

The Intelligent Transportation Society of America

## **VII White Paper Series**

### **Primer on Vehicle-Infrastructure Integration**

#### **Introduction**

For nearly 15 years, the US DOT and ITS America have hypothesized that applications such as intersection collision avoidance could best be accomplished through sophisticated vehicle-infrastructure and vehicle-vehicle communication. During the past two years, this vision has been under intense exploration as part of the US DOT's Vehicle Infrastructure Integration (VII) major initiative.

The current level of knowledge concerning the VII initiative is extremely variable throughout the ITS industry. The intent of this Primer is to fill-in some of these gaps in knowledge as well as help document the history for future reference. It is not intended to answer every possible question - a feat that would be difficult if not impossible.

The aim of the VII initiative is to deploy and enable a communications infrastructure that supports vehicle-to-infrastructure, as well as vehicle-to-vehicle communications, for a variety of vehicle safety applications and transportation operations. Additionally, VII will enable the deployment of a variety of applications that support private interests, including those of vehicle manufacturers.

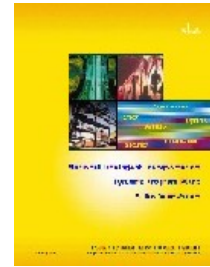
A public-private VII Coalition has been formed and will determine if the infrastructure deployment can be synchronized with the vehicle integration. Based on their planned development and exploration, the VII Coalition will not render its final decision for a nationwide rollout until the 2008 timeframe.

#### **Early History**

The concept of technology enabling a vehicle to communicate with the roadway is not new. In 1992, IVHS America (the Intelligent Vehicle-Highway Society of America) brought its industry sectors – private industry, academia, and government – together with the US DOT and collaborated on the development of a *Strategic Plan for IVHS* in the United States. The plan clearly noted “as development proceeds, there will be increasing interaction among traffic management, traveler information, and vehicle control systems.”

In 1995, the newly-renamed ITS America again collaborated with the US DOT on the development of a *National ITS Program Plan* that clearly visualized intersection collision avoidance applications that “may involve infrastructure-to-vehicle and/or vehicle-to-vehicle communications.”

Six years later in 2001, ITS America and the US DOT came together yet again, and began to lay the groundwork for the future in the development of a new strategic document, the *National ITS Program Plan: A Ten-Year Vision*. This Plan outlined an enabling path to collision avoidance “through the use of dedicated short-range communications to support infrastructure-vehicle and vehicle-vehicle communications,” particularly in the 5.9GHz band allocated by the Federal Communications Commission (at the request of ITS America) for ITS safety applications.



But it did not stop there. In the plan, the concept of an Integrated Network of Transportation Information opened wide the doors to the power of data - and the utility of the information that could be generated as a result of that data.

The National ITS Program Plan of 2001 outlined a vision for creating, operating, maintaining, and updating the mechanisms that will gather, analyze, coordinate, extrapolate, and store the data, and interact with adjoining external systems. It was clear that this would not be simple, and in fact the Plan noted that building the Integrated Network of Transportation Information would be more complex than building the Interstate System. However, the groundwork was presented, and it was hypothesized that the process could be guided and led from the center, but with the activity being highly distributed.

ITS America set about organizing this effort, and held an exploratory workshop in early 2003 to energize our diverse industry toward the concepts of “more and better data.” It was at this now historical “INTI Workshop” that automobile manufacturers and state transportation officials began to talk the same language and see that such a connected concept was indeed possible - and building upon that energy, the US DOT began planning to launch its new VII initiative.

### **Evolution of Stakeholders**

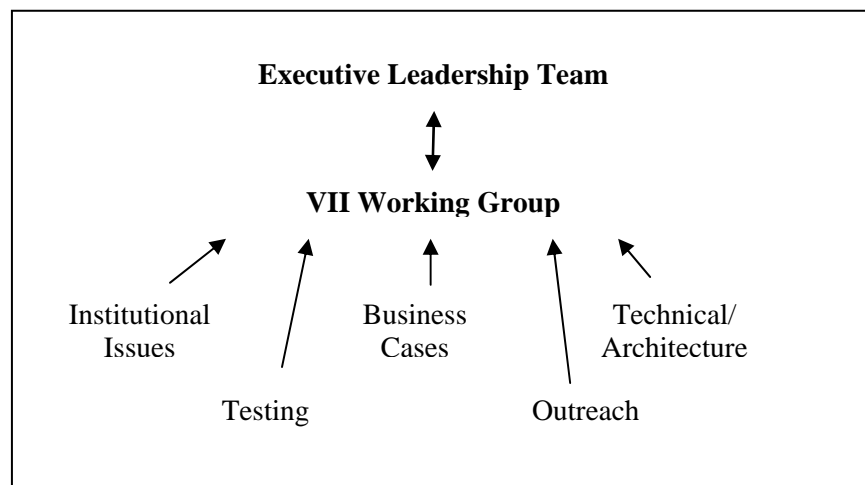
At ITS America’s 2003 Annual Meeting in Minneapolis, the US DOT gathered stakeholders from several state departments of transportation with several representatives from automobile manufacturers in a small exploratory set of meetings. From those initial meetings, a series of brainstorming discussions led to the concepts that today embody VII, and it was from that humble beginning that the current governance structure was first envisioned.

Minnesota DOT, Florida DOT, Caltrans (California DOT), and Michigan DOT were early participants in what would become the VII initiative, as were representatives from DaimlerChrysler, General Motors, Toyota, and Nissan. The American Association of State Highway and Transportation Officials (AASHTO) was front and center during those early meetings, and helped organize the public sector representation for future meetings, as was the Alliance of Automobile Manufacturers (The Alliance).

US DOT leaders were purposeful in keeping the group small, so that the great many challenges associated with developing the scope of such a significant project could be fleshed out. Over the next 12 months this group added a few more state DOT's and automobile manufacturers, but maintained a tight circle so as to facilitate exploration of issues concerning governance, privacy, and data sharing.

At ITS America's 2004 Annual Meeting in San Antonio, the US DOT formally announced its "major initiatives" program approach, and the Vehicle-Infrastructure Integration initiative was one of the nine new programs. By then, the "VII Working Group" was showing signs of stable organization. The group had held several meetings and conference calls, had developed a clear vision, and were working on specific use cases (applications) on which to focus. Organized subcommittees were working on key issue areas, and the group had begun to engage senior executives from the states and the automotive manufacturers. What is known today as the VII Coalition was now coming together. Figure 1 depicts the general organization of the Coalition.

**Figure 1** - General Organization of VII Coalition



But this new Coalition faced many challenges in developing consensus on the finer details of a VII program plan, and the US DOT continued its deliberate approach of keeping the circle of participants limited in size. By then, however, questions from a large number of other potential stakeholders were beginning to mount.

Over the next 6 months the VII Working Group steadily worked on fleshing out various deployment approaches, tackling the immense task of developing an architecture, and continuing to massage the delicate relationships necessary to find consensus amongst the states and automakers. Potential stakeholders who were not represented in VII began to voice their rising interest in VII, and the Outreach Subcommittee of the Working Group set about the task of developing a "public meeting" so that VII progress could be clearly and publicly presented.

As the Working Group began planning this public event to update those not around the table, they also made it a point to invite some additional stakeholders to the debate that would be directly affected by the deployment of VII. Local transportation officials - city, county, and MPOs (metropolitan planning organizations) - were sought for involvement and represented through the Institute of Transportation Engineers. Toll agency officials were given representation through the International Bridge, Tunnel and Turnpike Association. And international automakers were given representation from the Association of International Automobile Manufacturers.

The February 2005 public meeting for VII was a resounding success, relieving some of the pressure for knowledge, and opening the door to new ideas and input. The US DOT and VII Working Group continued this pattern of outreach at subsequent meetings of associations, including ITS America's 2005 Annual Meeting in Phoenix. But the industry also began organizing its own debates and exploratory discussions at that Phoenix meeting, with several educational sessions and Forum Showcases dedicating chunks of time to the issues and concepts associated with VII.

ITS America was invited as a formal member of the VII Coalition (through representation on the Working Group and Executive Leadership Team) soon thereafter, with the express purpose of representing the parties not currently around the table, with primary emphasis on those that will develop and/or deploy applications relying upon VII.

Today, the Working Group representation includes:

- US DOT - FHWA, FMCSA, ITS JPO and NHTSA.
- Automotive Manufacturers - BMW, DaimlerChrysler, Ford, General Motors, Honda, Nissan, Toyota Motor North America, and Volkswagen.
- State/Local Agencies - CALTRANS, Florida DOT, Idaho DOT, Indiana DOT, Maryland State Highway Administration, Metropolitan Transportation Commission (San Francisco Bay Area), Michigan DOT, Minnesota DOT, New York State DOT, Utah DOT, Virginia DOT, and Washington State DOT.
- Associations - AASHTO, Alliance of Automobile Manufacturers, Association of International Automobile Manufacturers, IBTTA, ITE, and ITS America.

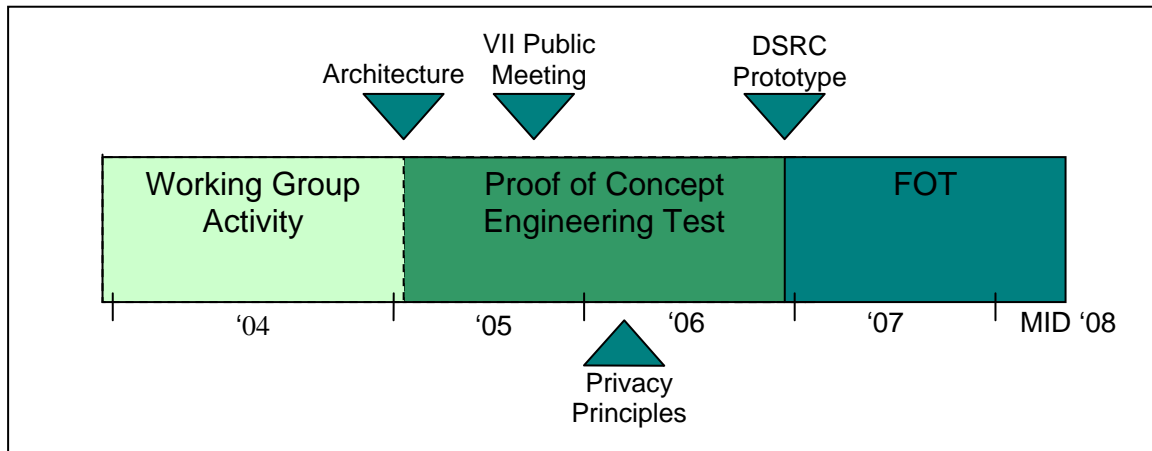
## **The VII Program**

The VII program is a multi-faceted, multi-disciplinary program. Its ultimate rollout and deployment will insert various ITS technologies into the transportation infrastructure and integrate ITS communications and sensors in vehicles.

The aim of the VII program is to deploy and enable a communications infrastructure that supports vehicle-to-infrastructure, as well as vehicle-to-vehicle communications, for a variety of vehicle safety applications and transportation operations. Additionally, VII will enable the deployment of a variety of applications that support private interests, including those of vehicle manufacturers.

The VII Coalition will determine if the infrastructure deployment can be synchronized with the vehicle integration. Based on this implementation strategy, the VII Coalition will not render its final decision for a nationwide rollout until the 2008 timeframe. Figure 2 depicts this general approach.

**Figure 2** - General Timeline of VII Initiative



The VII program builds upon work previously done, in separate projects, under the auspices of the US DOT's IVI program, Vehicle Safety Communications (VSC) project, the Enhanced Digital Map (EDMap) project, and the Federal Communications Commission's (FCC) spectrum allocation for Dedicated Short Range Communications (DSRC) in the 5.9 GHz band. Use of the research results and operational tests from these independent projects enables the VII program to bring a wide range of initiatives under a single umbrella with clearly defined goals and objectives, as well as clearly defined roles for the public and private sectors.

From a pure engineering perspective, most agree that VII is technically feasible. There are, however, a large number of economic and institutional issues (and perhaps some political issues) that must be addressed and resolved prior to the VII Coalition's final decision to deploy DSRC around the country.

Reporting to the VII Coalition's Working Group, several subcommittees are examining various facets of the program, such as the technical aspects (including operational tests, standards development and prototyping), institutional issues (security, privacy, data ownership, product liability, certification and registration), business models (including the development of use cases or "killer applications," which may be immediately available as the network is rolled out, and deployment costs for roadside units), and a much needed outreach effort.

Version 1.1 of the VII Architecture and Functional Requirements (dated July 20, 2005) is already available and was outlined at a public meeting in late July 2005. This high level architecture, based upon DSRC as a communications medium, describes the functional requirements of the proposed system, which is further divided into 4 elements (the

vehicle, roadside infrastructure, and a network for each of public and private uses). The development of the VII Architecture, which is fundamentally similar to the development of the National ITS Architecture, provides a logical framework defining not only the flow of data, but also the location and ownership of the VII data, to meet the requirements of more than 70 use cases.

The development of the VII Architecture remains a dynamic process, which reflects the complex nature of the VII technical and institutional issues. Therefore, Version 1.1 of the VII Architecture is by no means the final version. The US DOT and the VII Coalition welcome comments from all interested potential users and providers of the system.

It is important to highlight that, although DSRC is the basis, currently, for specific VII safety applications, DSRC is simply one of several communications technologies being investigated for the delivery of VII applications. In fact, there are several wireless technologies that could provide the vehicle-to-infrastructure link, while other wired or wireless technologies could extend the communications link from the roadside infrastructure to a traffic management center or a data content provider.

### **Potential Benefits of VII**

As mentioned in the history, intersection collision avoidance has long been considered an important tool in our fight to reduce highway fatalities. If two vehicles are approaching an intersection at a right angle, they can communicate with the infrastructure - and each other - to presumably stop themselves from potentially crashing. But so many other potential benefits are possible by opening up this channel of communications. Here are a few examples:

- Traffic flow through signals could be made more efficient, through the use of probe data that would allow more frequent or improved re-timing of the signal, and/or dynamic control of the signal based on real time traffic counts or queues at the intersection.
- Re-routing of traffic due to construction, accidents, or planned special events could be made more efficient based on the knowledge of real-time freeway traffic as well as real-time traffic conditions on arterials.
- Defect and Warranty information can be transmitted to/from the vehicles from the moment they roll off the assembly line to the last moment that vehicle is driven. This can improve the speed with which problems are repaired, enhance the ability to notify drivers of potential problems, and even help diagnose recurring problems that can be fixed sooner in the manufacturing process.
- Transit and fleet vehicles could exchange real-time schedule information with a dispatch center, as well as with waiting passengers or waiting customers.

- Curve Speed Warning and Lane Departure Warning are currently being done with sensors on the vehicle only, but could be improved with high quality maps made possible by a significant increase in vehicle probe data.
- The ability to transmit dynamic signage directly into the vehicle ( known as in-vehicle signing) can improve the driver's awareness of work zones and prevent accidents, or even provide variable speed limits to smooth out congestion.
- Detection of roadway hazards such as potholes, road weather problems, or even sight distance and design problems can all be potentially identified by vehicle sensors and shared with managers of the roadway faster than is possible today.

**Note:** this list is not meant to be all inclusive nor is it meant to be representative of any decisions that have been made final by the VII Coalition. It is merely a representation of the types of benefits and their applications that might be possible.

## **ITS America**

ITS America has long been an advocate for a vehicle-infrastructure and vehicle-vehicle communication infrastructure, and has worked with the US DOT for nearly 15 years in pursuit of such goals. Now that the VII initiative is entering its third year, ITS America plans to help in many different ways. Beginning with its work on reaching out to potential VII applications providers, ITS America, through its ATCE Forum, will be hosting a meeting for the discussion of VII applications and communications on an international level. This meeting will take place on Friday, November, 11 in San Francisco following the ITS World Congress.

Additional presentations, discussions and live demonstrations will be held during the ITS World Congress in San Francisco, California, November 6-10, 2005. In addition to presentations to be made at Special and Technical sessions of the ITS World Congress, several technologies, including DSRC, lane departure warning systems, intelligent intersection, and many others will be demonstrated live during ITS America's Innovative Mobility Showcase (IMS) at the ITS World Congress. While these technologies or demonstrations are not directly funded by the federal VII program, their feasibility and success constitute the core elements of VII - and many of the partners that are engaged in the VII Coalition will be heavily engaged in the IMS.

In the near future, ITS America will begin hosting the VII public website on behalf of the VII Coalition. This site will have available all of the documents that are currently public as well as outcomes from the previous public meetings. There will be a registry for users to sign up and be kept informed of future meetings and events. The site will also report on the progress of state-led VII test beds currently building out across the country and testing various applications.

One of the planned workshops of the VII Coalition will include presentations and discussion from the Institutional Issues subcommittee. This group is charged with,

among other things, helping to sort out the complex issue of privacy as it relates to VII. Sometime in February, this group plans to present this issue in a public format with input and discussion from a number of groups highly concerned with personal privacy.

### **The Future**

In the next few years leading up to the 2008 decision on whether or not to roll out a nationwide VII system, we will see test bed activities throughout the country that will be probing a number of different types of communication systems, applications, and approaches to integration. Different states will be using different wireless protocols and will certainly have different outcomes and results as wireless on board units and roadside units are deployed.

The lessons we can learn from these test beds are as important (if not more) than some of the intellectual analysis currently underway in Washington, DC. At the same time, application developers will also engage in this process as they begin to see the value of such a system for safety applications. As the parameters of VII are more clearly defined, opportunities will be abound for ITS America members providing data, equipment and software to VII systems.