Developing a System Architecture for Intelligent Transportation Systems with Applications to San Juan, Puerto Rico

by

Daniel Andres Rodriguez

Executive Summary

by

Iris N. Ortiz

Submitted on:

September 21, 1998

Executive Summary:

Developing a System Architecture for Intelligent Transportation Systems with Applications to San Juan, Puerto Rico

by

Iris N. Ortiz

A. Research Objectives

The main objective of this thesis is to establish a framework for defining certain attributes of a system architecture for deploying advanced technologies for transport as a function of regional characteristics and goals. Then, the framework developed is applied to the San Juan Metropolitan Area (SJMA) in the context of Tren Urbano's implementation.

B. Methodology

The methodology used to develop this research may be described by the following step:

1. Presentation of framework for defining architecture attributes.
2. Architecture needs, definition of terms and relevant issues.
3. Critical evaluation of Case Studies: new system architecture presented in chapter 3. Case studies are from New York, Boston, and Houston.
4. Finding and lessons learned from case studies.
5. Two sample system architectures, applications to SJMA.
6. Final Comments and further research.

C. Summary of Content

A system architecture for ITS deployment

A system architecture is a tool or framework that brings together major stakeholders and strategies to achieve a set of tasks. In the context of ITS deployment, system architecture may be redefined as follows:

1. Identifies the subsystems involved in deployment of advanced technologies applied to transportation. These subsystems include human, institutional, technological and physical systems that play a role in such deployment.
2. Assigns roles and functions of these subsystems in achieving transportation system and other societal goals.
3. Promotes an understanding of integration, interrelationship, and inter-dependencies among the sub-systems, including information exchanges and flows.

The development of the system architecture consists of the proposed systematic approach defined below:

1. Regional transportation objectives
2. Definition of regional ITS goals and objectives
3. Define user services
4. Transportation System characteristics
5. Identify architecture attributes
6. Propose system architecture
7. Refine architecture
8. Design and implement system
9. Modify or update architecture

To develop an effective architecture framework some aspects and their attributes should be considered in order to select the best framework that fits the regional characteristics:

1. Communication issues (information centralization or decentralization, in-vehicle or infrastructure intelligence)
2. Future expansion needs (stand alone or platform architecture)
3. Proprietary information questions (open or closed architecture)
4. ITS functions assigned to regional entities (creation of new agencies, relevance of transit agencies and the private sector in the architecture development process, command and control or information and advisory)
5. Inter-agency cooperation (degree of independence of user services)
6. Modal and technology inclusiveness of the architecture (uni, multi or intermodal architecture and inclusion of pre-ITS technology deployments)

Case Studies

The case studies considered in this research are New York, Boston and Houston. The urban characteristics of the three cities are very different; New York and Boston are mature cities, while Houston is a young city with no defined core metropolitan area. In comparison, San Juan is an old but still growing metropolitan area with considerably smaller geographic area than the cases studied.

In terms of their transportation system characteristics, we have that the three cities have a multimodal transportation system that includes various passenger and freight modes. While New York and Boston have a transportation system that is based on public transportation, Houston system is based on the car, very similar to Puerto Rico.

In New York we have TRANSCOM which offer services on information dissemination, regional construction coordination and technology development program. Some of the findings from this system analysis are:

1. The need for a system architecture for deploying advanced technologies should come from within the regional transportation system.

2. Application of high technology could have been used to redefine regional roles; instead it was limited to solving transportation technology specific problems.
3. The role of the private sector is implicit in the system architecture definition.
4. Regional coordination for deployment of agency-specific systems was strictly constrained by the respect for agency autonomy.
5. Freight was implicitly excluded from the regional architecture definition process.
6. Suburban travel is the focus of TRANSCOM's system architecture for deploying ITS.

The conclusions obtained from New York's case study are:

1. The need for a system architecture for deploying advanced technologies should come from within the regional transportation system.
2. Application of high technology could have been used to re-define regional roles; instead it was limited to solving transportation technology specific problems.
3. Early recognition of institutional constraints and dependencies influence the architecture's outcome.
4. Capital sources have direct incidence on the communications network deployment strategy.
5. Integration of public transportation in the architecture development process should occur from the moment the user services are being defined.
6. Scope of the architecture created functional and deployment barriers.

For the Boston case study the findings are as follows:

1. User services of the architecture concentrate on information and advice
2. Inter-agency deployment should be incorporated explicitly into the architecture.

3. Initial system design issues can be highly correlated with the architecture's success.
4. A tradeoff exits between command/control functions and regional information/advisory functions.
5. Freight shippers and carriers were implicitly excluded from participating in the architecture definition process.
6. Public transportation was not adequately involved in the architecture definition process.

And the conclusions are:

1. A command and control architecture requires high levels of integration.
2. Representation of regional objectives should not be limited to a cardinal measurement.
3. Flexibility in creating innovative user services.
4. Importance of regional coordination as a levering tool.
5. The communications network configuration can prescribe or preclude the public or private sector when providing a service.
6. Technological sophistication can hinder coordination and exclude agencies from benefiting from the strategic sense of a system architecture.
7. A centralized system architecture generally increases public and political accountability.
8. Public transportation can utilize current technological investments to highlight their importance in the region.

Finally, the Houston case study is presented. This city is very different from New York and Boston. Transtar is one of the ITS initiatives in this city. Transtar is an intermodal transportation management center, the core of a regional system architecture for deploying and operating ITS. The center manages transportation services and information in the metropolitan region, as well as the development of other ITS services in the area. The findings from the analysis of this system architecture in Houston are the following:

1. Commercial vehicles played a role in neither the development of the system architecture nor the functionality of the system.
2. The regional system architecture for ITS had the political push to become an important element for the region.
3. The regional system architecture needed no anchor project to position itself in the metropolitan area.
4. Physical co-location of transit and highway operations and control facilities does not guarantee intermodal integration and coordination.
5. Transtar's architecture was pre-determined as centralized and containing highway operations and control functions.

The conclusions are:

1. Transtar's system architecture for ITS concentrated on improving inter-suburban travel.
2. Transtar's innovative funding mechanism garnered high political and public support.
3. The small number of agencies and the size of the metropolitan area provide high levels of inter-agency integration and coordination.
4. Effects of land use planning on a regional system architecture for ITS are reflected on the architecture enabled functionality.
5. Advanced technology assists on transportation management tasks, but is no substitute for them.

From the three case studies major conclusions and observations were drawn to serve as input for the SJMA application. The lessons learned are divided in two categories: (a) lessons learned about the architecture definition and development process, and (b) architecture attributes and the system functions they enable. The following table presents the lessons learned in each category.

Lessons on regional system architecture development process	Lessons on regional system architecture aspects, attributes and system functionality
1. Some aspect s of regional transportation systems that are critical to the well-being of regions were not considered during the architecture development processor by the resulting architecture.	1. Regional system architectures in the three case studies concentrated on improving suburban mobility.
2. Regional needs and objectives of non-highway transportation sectors need to be represented more directly in the architecture's definition and the system functionality it enables.	2. Regional coordination and inter-agency cooperation are the core benefits directly resulting from implementation of a regional system architecture for deploying ITS.
3. System design and system architecture are concepts closely associated with each other.	3. A system architecture that respects local autonomy yields higher chances of acceptance, but regional will be limited.
4. A truly strategic regional system architecture for implementing ITS requires strong political will and institutional attention.	4. The private sector plays an important role in the provision of architecture-enable user services.
5. The ITS architecture definition processes studied were highly politicized.	5. A trade-off between geographic coverage of the system architecture and aggregate benefits emerged.
6. Creation of a new regional agency or entity managing ITS coordination and deployment enables an architecture definition with broader system functionality than assigning the tasks to an existing agency.	6. So far, infrastructure intelligence, rather than in-vehicle intelligence, has been a result of the limited initiative exhibited by private firms in getting involved with architecture development and definition of user services.
7. The national ITS architecture may serve as a basis for regional ITS architectures.	7. A partnership between ITS and communications network carriers that form a national information infrastructure seems natural.
	8. Platform-based regional architectures are prevalent.
	9. The system has proven valuable in bringing ITS to the discussion table as a way to solve regional transportation problems.

San Juan Metropolitan Region Case Application

The Commonwealth of Puerto Rico began the construction of a 12 mile rapid rail system in the SJMA. The construction of Tren Urbano opens a window of opportunity for deploying modern technologies that can assist Puerto Rico in conveying Tren Urbano as an advanced and efficient system. These technology applications can support Tren Urbano's goals at the same time they can enhance the overall level of service of the Transportation System and improve local perception of mass transit.

The lessons obtained from the case studies were applied to the SJMA. From this analysis we obtain two lesson categories: (a) lesson on the architecture development process for the SJMA, and (b) lessons on architecture attributes for the SJMA.

Lessons on the architecture development process for the SJMA	Lessons on architecture attributes for the SJMA
1. Development of a system architecture for ITS should be anchored to one or more critical transportation issue of the SJMA. Transit is the most promising anchor for a system architecture in the region.	1. A platform-based architecture is preferred due to technological commonalties between user services that can provide institutional coordination and additional financial leverage for user service deployment.
2. The system architecture can become instrumental in redefining roles of transportation regional agencies at the same time that it can help in positioning Tren Urbano as a modern and efficient public transportation system.	2. The system architecture for ITS can and should serve as a strategic integrator of the different modes in the region. Urban and suburban mobility benefit from such an integrated approach.
3. Multiplicity of agencies regulating, operating and supervising transportation services will likely generate a highly politicized architecture definition process.	3. An information/advisory oriented architecture rather than a command and control oriented architecture preferred.
4. System architecture and system design: how the ITS communications network can work.	4. An open architecture is recommended because it minimizes market risks.
5. There are two broad organizational approaches for managing and coordinating ITS deployment: modify the responsibilities of an existing agency or create a new entity	5. The private sector role in the functionality of the system enabled by the architecture includes a proactive role in freight services, transit operations, and the provision of transportation information for the metropolitan area. Services tailored to the individual consumer will evolve as the market allows it.
	6. An architecture that ensures multi-level coordination and that respects local decision making and autonomy is favored.
	7. Regional geographic coverage of the system architecture is preferred.
	8. Infrastructure-based intelligence is preferred over in-vehicle intelligence.

Two scenarios were developed to study the application of ITS architecture in the SJMA. One is called COORDINAR (Centro de Coordinacion Regional del Transporte), and the other is TACT (Tren Urbano, AMA, ACT). The following table show the characteristic of each scenario.

	COORDINAR	TACT
Entity responsible for ITS coordination and information management	COORDINAR	ACT (Autoridad de Carreteras y Transportacion)
Operations housed at the coordinating entity	AMA, TU & ACT co-located	No co-location. Dedicated communication links between ACT, TU and AMA
Traveler Information Dissemination	Independent Service Providers (ISPs) and ACT's variable message boards	ISPs and individual mode-specific agencies (AMA, TU, ACT, Ports Authority)
Role of publicos	Publico information center co-located at COORDINAR; active participants in intermodal user services	Users of information retrieved via ISPs and electronic toll collection only
Responsibility for local traffic signal systems	Municipalities	ACT
Responsibility for Park & Ride ITS implementations	ACT & TU	TU and municipalities
Acua-expreso services	Information service co-located at COORDINAR	None
Role of the Ports Authority	Enable Acua-expreso information service co-location	Intermediary between ACT and airport and seaport services
Construction management user service	None	Yes; directly from ACT
Incident management program	Yes, directly from COORDINAR	None
HAZMAT and commercial vehicle administrative processes	None	Yes, directly from ACT

These two architecture scenarios developed show the importance of several major conclusions reached from the case studies. The importance of high-level deployment coordination is exhibited by always having a lead agency in charge of ITS deployment. In addition, it is clear from the scenarios that public transportation and its importance for improving urban mobility is considered a critical element for the SJMA that should be considered by the attributes of a regional architecture.

Further Research

There are two areas related to ITS architecture that need further study. The first area pertains to a regional system architecture definition and deployment process (effects of political, social, economic and institutional conditions, use of public funds). The second research area is concerned with developing and making operable an architecture for the SJMA based on the recommendations provided in this thesis.