Use of the National ITS Architecture and Emerging Standards in the Metropolitan Model Deployment Initiatives

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Executive Summary

The US Department Of Transportation's Model Deployment Initiative (MDI) program is integrating and extending the existing ITS infrastructure in four metropolitan regions: New York/ New Jersey/Connecticut, Phoenix, San Antonio and Seattle. The National ITS Architecture Team was tasked by USDOT to work with the MDI teams to assist them in their goal to be models for future ITS deployments with respect to the National ITS Architecture.

We found that the four MDI sites made progress in 1997 and the first three-quarters of 1998 to meeting this goal. First, the Architecture Team found that at a high level, the MDI sites have a high level of commonality with the National ITS Architecture framework. Second, the four MDI efforts made significant steps to achieve commonality of interface definition between sites, particularly in the areas of broadcast interface to vehicles and location referencing. Finally, they have shown evidence of both using developing standards and, with Architecture Team assistance, of positively influencing the standards development efforts.

The Architecture Team efforts to review and engage the MDI technical teams have resulted in the following benefits: 1) Increased MDI awareness of pertinent standards activities and other deployment activities. This awareness contributed to relatively heavy direct participation of the MDI sites in the standardization process. 2) Insight for US DOT into the four MDI sites evolving architectures. This insight provided US DOT an independent view of the major technical decisions made by the four MDI teams and provided US DOT the opportunity to provide focused architecture feedback to the sites. 3) Facilitation of direct feedback from the evolving MDI designs into the standards activities thereby improving the standards, with minimal requirements on the MDI design teams time.

Specific results include the following:

- When expressed in common terms it became clear that all of the sites were implementing the basic framework of the National ITS Architecture.
- The Seattle MDI is adapting the National ITS Architecture data dictionary and message set approach.
- The NY/NJ/CT MDI technical interface requirements for additional ISPs (beyond the Travel Information Center under development) are developing along the same lines as the Seattle methodology for interfacing ISPs to the MDI (even if a different business model for distributing the data is used).
- Early focus on the Location Reference Message Specification (LRMS) area resulted in publication of the "Location Referencing Message Specification: Revision B (MDI)" that incorporated comments and new requirements from all four MDI sites. This version of the specification adjusted the Point/Link ID and ISP-Vehicle profiles in particular to better address MDI location referencing requirements. This process highlighted the potential for parallel standardization and deployment activities to positively affect each other; the specification benefited from vigorous review by practitioners and the deployments benefited from the availability of a baselined set of location referencing profiles. The SAE J2374 Location Referencing Message Specification Information Report available from SAE today reflects the early deployment experience and review provided by the MDI program.

- The Draft SAE J2256 recommended practice was used as a basis for the message set that was developed for the High-Speed FM Subcarrier STIC system in San Antonio. As the message set was developed and refined, several changes were adopted by SAE into J2256. This collaboration provided an early field test of the SAE specification and provided San Antonio with a headstart on their design.

Goal and Approach

The overall goal of this effort was to identify how well the MDI's are serving as models for future ITS deployments in the area of integration of individual ITS features to achieve some interface commonality across the four sites, and then to assist the MDI teams in serving as models. To answer the assessment question the Architecture Team looked at the following aspects of each MDI:

1. Usage of the National ITS Architecture framework.
2. Commonality with other MDI sites in definition of key (subsystem-to-subsystem, subsystem-to-terminator or "foundation") interfaces.
3. Use of ITS standards (or emerging standards) in the definition of key interfaces.

Architecture Commonality

Our approach to assessing architecture commonality was to review each effort beginning shortly after the MDI contracts were begun and to translate their overall system concepts into common architecture block diagrams which could be compared to the National ITS Architecture and with each other.

Once the MDIs had been expressed in National ITS Architecture terms we reviewed the interfaces to identify those that occur in all or most of the MDI architectures. A cross-reference of the Architecture interfaces and the MDI interfaces identified 56 potential interfaces for showcasing the National ITS Architecture. Further analysis of the interfaces indicated that there were 6 key interfaces that were being developed or modified in three or more of the MDIs. These interfaces, which became the basis for our efforts to define and foster commonality between MDI sites, are defined below and depicted in Figure 1.

1. Traffic Management Subsystem to (Other) Traffic Management Subsystem Interface
2. Traffic Management and Transit Management Subsystems to Information Service Provider Interface
3. Utilize Location Reference Message Specification for Location Referencing across multiple interfaces.
4. Information Service Provider *Broadcast* to Vehicle or Personal Information Access Subsystems Interface.
5. Information Service Provider *Interactive* to Personal Information Access Subsystems Interface.
6. Transit Management Subsystem to Traffic Management Subsystem Interface

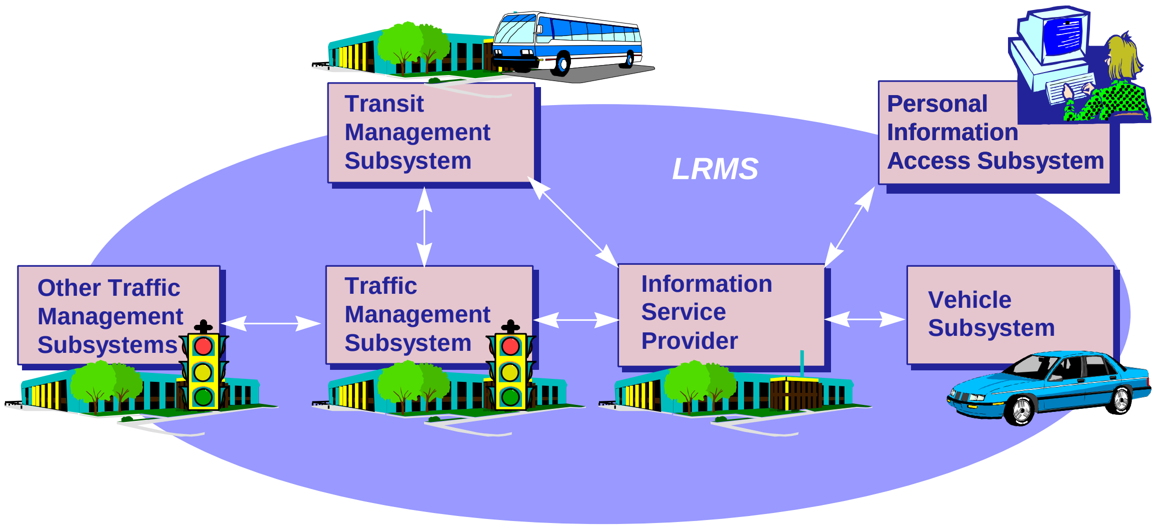

Figure 1. Selected Priority Interfaces Common to the Four Model Deployment Initiative projects, noting that Location Referencing Message Specification impacts all interfaces.

Interface Commonality Across Sites

Varying levels of commonality are possible when assessing the six interfaces across the four MDI sites. The lowest level of commonality (and easiest to achieve) is common requirements or functional allocations. For example, each traffic management subsystem collects similar data (e.g. link speeds) and passes this to the ISP. The next higher level is the use data elements or messages on an interface. For example, if a Transit Communications for ITS Protocol (TCIP) specification existed and each site used this then this second level of commonality would be achieved. The most stringent level is complete interoperability, which implies not only message commonality, but also that compatible communication protocols are used by the sites. A simple example of this is using identical FM subcarrier protocols and messages so that an FM receiver, which works in one region, would work in another.

A goal of the Architecture Team in its participation was to assist the MDI deployers to achieve at least common interface requirements on the key interfaces so as to maximize the momentum toward achieving useful interface standards through these deployments. If the four deployments use common interfaces, they maximize the likelihood that the common interfaces will become standards, and thus reduce their own risk of having non-standard interfaces with all the disadvantages (including expensive upgrade costs and limited supplier choices).

The results achieved in interface commonality range across all three levels and are discussed below under Detailed Results. One of the benefits of the Architecture Team participation was to raise the awareness of the interface commonality issue with the four MDI teams. Our participation helped facilitate the sharing and coordination of data, which led to increased levels of commonality between the sites.

Use of Standards

The Architecture Team worked with the sites to identify potential emerging ITS standards which were applicable to their interfaces and acted as liaison between the MDI sites and the ITS standards efforts to provide the latest information to them. A natural recommendation to each region was to use evolving Standards Development Organization products for any interface they are developing from scratch, and consider moving to the emerging standards for interfaces that are being modified. Unfortunately, after reviewing the regions deployment schedules and the Standards Development Organizations schedule plans for standards, there has been little opportunity to easily execute this recommendation. The Standards Development Organizations in general only had draft outputs available in 1997 (which were still rapidly evolving), with more stable balloted standards not due until mid 1998. Unfortunately, this standards completion schedule was well beyond the design stage (where stable standards input is needed) for 3 of the 4 MDI projects. Only the NY/NJ/CT project, which is still in development, may be able to benefit from stable standards outputs. One positive benefit of the Architecture team’s liaison between MDIs and SDOs was the facilitation of direct feedback from the evolving MDI designs into the standards activities thereby improving the standards under development.

Usage of the National ITS Architecture Framework

When expressed in common terms it became clear that all of the sites were implementing the basic framework of the National ITS Architecture. In fact, there were several architectural areas of similarity within all four sites:

1. Each was using an extensive surveillance network to create a real time picture of the highway (and in some cases transit) network.
2. Each was collecting data in a central repository for dissemination to one or more Information Service Providers (ISPs).
3. Each began with a single “trusted” ISP (although Seattle has since added additional ISPs beyond the initial trusted ISP).
4. Each has a significant component of provision of real time traveler information to the public through the trusted ISP.

Also worth noting are a few cases where the MDI architectures contain elements outside the National ITS Architecture, responding to local requirements. For example, the flood sensors/ monitoring requirement in San Antonio. This is a perfectly appropriate finding because the National ITS Architecture encompasses only the 30 defined User Services, not all possible ITS applications.

Detailed Results on Commonality between Sites and Use of Standards

The following sections detail the results achieved on each of the 6 key interfaces towards meeting the goals of commonality between sites, and of use of standards.

Traffic Management Subsystem ⇔ Other Traffic Management Subsystem

The types of data being exchanged across this interface include traffic data (volume, speed, etc.), incidents, and coordination. This interface includes numerous legacy interfaces and distinct approaches with NY/NJ/CT, San Antonio, and Seattle being message based and Phoenix using a (currently proprietary) object toolkit. Our objective on this interface was to establish common requirements and where possible common data elements among all of the sites. The status of this interface is that there is a high degree of commonality in the basic requirements of the interface, with incident data and link details being the primary information exchanged. Due to the wide range of legacy interfaces this is judged to be the highest level of commonality obtainable at present. Regarding the use of standards, the sites were able to benefit from draft efforts of the Traffic Management Data Dictionary Standard in the definition of incident data. If the National Transportation Communications for ITS Protocol (NTCIP) Center-to-Center standard had been available then it could have been a key consideration for the sites, but it will not be available until late 1998 (currently "ballot draft") and so can only figure into some of the later stages of the implementations.

Traffic/Transit Management Subsystem ⇔ ISP

The Traffic Management Subsystem (TMS) and Transit Management Subsystem (TRMS) interfaces to Information Service Providers (ISP) are being implemented in the same high level manner at each site. The TMS ⇔ ISP interface will focus on traffic and incident surveillance data. The TRMS ⇔ ISP interface will focus on static routes, schedules and fares, and, possibly, vehicle locations. The objective on these interfaces was to develop common requirements/ allocations and where possible common data elements.

San Antonio is using an internal network for their internal “trusted” ISP, and the Internet for this interface. The data dictionary and message sets are locally developed and based on the data structures of their internal database. The Seattle MDI is adapting the National ITS Architecture data dictionary and message set approach. In their MDI, ISPs will be able to access real time streams of traffic and transit data using a subset of the National ITS Architecture Data Dictionary. The Phoenix MDI has adopted a proprietary interface between the TRW database and the ETAK ISP. The NY/NJ/CT MDI’s TMS ⇔ ISP interface will evolve the legacy Inter Enterprise Network (IEN) message set and data dictionary to the Center-to-Center standards after they are approved (probably after the MDI is concluded). For the TRMS ⇔ ISP interface there have been active discussions to consider using TCIP vs. a proprietary interface. The IEN is the basis for the TRANSCOM to TIC (the Traveler Information Center, which is the NY/NJ/CT “trusted” ISP) interface. While at this time the NY/NJ/CT MDI interface requirements for any ISPs in addition to the TIC are still developing, the contractors have taken a detailed look at the Seattle methodology for interfacing ISPs to the MDI. A common MDI data dictionary and message set (in at least Seattle and NY/NJ/CT) for TMS/TRMS ⇔ ISP will encourage private sector ISP participation since data elements and messages will be the same at more than one site reducing investment and risk to enter this market.

In summary, common requirements/ allocations exist between the sites, with the possibility of future movement to common data elements on those interfaces still under development.

Location Reference Message Specification (LRMS)

LRMS does not represent a particular interface, but it is a crosscutting data element for all MDI interfaces. While there are one or more legacy (and usually proprietary) location referencing systems already in place at each of the MDI sites, the MDI Teams are generally receptive to seeking a standardized LRMS approach. Our objective on this interface was to coordinate LRMS adoption among the MDI sites so that a common location referencing approach can be demonstrated across applicable interfaces, in particular, TMS/TRMS ⇔ ISP and ISP ⇔ PIAS/Vehicle (Broadcast). This interface has been an example of where a joint effort of the MDI teams (particularly San Antonio but also Phoenix) and the architecture team has really made a positive difference. Early focus on the LRMS area resulted in publication of the "Location Referencing Message Specification: Revision B (MDI)" that incorporated comments and new requirements from all four model deployment sites. This version of the specification adjusted the Point/Link ID and ISP-Vehicle profiles in particular to better address MDI location referencing requirements. This process highlighted the potential for parallel standardization and deployment activities to positively affect each other; the specification benefited from vigorous review by practitioners and the deployments benefited from the availability of a baselined set of location referencing profiles. In the most recent activities, the SAE J2374 Location Referencing Message Specification information report has been developed and balloted (successfully) and soon will be published by the SAE ITS Division. This information report reflects the comments and early deployment experience from the earlier location referencing harmonization efforts.

ISP ⇔ Personal Information Access Subsystem (PIAS)/Vehicle (Broadcast)

This interface is an over-the-air interface, which focuses on one-way FM Subcarrier broadcast. A mix of systems was planned across the MDI sites as illustrated in the following table:

	San Antonio	Phoenix	Seattle	NY/NJ/CT
STIC (Scientific Atlanta)	●	●		
HSDS (Seiko)			●	
Low Speed RBDS		●		

The original objective on this interface was to have interoperable systems where the same FM Subcarrier technology was used (the NY/NJ/CT MDI has no plan for any FM subcarrier service). Unfortunately, as the model deployments progressed, a series of business decisions by the providers of these systems resulted in no common FM Subcarrier deployments across the sites. Although we were unable to demonstrate a geographically interoperable FM Subcarrier systems across more than one site, this interface did benefit from a highly collaborative interaction between the formative ITS standards efforts and the model deployments. The Draft SAE J2256 recommended practice was used as a basis for the message set that was developed for the High-Speed FM Subcarrier STIC system in San Antonio. As the San Antonio message set was developed and refined, several changes were recommended and adopted by SAE into J2256. This collaboration provided an early field test of the SAE specification and provided San Antonio with a headstart in their design.

ISP ⇔ Personal Information Access Subsystem (Internet Interface)

This interface supports World Wide Web user information typical of traveler information web sites. User interfaces vary from site to site. Our goal has been to coordinate Web information requirements among the MDI sites. Each site has developed their own Web page to different requirements. In several cases, side-by-side hyperlinks to other MDI site Web pages were added to each web site to tie the sites together. Microsoft has released its TrafficView ATIS Application in Seattle. This application provides personalized information and information push using e-mail. Similar Web sites are up and running at Phoenix and San Antonio with differing user interfaces. The sites are using broadly accepted Internet standards for their web pages, in various states of development. They are generally moving toward similar requirements, with maps and real time information available to anyone with access to the Internet.

Transit Management ⬄ Traffic Management

Data being exchanged across this interface includes static data (routes, schedules, fares) at all of the MDI sites and real-time schedule adherence at NY/NJ/CT and Seattle. San Antonio, NY/NJ/CT, and Seattle are message-based implementations while Phoenix uses a (TRW proprietary) object toolkit. The objective for this interface has been to coordinate a common approach for static data and real-time data among the MDI sites; and to establish common requirements among all the MDI sites and common data elements and messages where possible. In general the sites do have common requirements split into two areas- static and real time information. Some activity, such as NY/NJ/CT efforts are just beginning, and in one case, Seattle, the real time bus information interface has already been created under a program other than MDI. Hence we believe that common requirements is the best result which can currently be obtained on this interface. In the area of standards, an opportunity may still exist to leverage initial draft ballot standards outputs from the Transit Communications Interface Protocol (TCIP) and the TMDD in the NY/NJ/CT MDI. In addition, we have encouraged Phoenix (and TRW) to offer their proprietary TRW data model as a basis for one of the center-to-center open standards. A level of compatibility among the sites on the exchange of transit information will further integrate transit management and traffic management centers in the region.

Overall MDI Interface Status

The Architecture Team has been working with MDI site contacts for each key interface to coordinate their approaches and facilitate data exchange. Some significant levels of commonality have been obtained on the LRMS and broadcast interfaces, with common requirements/ allocations the result on the other key interfaces. The interactions of the Architecture team with the sites, and the sites with each other, has definitely furthered the level of commonality between sites on key interfaces. In the areas of standards, no completed ITS standards were available to meet MDI schedules for design decisions. The Architecture Team has taken existing ITS standards development data and knowledge gained from standards support activities to help the MDI sites formulate MDI specifications. The results of these efforts were fed directly into the relevant ITS standards development activities, preserving the work accomplished and promoting compatibility with other deployments through the future standards.

Recommendations and Lessons Learned

A number of factors have conspired against total success in creating a high degree of commonality on the key interfaces, including that the four sites were selected because they were uniquely different regarding their transportation systems. Similar sites may have had more common interfaces. First, interface commonality was not a priority for regional deployment managers, who were more concerned with identifying the best technical solution within budget and schedule. Second (and discussed earlier), achieving consensus was difficult since timely draft (or better yet, balloted) standards were not available for the key interfaces. Third, a large proportion of the interfaces in the MDIs were legacy, with no funds to support migration to new or emerging standards. A final issue was the schedule variability for contract negotiations with prime contractors in different MDI regions which has made coordinating interface consensus across regions difficult, because the projects are significantly (as much as 1-1/2 years) out of phase.

Several lessons learned stand out and should be considered when funding future deployment efforts:

1) Up-front, in-depth understanding of the National ITS Architecture and Standards is important where we wish to encourage use of the architecture and standards to enhance compatibility. Generally, there was only a surface level understanding of the architecture at the four MDI sites at the outset, which probably contributed to initial development of inconsistent solutions. Schedule pressure drove a reluctance to change initial system architecture decisions. Consider teaching a "Using the National ITS Architecture for Deployment" course at major deployment sites in the future so that the participating teams clearly understand the National ITS Architecture and how it can be applied. This course was only first available in September 97, however by the end of October 98, 800+ public sector and 250+ private sector personnel have taken the course.
2) Site priorities must include architecture/standards. Use of the National ITS Architecture and standards have some immediate benefits (e.g. accelerated architecture development as experienced in Denver's "RMDI"), but mostly long-term benefits for MDI regions. These are difficult to incorporate when deployment teams are driven by near-term cost/schedule/system performance goals. Use of National ITS Architecture and Standards must be tangibly encouraged in contracts (similar to how they have been in this year's TEA-21 legislation). Mainstreaming use of National ITS Architecture and Standards into the regional planning process will significantly ease their subsequent use in specific projects.
3) Standards which are in early draft stages are not of much value to a deployment team because the chances of change in the standard is great. This problem will be alleviated in follow-on efforts as proposed standards are produced and balloted.
4) Within the National ITS Architecture, the traveler interfaces represent a sort of paradox since they are very important for national interoperability but the US DOT wields comparatively little influence over how these predominately private sector interfaces are marketed and implemented. The best laid and coordinated plans for encouraging FM Subcarrier interoperability spanning more than one site were ultimately unraveled by these free market forces and independent business decisions. The forward policy must take these external

forces into account as we continue to encourage national interoperability for these traveler interfaces.