Life After Regional Architecture:

Experience from NOVA ITS Regional Architecture Development and Practice

Author Name:	Amy Tang McElwain
Affiliation:	Virginia Department of Transportation – Northern Virginia District
Mailing Address:	14685 Avion Parkway, Chantilly, VA 20151
Voice:	(703) 383-2240
Fax:	(703) 383-2250
Email:	atm@VirginiaDOT.org

Co-Author Name:	Cliff Heise
Affiliation:	Iteris, Inc.
Mailing Address:	107 Carpenter Drive, Suite 230, Sterling, VA 20164
Voice:	(703) 925-3809
Fax:	(703) 471-1757
Email:	cdh@iteris.com

Abstract

In recognition of the value of a fully integrated and cohesive transportation program, Virginia Department of Transportation (VDOT) Northern Virginia District (NOVA) developed a regional ITS Architecture in 2002 and has since strongly promoted its use. The NOVA ITS Architecture meshes well with Architecture efforts in Maryland and the Washington Metropolitan area. It has significant participation of stakeholders and it includes a plan for how the Architecture will be used to program and implement projects. Furthermore, VDOT also developed strategies in implementing the use of architecture.

This paper presents the project background, the development of the NOVA ITS Architecture, then introduces the development of strategies in using the regional architecture and concludes by presenting the lessons learned and recommendations on the development of NOVA ITS Architecture and its implementation.

The development of the architecture is a “process” that we all benefit from and this process should be a well managed effort with strong championship by the project’s leading agency. The regional architecture has to be a “needs-based” effort with a robust outreach program that is carefully planned. One should pay more attention to using the architecture than just developing it. Maintaining the “living” architecture is an effort that NOVA is committed to. To successfully implement and use the architecture, institutions must embrace and understand it. Easily understood tools and training materials must be made available and adjustments must be made to the ITS project initiation process.

Background

VDOT's Northern Virginia ITS Program, known as the Smart Travel Program, includes multiple locations, activities, facilities, technology tools, and staff skills. These various elements are essential to the overall success of Smart Travel and are unique in their own blend of technology, resources and "people power". They work together to monitor traffic, provide information to travelers, manage the transportation system, and respond to incidents. The Program follows an integrated "full-cycle" process (Figure 1) to bring projects and activities from vision to reality, and to continuously improve those projects.

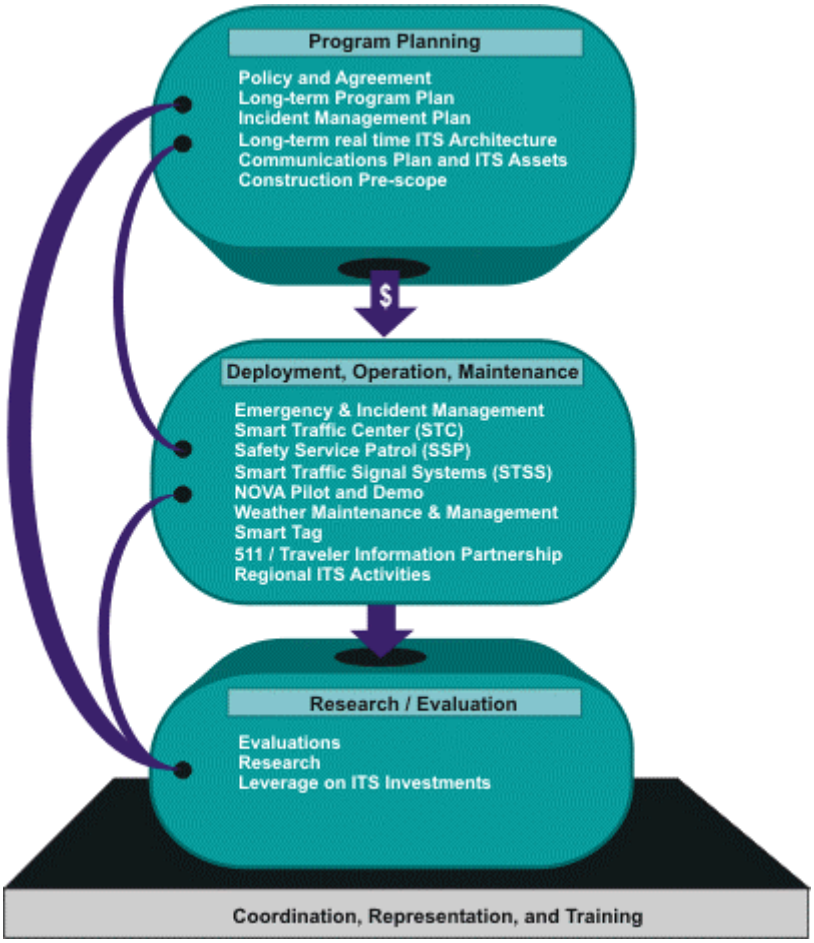

Figure 1. The VDOT Northern Virginia ITS Program Cycle

The process begins with detailed planning, moves through implementation, and includes thorough evaluation. Evaluation results feed back into ongoing planning, and are used to plan and implement improvements to existing projects as well as to initiate new projects. Key to this entire process is input and involvement from partnering agencies, also known as stakeholders. A primary output of the VDOT NOVA Smart Travel planning process was the development of the VDOT NOVA ITS Architecture. Although Federally-mandated and with USDOT-developed guidelines available, building a Regional ITS Architecture for a major metropolitan area remains an inexact science. Geographic constraints, political and institutional realities, even stakeholder disposition are all issues that can complicate Architecture development. Effectively addressing such issues requires creativity, flexibility and a willingness to try unique approaches. This is exactly the path the Virginia Department of Transportation's Northern Virginia District (VDOT NOVA) took in crafting the VDOT NOVA ITS Regional Architecture. Strategically situated in the National Capital Region (see Figure 2), the NOVA ITS Architecture details the interconnection of VDOT facilities with other non-VDOT stakeholders' systems, and describes the flow of information between these agencies and VDOT NOVA operations. 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.

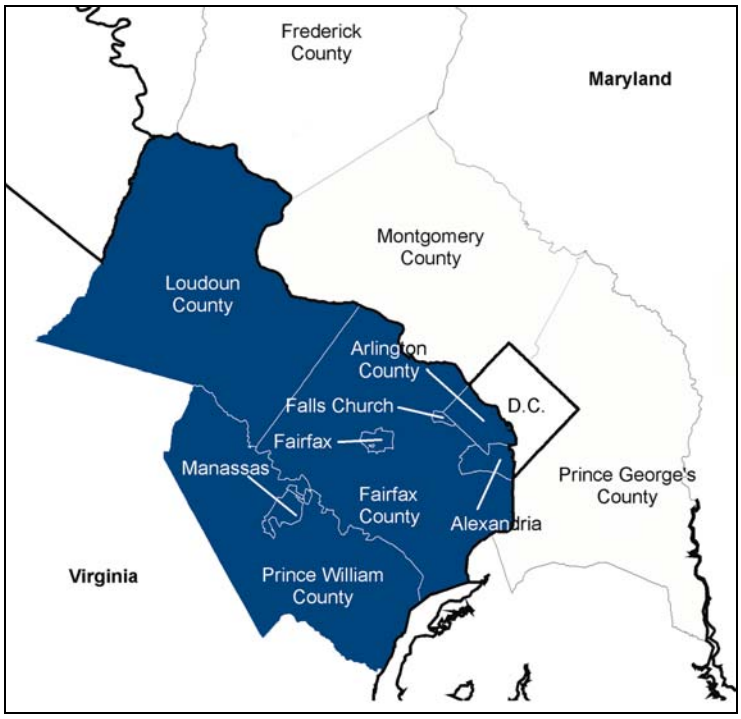

Figure 2. VDOT Northern Virginia District in the National Capital Region

While the NOVA ITS Architecture was under development, two related ITS architecture development efforts were undertaken; the Metropolitan Washington Regional ITS Architecture and the Maryland Statewide ITS Architecture. The NOVA ITS Architecture is interwoven with these two efforts in DC and Maryland. The Metropolitan Washington Regional ITS Architecture encompasses the entire NOVA ITS Architecture region. The overlap required extensive coordination among three efforts to synchronize the architecture nomenclature and interfaces that were common to both architectures. As a result, the NOVA ITS architecture could focus on a VDOT NOVA-centric architecture which focuses on the interfaces and integration opportunities with VDOT NOVA systems. The Northern Virginia interfaces that are not included in the NOVA architecture 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, therefore, the coordination is focused on the boundary interfaces. In order to accomplish greater regional harmony among all three architecture efforts, the NOVA team established and maintained cooperation throughout the entire project. The result of the extensive coordination among three architecture efforts is shown in the consistency of terms and nomenclature throughout the individual architectures and the consistency and cohesive stakeholder input.

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, distinctive 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 a framework for future planning and integration.

The NOVA ITS Architecture documentation identified when and how the architecture can be used. It can be used before funding is identified for a project to better define the project’s scope and develop a cost estimate. It can be used when funding is identified but a project architecture is needed. After a project is completed, a project architecture is submitted for incorporation into the regional architecture definition. The NOVA ITS Architecture also identified three strategies in implementing the use of the architecture:

1. Tool Development – A web site was determined the best way to keep the “living” architecture available to users, provide general navigation of the information, and

present a step-by-step process in using the architecture based on the stage of the project.

2. Education – A training program is to be developed for all potential users of the NOVA ITS Architecture. The training would utilize the web site and Turbo Architecture extensively to accomplish the goal of offering the instrument to potential users.
3. Institutional Embracement – An on-going champion effort is underway to include "Use of the Regional Architecture" in the existing ITS project initiative and development processes.

Development of the NOVA ITS Regional Architecture

The purpose of the architecture is to establish a framework that will guide regional transportation planning, project development, and execution to achieve increased integration of VDOT's transportation system with other transportation systems. It does this by supporting and establishing center-to-center information exchange. The formal name of this project, the VDOT NOVA-Centric ITS Architecture, highlights this focus on VDOT interfaces. The NOVA ITS Architecture Team followed the process identified in the Federal Highway Administration's Regional ITS Architecture Guidance Document for Developing, Using, and Maintaining ITS Architectures. The process was slightly tailored to fit the needs of NOVA. Figure 3 illustrates the process used to develop the NOVA ITS Architecture. The two final steps that deal with the use and maintenance of the architecture are addressed further in this paper.

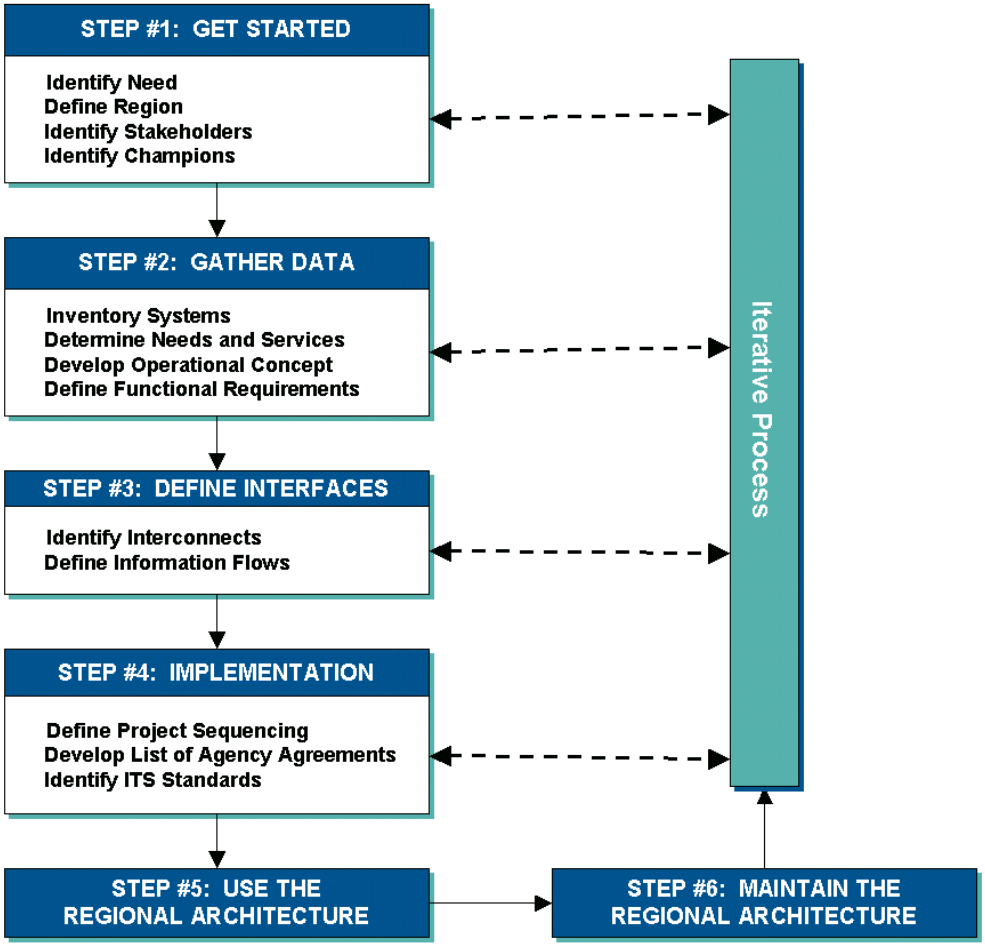

Figure 3. NOVA ITS Architecture Development Process

The key to the success of the development process was the involvement of the stakeholders in the region from the very beginning. As mentioned earlier, in addition to the stakeholders within the region, there were 2 other regional architectures that were strong influences on the NOVA ITS Architecture: the Metropolitan Washington Regional ITS Architecture and the Maryland Statewide ITS Architecture. To establish a solid baseline from the outset of the development efforts, the 3 architectures were coordinated at the systems inventory, interconnect, and information flow levels to maintain continuity among the architectures through a series of meetings and reviews.

The most fundamental and important coordination was the resolution of nomenclature for the various components of all the architectures.

The Outreach element was a unique effort designed to critique and validate the needs identification, systems inventory, planning of user services, and associated activities. 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. The success of this Outreach effort is evident in the quality and quantity of stakeholder participation and feedback, and the increased accuracy and relevance of the final Architecture product.

Use and Maintenance of the NOVA ITS Architecture

The work done to develop the NOVA ITS Architecture is valuable only if it contributes to improving the integration of transportation systems in Northern Virginia, particularly VDOT systems. VDOT transportation planning is a process that involves project definition, review, prioritization, approval, funding allocation, and incorporation into the transportation plan. The path that a project follows in the planning process is dependent on the funding source being sought for the project. There are three areas in the process that the NOVA ITS Architecture can and should be used:

1. It can be used before funding is identified for a project to better define the project's scope and develop a cost estimate. To define the scope, the user would identify the subsystems or stakeholders that best match their organization by navigating the NOVA ITS Architecture web site. From this web site, www.vodt-itsarch.com, one

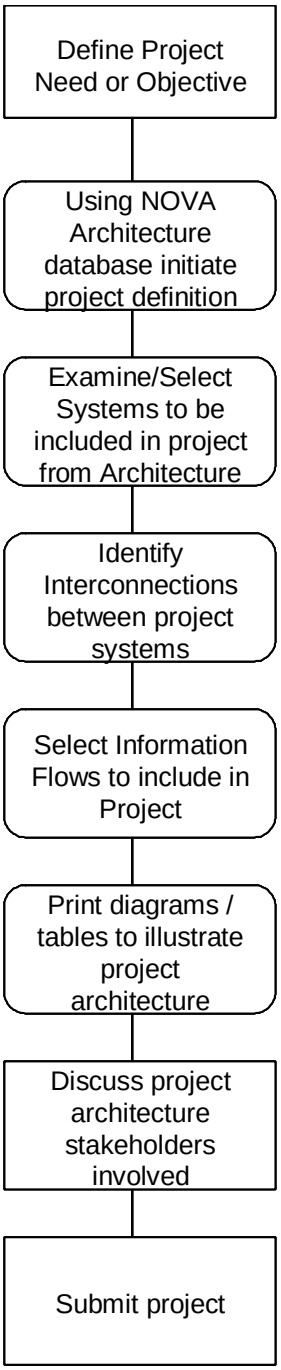

Figure 4. Use Turbo Architecture

can click on the Stakeholders or System Inventory buttons on the site's link menu. Examination of the subsystems will provide information about what other subsystems might interface with the subject system. This will provide a better understanding of the proposed project's scope and interface requirements.

2. It can be used when funding is identified but a project architecture is needed. The regional architecture would be used to define a project architecture and gain consensus from stakeholders on its scope, interfaces, and integration opportunities. A project manager would associate the project components with regional architecture subsystems that match functionality required in the project. When defining a project from the regional architecture, the NOVA ITS Architecture Turbo Architecture database is a valuable tool. The most recent NOVA ITS Architecture Turbo file can be downloaded from this web site by selecting the NOVA Turbo DB button on the link menu. Figure 4 illustrates a basic process to develop a project architecture using Turbo Architecture, the software application that was used to build the NOVA ITS Architecture. The boxes with the rounded corners are steps that use the Turbo Architecture Tool. Using Turbo Architecture, the Project Manager will examine the NOVA ITS Architecture database and analyze

the interconnections and information flows pertaining to each of the subsystems of interest. Definitions of the information flows and subsystems can be examined on the website. This analysis may identify other subsystems that should be included in the project. The Project Manager will then create a project architecture using Turbo Architecture and the NOVA ITS Architecture. By creating a project Architecture in this manner, the Project Manager is using the NOVA ITS Architecture as a reference and defining a project that is consistent with the NOVA ITS Architecture. This maximizes the possible integration opportunities that can be considered for the project. The Project Manager can make informed decisions about the integration boundaries of the project in the initial implementation and what will need to be supported in the future, therefore defining a project that will support expanded capabilities in the future as the need or funding becomes available. The Turbo Architecture tools can be used to examine and select which systems will be interconnected and the information exchanges that will take place between them. Turbo Architecture also contains several reporting formats that allow the user to produce diagrams and tables to convey the architecture to others for review and approval.

3. After a project is completed, a project architecture is submitted for incorporation into the regional architecture definition. This is a very important use of the web site. It allows for the evolution of the regional architecture to maintain its usefulness to other stakeholders. The project manager would send the project architecture's Turbo Architecture file the NOVA Smart Travel Manager to be folded into the regional architecture definition by selecting the "Submit Project Architecture" button on the

site's home page. This will guide the project manager on how to submit their architecture for incorporation. Following project completion, the NOVA ITS Architecture must be updated to reflect the establishment of interconnects and/or information flows or new subsystems in the architecture. If portions of the project architecture were not implemented as planned, they should not be reflected in the updated architecture so they may be considered as an aspect of another project in the future.

The web site also provides a simple guideline on when to use the NOVA ITS Architecture. As mentioned earlier, there are other regional architectures in the Northern Virginia Area and the NOVA ITS Architecture focuses on VDOT system interfaces with other systems. Which Architecture should one use? The rule of thumb is that if one owns or operates a VDOT system or the system interfaces with a VDOT system, one should use the NOVA ITS Architecture. If one is interested in a non-VDOT system and it doesn't interface with a VDOT system, one should consult the Washington Metropolitan Regional Architecture. Information and contact data for the Washington Metropolitan Regional and Maryland Statewide Architectures are available on the web site.

VDOT is committed to leveraging this architecture to deploy ITS more efficiently. The NOVA ITS Architecture has been defined and documented and is available on the web. It is important that the architecture database and the website information be maintained as current as possible so that stakeholders wishing to use the data are leveraging the most accurate data available. VDOT will collect potential changes and keep the changes in a database in addition to the project architectures submitted by project

managers to the web site. All changes will be evaluated and confirmed with stakeholders and used for updating the NOVA ITS Architecture definition. The change to the NOVA ITS Architecture database will automatically update the web site to reflect the database content. Changes to the website and database information will be documented and made available to users under a "What's New" link on the website.

Strategy in Implementing the Use of Regional Architecture

While the VDOT NOVA Architecture team is committed to the use of the regional architecture, implementing the use of architecture is quite a challenging task. As previously mentioned, three strategies were developed to support the implementation of the regional architecture:

1. Tool Development – A web site keeps the "living" architecture available to users, provides general navigation, and presents a step-by-step process for using the architecture depending based on the stage of the project.
2. Education – A training program has been developed for all potential users of the NOVA ITS Architecture. The training would include an overview of the NOVA Architecture Website, an overview of the application of the architecture in the NOVA planning process, an overview of Turbo Architecture, and instruction on the application of Turbo Architecture and the NOVA ITS Architecture in the development of a project architecture. The training would accomplish the goal of providing the users with the proper instruments.
3. Institutional Embracement – An on-going champion effort is underway to "Use the Regional Architecture" in the existing ITS project initiative and development

processes. The goal of this effort is not to impose more work upon the NOVA Staff managing the ITS project development, but to ensure that the projects are defined with integration in mind. Each project should consider all potential integration possibilities. Projects defined without considering integration opportunities will be found to be more costly in the long run due to the cost of redesign in the future. These tools will allow VDOT to better financially plan ITS investments and assist VDOT managers in understanding the priorities of ITS deployment in the NOVA District. After one year of champion effort, VDOT has included "Using the Regional Architecture" in the effort for developing a Statewide ITS Project Development Process.

Lessons Learned

VDOT NOVA's experience offers some significant lessons that are of value to any jurisdiction undertaking a Regional Architecture effort. Following are some of the more important lessons learned in Northern Virginia:

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.

Flexibility to adjust architecture definition. The Architecture definition was nearing completion when the September 11th attacks occurred. The project team met with the most closely involved VDOT stakeholder, the NOVA Smart Traffic Center (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.

Organize Stakeholders by Functions. The project 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 promote discussions during the meeting on the subject. Stakeholders also seemed more at ease interacting with peers who had common interests and concerns.

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. Figure 5 is an illustration of the general planning process in NOVA and how the architecture can be used in general terms. 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 Baseline 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. At the web site, a step-by-step process illustrates to users when, what, and how to use the NOVA ITS Architecture. 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.

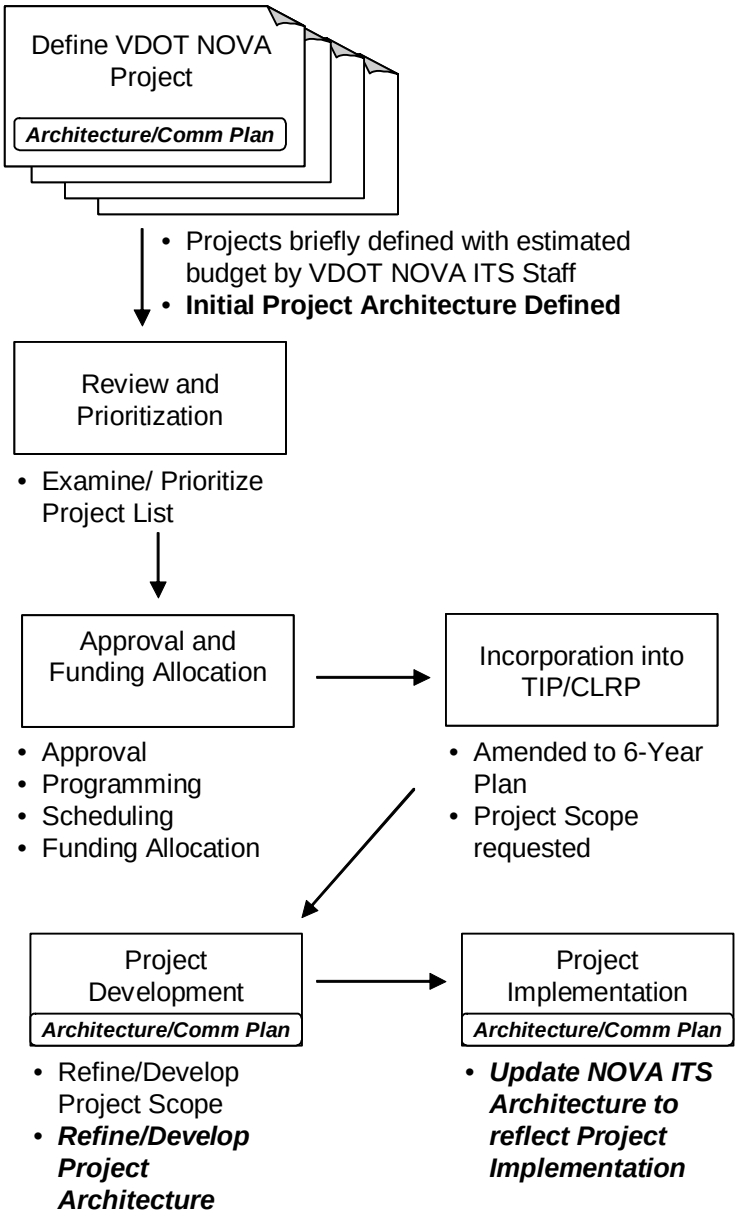

Figure 5 Applying Architecture in General Planning Process

Identify A "Champion". The project team recognized early 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. This energized the stakeholders to work alongside the region's primary provider of transportation services.

Maintain Stakeholder Interest. The project team discovered that details such as information 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 it was otherwise unclear based on the flow name alone,. 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. It is also very challenging to maintain stakeholder interest after the architecture is developed. An on-going effort of championing the use of architecture is critical to gain the attention and interests of stakeholders.

Be Willing to Change the Architecture. Do not assume that stakeholders understand that the project 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. After the architecture is developed, education and outreach efforts are needed to make stakeholders aware of the importance of their input after the architecture is completed, because the architecture is a "living" process, not a one-time deal.

Coordinate with Adjacent Architecture Efforts. In a region that is in 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. Working sessions were held with these other architecture efforts to maximize consistency among all the architectures.

Tailor the Process to the Region. The USDOT 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, or 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.

Stakeholder ITS and Communications Staff May Be Different. It became apparent 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.

Be Ready for the Life After Architecture. As ITS deployment evolves, changes to the Architecture are inevitable. Agencies should prepare the resources, have a plan on how the changes will be made to the architecture, and determine how best to distribute such changes to the users. The website has proven to be a very effective tool in keeping the "living" architecture available to NOVA ITS Architecture users. The annual update to the architecture is efficient for NOVA architecture. The Outreach effort does not stop after the architecture is developed, as a matter of fact, the challenge just begins. Agencies are encouraged to have a plan for this continuous outreach effort. In Northern Virginia, the first phase of outreach after the architecture is to roll out the education program and publish articles to attract stakeholders' attention. Should the architecture be used by most stakeholders, the outreach effort could become a less challenging task.

Face the Challenge on the Use of Architecture. Even with the best tools and training developed, if using the architecture does not show any incentives to project managers it will be very difficult to have project managers conform to the demand. Changing business conduct institutionally becomes the next best approach. "Using the architecture" should become one of many steps that an agency has to follow while developing a project. This is a greater challenge than just ensuring the correct use of the architecture.

Acknowledgements

The authors would like to thank all the stakeholders whose active participation has helped us develop an outstanding regional Architecture! Their time, professionalism, and expertise made the NOVA ITS Architecture a comprehensive and useful tool. The author would also like to extend her appreciation to Federal Highway Administration and VDOT for their financial support. The NOVA ITS Architecture working team consisted of three consulting companies, ARINC, Iteris, and PB Farradyne, and VDOT NOVA Smart Travel Program team. The authors would like to thank all the working team members for their hard work and exceptional performance. We also appreciate the participation of the two other architecture efforts in DC and Maryland for coordinating the development this architecture with theirs.