Everything you ever wanted to know about building an ITS architecture

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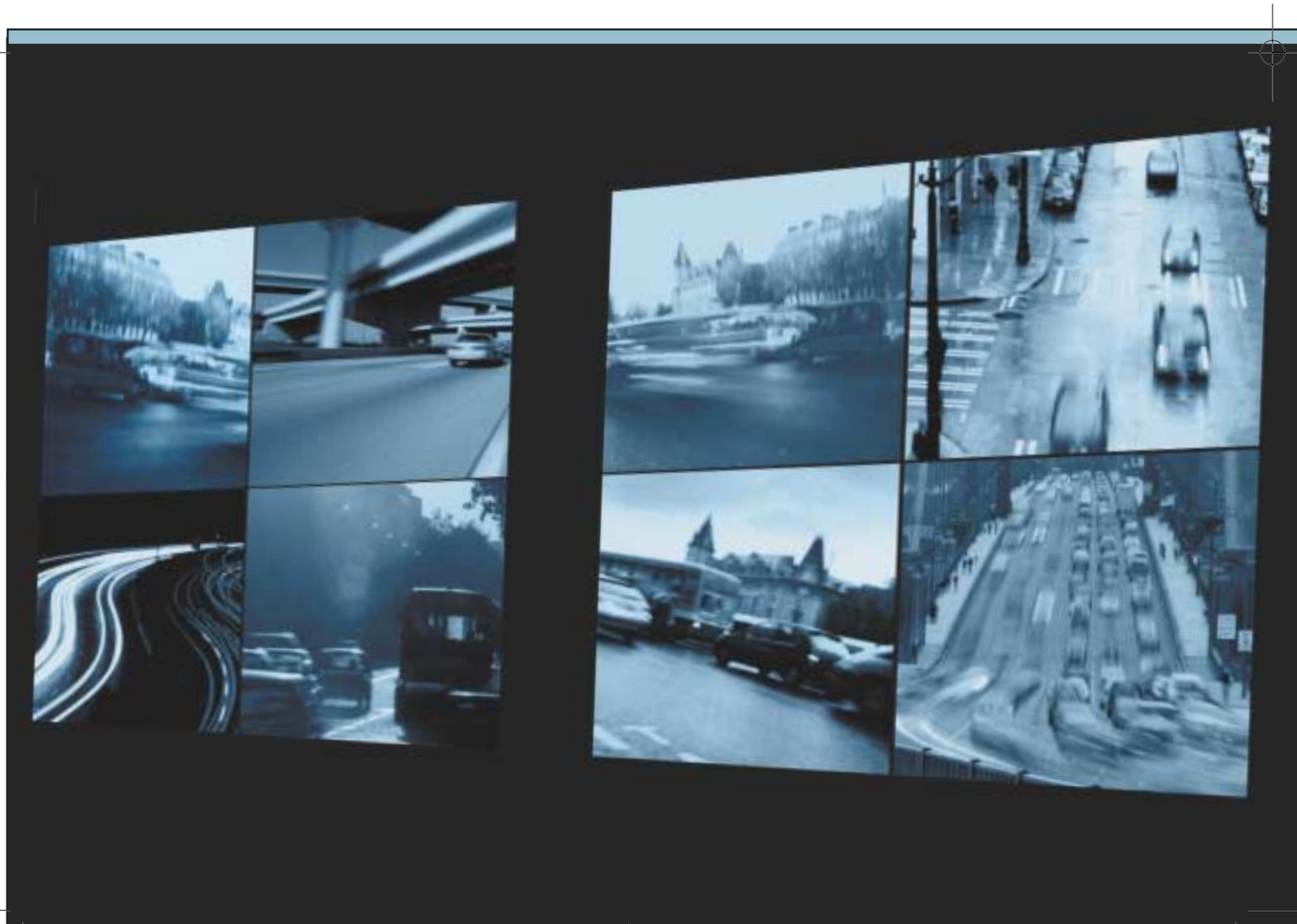
Virginia DOT's Northern Virginia District shows the way to effective regional architecture development



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. This architecture is not only acknowledged as the model for further regional architecture efforts in Virginia, but offers an outstanding example to any authority throughout the United States that realizes that an effective architecture must mesh with the characteristics unique to that jurisdiction. To this end, the VDOT NOVA ITS Architecture is now being used by the Federal Highway Administration as a 'best practices' model for developing regional architectures.

A unique architecture

Strategically situated in the National Capital Region, VDOT's Northern Virginia District is a burgeoning, vibrant area of international importance. Its hardy 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 co-operate, 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. This 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.

A tailored approach

The VDOT NOVA District is immediately adjacent to the District of Columbia and separated from Maryland by the Potomac River. It 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 NOVA, working with a project team that included PB Farradyne, Iteris and ARINC, embarked on the development of a Regional ITS Architecture. The NOVA District includes many inter- and intra-state roadways and transportation facilities traversed daily by local and regional travellers. There are also numerous public and private-sector agencies within the district and surrounding region that provide transportation-related services and/or are substantial users of the surface transportation network. This makes each of these organizations stakeholders in the architecture. The development of an ITS architecture for the NOVA District supports the regional deployment and integration of multi-modal transportation services that impacts all of these stakeholders.

The project team developed several principles to guide development of the architecture. These were:

- Directly support ITS within the Northern Virginia District;
- Leverage previous projects (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;
- Provide a framework ('blueprint') that will drive regional decision making on transportation related endeavors and guide NOVA operations managers through system deployment;
- Provide general guidance and sufficient 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 travellers;
- 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.

In keeping with these guiding principles, the project team followed a process tailored to Northern Virginia: a process designed to involve and interest stakeholders while making it easy for them to participate; to anticipate and be able to respond to change and technology development; and to create related tools that would augment the Architecture itself while adding value.

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VDOT NOVA Smart Traffic Center

Super Nova

One key element to this approach was the use of a Strawman Architecture, based on existing ITS frameworks and the team's knowledge of ITS needs in the region. This provided stakeholders with something to respond to, rather than asking them to develop portions of the Architecture from nothing.

Another important element was coordination with the Washington D.C. ITS Regional Architecture, and the Maryland Statewide Architecture. The NOVA ITS Architecture is interwoven with each of these efforts. 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 collaborate on nomenclature and system definitions at the boundaries of the architectures to support information exchange between the regions. In order to achieve greater regional harmony among all three architecture efforts, the development teams established and maintained cooperation throughout the entire project.

In addition to developing the actual physical or systems architecture, the project creatively made use of some new elements to enhance the accuracy and usefulness of the architecture. This resulted in several non-traditional products that complement the architecture itself.

Stakeholder involvement

The NOVA ITS Architecture included what the project team believes to be the most comprehensive and proactive outreach effort ever undertaken in developing a regional architecture. The Outreach element 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 project 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 project 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.

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 stakeholder support and consensus.

Following completion of this series of meetings, the project 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 11 September 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 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.

Understanding the backbone

To support implementation of the Architecture, a plan was needed to address infrastructure and services available or needed within Northern Virginia to develop robust interagency communications and support regional ITS initiatives. The primary purpose of the Communications Plan was to provide the framework needed to support the interconnects and information flows identified between VDOT and the project stakeholders.

As a first step, the architecture was translated into high-level communications requirements. The System Architecture Flow Definitions were translated into communications-related requirements and a projected bandwidth was considered. Then, existing and planned communications infrastructure belonging to both VDOT and stakeholders was inventoried and analyzed to determine to what extent it would meet the needs of the architecture.

To meet the communications needs identified by this inventory, an assessment of candidate technologies and applicable standards was conducted. Included was analysis of wide area wireless and wireline communications options, as well as discussion of important standards such as the National Transportation Communications for ITS Protocol (NTCIP) and Dedicated Short Range Communications (DSRC). Recommended technology choices were mapped against requirements to reveal the best

technology fits, and a proposed communications backbone architecture was presented.

Finally, the plan provides recommendations on the deployment of communications infrastructure and services. The recommended phased approach will position VDOT NOVA 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.

Asset baseline: "What we have"

Another unique 'by-product' of the Architecture was creation of an ITS Asset Baseline depicting facilities and equipment in a Geographic Information Systems (GIS) database.

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. 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. Within the constraints of the project, the team was able to build an efficient inventory, in a relatively short period of time. The Asset Baseline 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 the initial inventory and analysis effort even more useful.

Ensuring a living architecture

A regional architecture is only useful as long as it remains current, accurate and relevant. Recognizing this, the project team undertook another first in the annals of architecture development: creation of an Internet-based tool for updating and maintaining the architecture.

Upon completion of the architecture itself, the project team created an interactive project Web site (located at www.vdot-itsarch.com) that makes the architecture a dynamic, living tool. The Web site features all project reports, documentation and work products as well as materials germane to the architecture, such as PowerPoint presentations and links to team members.

More importantly, the Web site is the mechanism by which any stakeholder can download the architecture itself; and the NOVA ITS Architecture database, suitable for use in FHWA's Turbo Architecture tool. Stakeholders can upload their project architecture to the Web site and VDOT will incorporate that information into the VDOT NOVA ITS Architecture, the Asset Baseline and Communications Plan. In this way, the architecture remains current and responsive to changing technologies and institutional relationships. It becomes a truly living architecture.

Lessons for any jurisdiction

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 co-operation.

The breadth of the project was written well in advance of project execution.

> "A regional architecture is only useful as long as it remains current, accurate and relevant"

Aerial view of Washington, DC

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 teamwork 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 11 September attacks occurred. The project 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 co-ordination that was required for such an event. It is important to monitor the architecture to ensure that it is as accurate as possible, even in the late stages of its development.

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 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. By focusing on the use of these products, VDOT has already strengthened the product's chance for making a positive impact on the integration of ITS in Northern Virginia.

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 keep discussions during the meeting on subject. Stakeholders also seemed more at ease interacting with peers who had common interests and concerns.

Identify a champion

The project team recognized early on that a respected and viable champion would lend significant credence to the Outreach process. Accordingly, VDOT's project manager 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 project 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.

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.

Co-ordinate 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 harmonize 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.

Tailor to the region.

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 and 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 & 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.

A regional and national model

The NOVA approach is and will be used throughout VDOT's districts as a model in preparing their own ITS Architectures. But its lessons and hallmarks can be of value to any jurisdiction in any part of the country. Proven, effective tools and methods; a willingness to uniquely adapt those tools and methods to fit specific geographic and institutional realities; the ability to conceive and implement different and non-traditional tools and methods where appropriate, and; the flexibility to adapt and change both the process and the product as circumstances dictate: these are the hallmarks of an effective architecture development program, and aptly describe the approached pioneered in Northern Virginia. ■

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