do not move" and the secondary circuit could be tagged as "avoid."[9] This can only be done with one carrier -- if the circuits were to come from two different carriers, they would not know of the existence of the other.

While this option may seem desirable, the members of the team do not believe this is a viable option. It is highly unlikely that one carrier would be able to provide a customer with a complete end-to-end network without using other carriers. Typically, a carrier cannot provide service to all geographic locations without having to physically build out its network.

Specific Contractual Agreements with the Carriers

A customer could establish bilateral contractual arrangements with each of its providing carriers (act in the role of *prime carrier*). Similar to the agreements that were established for the NDAI, ongoing agreements would enable all parties to assess and ensure circuit diversity. Contractual agreements would permit information sharing among carriers so they could more easily provide the customer with circuit routing information. The customer would also be able to specify service level agreements and mean time to repair. There do not appear to be any regulatory barriers to this approach.

However, the customer would need to ensure consistent interpretation of contract terms and conditions for diversity assurance across different carriers. In addition, this scenario would not involve the use of a third party to collect and aggregate circuit information and create circuit maps. Taking this approach would be very labor-intensive on behalf of the customer and carriers, as they would have to aggregate the information themselves and create their own circuit maps.

Dedicated Managed Service

The use of a *dedicated managed service* from a vendor (similar to those implemented at the Federal Aviation Administration and NASA) is a readily available solution that would provide the customer with an assurance of diversity. In this scenario, the vendor creates a virtual managed network via contractual arrangements between the customer and the prime carrier, supported by additional contract arrangements between the prime and all

[9] Detailed explanations of the terms "do not move" and "avoid" are provided in the Glossary.

of the subs such that the prime can fulfill its contractual obligations to the customer. Based on those arrangements, the vendor holds carriers accountable for providing the uptime, mean time to repair, and limits rearrangements as stipulated in service level agreements. Although this solution ensures high availability and assures diversity, it is significantly more expensive than other capabilities, and therefore may only be justifiable in life-safety situations, where there is no margin for loss of connectivity.

Use of an Independent Third Party to Provide Diversity Assessment and Assurance

Similar to NDAI, the *use of an independent third party organization* to manage and coordinate diversity assessment and assurance would be available to the customer as a business solution. This solution would provide project management, technical, legal, and administrative support to assess a customer's circuits that are provided by multiple carriers, and also perform periodic reviews to assure that the circuits remain diverse. The third party would be responsible for setting up legal agreements with all of the participating carriers to ensure that the necessary information is available in order to provide services requested by the customer. If this solution is pursued, the customer should select a third party that can provide the process and technical expertise that addresses the challenges that have been described in this report.

Technological Capabilities

IP-based Network

An *IP-based network* (packet-switched) is a solution that many organizations are planning to implement. An IP-based network would reduce the size of the network that would have to be examined for diversity. More of the network traffic would be riding on the IP cloud (backbone network) and only the connection from the cloud to the customer POP would have to be considered for diversity issues. However, the use of an all IP-based network is not a fail-safe solution. In the event there is a denial of service attack to the network, the customer would not be able to transport data. In addition, carriers would still have to look at diversity in the last mile. An IP-based network does, however, provide an advantage in its ability to compensate for less than ideal diversity situations by providing automated network resiliency to overcome failures.

Alternate Transport Technologies

Alternate transport technologies could provide additional opportunities for diversity solutions. It may be possible for the customer to obtain an engineering assessment from all of its vendors and pick and choose what makes the most sense for its business. This would allow the customer to explore multiple carrier engineering solutions. For example, it may be possible to make the customer location a node in the network cloud, therefore eliminating the last mile connection to the customer.

The use of alternate technologies, however, does not eliminate the problem of diversity assessment and assurance. Diversity requirements and constraints must still be identified and developed. Due diligence is required to ensure that diversity is achieved and paths are independent. For example, at some point, wireless connectivity becomes terrestrial and it would be necessary to ensure that the terrestrial connection and those circuits that need to be physically separate do not converge on common paths.

Automated Solution

The development and implementation of an *automated solution* would significantly enhance the delivery of some key activities necessary to assess circuits for diversity and help ensure circuits remain diverse over time. One of the key findings identified from the Assessment is there is no common way to track circuit segments across carriers that enables an easily repeatable, end-to-end assurance of multi-carrier circuits for diversity concerns. The team concluded that the basic component of any automated solution would be the inclusion of a unique common identifier similar to how TSP is identified on critical NS/EP circuits today.

At a general level, the implementation of an automated solution would require that *all* carriers involved in providing service for a specific customer would be required to participate and comply with established standards and guidelines. In addition, implementation would require a contractual agreement among all of the participants and a third party to manage the solution. Implementation would require process and system changes for each of the carriers that would participate.

An automated solution would require the use of multiple components: a standard *unique identifier* for each pair of circuits required to remain diverse, and a *central repository* as the collection and analysis point for information on individual circuit segments from multiple carriers associated with a pair of diverse circuits. The standard identifier would be used to tag all of the circuit segments that comprise a diverse circuit pair. This identifier would be used by all of the carriers providing circuit segments and added to existing circuit information stored and maintained by the carriers in their individual inventory systems. Once a circuit has been tagged with an identifier, the circuit's information would be stored in a central repository. Some required elements of the circuit information would be stored in a central repository to facilitate the review of circuits from multiple carriers.

The central repository, managed by a third party, would serve to link all the circuit segments from all carriers that comprise a diverse circuit pair. When a change is made by the carrier to a tagged circuit, information regarding the change would be submitted and updated in the central repository. This would trigger an alert that identifies the changes that were made and the need for an evaluation of potential diversity concerns.

The use of an identifier and central repository would facilitate a common process among the carriers to identify and aggregate circuit segments that comprise a circuit and identify changes that could affect diversity over time. This solution would also permit different levels of reporting that could be generated depending on the customer's needs.

The team identified different levels of reporting that could be implemented depending on the customer's needs. These different levels of reporting include:

- *CLLI*[10] *code changes* would notify the carrier if a particular circuit was changed and now traverses through a different central office and respective equipment. Tracking CLLI codes would not be very complex, since a database of CLLI codes already exists and is a common data element that is used by all of the carriers.

- *Identifying single points of failure* would track any single points of failure that have been identified in the network. This process would only require that cable routes and collapsed rings be mapped in order to identify these common points of failure. This method would provide an end-to-end view of the circuits for the customer.

- *Street level detail* would provide geographic, street-level detail for critical circuits. This is the most accurate way to ensure that circuits are diverse and the most accurate way to determine if changes to the location of the circuits affect diversity. This, however, comes at a significant cost as it is extremely manual labor intensive. Street level maps provide useful information on the circuit paths between switching facilities; however, given the expense of providing street-level detail, high-level circuit routing descriptions that identify circuit numbers, circuit type, and facility location can also provide an adequate representation of circuit diversity.

The team believes that all of these capabilities address the concerns that have been raised regarding telecommunications diversity. The team considers these capabilities to be viable; but each must be scoped with regards to effort and cost prior to making a decision to pursue one. Each capability will require different implementation costs and would involve process changes for each of the carriers involved. The consensus of the team is that no individual carrier can implement any of these potential capabilities as a stand alone service offering. Implementation will require the involvement of all the telecommunications carriers providing service to a particular customer. Due to the costs involved in implementing any of these capabilities, it is important that a business case study be conducted by the carriers to ensure that the demand for the service and the willingness of customers to subscribe to the service at the projected price justifies the cost to develop it. As a part of this study, customers will need to conduct a cost/benefit analysis to determine if the benefits derived from the proposed service will justify their cost to obtain the service.

[10] Central offices and equipment are designated by Common Language Location Identifier (CLLI) codes.

CONCLUSIONS

The NDAI was a valuable research project that resulted in many insights and learnings. Prior to this Initiative, there was no industry analysis conducted to determine the level of effort or to quantify the costs involved in assessing and assuring diversity of telecommunications circuits at a street-level detail in a multi-carrier environment. The team recognized that the customer base for requiring circuit diversity assurance is small -- primarily organizations performing NS/EP or Critical Infrastructure Protection (CIP) functions -- and the demand is not likely to change in the near future.

The Initiative successfully met the research goals and critical success factors as defined in this report. The team recognized after reviewing the results of the Assessment Phase that the primary objective for both Assessment and Assurance had been accomplished during that phase. Assessing the diversity of the Fedwire circuits across multiple carriers was costly and labor intensive. The team determined that the cost for assuring circuit diversity was far higher than expected since approximately 80% of the steps involved for Assessment must be replicated in each Assurance cycle.

Several factors contributed to this high level of effort and cost. These factors include complexity of the circuits and the systems used to access the circuit information; company structure (internal processes); no common automated mapping process in use by all parties; and the lack of a common identifier for each circuit diversity group. Moreover, it was evident that the multi-carrier relationship itself is very complex. The business relationships and inter-carrier processes varied and complicated the process of obtaining circuit information and ultimately led to a large level of effort and high costs. The team concluded that conducting an end-to-end multi-carrier assurance of telecommunications circuits is a very labor- and cost-intensive process and can currently only be conducted in a manual fashion.

Circuit route diversity, as defined by the scope of this Initiative, is widely promoted as a public and private sector best practice. Based upon the learnings of the Initiative, however, organizations relying on circuit diversity as a component of their telecommunications resiliency program should be aware that the lack of a process to provide real time assurance results in some residual risk. Manual circuit diversity assurance as currently conducted does not guarantee that diverse circuits remain diverse over time. Moreover, the NDAI pilot determined that the cost of manual circuit diversity assurance as a general commercial practice is prohibitive. Due to the high level of effort and cost involved in performing manual end-to-end circuit diversity assurance in today's multi-carrier environment, it may be justified for organizations with life safety missions and critical business needs.[11]

In order to validate the approach and outcome of the Initiative, the NDAI team assembled leaders from the financial sector to form a SME group. The SME group reviewed key points throughout the Initiative to compare the processes executed and the conclusions made from the Initiative with their organizations' experiences and practices undertaken to provide telecommunications resiliency. SME members believe that the responsibility for providing telecommunications resiliency and performing due diligence lies with financial institutions. SME members indicated that the results of the study confirmed their suspicions that, in general, circuit diversity cannot currently be assured in a multi-carrier environment. A key point validated by the SME group is that their organizations do not rely solely on circuit route diversity; rather, it must be a facet of an organization's overall telecommunications resiliency plan. SME members indicated that they use a combination of diversity alternatives, such as geographic dispersion of data centers or using multiple carriers for multiple communication paths, assuming carriers can share information to provide engineered diversity. In other cases, where practical, these organizations have made special contracting arrangements, similar to those made by the Federal Reserve, with their prime carriers to maintain engineered routes for certain critical circuits. While recognizing that these approaches may not eliminate the risk of losing services due to a telecommunications failure, the SME members believed the collective results of these approaches significantly reduced the level of risk to their organizations. Financial service organizations also

[11] The team recognizes that some organizations with critical business needs, such as SFTI (SIAC), SMART (DTCC), and Links (FAA), have elected to bear the cost to engineer networks with diverse physical routes and establish ongoing assurance processes.

recognize the potential possibility that new and existing technologies could address diversity concerns that exist in the last mile to the customer.

The team concluded that if multiple carriers are required to provide end-to-end telecommunications services, an automated solution will be required to provide the capabilities for assuring circuit diversity efficiently. An automated solution would address concerns regarding the resource intensive nature currently required to perform end-to-end multi-carrier circuit diversity assurance. The NS/EP customer base demanding circuit diversity assurance is small and the telecommunications carriers believe that this base may be insufficient to support a business case for a private sector automated solution. However, an automated solution to address circuit diversity assurance is only required in a multi-carrier environment. If a customer has the ability to obtain all of the necessary services from one telecommunications carrier, that carrier could provide circuit diversity assurance since it has access to all of the circuit information necessary to perform circuit diversity assurance.

The Federal Reserve also gained valuable insights from the Initiative. The Federal Reserve's view of a circuit was distinctly different than the carriers' points of view. While the primary carrier understood the Federal Reserve's end-to-end perspective of a circuit, the views of sub and sub-sub-carriers were limited, focused only on their segment of the circuit. The role of the primary carriers appears to be similar to that of a general contractor, sourcing segments of the circuit to the appropriate sub-carrier. However, the primary carrier does not have visibility or authority regarding the management of the individual segments and any insight it has is based on the business relationship. The Federal Reserve is a stakeholder in how the sub-carrier manages its segments; however, the sub-carrier does not know that the segment supports critical Federal Reserve NS/EP operations.

The success of the Initiative was attributed, in large measure, to the trust relationship that developed between the telecommunications carriers and the Federal Reserve. This relationship promoted two-way communication that led to a common taxonomy of terms and concepts. Both entities developed a better understanding of what each meant when using the term circuit and acknowledged all of the business relationships involved in contracting an end-to-end circuit. The Federal Reserve was initially unaware of the complexities that existed between the prime carrier, sub-carriers, and sub-sub-carriers, and viewed a circuit as a connection from one location to another, regardless of the number of individual carriers involved. Carriers viewed the same connection as a series of connected carrier circuits. In addition, the Federal Reserve and the carriers developed a common understanding that the definition of diversity is dependent on individual user requirements and business situations. This common taxonomy enabled both entities to fully understand how the network is structured and how certain aspects of the network can contribute to diversity issues. Working together, this cohesive team was a significant factor contributing to the success of the Initiative.

In conclusion, the Initiative demonstrated that circuit diversity assurance, as it currently exists today, cannot be offered as a commercially viable product. The problem is complex and the solutions will require extensive resources; however, the findings of this Initiative will provide a sound base for subsequent efforts in addressing circuit diversity assurance.

RECOMMENDATIONS

The team developed the following recommendations based upon the Initiative learnings and conclusions:

Diversity Guidance

The team recommends that the National Communications System and its National Coordinating Center[12] make the results of the Initiative available to other critical sectors, to assist them in evaluating their current risks in regards to telecommunications continuity and to take the necessary steps to mitigate those risks.

The results of the Initiative provide information and terminology that could be used as guidance to other organizations supporting critical NS/EP functions to better understand the telecommunications infrastructure supporting their business needs in a multi-carrier environment. This guidance will provide customers with the knowledge they need to identify the diversity risks that exist in their current telecommunications environment. It would also provide them with terminology that could be used to establish a common understanding with carriers when evaluating circuits for diversity assessment and assurance, as well as how circuits are engineered to address diversity concerns. Customers could then better determine the acceptable level of risk as it pertains to their telecommunications services.

Evaluation of an Automated Solution

The team also recognizes that the implementation of an automation solution could address circuit diversity assurance concerns in a multi-carrier environment. An analysis should be performed by a small "study group" composed of knowledgeable telecommunication carriers, critical sector representatives, and Federal government participants to create high-level requirements, a cost estimate, and the level of effort involved in the development and implementation of an automated solution.

While prescribing a specific solution for providing diversity assurance in a multi-carrier environment was not the primary objective of the NDAI team's project, the results of the Initiative did enable the team to identify several key issues inhibiting diversity assurance. Based on these learnings, the team recommends a small-scale follow-up effort be undertaken by the study group to scope the objectives and requirements for providing an end-to-end diversity assurance solution in a multi-carrier environment. This scoping effort should include the creation of high-level requirements, cost estimates, and the level of effort to develop and implement an automated circuit assurance solution. The telecommunications carriers believe that this effort will need to be sponsored by the Federal government.

The development of an automated solution will require the implementation of a common cross-industry circuit identifier. This identifier will be used to identify all of the circuit segments that comprise a diverse circuit pair. A common circuit identifier could potentially be used to cross-reference contextual information regarding the circuit across multiple carriers. Subsequent steps in the development of an automated solution may involve:

- Identification of system and process changes required by each of the carriers to implement a common circuit identifier;
- The development of a common central repository (database) to aggregate all of the circuit segments;
- An appropriate third-party integrator to manage the central repository;
- Proactive and reactive methods to automatically determine if circuit changes affect circuit diversity.

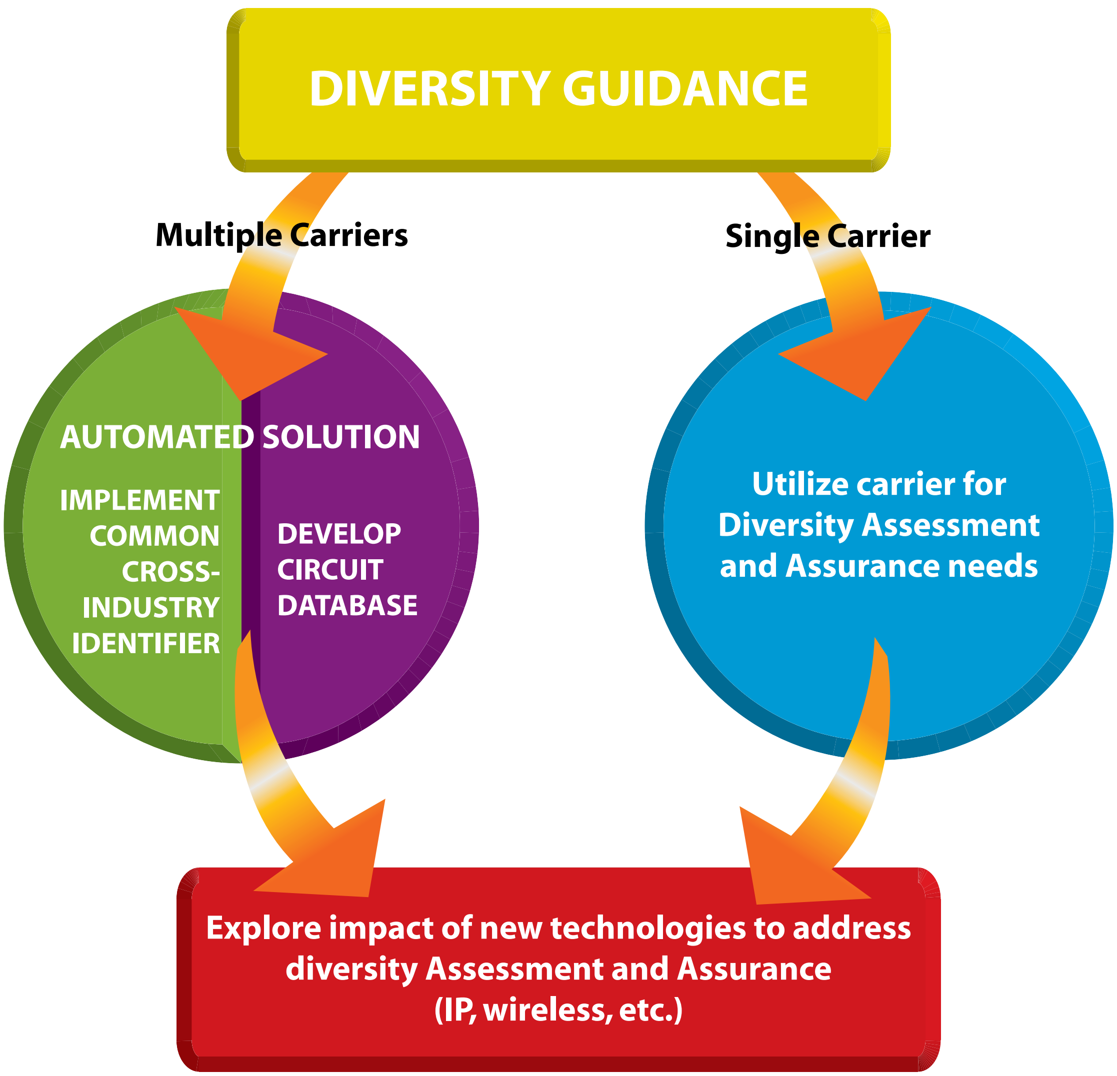
This solution would need to be scalable to accommodate future demands to assess and assure the diversity of critical NS/EP circuits. This solution would not eliminate diversity assessment and assurance concerns; however, it would serve as a tool that can be used to identify, address, and potentially mitigate those concerns. The results of the scoping effort could assist in quantifying the project scale and costs required to consider implementation of a diversity solution that could be used across different sectors. The analysis of any automated solution for tracking diversity assurance must consider its relevance

[12] The NCS is part of DHS and has responsibility for NS/EP telecommunication programs and the NCC is an on-site industry support arm staffed by telecommunication carriers.

to next generation telecommunication technologies, such as IP-based networks, as well as today's public switched network.

Telecommunication carriers believe that developing and implementing a next-step program that will assure telecommunications diversity in a multi-carrier environment will be costly and external funding will be required. The NDAI team, however, does not know the importance of diversity assurance to other critical sectors. An agency of the Federal government, perhaps the Department of Homeland Security could provide a collective view of the urgency for diversity assurance of telecommunication circuits supporting critical NS/EP services of the other critical sectors.

Recommendation Exhibit



APPENDIX A – NDAI PARTICIPANTS

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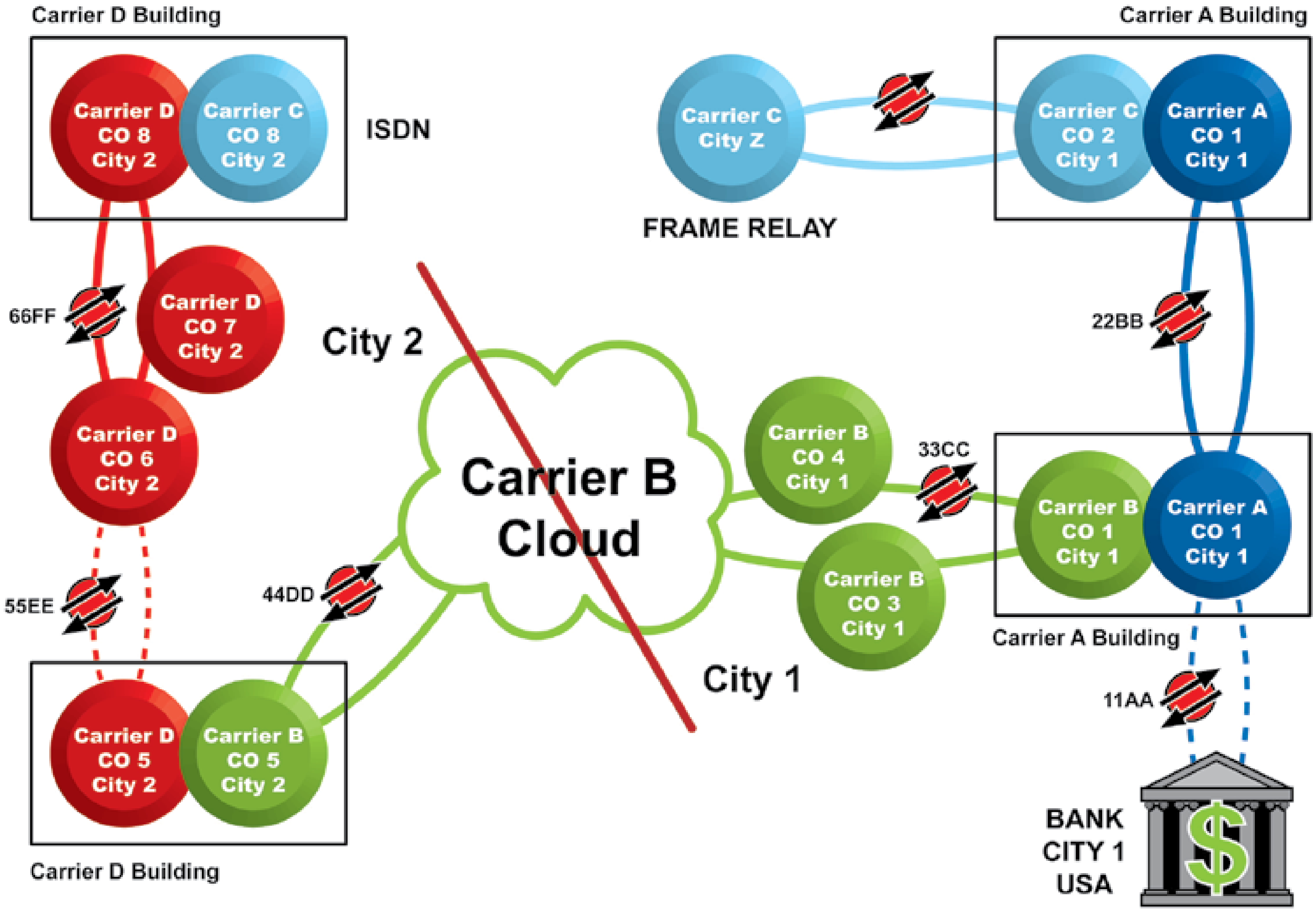
Stu Elby	Verizon
Darshan Mheta	Verizon
Sam Bhatta	Verizon
Karen Bearce	Verizon

APPENDIX B – SAMPLE COMPOSITE CIRCUIT DIAGRAMS AND MAPS

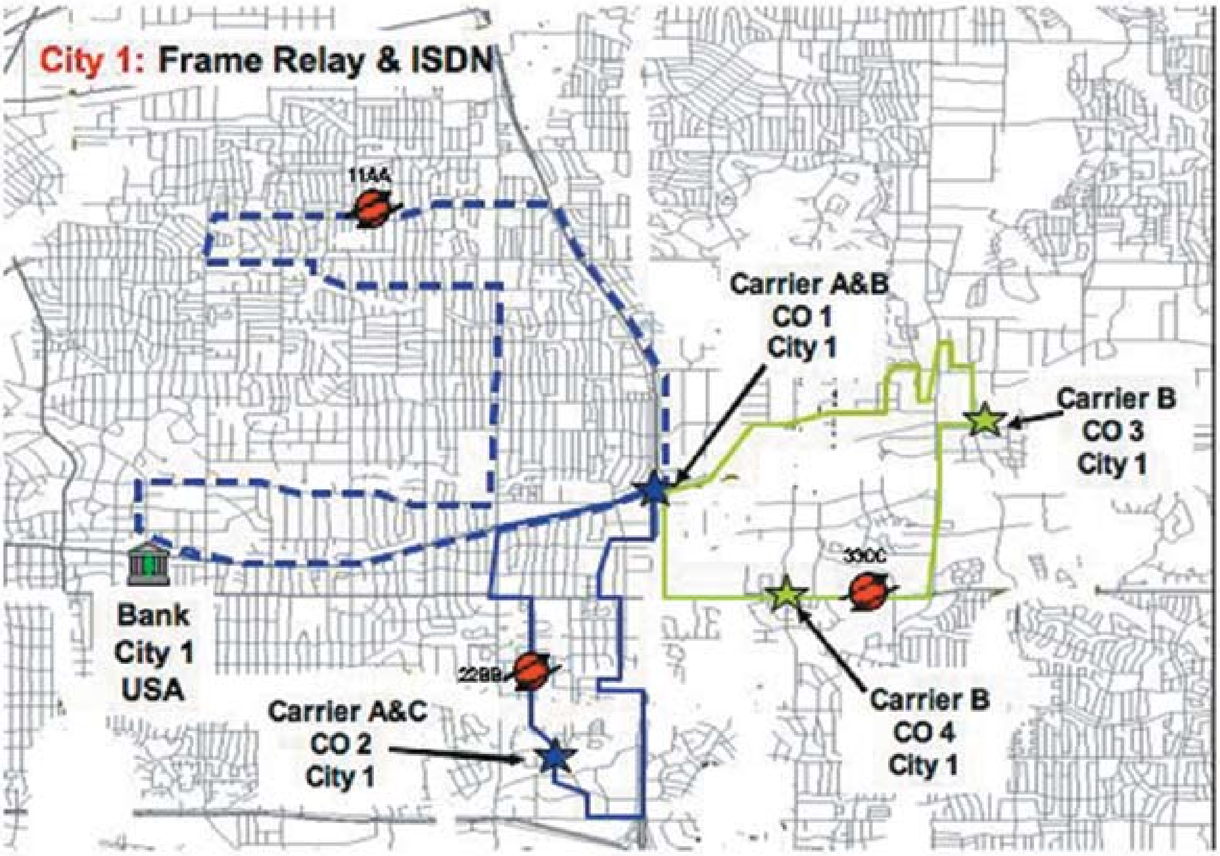
High-level Architectural Perspective



The circuit diagram is illustrative and does not represent any actual circuit information.

APPENDIX B – SAMPLE COMPOSITE CIRCUIT DIAGRAMS AND MAPS

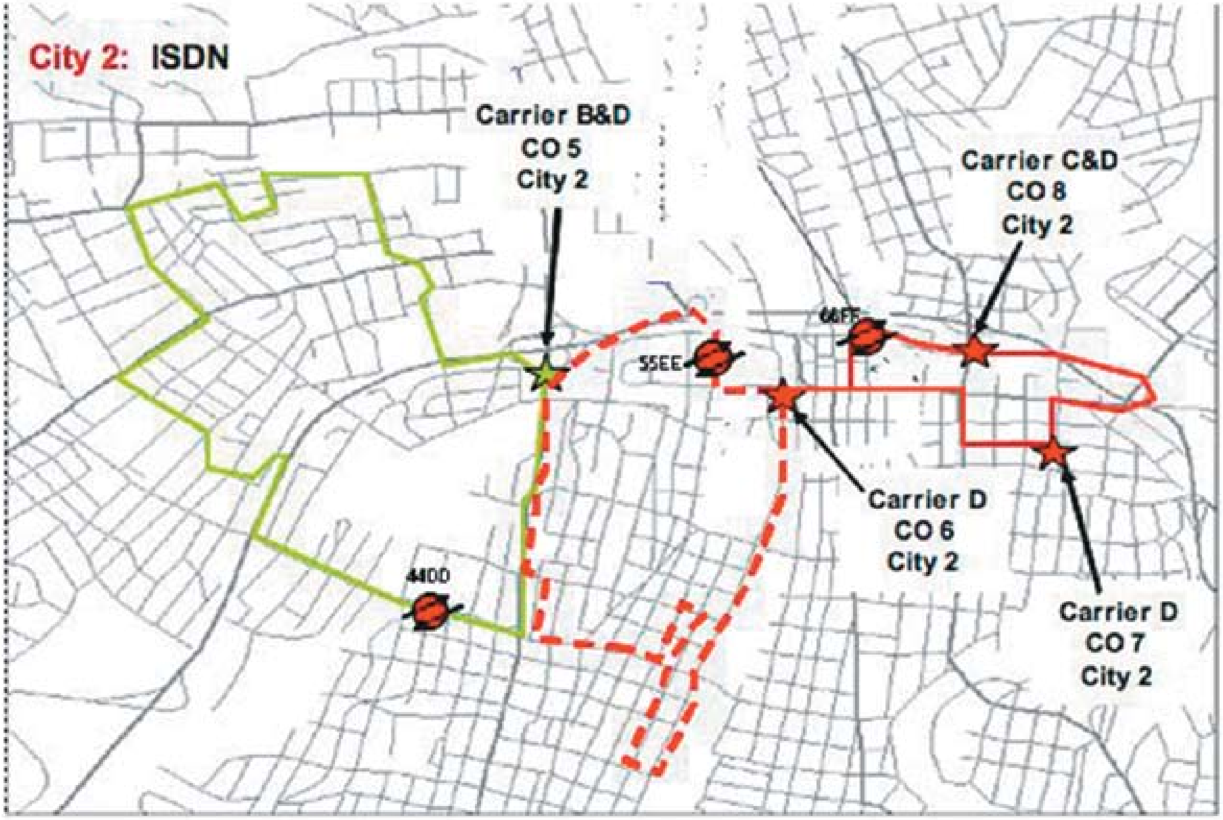
Street-level Perspective – City 1



The circuit diagram is illustrative and does not represent any actual circuit information.

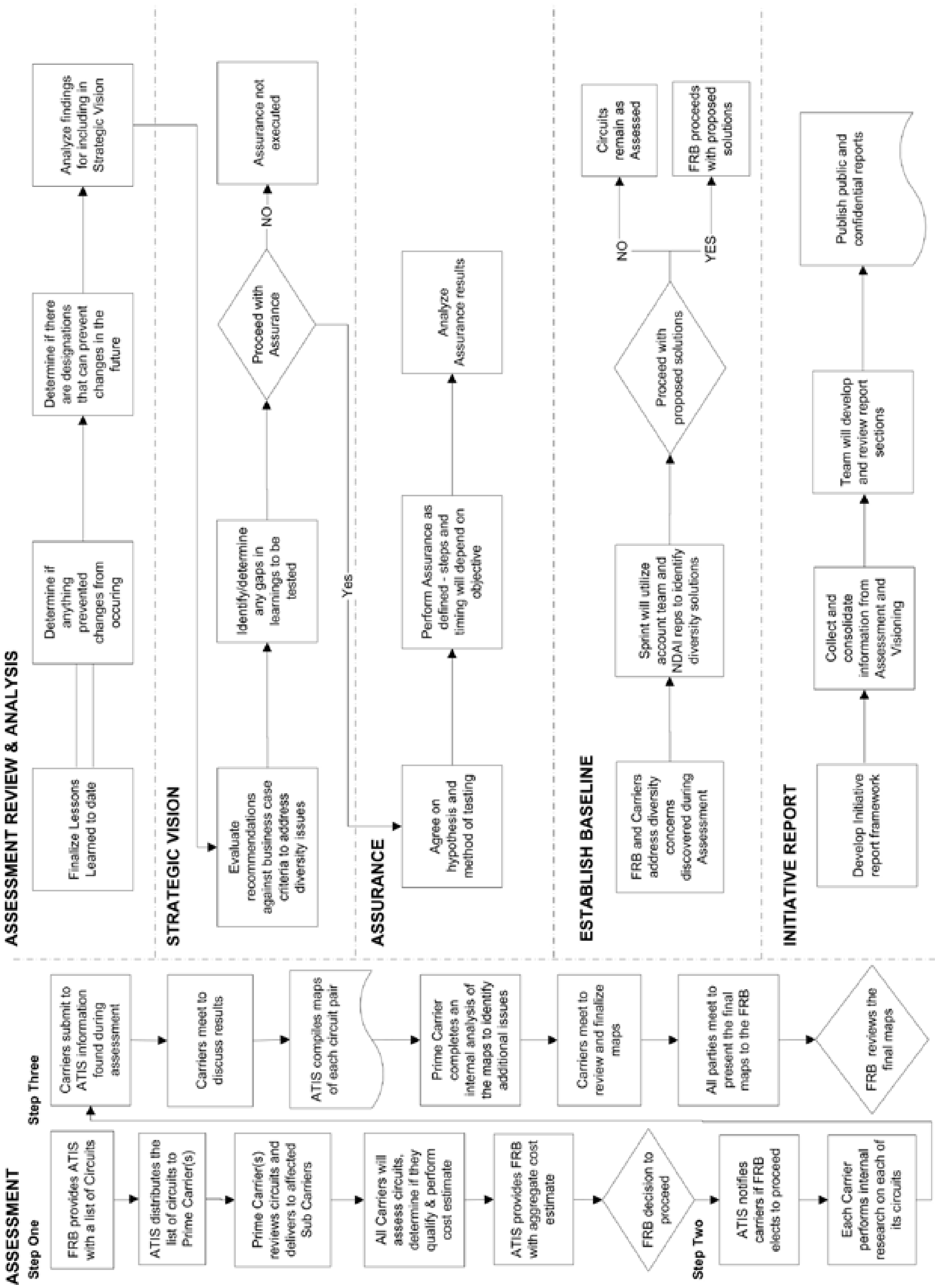
APPENDIX B – SAMPLE COMPOSITE CIRCUIT DIAGRAMS AND MAPS

Street-level Perspective – City 2



The circuit diagram is illustrative and does not represent any actual circuit information.

APPENDIX C – INITIATIVE PROCESS FLOW



APPENDIX D – LESSONS LEARNED

Initiative Learnings

Structure and Processes

- The contractual framework necessary for the carriers to work together to deliver consolidated assessment and assurance reports was complex. This framework could be streamlined as the defined processes are executed, but it will remain complex given the telecommunications industry's regulatory and competitive environment.

- Complexity also exists in developing a contractual agreement with major customers. The industry segment of the customer is irrelevant to the complexity of the contractual terms and conditions.

- Antitrust considerations (e.g., cost/pricing, circuit maps) required the use of a third party to serve as the project facilitator; the use of a third party added another layer of complexity in the role as a broker of sharing information between the carriers and the Federal Reserve parties.

- The regulated and competitive nature of the telecommunications industry often made it difficult for the carriers to act in concordance as an industry; rather, they were seven companies with diverse business reasons working toward a common goal with the customer.

- Security considerations to protect circuit information and maps led to another layer of complexity.

Circuit Identification/ Network Complexity

- Due to the complexity of the carriers' operations support systems, more time than expected was needed to compile initial circuit information for the Initiative circuits.

- During the circuit identification process, it became evident that the prime carrier often contracts to another carrier for local access service. In some instances, the local access service provider that the prime contracts with, also contracts with yet another local access service provider. As a result, there are sub-carriers of the sub-carriers.

- The sheer complexity of the networks to be assessed and monitored became clear as sub-carriers and sub-sub-carriers were identified. The Federal Reserve provided us with 10 "circuit pairs." As we reviewed each of the "paths" and identified the prime carrier, sub-carrier, and sub-sub-carrier relationships, the actual number of circuits totaled 68.

- The customer viewed the circuits as "whole connections from one location to another." The customer does not know, nor do they have any control over how many circuit segments are needed to comprise a circuit. There may be an ongoing need for the customer to know the number of carriers involved in an end-to-end circuit.

Cost

- The original cost estimate parameters did not account for connectivity between multiple carriers within the local loop. Upon learning that there were scenarios with sub-carriers of the sub-carriers, cost estimates had to be modified to account for this situation.

- Complexity of network design drove cost since it increased the amount of manual work to be performed:
  - *Some carrier Assessment work was confined to one geographic region and one system and others involved multiple regions and multiple systems, which accounted for a greater level of effort.*
  - *The specific cost drivers to complete the Assessment Phase varied greatly across the circuits.*

- The number of COs and hops between the bank and the prime carrier's POP increased the cost of mapping the circuit.

- Street level information cost substantially more than building level information.

- The systems that the carriers had to access to obtain circuit information, the complexity of the circuits, and the company structure (internal processes) drove the costs for completing the Assessment Phase.

Assessment Circuit Information

- Data elements and terminology among the carriers were not common:
  - *A template was developed for all of the carriers to collect Assessment information; however, there was difficulty with obtaining a common identifier from all of the carriers since they did not all use the same record keeping systems.*

- Lack of any common identifier for each "circuit diversity group" made cross-carrier correlation a major challenge. These included:
  - *Correlation of the components that comprised one "customer" circuit.*
  - *Correlation of the two circuits intended to provide diversity.*

- The customer must rely on the carriers and a third-party integrator to ensure consistency of circuit information and the creation of circuit maps. Translating the information from the carrier records into the mapping model was a manual process and open to human error. The customer has no ability to verify the accuracy of the information presented to them.

Carrier Learnings

At the conclusion of the Assessment Phase, each carrier was interviewed to determine the steps and processes involved to obtain and analyze their respective circuit information as well as any difficulties they encountered while executing this work. The following generalizations affected the majority, if not all of the carriers:

Labor Intensive Effort

- In order to obtain all of the necessary circuit information, the carriers had to reverse engineer their circuits. This required tracing the circuit from the circuit record detail through the carrier system multiplex to the optical level and ultimately to the SONET rings and their underlying cable assignments.
  - *Upon receipt of circuit information from the prime carrier, sub-carriers had to access multiple systems to determine the circuit hierarchy (DS0, DS1, DS3, to SONET) in order to get to the cable level (most systems do not automatically make this linkage). Different engineering groups and outside plant groups were involved in producing the circuit route maps; in some instances, up to 6 different groups were involved.*
  - *Not all circuit maps could be printed from a software program. Some carriers needed to scan paper maps.*
  - *Manual circuit evaluation was required to ensure that all circuit information was included and accurate.*

- The Assessment required carriers to use multiple resources and access multiple systems in different geographic regions, and in some instances, to analyze paper maps. The following represents examples of very intensive and less intensive Assessment analysis:
  - ***Carrier A –*** *Three geographic regions, used a total of twenty four resources, and accessed four different systems.*
  - ***Carrier B –*** *Four geographic regions, used four resources and two engineering teams, accessed three different systems, and required paper map analysis.*
  - ***Carrier C –*** *Localized region, used one resource and one engineering team, and accessed two different systems.*

- Sub & sub-sub-carrier relationships created challenges:
  - *There is no direct reporting of the sub-sub-carrier relationship to the prime carrier. Therefore it was necessary for sub-carriers to inform the sub-sub-carrier of their involvement in the Assessment. The sub-sub-carrier then acted independently providing circuit information to ATIS in order for ATIS to compile the composite view.*

- Inter-carrier logistics were challenging to manage:
  - *Carrier NDAI POCs had to explain the Initiative to each new individual/team as they became involved.*
  - *Some employees were reluctant to give out proprietary circuit information until they had a full understanding of the Initiative.*
  - *Difficulties were encountered in determining and locating the correct people to get circuit information and questions answered.*
  - *There were many people involved at different stages*

who also had their regular workload, so keeping deliverable dates was often difficult.

- *Internal communication gaps existed -- different groups use different terms for expressing circuit information.*

Federal Reserve System Learnings

Costs

- Several common factors must be addressed across carriers in order to reduce the costs for performing circuit assessments. These factors cannot be influenced or controlled by the customer.

- The cost of and the level of effort for performing assurance are not scaleable and cannot be reduced without systemic changes across all carriers.

Assurance

- There is a need to determine if there are other methods to assure diversity that provide the same benefits as a manual circuit diversity assurance exercise.

- At this point in time, the manual circuit diversity assurance approach as explored in this Initiative, is too expensive to be considered viable for financial services.

- The customer assumed that carriers had consistent methods to track and identify NS/EP circuits covered by TSP. The TSP code assignment to all components of an NS/EP circuit would provide tracking continuity across carriers. Carriers, however, do not always directly identify the TSP code as part of the circuit record.

- There are no factors, conditions, or circumstances that a customer could use as "flags" to indicate when a circuit pair should selectively undergo assurance or to predict the likelihood that diverse circuits may have undergone changes.

- Customers cannot be assured of any level of risk that they may be accepting over time.

- Until circuit diversity becomes commercially viable and scalable, carrier-managed diversity should not be promoted as a best practice to provide telecommunication resiliency for financial service firms.

Customer and Carrier Relationship

- Mutual agreement on the taxonomy of terms used to describe diverse circuits is important for setting service expectations.

- It is important that the carrier understands 1) the customer's business and critical operations supported by the telecommunications network; 2) critical business partner connections supported by the customer's network; and 3) network fallback and recovery plans.

- It is important that the customer understands 1) the extent of the carrier's network to geographic customer endpoints; 2) business relationships/service agreements between the prime carrier and sub-carriers; 3) business continuity plans; and 4) future network plans or significant changes.

- The customer's business relationship with the prime carrier enables the customer to inform that carrier of its business operations and the critical functionality that certain circuits provide with respect to their business. However, the customer does not have the same relationship with the sub and sub-sub-carriers, therefore the customer cannot know if this information is passed from the prime to the subs regarding businesses supported by critical circuit components.

APPENDIX E – GLOSSARY

Carrier System Multiplex – A system where several different signals can be combined onto one carrier by changing some feature of the signals transmitting them, and then converting the signals back to their original form.

Circuit *"Do Not Move"* and *"Avoid"* Tags – Telecommunications carriers designate circuits that should not be moved or modified in multiple ways. A circuit designated as "Do Not Move" indicates that it should not be moved under any circumstance. A circuit designated as "Avoid" means that all changes to the circuit should be limited. Specific procedures vary by company depending upon the action required.

CLLI Code – *Common Language Location Identifier* – An alphanumeric code composed of 38 characters that identifies physical locations and equipment such as buildings, central offices, poles, and antennae.

Collapsed Ring – A collapsed ring topology is one in which the ring fibers are laid in the same fiber bundle. If the fiber bundle is cut, and all fibers in the ring are cut, the ring collapses.

Facilities-based Carrier – A telecommunications carrier which owns most of its own facilities, such as switching equipment and transmission lines.

IP Cloud – The unpredictable part of any network through which data passes between two end points.

Mean Time To Repair – The vendor's estimated average time required to do repairs on equipment.

Packet Switched Network – Sending data in packets through a network to some remote location.

POP – *Points of Presence* – A long distance carrier's office in the local community.

Service Level Agreements – An agreement between a user and a service provider, defining the nature of the service provided and establishing a set of metrics to be used to measure the level of service provided against the agreed level of service.

SONET – *Synchronous Optical Network* – A family of fiber optic transmission rates from 51.84 million bits per second to 13.27 gigabits per second, created to provide the flexibility needed to transport many digital signals with different capacities, and to provide a design standard for manufacturers.

TSP – *Telecommunications Service Priority* – The regulatory, administrative, and operational system authorizing and providing for priority provisioning and restoration of NS/EP telecommunications services.

National Diversity Assurance Initiative

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