VDOT NOVA-Centric ITS Architecture
Advancing Northern Virginia's Transportation System

Executive Summary

VDOT
NOVA ITS Architecture

Smart Travel
VIRGINIA

A Message from the Project Leader . . . . .

It is my privilege to present to you the Virginia Department of Transportation, Northern Virginia District's VDOT NOVA-Centric ITS Architecture! As leader of the NOVA ITS Team, which developed the Architecture, I am proud of the work that we have accomplished. Whether you are a stakeholder in Northern Virginia, an industry professional, or just have an interest in transportation issues, I believe you will find the enclosed Executive Summary and CD to be enlightening and useful.

Strategically situated in the National Capital Region, VDOT's Northern Virginia (NOVA) District is a burgeoning, vibrant area of international importance. Its robust economy, attractions and desirable communities create unique opportunities and challenges for agencies operating and maintaining the region's transportation system.

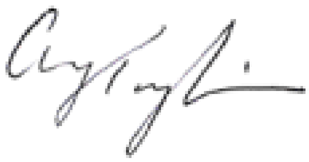
To address these challenges, VDOT utilizes Intelligent Transportation Systems (ITS), under an integrated and intermodal program called the NOVA Smart Travel Program. The success of this program hinges on the ability of VDOT and the Myriad County and local transportation, emergency response and enforcement agencies to cooperate, communicate, and exchange information. To maximize the effectiveness and efficiency of this program, the NOVA ITS Architecture was developed which details the interconnection of VDOT facilities and stakeholders, and describes the flow of information between these agencies and VDOT NOVA operations. The Architecture program included a comprehensive Outreach effort to garner involvement, input, and consensus from stakeholders.

"Cookie cutter" approaches cannot adequately address transportation needs in an area like Northern Virginia. To truly meet the needs of the region, the NOVA-Centric ITS Architecture had to be both strategic and unique. The Architecture's strategic nature is evidenced in how it meshes with Architecture efforts in Maryland and the Washington Metropolitan area, in the significant participation of stakeholders other than VDOT, and through VDOT's role as a "champion" driving the process to successful completion.

The VDOT-championed Architecture process emphasized elements such as development of an "Asset Baseline" to catalog infrastructure and communications assets; a robust Stakeholder Outreach program; and development of a Communications Plan that guides implementation of the Architecture. Finally, unique to the VDOT NOVA-Centric Architecture is the development of a plan for how the Architecture will actually be used to program and implement projects.

The result of this effort is a "living" Architecture that meets current needs, flexibly responds to a dynamic transportation system, and provides framework for future planning and integration. The NOVA ITS Architecture is the prototype Regional Architecture for all of Virginia, and offers a successful model for the entire nation. For a more detailed look at the NOVA ITS Architecture and Communications Plan, please visit www.vdot-itsarch.com

Yours sincerely,



Amy Tang McElwain
VDOT NOVA Smart Travel Program Manager

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1 INTRODUCTION

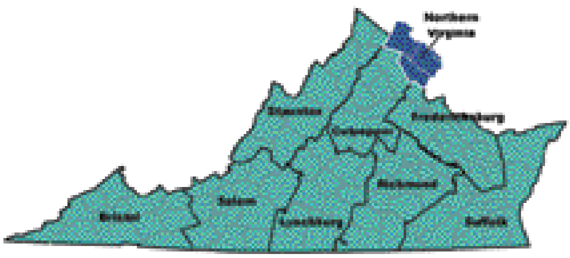

Figure 1-1 Virginia Department of Transportation District

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Additional information about the NOVA ITS Architecture Project, including all related tasks and project reports can be found online at the following web address:

http://www.VDOT-ITSArch.com

Series of Documents

- Executive Summary
- Outreach Report
- System Architecture
- Communications Plan
  - ITS / GIS Assest Report

As part of the ongoing effort to improve the quality of transportation throughout Northern Virginia (NOVA), the Virginia Department of Transportation (VDOT) has adopted the NOVA Smart Travel Program, utilizing Intelligent Transportation Systems (ITS) to achieve program goals. ITS plays a vital role in improving transportation operations and providing information to travelers (e.g., alerting about accidents, road work, or congested areas). ITS is used in conjunction with various other conventional engineering programs and techniques that are already in place. Being systems, these ITS solutions should not be deployed in isolation, and will require regional integration for the benefit of the transportation customer.

The Commonwealth of Virginia is segmented into nine transportation districts, as shown by Figure 1-1. The VDOT NOVA District covers Arlington, Fairfax, Loudoun, and Prince William Counties. VDOT NOVA builds, maintains, and operates freeways and primary roads within the district, and operates traffic signals throughout Fairfax, Loudoun, and Prince William Counties. There are numerous other units of local government within NOVA, which are responsible for operating and maintaining the secondary roads and providing emergency response services in their jurisdictions.

In recognition of the value of a fully integrated and cohesive transportation program, VDOT embarked on the development of an ITS System Architecture for District 9, NOVA. There are many inter- and intra-state roadways and transportation facilities within the NOVA District, traversed daily by local and regional travelers. There are also numerous public- and private-sector agencies (stakeholders) within the district and surrounding region that provide transportation-related services and/or are substantial users of the surface transportation network. The development of an ITS architecture for the NOVA District supports the regional deployment and integration of multimodal transportation services.

This Executive Summary is one in a series of related VDOT NOVA ITS documents. The series includes the following (related tasks are described more in detail in a subsequent section):

<u>Outreach Report</u> - identifies the regional stakeholders, and documents the outreach process and coordination effort required to verify aspects of the NOVA ITS strawman architecture and create regional compatibility between the NOVA ITS and Washington, D.C. and Maryland ITS architectures.

System Architecture - documents the iterative system architecture development process, presents the NOVA ITS system architecture in logical and physical formats, relates the NOVA ITS architecture to the National ITS Architecture, and provides guidance for using the system architecture in the project planning and development process.

Communications Plan - documents the communications plan development process and its relationship to the Outreach and System Architecture efforts, translates the system architecture interconnects and information flows into stakeholder communications requirements, presents related communications infrastructure, evaluated various communications technologies, and provides recommendations on investing in communications to support the system architecture.

In addition to the above reports, the project also includes the future publishing of an interactive Internet web site for the distribution of System Architecture and Communications Plan information. Also, a major component of the Communications Plan is the creation of an ITS asset and communications infrastructure database, and development of an enhanced web-based (initially a VDOT Intranet application) Geographic Information System (GIS) for managing the assimilated data.

While this project has reached a major milestone with the publishing of the System Architecture document and Communications Plan, it is clearly recognized by VDOT that neither of these reports should be static. Over time, the ITS System Architecture and the Communications Plan will need to be modified to reflect the integration of systems and deployment of communications services within the District. The System Architecture and Communications Plan are also subject to modification as a result of updated (or new) stakeholder requirements and/or changes in VDOT operations philosophy. This approach will allow the system architecture to provide continuous benefit to stakeholders by providing a useable regional framework that is truly representative of the transportation requirements and improvement goals established by VDOT.

2 PROJECT BACKGROUND

By their general nature, transportation systems can be (and at times are) studied, planned, and evaluated almost indefinitely. VDOT recognized that the best way to provide substantial benefits to the users of the NOVA surface transportation network is through results-oriented activities. Thus, VDOT initiated a project to develop an ITS System

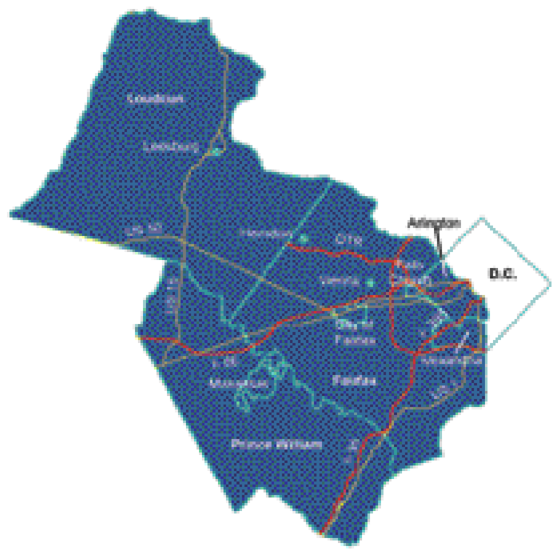

Figure 2-1 VDOT NOVA District

Architecture and accompanying Communications Plan based on studies completed to data and, most importantly, also based on the physical realities of the NOVA District (see Figure 2-1). This section presents the overall project scope, established goals and objectives, and the project team.

2.1 SCOPE

The scope of the System Architecture was to confirm the existing interaction between VDOT and stakeholder facilities, and to document planned interactions between the same operations centers. Essentially, the System Architecture describes what ITS information agencies would like to exchange. It was the scope of the Communications Plan to help define the framework of how this information could (or in some cases, should) be exchanged.

Guiding Principals

- Directly support ITS within the Northern Virginia District.
- Leverage previous works (i.e., "don't reinvent the wheel").
- Develop an architecture that regional stakeholders can easily understand and readily implement in integrating with VDOT NOVA operations. The architecture should be useful and manageable, and NOVA-centric.
- Provide a framework ("blueprint") that will drive regional decision making on transportation-related endeavors and guide NOVA operation managers (e.g., Smart Traffic Center, Smart Signal) through system deployment.
- Provide general guidance and sufficient enough detail for agencies within the NOVA boundary to determine integration needs when deploying systems that are required to interface with the VDOT systems.
- Support neighboring ITS programs (within Maryland and Washington, D.C.) to provide transportation services to interstate travelers.
- Develop a communications plan that will guide the resource sharing project to ensure VDOT receives adequate in-kind contributions from private sector partners (telecommunications service providers) for granting access to public right-of-way along interstate highways and non-interstate roads.
- Develop recommendations that will guide VDOT NOVA and stakeholders regarding the investment, implementation, and/or leveraging of communications infrastructure to support NOVA ITS operations and agency integration in NOVA.
- Develop an architecture that adheres to the USDOT policy on consistency with the National ITS Architecture and standards.

Tools were available (e.g., National ITS Architecture) that greatly assisted the architecture development. Also, VDOT had previously invested in other efforts that were leveraged during the project. For example, the ITS Early Deployment Study outlined the cooperation needs of regional agencies, and the NOVA Smart Travel Plan focussed specifically on the requirements of the District. However, care was executed to ensure the NOVA ITS system architecture was not simply a concept that was locked in the pages of a document. Rather, the architecture is useable, scaleable, and is based on documented needs - it does not encourage integration solely for the sake of integration. The region needed a framework for the coordinated development, deployment, and integration of ITS. The NOVA ITS System Architecture and Communications Plan provide this framework and serve the existing and immediate needs of all stakeholders, yet are also flexible enough to accommodate future requirements and technological improvements.

2.2 GOALS & OBJECTIVES

VDOT and Federal Highway Administration (FHWA) representatives met with private-sector on-call consultants to consider all potential aspects of a NOVA ITS System Architecture and to establish an accepted project scope. During the "brainstorming" session, a series of goals and objectives emerged. The table to the left serves as "guiding principals" behind the development of the NOVA ITS System Architecture.

A true measure of success of this project is the ability of the NOVA ITS System Architecture and Communications Plan to satisfy the region's transportation needs for the near future (e.g., 5 - 10 years). While no one can with complete certainty forecast all of the technological advancements that will take place in transportation and communications within this timeframe, it was critical to the project that this at least be considered. As such, the System Architecture was developed with consideration given to its ability to be reconfigured to meet changing needs (e.g., in-vehicle traveler information services), and the Communications Plan includes a maintenance strategy to allow the plan to accommodate future communications technologies (e.g., Dedicated Short-Range Communications).

2.3 PROJECT TEAM

In addition to the goals and objectives presented above, VDOT also carefully considered the method by which the architecture was actually developed. Specifically, as presented in subsequent sections, VDOT took advantage of existing contracting mechanisms and engage multiple consultants and/or systems integrators, and directed them to operate in a completely cooperative fashion. This unique approach allowed the Department to quickly comprise a NOVA ITS Team with the technical and non-technical expertise required for project success, and supported an accelerated (yet flexible) development schedule.

VDOT had the following existing ITS on-call contracts and contractors from which to draw the necessary resources and expertise. The lead consultant for each contract is shown. However, each contract lead organization had subcontractors from which to draw upon as well, as needed.

- ITS On-Call Telecommunications Consultant: ARINC, Inc.
- ITS On-Call Technical Consultant: Iteris, Inc.
- ITS On-Call Non-Technical Consultant: PB Farradyne

Collectively, each consulting team had the resources and experience identified by VDOT as critical to this project - systems architecture, telecommunications, standards, institutional issues, stakeholder involvement / outreach, etc. It was incumbent upon VDOT and the private-sector team members to foster the cooperation necessary for unified project execution. It was recognized that this would be challenging from a project management perspective given the unique team composition. However, VDOT was committed to working within such a framework in anticipation that the process would yield tangible and timely results - and it did.

The NOVA ITS project team is shown by Figure 2-2. It is important to recognize the hierarchy of the project management

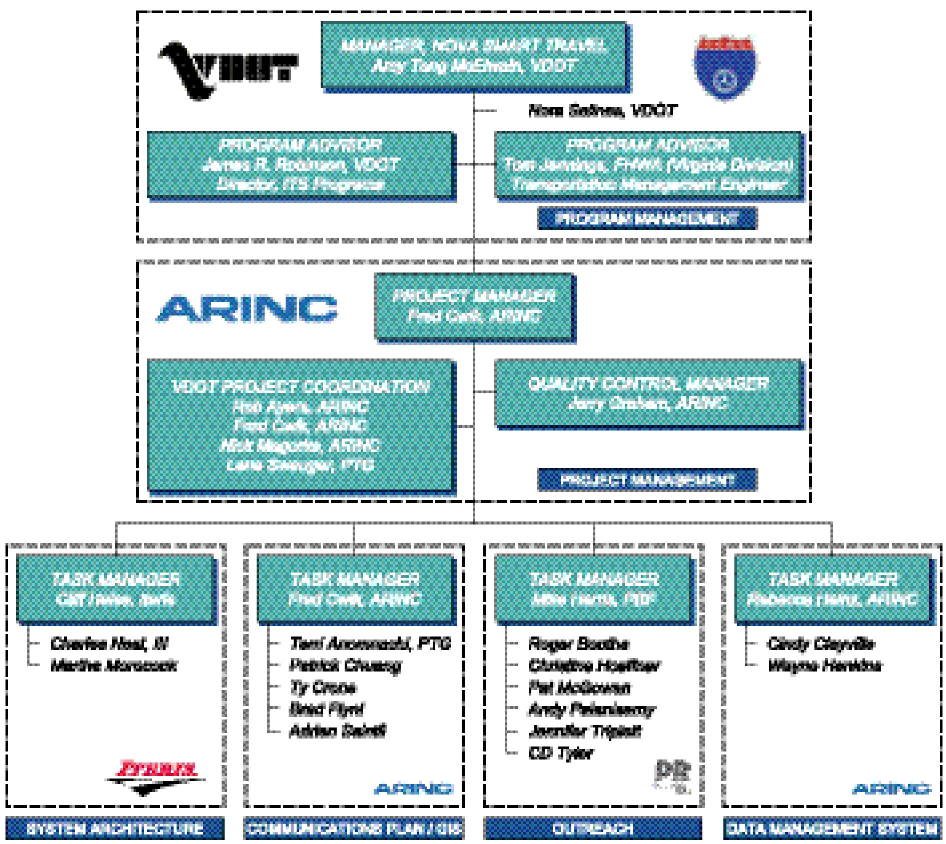

FIgure 2-2 NOVA ITS Project Team

for this project. Specifically, program guidance and direction came from VDOT. Overall project management was performed by ARINC, and each major task was managed separately by the lead organization identified. In essence, the task management team ultimately reported to the project management team which, in turn, reported directly to the Department. This was done intentionally to provide VDOT one primary organization to contractually coordinate with. However, practically, the entire management team (task management, project management, and program management) routinely worked as a cohesive unit.

The key staff identified in Figure 2-2 was critical to the task-oriented approach for this project - it was not a small undertaking. The concept for executing separate, yet coordinated, parallel tasks was discussed during the "brainstorming" session. This approach allowed VDOT to capitalize on the inherent capabilities of each on-call consultant and support the timely collection of stakeholder requirements, the documentation of the system architecture, and the development of a communications plan. The project team took an action-oriented approach.
The major project tasks defined are as follows:

- System Architecture
- Communications Plan & GIS
- Outreach
- Data Management System

These tasks are further defined in Section 4 - Major Tasks & Project Execution Strategy. However, it is important to recognize early that the scope of these tasks was developed with complete consideration of the VDOT-established goals and objectives. The primary tasks (i.e., System Architecture, Communications Plan & GIS, and Outreach) directly support the project objectives; whereas the secondary task (i.e., Data Management System) provides overall project information exchange and coordination that indirectly supports the project objectives. Clearly certain tasks support specific objectives more directly than others. However, all tasks were important to the successful realization of the project goals.

3 NOVA DISTRICT & REGIONAL ITS ARCHITECTURE EFFORTS

This section introduces the area surrounding the NOVA District, including the District of Columbia and the State of Maryland, provides a high-level overview of NOVA-related ITS architecture development efforts, and establishes the relationship between these efforts and the NOVA ITS System Architecture development program.

3.1 METROPOLITAN WASHINGTON REGIONAL ITS ARCHITECTURE

Developed by PB Farradyne (PBF) and the Computer Sciences Corporation (CSC) for the Metropolitan Washington Council of Governments / National Capital Region Transportation Planning Board (MWCOG / NCRTPB), the Metropolitan Washington Regional ITS Architecture provides the framework to facilitate numerous transportation management functions within the surrounding metropolitan region. These functions include data archiving, emergency / incident management, traveler information, traffic management, transit management, electronic toll collection, and parking management.

The areas covered by the Washington regional architecture are shown in Figure 3-1 and include the listed stakeholders.

The regional architecture is operations based and focuses on facilities where operational functions are performed and/or data warehouses - i.e., transit, police, and fire dispatch centers, and roadway operations centers. The development of the Metropolitan Washington Regional ITS Architecture was coordinated with the on-going efforts of the Maryland Statewide Architecture and the VDOT NOVA ITS Architecture. However, the Regional ITS Architecture includes aspects that the NOVA ITS Architecture does not (e.g., NOVA local traffic operations to NOVA local police). This difference in scope allowed the NOVA ITS Architecture development team to focus on a NOVA-centric architecture.

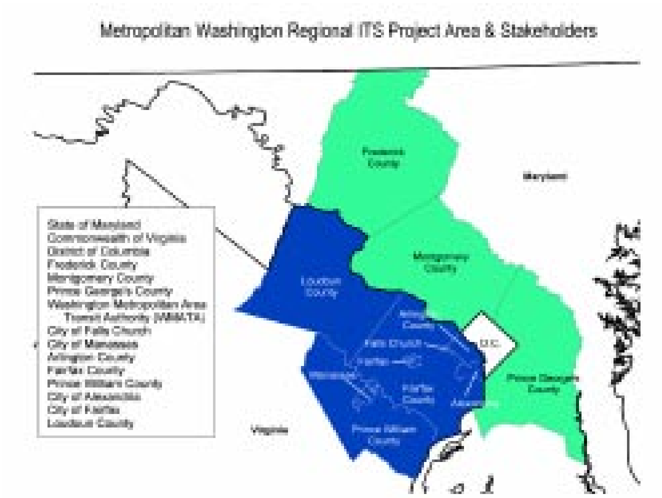

Figure 3-1 Metropolitan Washington Regional ITS Project Area & Stakeholders

NOVA ITS Architecture is interwoven with the architecture efforts in DC and Maryland.

3.2 MARYLAND STATEWIDE ARCHITECTURE

Maryland is working on a Statewide Architecture that covers all 23 counties (see Figure 3-2) and Baltimore City. The architecture focuses on center-to-center communications and includes over 220 centers representing arterial traffic management, freeway traffic management, public safety, commercial vehicle operations, transit management, electronic toll collection, archived data management, emissions management, parking management, information service providers, and intermodal facilities.

Major stakeholders include all Maryland Department of Transportation modal administrations, County departments of public works, Maryland State Police, 911 Center agencies, emergency management center agencies, as well as a host of other state and local transportation and public safety agencies.

The Maryland Statewide Architecture is consistent with the NOVA ITS Architecture having coordinated with the Metropolitan Washington Regional ITS Architecture which includes centers in both the NOVA and Maryland Statewide architectures. Currently, a Maryland Statewide Architecture report is underway and plans are in place to facilitate use of the architecture through use of the web.

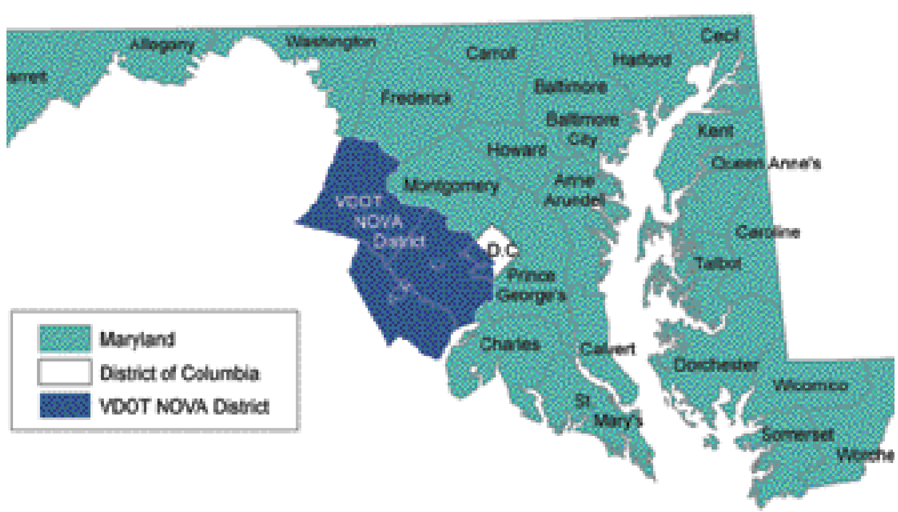

Figure 3-2 State of Maryland County Map

3.3 NOVA ITS ARCHITECTURE RELATIONSHIP

The NOVA ITS Architecture is interwoven with the architecture efforts in DC and Maryland. The Metropolitan Washington Regional ITS Architecture encompasses the entire NOVA ITS Architecture region. This overlap required the development teams to work closely together to synchronize the architecture nomenclature and interfaces that were common to both architectures. In addition, the NOVA ITS Architecture is VDOT-centric. It focuses on the interfaces and integration opportunities with VDOT NOVA systems. Non-VDOT stakeholder-to-stakeholder interfaces are not addressed within the scope of the architecture nor the Communications Plan. Those regional aspects that the NOVA ITS Architecture does not cover are addressed by the Metropolitan Washington Regional ITS Architecture.

The NOVA ITS Architecture relationship to the Maryland Statewide Architecture is at the boundaries of the architecture. The regions covered by each architecture meet geographically along state and jurisdictional borders, therefore the relationship to the Maryland Statewide Architecture is one of boundary interfaces. In this case, it was important for the development team to coordinate nomenclature and system definitions at the boundaries of the architectures so both architectures would support information exchange between the regions.

In order to accomplish greater regional harmony among all three architecture efforts, the development teams established and maintained cooperation throughout the entire project - especially, during the early phases. The NOVA ITS System Architecture development team (consultants and VDOT) met with representatives and decision-makers from the other system architecture development teams to discuss and agree to the overlap between the architectures. Consensus was reached on the identification of stakeholders and the terminology used within the respective system architecture definitions (i.e., Turbo Architecture database nomenclature).

4 MAJOR TASKS & PROJECT EXECUTION STRATEGY

The NOVA District is blessed with having developed, under VDOT leadership, numerous transportation plans (e.g., program plans, strategic plans) and studies (e.g., early deployment study) that provided both initial and long-term guidance for developing the ITS architecture. For example, these earlier initiatives provided valuable insight to the requirements of the regional stakeholders and helped establish the strawman system architecture. The Department recognized the importance of these projects and capitalized on the investment(s) made in each. With this demonstrated foresight, VDOT was positioned well to develop a comprehensive regional ITS architecture based on all previous transportation initiatives. As such, a common theme of each project task was to leverage, as much as possible, the results of these previous activities. A high-level overview of each of the major project tasks provided below. Also presented is the interactive relationship between these tasks and the overall project execution strategy.

The major project tasks are presented in the following subsections. The reader is encouraged to review the related project reports for the tasks for detailed information about each. Also, presented below is the interactive task execution strategy.

4.1 SYSTEM ARCHITECTURE

The NOVA ITS Architecture development effort took shape prior to the issuance of the FHWA's Architecture and Standards Consistency Policy. However, the development team adapted the NOVA Architecture development approach (see Figure 4-1) to meet the policy requirements. The development team reviewed existing documentation and gathered functional requirements from the NOVA ITS Strategic Plan and Early Deployment Plan. Operational concepts were also examined for each of the primary systems in the NOVA region. This information along with information about the many stakeholders in the region was input to the Turbo Architecture software tool. Given the

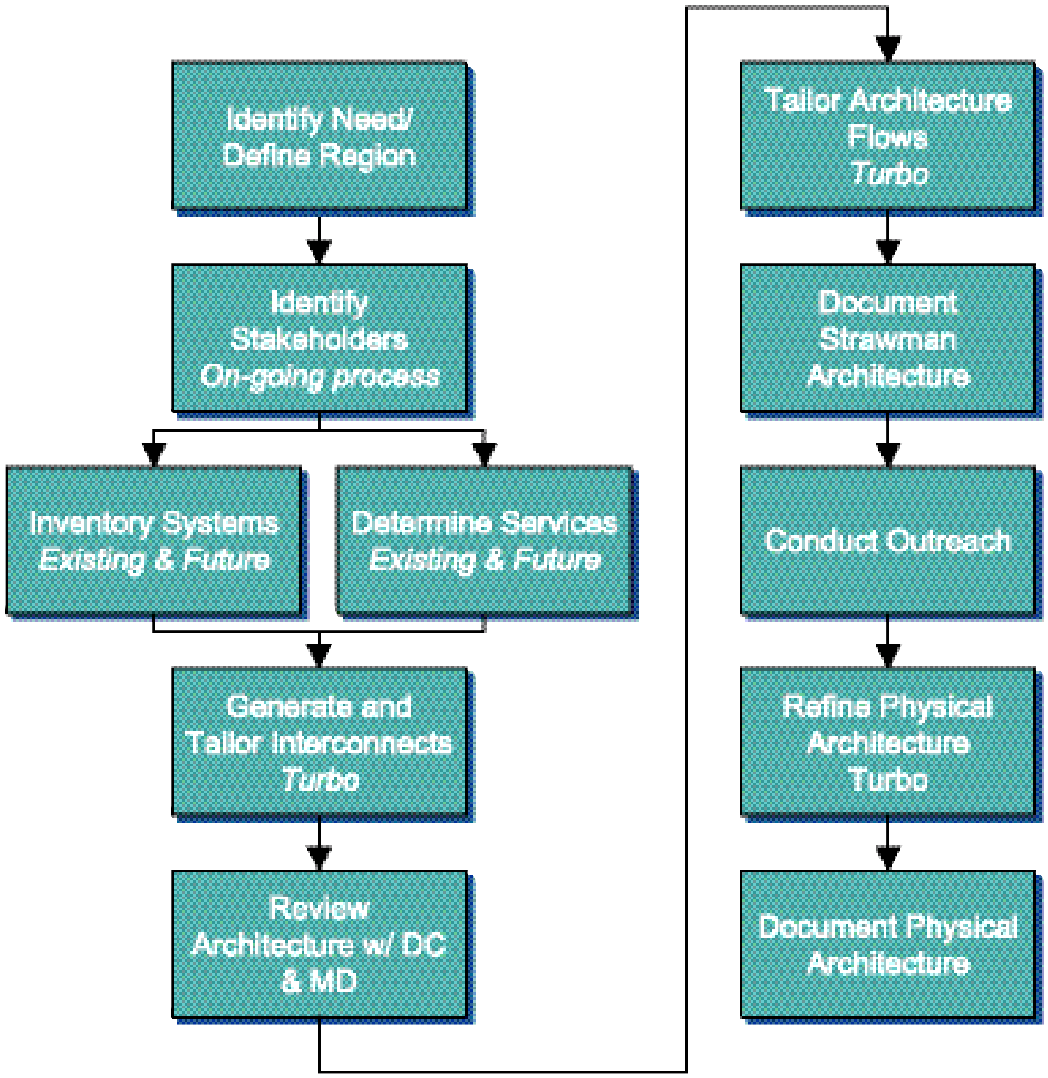

Figure 4-1 NOVA ITS System Architecture Development Process

Team's experience working with VDOT and other stakeholders in the region, a strawman architecture was generated and tailored to reflect the Team's understanding of the region. This strawman architecture was presented to the stakeholders a series of outreach sessions as discussed in the following section. The stakeholders provided valuable feedback to the Team to modify the architecture appropriately to reflect the environment and stakeholders' plans for their various systems.

Information was also gathered regarding the transportation planning process in which the architecture and the communications plan would be incorporated. The project initiation plans were studied and process steps were inserted or identified where these tools would be most effective. While VDOT has three project initiation processes based on different funding sources, the architecture and communications plan applications in the processes was consistent across all three.

4.2 OUTREACH

The Outreach element of the NOVA ITS Architecture was a unique effort designed to critique and validate the needs identification, systems inventory, planning of user services, and associated activities that occurred at the outset of a regional architecture development effort. The specific purpose of this Outreach effort was to validate the NOVA ITS Team's understanding, as expressed through the Strawman Architecture, and to refine the Strawman into a realistic, comprehensive and implementable architecture that garners stakeholder buy-in and support.

The scope of the Outreach effort called for the NOVA ITS Team to identify and categorize stakeholders, plan and conduct a series of Outreach meetings to obtain stakeholder input and validation, follow up with stakeholders as necessary after these meetings, to consolidate and utilize stakeholder input as a basis for modifying the Strawman Architecture, and finally to confirm with stakeholders the validity of the revised Architecture. This process is depicted in Figure 4-2 below.

In May, 2001, a NOVA ITS Team comprised of staff from ARINC, PB Farradyne and Iteris began working with the VDOT Northern Virginia District to plan and implement an Outreach program in support of the ITS Architecture. At a meeting on May 8, VDOT District staff and the NOVA ITS Team agreed on a process and approach for moving forward with outreach efforts. The process began with identification of stakeholder groups, and then of organizational stakeholders within each group. Points of contact were identified for each stakeholder organization. This process created stakeholder "champions" to help generate input needed for completion of the final Architecture. Rather than simply providing a series of workshops to present an overview of the Architecture, stakeholders were placed in smaller groups by function to add focus to the Outreach effort. Input was sought from these stakeholders to validate the VDOT NOVA ITS Architecture, as it pertained to each agency or stakeholder group.

An ITS Strawman Architecture was developed for the purpose of eliciting stakeholder input and reiteratively producing a final architecture that responded to stakeholder concerns, incorporated stakeholder vision, and engendered

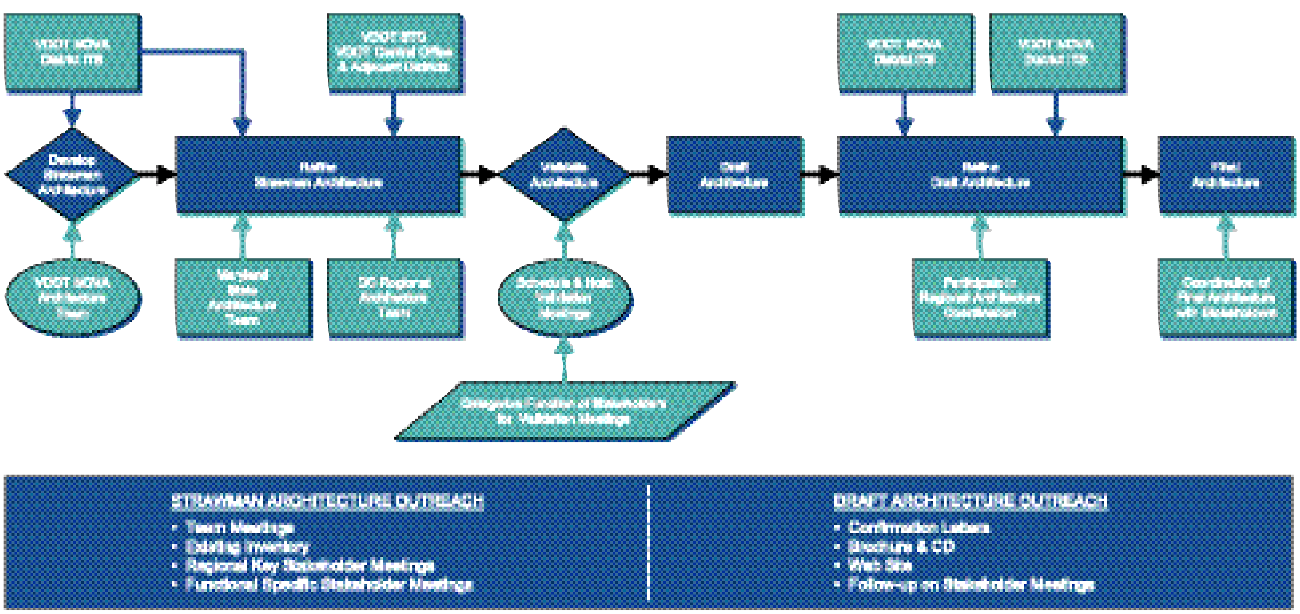

Figure 4-2 Outreach Process

stakeholder support and consensus. A series of 11 meetings were planned and executed in May and June, to address specific areas of system function and stakeholder interest within the Strawman Architecture.

Following completion of this series of meetings, the NOVA ITS Team reviewed all input obtained by stakeholders, followed up with more discussions with stakeholders, and made changes to the Strawman Architecture, as warranted. In particular, the Team met again with the VDOT NOVA Smart Traffic Center (STC) stakeholder group and the NOVA Transit Group following the September 11th attacks. The VDOT NOVA STC stakeholders had reviewed the events and a key architecture change that resulted was the addition of remote control for the NOVA STC in case of emergency situations. The NOVA Transit Group discussed communications options that would help each agency exchange data more efficiently to better serve their transit customers. The Team carefully documented all meetings. An Outreach Report that more fully details all aspects of the Outreach effort was produced.

4.3 COMMUNICATIONS PLAN

A plan was needed to address infrastructure and services that were (are) currently available or needed within Northern Virginia to develop robust interagency communications and support regional ITS initiatives. The focus of the Communications Plan task was to develop such a plan. The primary purpose of the Communications Plan was to provide the framework needed to support the NOVA ITS System Architecture - specifically, the interconnects and information flows identified between VDOT and the project stakeholders. The plan development process is shown by Figure 4-3.

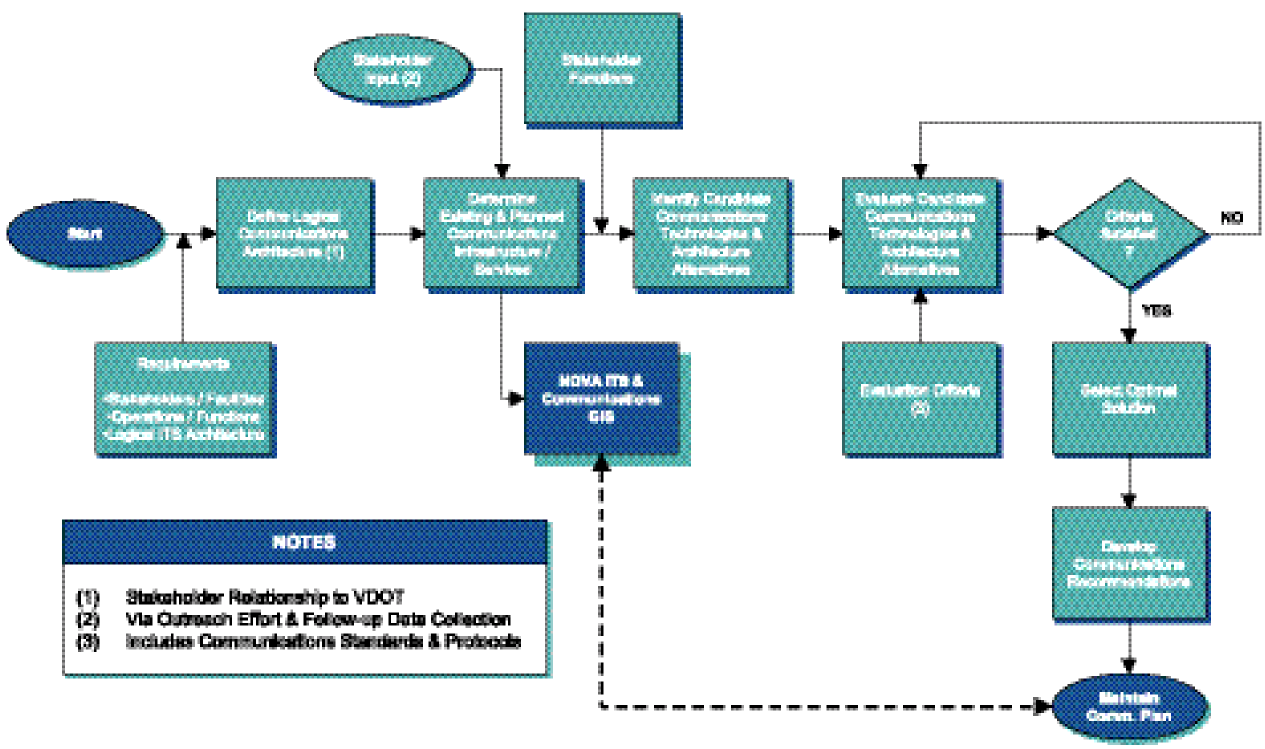

Figure 4-3 Communications Plan Development Process

Major Communications Plan Subtasks and/or Activities

Stakeholder Requirements

Stakeholder Requirements. The initial step to developing a Communications plan for NOVA was to confirm the list of stakeholders and translate the defined System Architecture into high-level communications requirements. The list of stakeholders was obtained from the Outreach task and the location of the operational facilities of these stakeholders was verified through independent outreach, and included within the GIS. With an understanding of the functional groupings of stakeholders (e.g., Traffic Operations), the System Architecture Flow Definitions were translated into communications-related requirements and a projected bandwidth was considered.

Communications Infrastructure & Services

Communications Infrastructure & Services. This subtask included the research, identification, and documentation of existing and planned regional communications infrastructure or other communications services (e.g., leased lines) of VDOT and the stakeholders. The collected data was analyzed to assess the potential of the infrastructure to support the System Architecture interconnects and information flows. The data was used to populate a by-product of this effort - the NOVA ITS asset baseline in GIS (further described below).

Candidate Technologies & Standards

Candidate Technologies & Standards. The various communications technologies were researched and center-to-center standards considered. Specifically, the plan addresses the communications aspects of the physical System Architecture, as defined by the “Sausage Diagram.” Intended to serve as a reference document for the stakeholders, detailed information on wide area wireless and wireline communications options is presented. The plan also includes the latest information on Dedicated Short Range Communications (DSRC). Vehicle-to-vehicle communications options are only lightly covered because they are not within the scope of the NOVA ITS system architecture and the technology is relatively premature - but the reader is instructed as to where to find additional information. A thorough review of the National Transportation Communications for ITS Protocol (NTCIP) is provided, along with consideration of its application to NOVA ITS.

Evaluation Criteria & Alternatives Analysis

Evaluation Criteria & Alternatives Analysis. An evaluation criteria (e.g., performance, availability, reliability, flexibility, security, etc.) was established and used to support the analysis of each communications technology alternative. The plan then identifies those technologies that are well-suited to support certain aspects of the System Architecture (i.e., interconnects and information flows) and stakeholder requirements.

Communications Architecture

Communications Architecture. Various communications network topologies were considered, and an overall system architecture for NOVA is presented that supports the ITS System Architecture and stakeholder requirements.

Infrastructure Deployment

Infrastructure Deployment. The plan provides recommendations on the deployment of communications infrastructure and services within NOVA. The phased approach (near- and long-term recommendations) is intended to position VDOT well to quickly increase the level of integration within the District and ultimately provide enhanced services to users of the transportation network through substantial information exchange.

Communications Plan Maintenance Strategy

Communications Plan Maintenance Strategy. It was recognized at the beginning of the NOVA ITS Architecture project that this process should not end with the publishing of project reports. Rather, it was established by VDOT at the outset of the effort that the System Architecture and Communications Plan needed to be maintained over time. As such, a maintenance strategy for the Communications Plan is included within the final report.

4.4 GEOGRAPHIC INFORMATION SYSTEM

Due to the importance of linking location to data acquired during the NOVA ITS Architecture project, a Geographic Information System (GIS) was a useful tool in aiding in an inventory/data gathering phase, as well as in the communications and architecture analyses. GIS was used to assemble, store, manipulate, analyze, and display information about relevant NOVA ITS assets, facilities, and communication infrastructure and how they are spatially related in Northern Virginia. Initially, master lists were created of relevant assets/infrastructure, and what attributes would be beneficial to have in that asset's database or layer. Data was gathered by email, phone interviews, and in-person interviews with relevant stakeholders, and a master database was created. These spreadsheets were then imported into the GIS tool and brought to life in customized display maps for use in documents or analysis involving any variety of scenarios desired by the project team.

For both the database and display maps, the GIS technology was very effective in creating and organizing a comprehensive ITS asset inventory, along with the existing and planned communications infrastructure (see Figure 4-4). Within the constraints of the project, the team was able to build an efficient inventory, in a relatively short period of time. The GIS aids the decision making process of locating potential connection points for the sharing of ITS data, now and in the future. GIS is a proven tool that capably handles and allows for updating as well as manipulation or analysis. Due to the very dynamic nature of ITS and the communications industry, GIS can be used over time to help grow and make even more useful the initial inventory and analysis effort.

Geographic Information System (GIS) was a useful tool in aiding in an inventory/data gathering phase, as well as in the communications and architecture analyses.

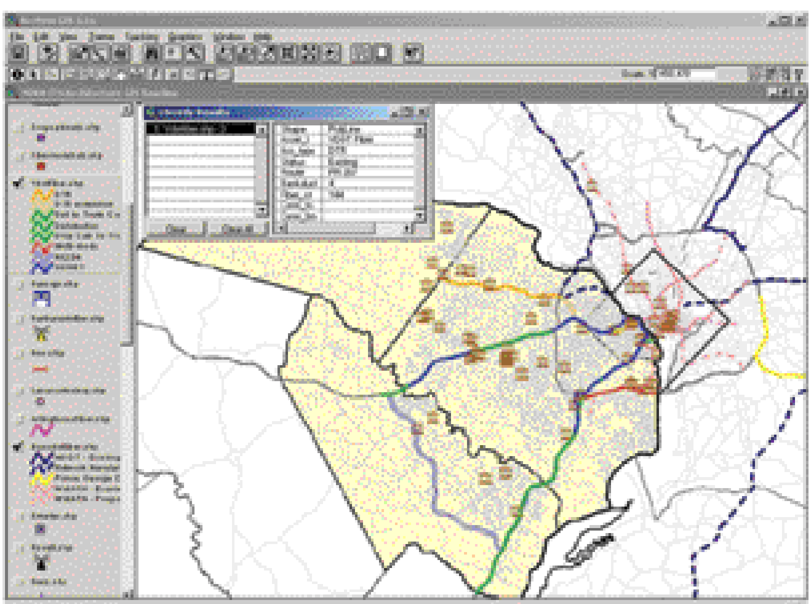

Figure 4-4 NOVA ITS Asset & Communications Infrastructure GIS

Using ESRI's suite of core GIS products, ArcInfo 8.1 and ArcView 3.2, the team was able to comply not only with the local VDOT NOVA GIS tools and standard, but also with the VDOT central office in Richmond, VA. This is important as it enables a future integration with a statewide repository of data for VDOT's central office. A pilot project for a statewide effort has recently concluded and the same ESRI tools and technology was used, again allowing for a smoother future integration. Locally, it aids the VDOT NOVA GIS team in achieving one of the project's goals, for their team to assume responsibility for data and other GIS administration and maintenance internally. Another currently deployed tool by VDOT is an Internet/ Intranet Mapping Server made available from ESRI called, ArcIMS. There are plans to deploy the NOVA ITS Architecture GIS project online using the GIS Integrator technology that's based on the ArcIMS product line. This allows GIS experts as well as any VDOT onlookers to either just view the data, or even make redline suggestions or additions, so that the NOVA GIS team may make appropriate updates. This increases the accessibility of the tool from local desktop installations, to the entire VDOT network by means of the existing GIS infrastructure already utilized and in place for both VDOT NOVA and VDOT Central Office. The GIS includes metadata in compliance with the Federal Geographic Data Committee (FGDC) standards adopted by Northern Virginia jurisdictions, and allows VDOT to convert to a statewide metadata standard, when such a standard is adopted. In summary, the development of the NOVA ITS asset baseline GIS serves as an example for other VDOT GIS projects.

4.5 DATA MANAGEMENT SYSTEM

This task included the development of an on-line project information, and document review and comment-tracking system. Specifically, an Internet web site (see Figure 4-5) was developed and maintained during the project. This web site allowed unlimited access to relevant project information. However, glitches in the off-the-shelf software tool selected and sporadic server downtime limited significantly the benefits this Data Management System provided to team members. As a result, a decision was made by the management team to minimize the financial investment made and reduce its use from a daily management system to a data archive system. At that point, routine team coordination and documentation exchange was accomplished via telephone and emails. The financial resources allocated for this task were ultimately re-allocated to other project tasks that realized an increase in scope or unanticipated level of effort required.

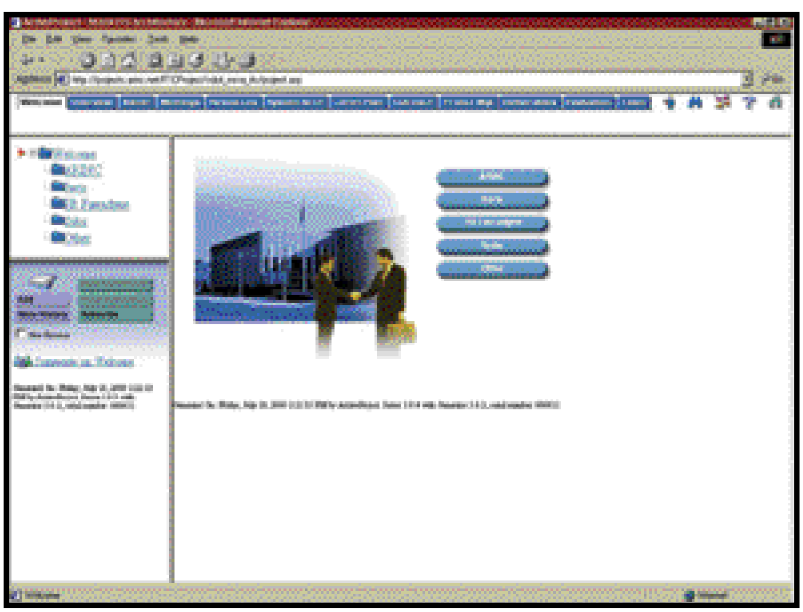

Figure 4-5 NOVA ITS Architecture Project Data Management System

4.6 PROJECT EXECUTION STRATEGY

Even though the above tasks were executed concurrently and by separate private-sector organizations, coordination among individual tasks (and subtasks) was established and maintained. Also, many subtasks were dependent upon information derived from activities of other tasks. The interactive nature of the relationship between the tasks and subtasks can be seen by Figure 4-6 below.

The interactive nature of the relationship between tasks presented the challenge to the team.

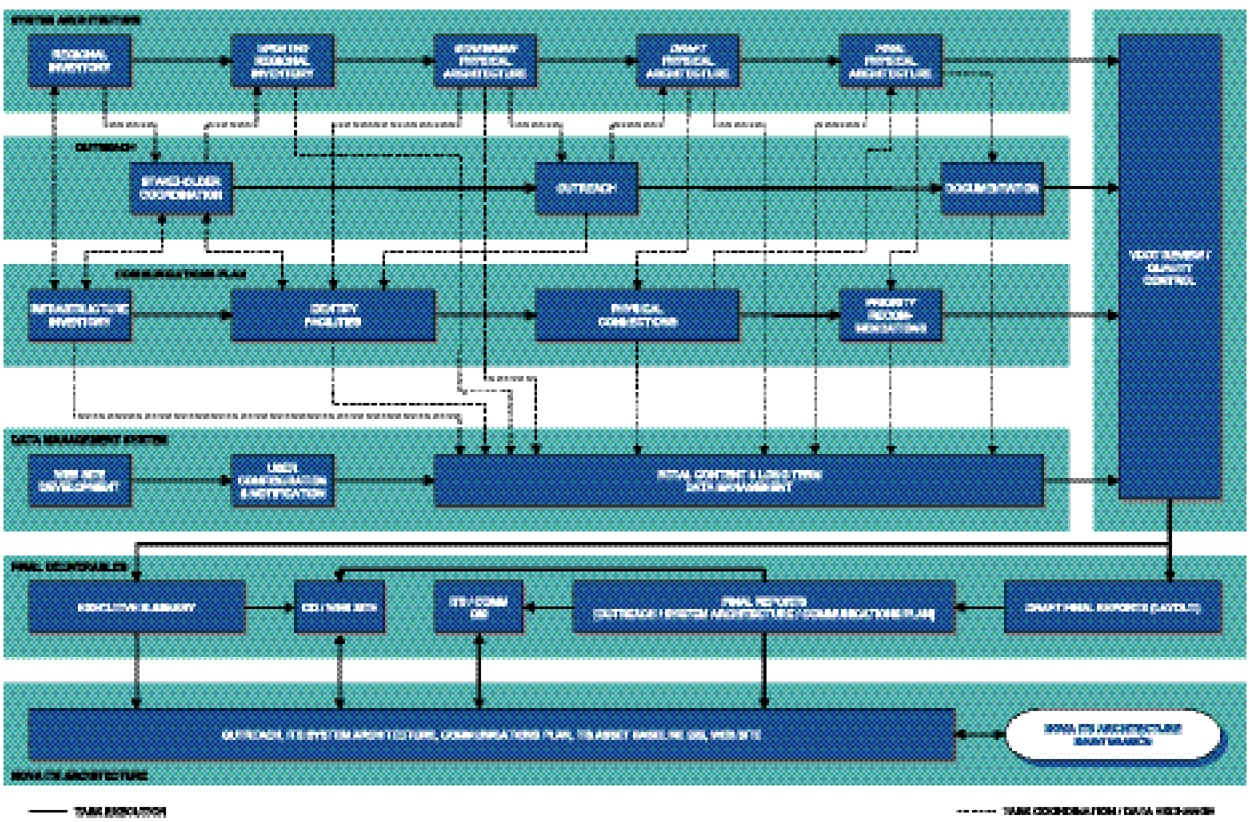

Figure 4-6 Task Flow Diagram

5 LESSONS LEARNED

This section summarizes the lessons learned, organized by major project tasks. In general, the project was executed as planned, but there were clear process adjustments that needed to be made. The project team experienced both reaffirming and unanticipated lessons learned. However, the adversity was overcome and the project was ultimately very successful and can provide valuable insight for others about to embark on a similar effort.

5.1 PROJECT MANAGEMENT

5.1 PROJECT MANAGEMENT

The geographically-distributed public- and private-sector team composition, coupled with an aggressive schedule that included regional coordination, presented a unique project management challenge. Below are the key lessons learned from this experience.

Timely Information Exchange

Timely Information Exchange. The routine exchange of project information among team members was a critical component to the overall effectiveness of the effort. This is especially true among the task managers and VDOT representatives. The Team instituted weekly teleconferences and periodic meetings, depending on the level of task activity. The Team also issued routine reports that updated the project schedule and budget, and informed the task leaders of the current and near-term focus. However, project resources and organizational conflicts became, at time, a challenge. It was recognized among the management staff that during the times of increased information exchange, the project schedule was less likely to be compromised. It was during the "regrouping" stages that the project direction became misalign with the developed schedule - adding pressure to the task managers and staff to accelerate certain activities.

Consensus Decision-Making

Consensus Decision-Making. Given the unique interaction between the major project tasks and their interdependency, it was important that the task managers discussed with VDOT critical decisions and arrived at a consensus position before such positions were communicated - especially, to regional ITS architecture development efforts.

Flexibility and Cooperation

Flexibility and Cooperation. The project scope was written well in advance of project execution. Within this document, collectively written by all consultants with VDOT input, the scope of each task was defined as best as could be done with established project goals. However, during the actual execution of the project, it became apparent that overall team flexibility and cooperation was required to execute the tasks. The Project

Management Plan (PMP) and assigned responsibilities were modified to apply project resources where and when needed. It was a total team effort where the sum of the parts was greater than the individual components.

Quality Control

Quality Control. It was beneficial to VDOT to identify a single consultant to provide overall project Quality Assurance (QA) control for all project deliverables Since the reports were developed by multiple consultants, this QA process allowed VDOT direct access to a single point-of-contact for the quality aspects of the project reports. This also aided in the assurance of a common project theme, as reflected in each document.

Significant Accomplishments

Significant Accomplishments (Under Budget). The funding available at the outset of the project was adequate for the development of the ITS System Architecture and limited stakeholder Outreach. This was recognized by the project Team. However, this did not alter the Team's commitment to expand the project scope and also develop a Communications Plan and ITS Asset Geographic Information System. Managing this additional level of effort within the project budget was challenging.

5.2 SYSTEM ARCHITECTURE

5.2 SYSTEM ARCHITECTURE

The VDOT NOVA ITS Architecture benefited from close coordination with other regional architectures, an effective outreach effort, and a unique enhancement of a communications plan that facilitates its implementation. This architecture development effort was not focused on "development" alone, it looked forward to the architecture use in transportation planning and project definition. The architecture is strengthened by the development of a communications plan and the ITS asset GIS. This collection of information will make this architecture more useful to the stakeholders that will plan and implement ITS projects in Northern Virginia.

Flexibile Architecture Definition

Flexibility to adjust architecture definition. The architecture definition was nearing completion when the September 11th attacks occurred. The Development Team met with the most closely involved VDOT stakeholder, the NOVA STC, to evaluate any changes to be made to the architecture. The result was a change to plan for remote monitoring and control of the NOVA STC system so that the facility could continue to function even after evacuation. The architecture was changed to accommodate remote control capabilities for the NOVA STC. The architecture definition was found to reflect the emergency services coordination that was required for such an event. It is important to change the architecture to be as accurate a possible even in the late stages of its development.

Expansion of Definition

Expansion of NOVA Architecture definition beyond National ITS Architecture. The NOVA ITS Architecture had several areas that were not defined in the National ITS Architecture. In particular, snow operations and public relations information exchanges were added. This expansion beyond the National ITS Architecture is aligned with several of the changes that will be coming in the new version of the National ITS Architecture, version 4.0. When the new version is released, the NOVA Architecture will be updated to take advantage of the new features in the National ITS Architecture. Many of the unique NOVA Architecture information flows will be modified for the National ITS Architecture definition.

Pay More Attention to Use

Pay more attention to Using the Architecture than developing it. A very strong element of the NOVA ITS Architecture is its attention to implementation in the transportation planning process. It is important to look at how the product will be used and not just develop the product for the product's sake. The Architecture, Communications Plan, and ITS Asset GIS have been developed to be used. The Architecture document contains information about how the architecture and communications plan will be used in each of the three project initiation processes that VDOT follows for different funding sources. By focusing on the use of these products, VDOT has already strengthened the products chance for making a positive impact on the integration of ITS in Northern Virginia.

5.3 OUTREACH

5.3 OUTREACH

The outreach effort was essential in engaging the stakeholders and assimilating requirements. The process was much more involved than originally anticipated. The major outreach lessons learned are listed below.

Identify Stakeholders and Organize by Functions

Identify Stakeholders and Organize by Functions. The NOVA ITS Team determined that it would be more efficient to work with stakeholders in groups with similar interests, focus, and areas of operational responsibility. Since individual stakeholders within each group had similar concerns and "spoke the same language", it was easier to both focus meeting materials and content, and to keep discussions during the meeting on subject. Stakeholders also seemed more at ease interacting with peers who had common interests and concerns.

Identify Meeting Facilitator

Identify Meeting Facilitator. The NOVA ITS Team recognized early on that a respected and viable "champion" would lend significant credence to the Outreach process. Accordingly, VDOT's project representative assumed a central role in leading each meeting. This demonstrated the commitment of VDOT to the process, assured stakeholders that this was a worthwhile use of their time and that their input would be valuable, and energized stakeholders to work alongside the region's primary provider of transportation services.

Maintain Stakeholder Interest. The NOVA ITS Team discovered that details such as data flows within the system architecture must be developed to some level of customization for each stakeholder group, prior to presentation for validation. While the purpose of the validation exercise was in part to enhance and further define data flows, it was apparent that presenting stakeholder groups with a “generic” architecture suggested that a certain amount of “homework” remained to be done, and caused them to lose interest. An effective approach was to use “scenarios” to explain certain information flows when, based on the flow name alone, it was otherwise unclear. This technique allowed stakeholders to more closely associate the system architecture to their own operations and helped to maintain an increased level of interest during the outreach meetings.

Maintain Stakeholder Interest

Listen Intently to Stakeholders. Stakeholders are the experts in their field of interest or responsibility. They know best what works in the real world. If stakeholders say that an element of the Architecture is either not necessary, or is missing, the Architecture must flexibly adapt to that input. Stakeholders will not flexibly adapt their practices and procedures just because an Architecture says they should.

Listen to Stakeholders

Maintain Project Team Coordination. Preparation before the meeting allowed the team to be coordinated and present as “one voice”. Debriefing after the meeting captured elements that might not have made it into written notes and spurred creative thinking while issues were still fresh in minds.

Maintain Coordination

Focus the Discussions for Each Stakeholder Group. Stakeholders who felt they were being shown a generic set of materials, not tailored to their concerns, needs and responsibilities, tended to lose interest.

Focus Discussions

Be Willing to Change the Architecture. It should not be assumed that stakeholders understand that the Architecture Team will act in accordance with their input. By proactively expressing this willingness, stakeholders were assured that their input was valued, and that the exercise was a worthwhile use of their time.

Willingness to Change

Coordinate with Adjacent Architecture Efforts. In a region that is in close proximity to other major metropolitan areas, or where major political and jurisdictional boundaries are present within the geographic scope of the Architecture, it is essential to coordinate with other Architecture efforts in those areas. By agreeing on common conventions and developing a shared understanding of practices and procedures among stakeholders, the value and usefulness of all Architectures is enhanced.

Coordinate Efforts

Focus on the Region

Focus on the Region. Federal approved processes, tools and documentation related to Architecture development provide an excellent guide for developing a customized Regional Architecture. However, the needs and requirements of the specific region must be paramount in crafting the Regional Architecture end product. Guidelines cannot anticipate or plan for every issue, concern, need that arises regionally. The Architecture team must be committed to developing an Architecture that works for the region, even if it steps outside existing guidelines.

5.4 COMMUNICATIONS PLAN

5.4 COMMUNICATIONS PLAN

The development of a communications plan is a unique and often overlooked (or not funded) aspect of an ITS architecture project. Many state agencies do not or are unable to follow-up the system architecture development with such a plan. However, VDOT recognized the importance of and natural relationship between system architecture and communications. Communications infrastructure is critical to the realization of the system architecture. The Department took this relationship even further by including the development of an ITS asset baseline GIS to support architecture and communications maintenance aspects. The process used to develop the NOVA ITS Communications Plan was multifaceted. The two major components that yielded significant lessons learned were stakeholder outreach (communications infrastructure), and the development of the ITS asset and communications GIS.

Time and Budget Consuming

Stakeholder Infrastructure Data Collection.
Time and Budget Consuming. The effort to outreach to stakeholders to collect existing and planned communications infrastructure data was time consuming and presented an overall challenge to the project schedule - especially, the development of the Communications Plan. Initial outreach efforts yielded limited results due to the unavailability of information. Securing relevant information became a repetitive process of telephone calls and emails, because the secured funding didn't support the travel required to directly engage each stakeholder (as was done for the architecture Outreach effort). Also, the redirection of project resources to other tasks created a disconnect in the communications infrastructure assessment effort. It is recommended that such substantial data collection efforts be properly budgeted and scheduled for, and include provisions for travel. Ideally, a separate follow-up outreach effort should have been executed, immediately after the system architecture outreach, to collect infrastructure information. There were problems concerning the acquisition of ITS asset information as this data varied in organization from hard copy file and electronic spreadsheets, to general memory or knowledge of a particular asset provided in an interview process. Having to depend on undocumented data was a risk in terms of reliability, currency, and accuracy. To improve these standards, many resources were investigated and several iterations were required to ensure that the ITS asset

database most accurately reflected what existed in the field. Unfortunately, there was a lack of existing and organized information in useful formats, and often reluctance to provide the team members the necessary data in a timely manner. This problem may have been minimized with another outreach effort that focused on the communications plan. However, the project budget and schedule did not allow for this approach to be taken.

ITS & Communications Staff Different

ITS & Communications Staff Different. It was recognized that the contacts identified within each stakeholder agency to review and verify aspects of the ITS Architecture were different than those with knowledge of or direct access to the communications aspects of the particular stakeholder agency. However, bridging this obvious gap between the ITS and Information technology (IT) staff, and fostering the internal communications required between these two groups was more difficult than anticipated. Lack of internal communications was a challenge to overcome. Where directly received information was lacking, the Team was able to leverage the contents of the regional telecommunications study.

Limited Available Information

Limited Available Information. Many stakeholders reported the availability of limited documentation on existing and planned communications infrastructure, and essentially no network drawings were available. Most of the information that was readily available from stakeholder dealt with internal network communications (i.e., Local Area Network, LAN). This was of limited use to the development of the Communications Plan because the NOVA ITS Architecture is based on the center-to-center exchange of information - field infrastructure was most critical. However, the LAN information allowed for a better understanding of the operational aspects of stakeholders and consideration of how the VDOT ITS data could be distributed internally to a particular stakeholder.

Interest and Demand

Present Interest / Demand. During the communications infrastructure data collection efforts and as a result of numerous conversations with stakeholders, it was clearly recognized that there is an existing and ever increasing regional demand for the interconnecting agencies and sharing data.

Geographic Information System (GIS).

Time and Budget Consuming

Time and Budget Consuming. The original limited scope and budget were based on the fact that a statewide ICAS effort was underway to collect location information (via GPS) of all VDOT assets. The assumed limited effort required was also based on an over estimated availability of ITS asset databases from NOVA GIS and other VDOT staff. With the limited availability of data and direct involvement by NOVA GIS, the NOVA ITS Architecture Team (VDOT and consultants) had to re-allocate resources to perform the whole tasks.

Increasing Scope and Opportunity

Increasing Scope & Opportunity. It was difficult to predict with great certainty the amount of data collection required and GIS application development involved when data collection mainly depended on feedback from stakeholders rather than actual field research. Also, once the baseline GIS was established, the inherent capability of the GIS to serve more VDOT functions (e.g., statewide applications) became evident and it was financially more cost effective to increase the scope of the GIS.

Cooperation from VDOT

Cooperation from VDOT. The GIS is completely data-driven, when there are issues with the data collection that are relying on others almost completely within VDOT, whom may not find that it's a high priority or in some way cannot turn in or research the data. Finding it difficult enough to find the best point of contact (POC) for each asset, comm infrastructure/facility, it can take a while to just find the "right" person from whom data should be collected. On top of the normal duties, it can be a lot to ask for the VDOT associate to aid in, at times, in depth and lengthy research. As such, the VDOT project manger assumed daily coordination with various VDOT staff for in-depth and lengthily research on accurate ITS asset databases. This could severely infringe into the budget and period of performance (POP), and makes it hard to proceed with other aspects of the GIS and any analysis.

Data Accuracy Standards

Data Accuracy Standards. It was recognized that there was a relationship between the project budget and POP, and the ability to establish and maintain very rigid standards that apply to both the database side as well as the positional accuracy of assets. In general, the smaller the budget and the shorter the POP the less standards can be applied. However, a properly developed long-term GIS maintenance strategy can overcome this initial shortfall.

Growing Pains

Growing Pains. The structure and development of the GIS required coordination and compliance with the NOVA GIS team, the central VDOT Data Management Program, as well as the NOVA and Central ITS Offices. This proved to be a series of compromises - from which base data to use, to what projection, all the way to what attributes to use for each ITS asset. Since the scope of the GIS was enhanced to allow VDOT to address statewide applications, this was seen as normal growing pains. It is fully expected that this additional coordinating with other VDOT interests (outside the NOVA District) will yield increased benefit to the Department.

Working Relationships

Working Relationship. It took time for the consultant to prepare the GIS and customize it to a clients needs. At times, client reviews facilitated large-scale changes in structure and appearance of some to all of the GIS. It was important to maintain a working relationship between the GIS development team and the user (VDOT) in order to avoid a misdirection of effort to prevent a situation where the entire GIS process had to be amended or, more significantly, repeated.

6 SUMMARY

All in all, the NOVA ITS System Architecture project was a valuable experienced for those involved.

The NOVA ITS System Architecture project was unique and unlike many other ITS architecture efforts, in that it included coordination with other complex regional architecture development efforts, and included the development of a tightly-coupled communications plan enhanced with a feature-rich GIS. The project should also be recognized for the significant stakeholder outreach effort that resulted in the organization of domain-specific focus groups and the confirmation of functional requirements. Another distinguishing aspect of the project is the development of a process for initiating ITS projects. Within the System Architecture report, there is direct guidance on how VDOT can use the architecture to plan ITS projects. Specifically, the availability of the System Architecture and Communications Plan has resulted in a new recommended project approval process, as shown by Figure 6-1. The Virginia Department of Transportation identified the need for an ITS System Architecture for the Northern Virginia District that was driven by stakeholders' requirements and conformed to the physical realities of the NOVA region. In addition to this, VDOT recognized the challenges the stakeholders would encounter when making decisions on how to use the system architecture at the project level, and provided appropriate guidance within the framework of the system architecture deliverable. Taking this one step further, VDOT realized the dependent nature of ITS on communications and set out to develop a Communications Plan to ensure investment in infrastructure and services is ultimately made with a vision in mind - a vision of increased integration and the provision of greater ITS services within the NOVA region.

Additional information about the NOVA ITS Architecture Project, including all related tasks and project reports can be found online at the following web address:

http://www.VDOT-ITSArch.com

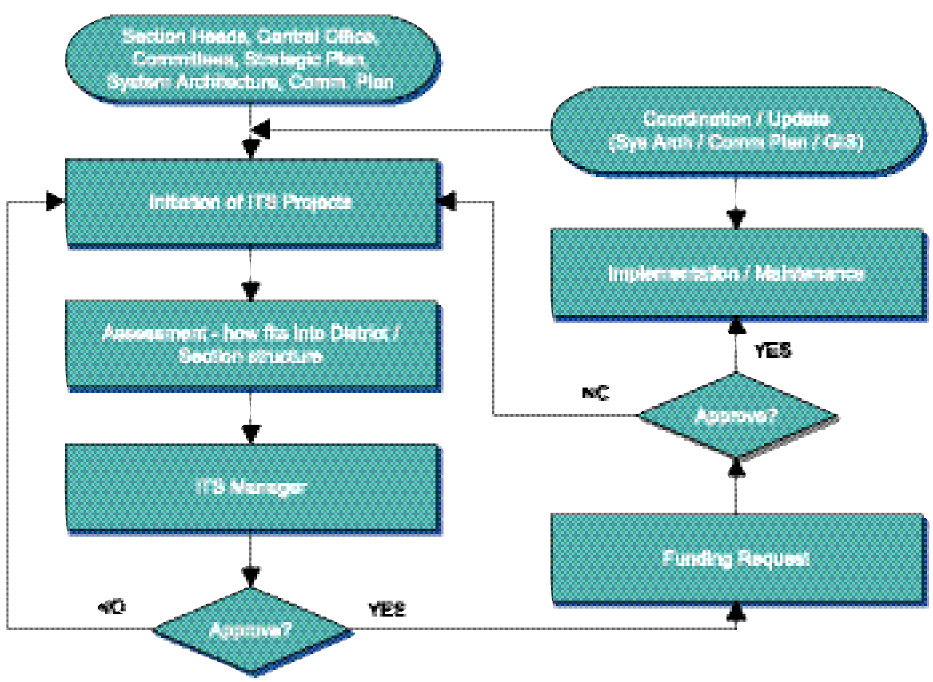

Figure 6-1 Recommended Project Approval Process

The NOVA ITS Team would like to thank all of the stakeholders whose active participation has helped us develop an outstanding Architecture!

Special thanks to the Federal Highway Administration and the VDOT ITS Division for financial support.

VDOT NOVA ITS Architecture

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14685 Avion Parkway
Chantilly, Virginia 20151
www.vdot-itsarch.com