Parallel Operations

Successfully Transitioning Mission-Critical Services between Contracts

Networks & Telecommunications Community of Interest

Federal Aviation Administration (FAA) Telecommunications Infrastructure-2 (FTI-2) Transition and Implementation Working Group

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Synopsis

One of the FAA’s main objectives is the continuation of high quality and availability of services during the transition period leading to full FTI-2 deployment. This paper explores issues related to Parallel Operations – keeping existing services in place to continue to support critical mission systems, while at the same time implementing new architectures, technologies, services, and practices. What issues are under FAA consideration for parallel operations of legacy and FTI-2 systems during the transition period? Do some sites and services require a different approach?

FAA also seeks considerations and strategies as to how to transition the current redundant backbone with Internet Protocol (IP) and narrowband, channelized Time Division Multiplexing (TDM) services to the new FTI-2 services including identification of elements that may have a positive and/or negative impact on transition schedules.

Some lessons-learned from the previous contract migration are examined as well as potential FTI-2 critical project activities, stakeholder communications, measures of progress and success, proper planning guidelines and preparation, creation of a general migration plan, and identification of anticipated risks and some associated mitigation strategies. Bear in mind these are historical observations which may or may not foreshadow future events.
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Introduction and Executive Summary

The migration of National Airspace System (NAS) telecommunications services from the Leased Interfacility NAS Communications System (LINCS) network to the current FAA Telecommunications Infrastructure (FTI) brought with it a requisite period of parallel operations involving the combined operation of both network infrastructures. This period of parallel operations required not only coordination and cooperation between the two network infrastructure owners, but required the design and operation of gateway elements and procedures, allowing NAS traffic to seamlessly flow between the two networks. As the FAA prepares for the acquisition of the FTI-2 network, adequate planning for the associated parallel operations period is essential to the successful migration to this platform. This whitepaper offers Lessons Learned from the LINCS-to-FTI migration, suggestions for establishing a set of minimum expectations for a successful Parallel Operations strategy and associated preparatory actions, identifies the essential business planning elements necessary to accommodate the period of parallel operations and identifies key schedule consideration. This whitepaper also identifies the clear need for consideration of strongly suggested prototype and network testing, definition and implementation of necessary gateway infrastructure, development of appropriate Methods of Procedure (MOPs) for migrating services between networks and finally establishes the importance of comprehensive integrated command structure with defined roles and responsibilities during the phases of parallel operations.

Scope of Assessment

The assessment and suggestions made in this whitepaper while primarily aimed at the planned acquisition of and migration to the FTI-2 network, but can also apply to other complex network migration efforts. Where appropriate, the impact of technology, service delivery and network enhancements introduced during the FTI contract period, are identified and consideration is made for continued evolution of technology and service delivery methodologies consistent with a dynamic network throughout the completion of the parallel operation of the new FAA network.

Analysis

Lessons learned from the FTI Migration

This section reviews the challenges faced during the LINCS-to-FTI migration. While these issues were identified, and resolved during that period of time, the networks have continued to grow and evolve and it is anticipated that these same types of issues will be a challenge for the upcoming migration to FTI-2.
Site Address verification.

Deployment of newly acquired telecommunications access circuits is predicated by the need for a complete and accurate inventory of site addresses. Significant effort has been exerted over the last 15 years to establish physical 911 addresses for all FAA facilities, and these could be the standard site addresses used by the local carriers, if appropriate functions are also identified with associated demarcation points. During the LINCS-to-FTI migration, the following examples resulted in complications and delays.

1. Multiple Telco demarks at the same address resulted in circuits being delivered to the wrong suites, floors or building demarks. The FAA address inventory should accurately specify which demark location for what function in the same building.

2. Differences between FAA-provided building address and ordering addresses in the local carrier databases resulted in Telco delivery delays because carrier provisioning could not find and/or reconcile the provided demark address with their records. For the FTI-2 migration, pre-coordination and reconciliation of FAA and local carrier address tables would assist in streamlining the migration process.

3. Undocumented cabling extensions by personnel resulted in delays until they could be located, ownership identified and authorization secured.

4. Incomplete or inaccurate Numbering Plan Area/Numbering Plan Exchange (NPA/NXX) information resulted in the incorrect design of circuits that delayed provisioning and delivery.

5. In addition to accurate and complete site addresses, it is essential for accurate site Points of Contact (PoC) telephone numbers. These numbers are one means to verify NPA/NXX information, and appropriate Telco demark address and locations. All cognizant PoCs need to be identified.

As part of the migration to FTI, a validated and configuration managed site address database was created which can potentially facilitate migration to FTI-2. However, the NAS is constantly evolving with consolidated facilities and new/moved facility service delivery points, it is suggested prior to engineering and service ordering additional address validation could be undertaken.

Undocumented interface implementations.

During the LINCS-to-FTI migration, there were multiple instances where programs or facilities deviated from industry conventions or where documentation inaccurately described the implementation. Some examples include serial interface connector pin-outs deviating from published standards and serial interfaces documented as synchronous but were found to be
asynchronous after significant troubleshooting. It was discovered that a number of the site-specific implementation deviations uncovered during troubleshooting were not accurately documented, resulting in protracted troubleshooting periods. Documentation of these non-standard interface implementations were performed during conduct of the FTI contract. While the FTI-2 acquisition may consider appropriate mechanisms to capture these interface specifications, it could be simpler to repair these anomalies before transitioning the circuits to the new contract vehicle and potentially different deployment methods. It is anticipated that additional instances of these non-standard interface configurations will be identified associated with moving voice off of narrowband channelized TDM circuits to Voice over IP based systems. These issues could be exacerbated if both activities occur simultaneously.

**Carrier facilities availability.**

During the earlier migration, there were multiple instances where Carrier facilities were inadequate to implement fully parallel connections between legacy and new networks. Carriers are following industry trends to replace their aging analog equipment and copper plant with fiber in the loop, facilities availability and suitability for FAA services need to be verified early in the process as the installation of additional infrastructure takes time and can affect the project plan. Specific areas of concern include:

1. Unavailable or inappropriate facilities has caused provisioning delays and increased both Non-reengineering (NRE) costs and project schedules.
2. Cabling unsuitable for digital services has caused provisioning delays and increased costs for construction and validation of cable facilities.
3. Inter Office Facility (IOF) infrastructure did not support diverse paths which will compromise avoidance requirements and necessitate additional costs for construction of new diverse facility paths.
4. For some smaller and more rural areas all access to all Inter-eXchange Carriers (IXCs) in the local access and transport area (LATA) may be located in the same Wire Serving Central Office (WSCO) serving wire center can compromise avoidance requirements or increase costs to establish diverse paths.
5. Limited meet-me points (cable vaults, carrier hotels and PoPs) between smaller Independent carriers and Competitive Local Exchange Carriers (CLECs) can also compromise avoidance requirements and potentially increase NRE costs due to construction of new diverse circuit paths.
6. If site bandwidth is not consolidated as part of the migration, it is anticipated that Carrier phase-out of analog and/or sub-rate circuits could potentially increase
operational costs because existing T1 based circuits can be replaced with higher capacity circuits. If the facility is beyond the normal range of copper facilities more esoteric solutions may be required that could also increase costs.

While Carrier facilities are changing, and evolving, the types of issues discovered during the earlier transition from FTI can still potentially plague any new transition efforts so understanding of those situations is required not to repeat them. Carrier facility capabilities are also undergoing a significant transformation as they move toward both increased fiber in the backbone and the local loop.

**Inefficiencies resulting from piece-meal (service-by-service) migration.**

During the LINCS-to-FTI migration, new FTI service orders were not placed as a complete set for a location, but instead occurred over a period of time as unaffiliated service orders. Some of the resulting issues:

1. Multiple site dispatches to cut-over individual services or groups of services, instead of cutting over all of the services as the teams were on site.
2. Multiple independent equipment configuration changes over a period of time, increasing the likelihood of human error or misconfigured equipment.

It is anticipated that the following issues may potentially affect the FTI-2 migration effort.

**The importance of communicating “the plan” to the districts.**

During the early days of the LINCS-to-FTI migration, it appears that both the impacted FAA groups and locations as well as their management chains were not fully briefed on what was going to be occurring and what the expectation of the implementation teams had of the local FAA and District resources. This lead to Districts not allocating sufficient resources and/or giving timely approval of maintenance release of services which delayed implementation.

**FAA resource constraints.**

As the LINCS-to-FTI migration activities were reaching their maximum effort, personal policies and management imposed limits on authorized overtime required to complete off-shift activities restricted the pace of implementation. This situation resulted in multiple site dispatches to complete interrupted or cancelled migration actions.

**Facility logistics constraints.**

During any migration requiring parallel operations, there is a period of time where Customer Premise Equipment (CPE) for both networks need to be accommodated, taxing the limited
space, power, cooling and access at many FAA facilities. There were many instances during the previous migration where progress was stalled due to the lack of adequate FAA facilities including:

1. Inadequate space or power to accommodate equipment to be installed.
2. Inadequate grounding facilities which lead to equipment or service malfunctions.
3. Inadequate heating, ventilation and air conditioning (HVAC) to support sensitive electronic equipment leading to equipment malfunctions.

Because of the technology advances since the last migration, it is envisioned that certain FTI-2 CPE and other equipment may have less Size, Weight and Power (SWaP) requirements that previous generations of the same type of equipment. Form factor differences between narrowband channelized TDM channel banks and IP/MPLS/Carrier Ethernet equipment will need to be factored in. It is unclear on the timing of these technology refresh activities and how they may affect the FTI-2 migration effort.

Some observations to remove impediments to successful Parallel Operations

A number of these observations were derived from the LINCS-FTI migration period including some lessons learned during the FTI period. No two migrations are identical so these observations are provided as our suggestions to the FTI-2 Program as to potential areas of concern. It is also suggested that the FAA FTI-2 Program Office establish and communicate to all stakeholders, appropriate policies, criteria and operating principles relating to the following:

- Identifying relationships and dependencies between facilities –

While the LINCS-to-FTI migration strategy transitioned individual point to point circuits to FTI, which was sufficient for the simple data services at the time, the upcoming migration from FTI has an increased number of services including increased applications and data dependencies that have to be accommodated. The original circuit cutovers to FTI only involved the end points as these was just layer one connectivity. The FTI network has matured into a diverse set of services over a much wider collection of physical network connections which has to be taken into account in the new migration plan. The FTI network, unlike traditional intranets, requires that all nodes be continually available since one node may generate data or information required by every other node in the network.

Because of the new levels of complexity the traditional physical topology and dependency models need to be supplemented by dataflow and Netflow information associated with each application, service as well as the aggregate. This complete compilation of information can allow the Government to better assess the overall impact on the network and customer
during the migration period. It is anticipated that some services may be incompatible with a concurrent cutover and those additional aspects will need to be factored into the migration strategies. The migration efforts can be hampered if the scopes of management and control are not clearly delineated for all aspects of the combined networks (i.e. FTI and FTI-2 during parallel operations) and their operations.

- **Continuity of service among all locations** –

  It is anticipated that all services will span both networks during parallel operations. Since data may be generated from any node in either network and distributed to any other node in the both networks, some sort of interconnect or gateway function is required for all services and applications on the underlying network layers. This could include legacy narrowband TDM services as well as EMS (Enterprise Messaging Services), IP based and other applications. To provide visibility into applications delivery (i.e. service continuity) over the combined networks, it is suggested that appropriate metrics and monitoring be included in the design and implementation, to allow distribution of availability and other monitored parameters of the operating network. These metrics need to support both legacy and new provider as well as function during the periods of parallel operation to ascertain Service Level Agreement compliance.

- **Developing a consistent Quality of Service (QoS) across the networks** –

  Part of service availability is appropriate QoS metrics required for the successful operation of the service or applications in the NAS. In addition to the metrics for FTI, additional metrics need to be determined for the FTI-2 and combined networks. It is usually straightforward to develop QoS metrics for one network or the other, but it is more difficult to identify the components of a QoS measurement between two interconnected networks with a gateway function in between. For example, if a particular application requires a maximum of 50 milliseconds of latency in its data transmissions then each network needs to meet more stringent criteria, including the additional time through the gateway, to ensure that the total transmission time across both networks stays under the limit. The FAA needs to develop the metrics for each service type and application in the NAS and then specify corresponding QoS requirements for both FTI, FTI-2 and the combined networks. In addition, standard methods and equipment to measure QoS performance are needed to verify SLAs are being met.

- **Potential multi-vendor complex service ordering, scheduling, turn up and testing** –
Because of the increased complexities and dependencies of service types in the current FTI network, more sophisticated orchestration methods need to be developed. In many cases, the optimal service migration approach will necessitate concurrent activities across the NAS spanning multiple site locations and regions of the country. This approach requires detailed schedule planning, synchronized service ordering on FTI-2, communication with the FTI vendor, complicated testing scenarios, and eventually tightly coordinated maintenance activities. Synchronized service ordering is most likely to occur should the FAA choose an FTI-2 acquisition model which separates the WAN, Security Gateway and Enterprise Messaging services. Currently, a single order to the FTI contractor is adequate to coordinate the necessary sequence of events to implement Layer 1 through Layer 7 service components. If these elements are separately contracted, service orders and activations will need to be closely synchronized. Policies and procedures need to be developed to closely monitor migration progress and coordinate schedule modifications across all stakeholders as necessary. Later in this paper, a section on “Parallel Operations Architecture Prototyping and Testing” is provided, detailing the suggested testing methods of planned migration configurations and strategies.

• Identify NAS program unique hardware interface details –

It is anticipated that both service hardware and signal interfaces as well as other applications dependencies will be captured for the current FTI network. The variety of telecommunications provider’s service delivery options has increased since the original conversion to FTI. These options include Fiber in the Loop, Fiber to Facilities, Coarse Wavelength Division Multiplexing (CWDM) and Dense Wavelength Division Multiplexing (DWDM) to Facilities as well as Multiprotocol Label Switching (MPLS) and Carrier Ethernet. Signaling and frame formats include SONET, G.709 and Generalized Multiprotocol Label Switching – User-Network Interface (GMPLS-UNI) and Network-to-Network Interface (NNI) with Software-Defined Network (SDN) control.

Because of the simplicity and packet delivery performance, a number of enterprises are migrating to Carrier Ethernet (CE) in both the Metro and Wide area. As NAS applications get updated to support packet communications, CE is a viable option to consider. Plesiochronous Digital Hierarchy (PDH) wire is natively supported at both the UNI and the External Network-to-Network Interface (ENNI) interface points. Additionally, G.709 can simultaneously carry CE, SONET (with T1 and T3), and packet over SONET or Wave on the same physical fiber. If the interface implementation used for FTI-2 varies from the existing FTI approach, additional testing and coordination are needed.
• **NAS Enterprise Security Gateway (NESG) continuity during migration**

NESG was implemented on the FTI to allow NAS systems to securely connect to non-NAS applications. It is anticipated that this functionality will be required on FTI-2 as well as the combined networks. A number of issues in regards to the certification and operation of security devices will need to be addressed and resolved before an Authority to Operate (ATO) will be granted. As with other situations already described, which applications currently use NESG under FTI? Which ones need to use the function during the migration and which ones need it for FTI-2 has to be documented. An approach needs to be identified and thoroughly validated that will allow external (non-NAS) connections to use the FTI security Gateway while the intended NAS connections have been migrated to FTI-2. In addition, the dependency between migrating services connecting NAS systems to the NESG and eventually migrating the NESG functionality itself needs to be characterized and captured as part of the effort. During the period of parallel operations, depending on where the NESG functionality is housed, the security roles and responsibility need to be clearly articulated for all stakeholders. In addition, during any migration between two systems the attack vectors and risks multiply and will require the appropriate mitigation strategies to be implemented. Additional penetration and other testing should be performed on a more frequent basis to ascertain any open holes in the security posture and repair before they can be exploited. If the FAA considers acquiring NESG services through a separate contractor then additional integration planning, certification and operational issues need to be addressed.

• **Current and emerging services needs during the migration**

In addition to addressing the normal migration activities, there are continuing needs for NAS MAC (Moves, Adds and Changes) in the FTI network as well as the possibility of service offering differences from incumbent FTI contractors. Both the transition and MAC activities need to be closely coordinated to not interfere with each other’s objectives. Usually MACs occur on the operational network, which initially would be FTI but toward the end of the migration there could be MAC on both networks. The following evolving activities occur on FTI in an ongoing basis and need to be considered and they include:

1. FTI implements approximately 200 MAC activities per month to support changes in FAA service needs at new, moved, or decommissioned facilities. Depending on contract details on parallel operations as to whether “MAC” activity occurs on the FTI-2 or the combined network. Traditionally until the FTI-2 or the parallel network elements has been turned up and the operations team has taken over those
activities are considered deployment and not MAC activity.

2. Technology evolution in the Telecommunications Industry – FTI has already begun to respond to significant changes in the availability and support of legacy communications services used extensively in the NAS today. Carriers have started to sunset legacy capabilities such as analog private line services, local loop and narrowband channelized TDM services. At some point in the implementation of the FTI-2 network only MAC changes should occur in the legacy network and other major capability enhancements should be deferred until implemented in FTI-2.

• Safety and other Risk Management activities –

Risks of service interruptions are greatly elevated during transition, deployment and parallel operations activities in networks, especially when prescheduled service windows are not available for planned service outages. It is anticipated that additional and potentially more stringent risk management, safety and operational protocols need to be implemented for the periods leading up to parallel network operations and until the new network has been in continuous operation for a prescribed period of time. Components of the activities include additional FAA operations staffing, increased contractor involvement, oversight, and the additional liaison workload that is created by significant activity on the networks.

Preparing for Acquisition and Migration

To understand the level of effort and the associated budget, the following issues and activities need to be addressed:

• A complete and validated inventory –

For efficient operations of FTI, until the network and contract are no longer required as well as efficient transition to FTI-2 an accurate, validated and complete inventory of all components, hardware, software, applications and a myriad of other data elements, drawings, as builts, contractor and service provider documentation is required. As FTI has matured from the previous migration the number and complexity of relationships have increased dramatically in networks that have Continental United States (CONUS) wide footprints, a number of integrated moving parts that can interact at all network levels. Best database and document management practices are not to maintain copies of source data but to refresh from a single source using Application Programming Interfaces (API),
relational databases and document and object management systems are used to maintain the dynamic information not just static drawings and Portable Document Format (PDFs).

All of the data discussed in this and following sections should be maintained online, up to date and secured in a Network Information Center (NIC). One of the major customers of the NIC is the Network Operations and Security Center (NOSC) whose functions are discussed later in this document. By capturing and then maintaining this data as accurately as possible better budgeting, implementation, operations and technology refresh processes can be much less costly and more efficient. Also, Network models can be developed and used in capacity planning, migration and as a validated repository of equipment configuration information.

Netflow and other packet flow data can be captured and analyzed to indicate packet flows through the FTI, FTI-2 and combined networks. If possible, data should be accessed from sites with mobile devices or when that is not possible, drawings can be printed. Network models can be integrated with network and security management systems, IP address repositories associated with MAC and other address information as well as Voice and data Identifications (IDs) as well as circuit, cable and facility IDs. Cables, connectors and their pinouts can also be maintained on line for installation, turn up and maintenance activities.

These documentation and validation functions need their own budget, staffing, networking and computing resources and will continue for the life of the FAA’s networks. Mobile Test and QA devices can capture dynamic data on-site and immediately upload it to the data repositories. Local site resources can update their information so that all cognizant functions have access to the latest most accurate local data. Site location and service inventory data can be acquired programmatically from service providers and contractors or provided to the FTI-2 prime though the same methods. Additional uses of this on-line data include service billing reconciliation as complex billing systems have inherent inaccuracies which allows service validation. Reviewing existing service inventory against the actual facility needs (i.e., some existing services may no longer be required and can be disconnected) allows further cost reductions.

In a significant departure from the LINCS-to-FTI migration, the FTI-to-FTI-2 migration should now understand, validate and communicate the complex IP data flows interactively including representations and management of data flows that exist on both networks during the period of parallel ops. Several items of specific interest include:

1. Complete Service Definitions - The FTI network supports FAA services that encompass a complex network of point-to-point circuits from Digital Signal 0 (DS0)
to fibers with Dense Wavelength Division Multiplexing (DWDM) carrying multiple colors of light that are functionally overlaid with Layer 3 infrastructure all underpinning the Layer 7 based System-wide Information Management (SWIM) services. These services all coexist in one FTI network provided to the FAA. A migration to FTI-2 may need to provide parallel or alternative implementation services. A complete method and plan my need to be completed before executing this more complex migration effort. To potentially reduce the time, one approach may be to install and overlay network for complete connectivity before removing legacy services.

2. A plan defining the length of the migration period between FTI and FTI-2 should be considered. – The prior questions and commentary regarding the migration of service layers is directly related to timeframe required for a migration between FTI and FTI-2. For example, the migration period between LINCS-to-FTI first FTI services to the last LINCS service was about 3 years that began only after an extensive planning and testing phase. Again, this was a rather simple layer 1 point-to-point migration, whereas the FTI and FTI-2 parallel operations will require a complex multiple layer network infrastructure to support a migration of services. Layer 7 services cannot migrate to FTI-2 until the requisite Layer 3 FTI-2 network is established and the Layer 3 FTI-2 network cannot exist until the Layer 1 FTI-2 network is established.

• An in-depth knowledge of usage and bandwidth volumes –

It is necessary that a complete understanding and characterization of both the bandwidth uses and needs of each program within a facility be identified and an aggregate for the entire facility. One of the more efficient ways to obtain this information is from equipment statistics that are captured in real time and then displayed interactively. This real-time data and statistics can be feed into a relational database model which contains the topology geography of the network and all links and circuits, but planned or provisioned bandwidth versus actual bandwidth. As expressed by members of the Implementation and Transition subcommittee, there are anecdotal instances where programs no longer require the currently provisioned bandwidth, and correcting for this could simplify the migration activity. When developing this usage data, it is important to accurately represent different bandwidth provisioning paradigms across the NAS. As an example, smaller FAA facilities are provisioned with bandwidth representing the sum total of all application needs within that facility, unlike larger FAA facilities where provisioned bandwidth is managed based on utilization to accommodate the stochastic nature of the ever-increasing packet-based traffic at those
locations. One of the reasons to create a dynamic data model is to accommodate design changes in the network as well as these following scenarios:

1. **Service Criticality.** The FAA has different service criticality levels which are partially defined by Reliability, Availability, and Maintainability (RMA) factors as well as the nature of the traffic being transported. Regulated telecommunications vendors have routinely transported life safety, executive override and National Command Authority (NCA) communications for years. Part of the dynamic data model for the FTI-2 is to tag data flows by application, location, RMA, life safety and other pertinent criteria so that those elements can be factored into the migration plan for both parallel operations and beyond.

2. **Management of “Emerging Service” introduction during the FTI-2 migration.** It is anticipated due to the dynamic nature of the NAS that enhanced or new services may need to be deployed as part of the migration effort. It is assumed that these services will be complaint with the FTI-2 design or be used for a brief period of time during the actual transition period and then removed from the network. Any additional non-production services need to be fully characterized, tested, validated and integrated into planning, design, deployment and operations. The deployment of these systems will be at increased risks because there will be no period of normal quiescent operation before adding the additional components, bandwidth and management systems. It appears that the NAS Voice System (NVS) deployment is currently planned for the same timeframe as the FTI-2 implementation. Networking best practices discourage this level of change in a network that needs to maintain absolute stability and operation. The decision to inject additional potential chaos into this critical activity should be carefully considered by Agency Executive Management. Unless the replacement FTI-2 network is completely deployed and characterized before migration activities begin, there will be no baseline to compare activities when the new services are turned up to identify the actual trouble locations.

   Depending on the technology needed to implement the new functions, for example, Carrier Ethernet, MPLS or straight IP flows they could potentially be managed as additional capacity on the network.

   • **Technology refreshment and new service delivery methods.**

   Larger footprint telecommunications providers are standardizing their service technology and delivery methods across their geographic footprint. They are delivering service over fiber and
enhancing the network management and service ordering function by driving to software controlled and defined networks. There will continue to be a potpourri of local loop delivery systems where data and voice may be converted and then transported over the fiber backbone infrastructure. If local area delivery is migrated to Ethernet than interconnecting with Carrier Ethernet can deliver the underlying frames and packet payloads across the backbone in a more efficient and timely manner. The leveraging of fiber and other more efficient and cost effective technologies is a major component of the deployment of FTI-2. Utilizing different delivery methods or complete end to end system changes require careful planning and integration into the over acquisition and migration effort. As the FTI network is already in place, any technology refreshment for it alone would be stranded investments, so those resources should be applied to activities with a longer operational lifespan. Some specific areas of concern include:

1. Device End of Life – It is anticipated that some network elements may reach both end of life and support during the transition. While there are Federal Laws that can be used to mitigate this situation it extreme circumstances, it is more appropriate to validate the end of life periods on any operational equipment and software in the planning and design phase. Mitigation strategies can include inventories of parts and devices with third party maintenance, third party acquisition of the product for continued support or black box replacement of the equipment.

2. Service Provider abandonment of services – While Service Providers have abandoned copper plant in rural areas where the replacement costs are too great, federal acquisition regulations appear to discourage this during the life of signed contracts. Contracts normally require notice periods for service termination for any reason. Unless the contacts specifically prohibits, carriers can replace underlying infrastructure as long as it is done with no service degradation or interruption. This process has occurred in large parts of the access networks as they transitioned from copper to fiber in the loop and then fiber to the actual premise. Certain percentages of carrier aging copper plant has been acquired by CLECs and alternative carriers who go not have the same reach as larger carriers.

3. Integrated device management – Depending on the architecture of the deployed networks during parallel operations, some level of coordination may need to occur between the two different Network Operation Centers, one existing for FTI and the new one for FTI-2 that may be collocated with the existing Network Operations Centers (NOC). Normal device management functions may need to be coordinated across both networks.
• **Special requirements.**

The LINCS-to-FTI migration uncovered many instances of non-standard and site-specific service interface implementations that were not documented and it is assumed not noted for the ATO or equivalent FAA process. There may still be situations that are not only unidentified but not understood by support and operations personnel. If this non-standard interface is supported by the manufacturer and their maintenance agreements but is not an FAA standard interface that is both a policy and documentation issue for the FAA and their contractors. If the modification is not supported by the manufacturer than other more serious issues may be involved. Since these interfaces were not documented at the time of installation, it is difficult to ascertain if proper testing and certifications were completed. As these undocumented cases are discovered, it is usually good policy to test, validate, document and certify for current and future network stability. It was also noted that these implementations and hopefully the associate designs were not filed in a device or cable configuration or other documentation system. Identifying, cataloging and having a complete understanding of the function of these potentially non-engineered, untested configurations should be part of each site’s on-line documentation packages as well as being available across the network. As part of the site survey or normal maintenance procedures it may be appropriate to convert these anomalies to “standard” FAA configurations to reduce the increased risk of abnormal behavior or service outages. It is up to the FAA whether this series of activities should be performed by the FTI, FAA or FTI-2 contractors but it is strongly suggested that these situations be resolved to a known state or status rapidly before the complexity of a major transition effort.

• **Accounting for any FTI network complexities -**

All FTI-2 stakeholders should have a thorough understanding of the FTI network including some of these factors:

1. The interrelationships between the operational network and the security applications - The FTI utilizes the NESG for secure connections between NAS and non-NAS applications and data sources. The scope and timing of having NESG available for the combined network or FTI-2 alone needs to be addresses in any planning activity.

2. The NAS Enhanced Enterprise Messaging Service (NEMS) is a Service Oriented Architecture (SOA) application which provides the NAS SWIM capability. The
efficiency and effectiveness of the system over the new transport network may need to be evaluated and tuned to meet FAA requirements.

3. There is a minimal interconnection between the NAS and administrative networks (Mission Support) that utilizes the FAA’s Remote Monitoring and Logging Systems (RMLS) among other applications. How this is handled in the operational FTI-2 and combined networks needs to be addressed.

Unique Infrastructure and Service Types

The section identifies several technical issues that may require additional examination during combined operations. These are:

1. Timing coordination and synchronization are required for the successful operation of the network. FTI already has a deployed timing system and it is anticipated that FTI-2 will have a similar capability. During the combined operations period synchronization issues have to be addressed between the two networks and all carriers. There are a number of timing methods that include Global Positioning System (GPS) based timing receivers, T1, T3, SONET carriers, fiber based G.709 and other methods.

2. Internet Protocol version six (IPv6) adoption velocity has accelerated across service provider backbone and access networks. Wireless carrier networks are almost exclusively IPv6 and all cellular phones for the last three to five years only have IPv6 addresses. Office of Management and Budget (OMB) is in the process of giving additional guidance to all CIOs and acquisition shops, through the Federal Acquisition Regulation (FAR) process, that no new major multi-year acquisitions occur without having appropriate IPv6 functionality. It is anticipated that this requirement will also be inserted in all FAA and other Department of Transportation (DoT) agencies acquisition guidelines. In the past waivers were required from the Department Chief Information Officer (CIO), but new policies may/will not allow waivers in the future because of the deprecation and potentially retirement of the IPv4 protocol in the Internet backbone. Some backbone carriers have already announced they will only be allocating IPv6 addresses for future customer needs. Chatty IPv4 layer 2 protocols are replaced by IPv6 link layer protocols and limited IPv4 Multicast groups are replaced by much more efficient Anycast groups. Potentially implementing an IPv6 based FTI-2 network as a virtual overlay, during the parallel process, at both layer 2 and 3 may be an appropriate method to
mitigate maintaining obsolete IPv4 protocol constructs. If FTI-2 implements Voice over Internet Protocol (VoIP), IPv6 is almost required to be able to address and manage the expanding number of IP addressed devices on the network. It is strongly suggested that the FAA and/or the current FTI contract holder continue or enhance network device testing and interoperability on the IPv6 protocol.

3. It is anticipated that some form of the existing IP Multicast services on the FTI network, will need to be implemented on the FTI-2 Network for the interim combined network and then for the single one. With the potential change in layer 2 technology, use of IPv6 instead of IPv4, MPLS, and other technologies that could be leveraged for FTI-2, the design and engineering of these new methods are required. For example, some layer 3 multicast groups may become layer 2 Virtual Local Area Network (VLANs) over Carrier Ethernet delivery.

4. While analog multipoint/multi-drop services currently exist on the FTI network, it is anticipated to handle combined operations, that early on these analog services may be converted to digital either with Integrated Services Digital Network (ISDN) or VoIP technology. The control channel signaling as well as the advanced voice CODECs support larger multipoint/multi-drop groups while removing analog systems noise that normally restricts the size of multipoint analog services. ISDN BRI and PRI services use the same T-carrier systems with either an analog or digital interfaces to the T1 channel card.

5. It is assumed that some manner of capability to support the serial multipoint for Radar Services will transit both the combined and the FTI-2 network. Both the combined and FTI-2 networks need to have the appropriate mechanisms to support the NAS Radar multipoint service.

Financial Planning and Funding

There are three components that potentially need to be funded and they are continued FTI operations, design, development, testing, deployment and turn up of the FTI-2 and coordinated combined operations which are required because of the close interactions between the two networks to maintain required operations during the transition period.

While normal FTI operations can be estimated with a yearly cost increase, the amount of effort required from the FTI vendor during the combined network period is difficult up to ascertain up front. Depending on how funding from Congress is obtained, resource estimates of next phases of the project need to be derived from the design, development and installation schedules.
If the network is to be funded from program budgets, then these dollars need to be aggregated with additional base funding developed for the underlying transport infrastructure.

It is suggested that a service order reconciliation function be setup to audit all parameters of the ordering and billing processes for both NRE and monthly service charges. For efficient auditing purposes, billing cycles should be normalized to the same period with a short initial bill and then adjusting to the agreed to billing cycle parameters.

The migration plan is a living document and should be used to minimize costs until the sites and services have to be installed. Funding for additional Subject Matter Experts (SMEs), FAA and contractor tiger teams should be available to allocate as those resources are needed. If sufficient active duty FAA resources, are there individuals who have retired or move to other employment that would consider short term contract positions in areas of the country where they are needed. Veterans with military communications experience are valuable and bring existing Government service to bear.

**Developing the Migration Plan**

The FTI-2 Program Office needs to develop a multi-faceted, complete, realistic migration schedule and milestones that supports the successful collaboration of all stakeholders in this complex, multi-party environment. The following are what the group considers some major issues that we suggest need to be addressed in the plan.

1. **Development of a comprehensive Migration Plan and schedule**

   For purposes of this discussion we will assume a single overall prime contractor which would not eliminate the potential for multiple awards for different areas and functions of the network and services.

   Planning for a complex services network of this size entails identifying all of the foundation projects on which the network is built and then addressing the services requirements of each layer so that like building a structure you have to put in the foundation first and then build succeeding layers on top of the foundation. One approach would be to design and engineer the backbone(s) of the network at the optical, layer 2 and 3 first and then add in sites as any site-specific work is completed. There are a number of sites across CONUS as well as Outside the United
States (OCONUS) so to reduce the total amount of installation time, it is assumed, that activities will be taking place in parallel at multiple sites. It is also anticipated that each site will require a site survey, review of requirements and services and then an adjustment to any general design and engineering documents because of site specific criteria. This presupposes that the Prime, FAA and all major and minor carriers have developed, tested and are ready to deploy these services to all appropriate sites.

At the same time, there is an FAA site survey, there is an associated carrier site survey to ascertain that the carrier has specific facilities required to provide the services to the Prime contractor and the FAA at that location. Any needed facilities should then be blocked out for exclusive use of the contractor. When facilities are not available, the service provider should install them and availability dates. The amount of the NRE (non-recurring engineering) charges needs to be part of the negotiation for the service order.

To obtain a complete CONUS, OCONUS network footprint, a number of major carriers and other service providers will be part of the team. The implementation team can either be in a central location or regional groups can operate under a national coordinator. During the design, engineering and implantation phases, it is best practices to have FAA, Prime Contract, Service Provider technical and operations personnel co-resident during the planning, design and implementation phases of the project.

As part of this effort, the team should mutually develop and establish an overall migration plan to include a master program schedule, site and service specific implementation planning details, site and service cutover and acceptance procedures, and as-built drawing package guidance with buy in from the FAA National, as well as local, field level management and technical personnel. Roles and responsibilities of all parties should be established and communicated to all levels of the FAA.

A concern about the overall plan is that it is a role up of shifting sands as at each site there is the traditional best, medium and worst case deployment scenarios that are very elastic especially with unavailable carrier facilities. Risk management and mitigation planning pertaining to any these mundane and more critical milestones with potential to impact the schedule should also be outlined with possible
executable steps. Qualitative, quantitative and measurable milestones should be
developed to track migration progress.

As was identified in the previous migration effort, appropriate resource allocation
from the FAA, Prime and other contractors as well as carriers is critical to smooth
implantation and efficient implementation. As there will be a rolling schedule of
which sites will have active work at then and therefore will require the appropriate
number of escort, contractor and other personnel, scheduling of these sites needs
to be undertaken when the personnel free up from other sites. It is critical to this
scheduling process that FAA sites, carrier services and vendor equipment sync up
for a rapid but stealth installation and turn up. It is anticipated that FAA will need
supplemental personnel during these activity periods for both normal NAS
operations as well as the migration efforts.

It is anticipated that the successful bidders on the contract will be experienced tele
and data communications companies with appropriately trained management and
technical personal.

2. Providing a complete, validated inventory of FAA and network elements

Before detailed project planning can take place an on-line complete, detailed and
validated inventory of equipment, applications, services and facilities needs to be
available. This aspect of the project needs to have adequate resources (funds,
people and equipment) to provide an accurate corpus of information that planning,
design and installation effort is fully based on. This information needs to be
combined with the design, installation and as built documents for ongoing
troubleshooting and operations that will be accessed by the NOSC. In additional
operational practices and procedures should also be on-line as well as any site-
specific exceptions. This process will require the tools, processes and procedures be
in place prior to the kickoff of the site and carrier survey process. This could also
impact workloads at the affected FAA facilities. A discussion of the tools that are
commonly used for this function was discussed earlier in this document.

3. Detailed migration planning by location and service.

It is anticipated that the FTI-2 Program Office will provide guidance and
requirements to the vendor on a per facility basis including required functionality,
any site-specific criteria with mutually acceptable design data in an online form. The installation team will adhere to all FAA National as well as local power, grounding, space standards and specifications and respond with a detailed site specific implementation plan per facility, including carrier requirements which will be reviewed and approved by the cognizant FAA, service provider and contractor personnel.

The site plan should address all pertinent issues of various dates, times, PoCs, shipping, receiving and equipment staging information as well as approved work schedules. The area coordinator, previously discussed can work with all parties to assist in the smooth operation of the deployment team and actual installation process. Site and district technical and management personal need to be briefed on the specific of each plan. A major element of the plan is how both the existing FTI and new FTI-2 equipment, services and access can be accommodated in space, power and weight challenged facilities.

The FAA, contractors and carriers should follow all documentation standards and tailor the engineered solutions to the different classes of sites. One method of standardizing installations plans is to identify critical criteria and group similar sites in their own class. The designs for the deployment of these classes of sites should be verified prior to deployment following the normal FAA processes. It is father suggested that Key site demonstrations be accomplished to fine tune both the requirements and the plans for wider adoption.

4. **Site surveys requiring physical access to sites by vendor personnel.**

It is anticipated that the site survey team will be composed of FAA technical resources, contractor and service provider personal as suggested in contract documents. The team can perform the site surveys at the FAA, service provider and any facility access locations required for service deployment. It is strongly suggested that site surveys be performed at all locations to validate pre-installation, installation and deployment requirements and statements of work (SOW). The FAA will have to provide all security, escort and other access requirements, including work hours, as a number of these facilities are in airport and other security zones.

5. **Development and placement of service orders.**
It is suggested that a group of service order teams be composed of FAA, contractor and service provider personal to effectively and efficiently develop and execute contractor and carrier orders. It is further suggested that these teams have direct access to customer ordering portals for all vendor services or that the vendor representative on the team execute the order function. The service provider site survey for the serving facility will be complete and any additional facilities construction orders will have already kicked off prior to placing any specific circuit orders. The early kickoff of potentially major construction orders is required for a number of FAA circuit and services because of service level diversity and avoidance requirements. It is strongly recommended that if diverse paths are available that they be contracted instead of new facilities constructed. It is especially critical that appropriate demark and any extended demark locations be specified for the services as well as any electrical and mechanical specifications. Accurate site addresses including E911 addresses, access requirements, PoCs and other necessary information needs to be available.

Once orders have been placed they can go to a service fulfillment desk to be closely tracked by other contractor and service provider personal. Any vendor circuit or order status change will either be directly acquired from the carrier’s provisioning systems or entered in real time by carrier personnel. The status should be integrated with the on-line, real time project management system.

6. **Coordination of commitment dates with local exchange carriers.**

Because of the size and length of contract award to the selected carriers, high level service provider executive management involvement is required in the project. Normally carriers utilize Major Account Teams whose job is to coordinate all activities between internal carrier resources and an authorized list of customer representatives. Typical firm carrier delivery dates range from weeks to months depending on the required but limited engineering resources available at the carrier. It is suggested that carriers commit under the contract for sufficient engineering resources to fully support the FAA deployments in their regions.

Depending on the architecture of the FTI-2 network, there may be initial carrier orders for sufficient facilities for the site with follow on actual turn up service on the encumbered or newly installed facilities. Firm service delivery dates are only valid after both the FAA site survey and the carriers site survey and contractor and carrier
engineering work has been completed and senior carrier management has signed off.

Once service orders have been placed, also most constant feedback from the carrier is required to verify actual service provider milestones have been completed. This activity is one of the purposes of the service fulfillment team previously identified. Service installation requires timely access to the FAA sites for installation, on site verification, testing, turn up and delivery to the customer. The service fulfillment function with update on-line schedules and allow the service order teams to work on alternative strategies if appropriate.

7. Special needs Engineering

One of the design criteria for the FTI-2 network is to be flexible and adaptable to current and future FAA requirements. These capabilities are to ensure that a high percentage of sites and services can be provided with standard, engineered and tested configurations. As part of the detailed site surveys any non-standard FTI installations need to be identified, documented and determined if these anomalies are to be corrected or maintained during either the combined network phase or supported under the FTI-2 contract long term. If FAA management approves the required additional funding then the design, engineering, unit and systems testing as well as extensive integrations testing has to occur before any site deployment activities can be scheduled. The FAA needs to establish the processes around these engineering activities as they will be design deviations whose lifecycle costs will far exceed the initial engineering and implementation costs.

These projects should be extensively reviewed by the technical teams to understand their scope of impact and then signoff by high level program management should be obtained.

8. Program communications plan and change management.

For rapid dissemination of program, project and status information there needs to be designated PoC’s assigned for national, regional and FAA district level communication, dissemination and discussion of all migration issues and activities. Daily, weekly and monthly national and local level conference calls will probably be led by the appointed FAA leads to discuss, track, manage and communicate scheduled task completions and any changes and resolution towards recovery post
schedule slips. For sites that may not have resources for a dedicated program representative, it is suggested that an area resource be assigned to work with these sites during the survey, planning, installation and turn-up phases to smooth transition activities with outside contractors and service providers.

Commercial best practices, have periodic calls with carrier executive management to discuss escalation of issues with carriers and other service providers. Team personal should have contact information for the carriers Major Account Team that is working the contract including, technicians, supervisors and management personal. These executives should sign off on the availability of carrier facilities once the carriers’ local site survey is complete.

It is envisioned that the FAA or contractor will provide a web based scheduling systems to maintain all schedules and changes for the program and all of the associated projects. This system will incorporate the appropriate change management capabilities.

9. **Network and Service Order Management**

In addition to the current FAA/FTI NOC it is anticipated that a FTI-2 NOC will also be stood up in concert with the current one. It is presumed that some level of integration will be required between the two systems or the new FTI-2 feeding into the older FTI NOC.

For Cloud and large customers, carriers have provided Customer ordering portals with MAC capability for direct use be the contractor or FAA resources. It is the opinion of the group that this should be a contract requirement for major service providers and this capability be provided at no cost to the Government. If this interface is not available than carrier service ordering personal should be collocated with the FAA service ordering function.

10. **Accommodation for new construction (Facility, access, carrier infrastructure)**

Because of the afore mentioned carrier site survey, all special construction should be identified in the planning phases of the project and factored into the migration plan and schedule for the site. If there is a carrier induced delay, then that situation should be handled in the contract. No actual installation steps should be started until all pre-installation checklists have been completed and approved.
Other potential options are reviewing options for temporary diversity or avoidance waivers as well as consideration of a hot cut option with a fall back plan. It is assumed, all options will be discussed within the agency and reviewed by FAA and air traffic personnel for approval.

11. **IP addressing administration**

It is anticipated that for the complexity of the combined network and automated IP address management system will be implemented. For IPv4 or IPv6 networks this system needs to coordinate any IP addresses whether assigned by the system, Dynamic Host Configuration Protocol (DHCP) or some other automated process. The IP addresses should also be associated with any Domain Name System (DNS) records, MPLS domains, Virtual Routing Functions (VRF), or Virtual Routing (VR) domains. No manual entry of IPv4 or IPv6 addresses or network device configuration files should be allowed. All addresses should be obtained from the cognizant FAA or other address authority. Proper security measures need to be implemented on all internal and any externally connected infrastructure. In addition, any risk to the NAS from these activities either inadvertent to deliberate need to be mitigated. The automated system should be able to manage all IPv4 and IPv6 address blocks, delegations and address assignments.

12. **Agency and regionally-specific moratoriums.**

It is anticipated that there will be FAA National and local site specific moratorium periods which will need to be incorporated into the planning and installation process. Waivers and guidance may be provided alternatively as agreed to upon a facility by facility basis.

13. **The need to implement unanticipated special features or enhancements.**

The FTI-2 team should potentially anticipate and plan resource allocation and scheduled task interval decrements in order to implement unanticipated design and feature enhancements required nationally, network wide, per site or on a service specific basis. These should only be approved after extensive review of the migration process and how this can affect the anticipated end date. Process and procedures for any enhancements or modifications should be tested and documented in a current FTI-2 scenario test bed, which probably not be known at the time, prior to incremental deployment in the field. If it assumed that this
additional capability would be rolled into the sites not yet migrated and after they are complete, go back to already migrated sites. These activities cannot be anticipated in the awarded contracts and would require additional funding to be available for the affected contractors and FAA personal.

14. **Multilevel Network Technical and Operational issues**

The FTI-2 will be a multilevel network encompassing a wide variety of physical distribution media and potentially complex interlayer dependencies in providing upper layer services. Some of these technologies include narrowband, channelized TDM, IP, satellite and microwave as well as the mission support and network operations as well as NESG functionality. It is anticipated that the design and migration plan will consider all of these options and implications.

**Parallel Operations Architecture Prototyping and Testing**

It is presumed that extensive design and evaluation testing be performed on both the FTI-2 and combined network prototype. If this testing is done at one facility it is suggested that link impairment and long line simulators be used to test in a full CONUS environment. A more advanced scenario, would be to use the FTI carriers’ network to have nodes at different parts of the country to more realistically simulate a large multilevel network. It is assumed that there is a FTI testbed available for use as part of the engineering and design effort. Once the architecture and services have been defined a comprehensive set of test scenarios need to be developed and implemented. Standard equipment configuration templates can be developed that will be modified for each facility as required. Testing for the combined network will be limited until contract award and the FTI-2 architecture and design are known. It is assumed that the first phase of the contract will be for the design, architecture, prototyping and testing before more detailed planning can begin.

Since any proposed testing is limited, it is suggested that complete network models be developed and simulated as one of the first phases of the testing regimen.

Some of the areas that prototyping and first article testing should address are:

1. Basic FTI-2 architecture, design and implementation to establish a benchmark baseline on the new multilayer network design
2. Advanced testing on supporting required services and legacy equipment
3. Integration testing between the new FTI-2 and legacy FTI network
4. Combined network operations analysis
5. Because of modern network technology a number of one-offs should be removed by the new design. Because of the enormous cost of one-offs, each one should be reviewed by FAA
technical management and then signed off at the Program and agency level before testing can commence. Some number of one-offs should be removed in the FTI-2 design.

*Interconnecting FTI and FTI-2 for a Combined Network.*

Once the FTI-2 network has been architected, designed, implemented and tested, then the integration with the existing FTI network has to be determined, designed and implemented both for the testing and production environments. An appropriate FTI-2 implementation strategy will drive how the network will be interconnected and what traffic may need to transit which network to what destination. Assume you completely deploy the FTI-2 backbone and then you connect to sites where you test the network in a non-production mode. Once you have an ATO you begin to connect the service generation points to the FTI-2 not disconnecting the FTI network. At the site, you have the service on the old network as well as the FTI-2 network. If you do a cutover you still have both services available at the site with a rollback available.

Some of the interconnections methods could be Carrier Ethernet that allows bridging of various VLANs with switch routing to interconnect different domains. If at the IP layer you can run an exterior gateway protocol between the two networks with interior protocols running intra Autonomous System Network (ASN). You could have an IPv4 or IPv6 VRF or routing instances on interconnected routers.

In addition to standard transport interconnects, it appears that gateway functionality is required for NESG and NAS NEMS should be. Some elements that should be considered are:

1. **Gateway locations, capacities and capabilities.**
2. **Gateway design considerations.**
   i. IPv4 / IPv6 Multicast or IPv6 Anycast
   ii. Will Multicast Source Discovery Protocol be implemented?
   iii. Integration or overlay of MPLS Networks
   iv. Are ED-8 gateways to be supported?
3. **Special considerations for NEMS gateways.**

NEMS has the same complications as any other IP service as well as a reliance on the NESG, Mission Support, and the NAS Operational Internet Protocol (OPIP) network. For combined NEMS operations, determining which system produces and
consumes, and into which location, has to be determined. Additionally, the current FTI NEMS has equipment at the FTI Primary Network Operations Control Center (PNOCC) used for their remote sites to publish into, offering data to the customers.

**Development of appropriate Migration SOPs. MOPs and EOPs**

It is anticipated that following FAA guidelines, Standard Operating Procedures (SOP), Methods of Procedures (MOP) and Emergency Operating Procedures will be developed for both the combined and FTI-2 networks. Once design and testing has validated configurations SOPs and MOPs can be generated, tested and validated in the FTI-2 and combined operations testbed. For example, once the MOPs have been developed, it is good practice to give the MOPs to a separate and isolated group to verify the MOP steps. These like all other documentation should remain under configuration control in an online, interactive documentation management system.

**Establishing a chain of command for the FTI-2 and combined networks**

The FAA currently has a well-established chain of command for the FTI network including contractors, service providers and equipment vendors. Operations, engineering, maintenance activities are all coordinated through the current processes and procedures. Some major challenges are when to stand up the FTI-2 chain of command for operations to take over from the chain of command for deployment and installation. The FTI network has to continue to run flawlessly and accommodate the installation and migration activities to the FTI-2. There are a number of network management and control functions that will be occurring on the combined network which means command and control has to be extended to the entire network by the FAA and cognizant contractors. Some of the issues include:

1. **Clearly defined Roles and Responsibilities.**
   
   It is anticipated that the FAA will clearly assign roles and responsibilities between all participating entities, establishing a clear hierarchy and escalation processes that encompass all contractors and service providers. Elements to consider include maintenance requests on one or both networks, how are they to be coordinated and de-conflicted? Who is the cognizant decision authority during the process? What are the contractual obligations between the FTI, and FTI-2 prime contractors and their associated subordinates?

2. **Identify scopes and rules of engagement for the Legacy FTI and FTI-2 NOCs**
It is assumed that a separated but close FTI-2 NOC will be implemented early on in the process to allow the installation and operation of the network management and monitoring network. Besides in-band management it is best practices to utilize an out-of-band (OOBA) network for initial configurations to bring the network up, and for emergency situations when there is no in-band connectivity to the device or network area. Depending on the structure of the FTI-2 deployment as to how procedures will work between the two NOCs until the FTI-2 is fully operational and the obsolete elements from FTI are removed from the network. For example a tipping point may be identified that has the FTI NOC is full charge of the FTI-2 NOC until that point or combinations of events transfers primary control to the FTI-2 NOC.

Initially it can be envisioned that the current FTI NOC capabilities be strengthen and enhanced to handle management and control of the initial deployment of FTI-2 systems until sufficient resources are in place that the FTI-2 NOC will assume control. There are a number of issues surrounding the NOC and chain of command structure that need to be normalized prior to active planning and deployment.

**Conclusion/Suggestions**

Migration from the current FTI network to its successor FTI-2 network represents an abundance of challenges that need to be addressed when planning for the period of parallel operations. The FAA can review the LINCS-to-FTI migration as an example of historical issues and problems to anticipate, and study the implications of the current FTI technology. To ensure the areas of complexity of this effort are fully addressed, best practices suggest the FAA identify this period of parallel operations at a full project level with its own requirements development, program planning, architecture definition and operations planning fully integrated into the FTI-2 program for success based outcomes. The table below summarizes the tasks suggested to address the period of Parallel Operations as a phase of FTI-2 deployment. Following is a suggested list of elements the team has identified to smooth the migration effort.
### Some pre-planning phase activities

<table>
<thead>
<tr>
<th>Suggested Activity</th>
<th>Potential Success Criteria</th>
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| 1. Collect, maintain an intranet web page of current and validated sites and services inventory | • Validated facility address and phone numbers representing the desired demark location for terminating Telco access  
• Validated facility-based service list accurately representing service type, count, and interface specifics – specifically non-standard implementations  
• Validated facility resource availability in support of parallel ops deployment (space, power, cooling, grounding)  
• Final facility-based usage and bandwidth models |

### Phase: Program Planning

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<tr>
<th>Suggested Activity</th>
<th>Potential Success Criteria</th>
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</table>
| 1. Develop a comprehensive migration plan and communicate across all stakeholder ecosystems | • All stakeholders have been briefed and understand the FTI-2 capabilities and associated migration plan  
• The migration sequence and dependencies have been defined and optimized  
• FAA support resources have been identified and are available |
## Phase: Program Planning

<table>
<thead>
<tr>
<th>Suggested Activity</th>
<th>Potential Success Criteria</th>
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<tbody>
<tr>
<td>2. Determine Carrier Limitations</td>
<td>• Understanding of available access facility capacity (e.g., available pairs)</td>
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<td></td>
<td>• Understanding of local and regional Carrier capability (e.g., ability to support native TDM or Analog service)</td>
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<td>• Identify network component obsolescence and end-of-support conditions and prioritize migration events for these elements</td>
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<td></td>
<td>• Identify (where possible), or have contingency plans in place for, instances of carrier abandonment of access or transport infrastructure</td>
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<td></td>
<td>• Migration plan inclusion of necessary coordination of services having dependencies across the OSI stack as well as Admin and Ops network dependencies</td>
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<tr>
<td>3. Identify and plan for industry trends during the period of parallel operations</td>
<td>• Ensure adequate budget to fund Parallel Ops activities</td>
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<td>4. Identify and accommodate complexities represented by FTI</td>
<td></td>
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<tr>
<td>5. Business Planning</td>
<td></td>
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</tbody>
</table>
## Phase: Architecture Definition

<table>
<thead>
<tr>
<th>Suggested Activity</th>
<th>Potential Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Implement high fidelity test environments at WJHTC for performance of prototyping and migration testing</td>
<td>• Successful execution of test cases reflecting the more complex migration scenarios as well as parallel operations configurations having dependencies on simultaneous use of both networks.</td>
</tr>
<tr>
<td>2. Gateway definition and deployment</td>
<td>• Identification of required gateway locations, capacities and capabilities.</td>
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<td></td>
<td>• Installation and verification of Gateway functionality</td>
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</tbody>
</table>
Phase: Operations Planning

<table>
<thead>
<tr>
<th>Suggested Activity</th>
<th>Potential Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Establish Parallel Operations Command Structure</td>
<td>• Defined Roles and Responsibilities for all stakeholders in the migration effort.</td>
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<td></td>
<td>• Established infrastructure, procedures and escalation protocols</td>
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<tr>
<td>2. Development of migration MOPs</td>
<td>• Specific MOPs developed for planned migration sequence</td>
</tr>
<tr>
<td></td>
<td>• Procedures in-place for closed-loop lessons learned incorporation</td>
</tr>
</tbody>
</table>

Authors & Affiliations

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