

Getting to the INFOstructure

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BACKGROUND

Traffic and roadway monitoring is the backbone of the Intelligent Transportation Infrastructure. Without reliable and ubiquitous data, it is unlikely that ITS will ever meet its full potential. The purpose of this paper is to address the obstacles and opportunities associated with the implementation of an ITS INFOstructure that can provide the complete range of roadway data required to support ITS functions. It has been prepared as the starting point for a focused discussion on the next steps to be taken.

Few would doubt the value of a reliable system that provides near real-time information on traffic flow, pavement conditions and weather, to travelers and system managers. The importance of this infrastructure to the ITS program is demonstrated by the 10 year Program Plan and Research Agenda prepared by ITS America. More than 70% of the “Outcome Oriented Themes” contained in this plan are dependent upon the existence of the INFOstructure for their successful implementation. In other words, it will not be possible to achieve the ten year vision of the ITS program, nor will it be possible to improve current levels of traffic operations, without its availability.

What is the INFOstructure

Before discussing the implementation of the INFOstructure, it is necessary to define its implementation and capabilities. Obviously, any discussion related to its implementation must be based on a common understanding of “what is being implemented”. For the purposes of this paper, a two level definition has been created; a local INFOstructure and a national INFOstructure.

The local level is defined as the set of field equipment and the associated communications and processing required for comprehensive measurement of roadway, traffic, and transit conditions at a level of detail required for management of localized incidents, and provision of information to local travelers. Local conditions and travelers are those that are found within a single metropolitan area. The local level INFOstructure would include all the devices traditionally used for transportation management in an urban area including CCTV, vehicle detectors, GPS on transit vehicles, weather and pavement monitoring equipment.

The requirements of a national INFOstructure are quite different. For example, there is no need for a traveler in Washington, DC to view CCTV images of traffic conditions on the Golden Gate Bridge in San Francisco. Thus the national INFOstructure is the set of field equipment and associated communications and processing for measurement of roadway and traffic conditions at a level of detail required for managing major regional incidents (multi-state incidents), provision of information required by long distance travelers, and offering of standardized traffic information for in-vehicle applications of national manufacturers (auto manufacturers and after-market electronics suppliers). While the needs for long-distance communications and standardization are significantly more extensive for the national INFOstructure, the data being collected is more modest. The national INFOstructure requires traffic flow and weather data. However, it would

not require CCTV, pavement condition or local transit data. It might require information related to long-haul transit such as railroad and airline status.

These differences are significant and should be considered throughout the INFOstructure planning, design and development. The experience of the Information Exchange Network (IEN) operated by the I-95 Corridor Coalition has demonstrated the importance of differentiating between local and (in the case of the Coalition) major regional incidents. While the IEN provided invaluable service during the attacks of September 11th, and during various snowstorms and hurricanes, it has proven to be of little value for localized events. As a result, operators in many states tend to ignore the IEN and do not enter incident data, unless a major event is occurring.

Obviously both the public and private sectors have an interest in the data produced by the local and national versions of the INFOstructure. Both the highway and transit communities will also benefit. The broad range of potential beneficiaries combined with the high cost of implementation suggests that careful consideration should be given to the most effective organizational approach to its implementation. These alternative approaches should be carefully evaluated based on considerations of financing (both capital and recurring costs), national standardization, coverage, schedules, costs and political acceptability.

Since the opportunities and obstacles associated with the INFOstructure will vary depending on the approach selected, it is important that this selection receive priority consideration early in the development process.

Status of INFOstructure Implementation

Obviously, the development of a national INFOstructure would not be starting as a “blank slate”. Significant installations of INFOstructure for traffic management applications have been completed in a number of states. This raises the obvious question of “why not let things continue as they are, since the states are currently installing the necessary equipment”. Figure 1 has been prepared using data available from the USDOT Joint Program Office describing the status of the ITS program. It provides an estimate of the total urban miles of freeway on which some sort of traffic detection has been installed. It does not include the installation of closed circuit television. This figure also includes both optimistic and pessimistic projections of the likely progress that will occur between 1999 (the last year for which data is available) and the year 2010. The optimistic projection is based on an extrapolation of the 3% rate of progress that existed during the last year of the survey. The pessimistic projection is based on the 2% rate of progress that existed during previous years. This figure indicates that, at best, only 55% of urban miles of freeway will be instrumented by the year 2010.

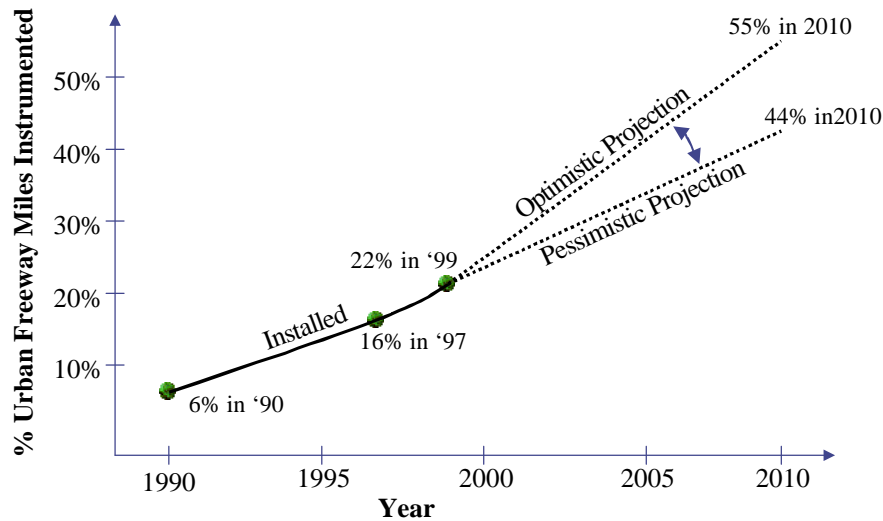


Figure 1. Electronic Traffic Monitoring Installed on US Urban Freeways

Obviously this is not an encouraging picture. Given the importance of the traffic monitoring element of ITS, it would be important to instrument nearly 100% of urban freeways within this time period. This data is even less encouraging in view of the fact that only 6% of urban arterials and no rural roadways have been instrumented. The condition of these existing miles of urban freeway and arterial instrumentation is also unknown.

These data provide compelling evidence that INFOstructure will not be developed in a climate of business as usual. Strong incentives must be devised if traditional approaches are to be used. Alternatively, innovative new approaches and institutions should be created that are given the responsibility for accelerating the INFOstructure implementation.

Defining Success

The issues and opportunities of the INFOstructure implementation cannot be addressed unless near term goals have been defined. The following goals are proposed for the installation and operation of the infrastructure within the next ten years:

- 95% of urban freeways instrumented for measurement of average traffic speed
- 12% of urban arterials instrumented for measurement of average traffic speed (doubling the existing number of installations)
- 25% of non-urban freeways instrumented for measurement of average traffic speed

- More than 90% of system operational at all times.

Even with these modest goals which limit national INFOstructure capabilities to the measurement of speed, these are aggressive goals. The desirability of measuring many other variables is recognized, and for this reason the system must be designed to permit expansion into these areas. However, speed measurement is the common denominator for most of the traffic monitoring and traveler functions and for this reason, it should be the focus of the initial system implementation.

ORGANIZATIONAL ALTERNATIVES

As previously indicated, there are a number of alternative organizational models for the INFOstructure implementation. A detailed description of these alternatives is beyond the scope of this paper. For simplicity, they have been divided into the general categories shown in Table 1, along with the advantages and disadvantages of each. It is possible for different models to be used for construction of the INFOstructure than that which is used for its management, operations and maintenance.

Rough estimates of the INFOstructure costs indicate that the goals stated in the previous section can be met at a capital cost of approximately \$500 million and a recurring cost of approximately \$50 million per year. Obviously, the selection of an alternative must consider the ability of the participants to absorb these costs.

As applicable, these organizational alternatives will serve as the basis for the following discussion.

OPPORTUNITIES AND OBSTACLES

Consideration of opportunities and obstacles associated with the INFOstructure is an important first step in the development of a plan for its implementation.

Opportunities

There has never been a greater need for a comprehensive source of information that defines the state of the transportation system. Increasing congestion, increasing numbers of incidents, the threat of continuing terrorist attacks and unstable weather systems all demand the availability of information if our transportation system is to continue to support our nation's economy. The promise of effective ITS implementation cannot be realized unless information is available to support its operation. These increasing needs offer an unparalleled opportunity to support funding support for the INFOstructure development.

Table 1. Alternative Approaches

Approach	Description	Advantages	Disadvantages
Locally led (Business as usual)	This is the current approach, in which state and local agencies lead the infrastructure implementation and maintenance	<ul style="list-style-type: none"> • Well defined source of funding • Infrastructure is being installed on public agency right-of way 	<ul style="list-style-type: none"> • This approach is not proceeding at an adequate rate • Inadequate maintenance • Lack of standardization
Federally led	A certain percentage of designated Federal Aid funding would be set aside for the installation of the needed infrastructure	<ul style="list-style-type: none"> • Public sector interests would be well represented • Standardization could be enforced • The rate at which infrastructure is installed would be controlled. 	<ul style="list-style-type: none"> • Unlikely that this approach would be accepted by the states since it reduces funding available for other projects. • The Federal government is unlikely to assume responsibility for maintenance and operations
Laissez Faire	This is the “every man for himself” business model. It is similar to the locally led approach, but includes future entry of large private sector “players”	<ul style="list-style-type: none"> • Minimum public sector investment • Private industry and public sector develops monitoring capability as it is needed and can be justified 	<ul style="list-style-type: none"> • Similar to the current approach • Lack of standards • Discourages synergism between private and public sectors
Partnership	A partnership is formed with both public and private sector support including financing that assumes responsibility for installation of the infrastructure	<ul style="list-style-type: none"> • Combines public and private sector resources • More flexibility than that which is available to the public sector • Permits focus on monitoring offering the greatest near-term payoff. 	<ul style="list-style-type: none"> • Loss of public sector control • Questions regarding consortium’s access to public right-of-way • Time required to form consortium • Questions regarding private sector support

Traffic monitoring technology has also evolved to a level at which it is cost-effective to consider its widespread implementation. Significant advances have been made both in localized (spot) detection and wide area detection such as:

- Sophisticated side-fire radar detectors capable of providing traffic flow data by lane
- Video imaging can now provide reliable measurements of traffic speeds, counts and queues
- Cellular geolocation technology with the capability of tracking individual vehicles in order to measure their speeds and travel times, has been successfully demonstrated
- Tracking of vehicles with toll tags to measure speeds and travel times is currently in operational use
- Tracking of vehicles through the use of license plate readers for the measurement of speeds and travel times is also currently in use
- Systems of instrumented probe vehicles using GPS for positioning and other sensors to measure travel speed, weather and pavement conditions are also under development

Thus mature technologies are available to support the INFOstructure implementation, with the promise of more advanced and less expensive technologies for the future. This explosion of technologies suggests that the design of the INFOstructure must retain adequate flexibility to accept new surveillance technologies as they are introduced.

The availability of a ubiquitous infrastructure will be likely to stimulate the development of decision support tools for improved traffic management. With reliable and comprehensive data, it is possible to foresee the day when automated incident detection will become more reliable, and when systems will permit operators to reliably display traffic conditions and alternate routes to motorists.

One of the most significant opportunities associated with the development of a national INFOstructure is the possibility of providing comprehensive traveler information to both local and long-distance motorists. In-vehicle navigation systems currently in use contain static displays that are only of value for motorists traveling on unfamiliar roadways. The addition of real-time travel times and incident information will greatly increase the utility of these displays, and their marketability to the public. The availability of this information will also improve the quality of the traffic information, which will also increase the value of the traditional traffic information outlets including the broadcast media and the Internet. Perhaps at long last, an adequate market will be developed for the private sector to initiate self-supporting activities based on the dissemination of traveler information to the public.

Obstacles

The single greatest obstacle to the implementation of the INFOstructure is the identification of public funding sources for its implementation. The argument has been made that funding for the INFOstructure is such a small percent of the total Federal Aid

program that there should be no problem with setting aside approximately \$50 million per year for its implementation. There are several problems associated with this reasoning:

- Public agencies are generally opposed to directed funding of Federal Aid for specific programs.
- In this time of Federal budget deficits and state revenue shortfalls, it is unlikely that new funding sources will be identified for the INFOstructure
- Even if funding for implementation can be identified, public agencies are concerned that there will be no accompanying funding for operations and maintenance. Thus the Federal government will leave them with a system that they cannot afford to maintain.
- While most state DOTs appreciate the benefits of CCTV for incident management, they are skeptical of the benefits of automated detection of traffic flow (loops, radar detectors, etc.). They do not feel that these latter techniques provide appreciable benefits, while at the same time representing a significant maintenance headache.

For these reasons, it will be difficult for the public sector to adopt a “go-it-alone” approach. It is inconceivable that a program of this magnitude could be implemented without considerable outside support from the private sector. However, this support will not be forthcoming without the anticipation of significant new business opportunities.

INSTITUTIONAL ISSUES

The INFOstructure implementation plan must recognize the presence of a number of institutional issues. Unless these issues are directly addressed the implementation will not be a success.

Public/Private Sector Relationships

Previous sections have emphasized the importance of including the private sector as an INFOstructure partner. While this approach is appealing, past experience has shown that it is not always an easy process. The majority of issues associated with these relationships are not exclusive to the INFOstructure implementation and for this reason they will not be addressed here. However, there are several issues unique to this implementation that must be considered if effective partnerships are to be established. They are all related to the private sector’s ability to earn a reasonable rate of return from its investment in the INFOstructure development and/or its operation and maintenance.

- **Exclusivity** – Many public agencies are legally required to disseminate any data collected with public funds to all requesting organizations. For this reason, an agency may be prevented from giving exclusive rights to a private sector organization with which it has entered into a data collection partnership. This requirement forces the private sector partner to compete with other organizations that have not made an investment in the INFOstructure.

- **Data ownership** – Public agencies have often taken the position that their partnership in the INFOstructure development entitles them to ownership of the data, or at least unlimited free access to the data. It is important to establish ownership early in the process, so that the rights of each party to use and/or sell the data will be defined.
- **Public sector competition with its private sector partner** – For equity reasons, the public sector is obligated to disseminate some of the data collected by the INFOstructure to certain outlets at no cost. This may be limited to the dissemination of incident information to the media. However in many cases, the dissemination of this data by the public sector becomes extensive including video images, weather information, traffic flow information, transit information, etc. all delivered in electronic form to any interested distribution source. While the motivations for this public sector dissemination are certainly worthwhile, agencies must recognize that dissemination at this level virtually eliminates any potential source of income from its private sector partners, and hence destroys the potential for outside investment.

The conclusions are obvious. If the public sector needs private sector investment for the INFOstructure to be successful, it cannot insist on data ownership, competition with its partner and lack of exclusivity. The alternative is for the public sector to provide 100% of the funding required for INFOstructure implementation, operations and maintenance. The third alternative is to abandon the INFOstructure effort.

Privacy

The term traffic surveillance has been used in this paper several times. The term vehicle tracking has also been used. Obviously, these terms and their associated technologies raise great concerns regarding the privacy of the motoring public. Equally great are the concerns associated with CCTV, electronic toll collection and photo enforcement, all of which have the potential for misuse by law enforcement and transportation officials.

If the INFOstructure is to succeed, it must directly confront the privacy issue, which is likely to become more of a problem as the installation of these systems becomes more widespread. Consideration should be given to the development of well-publicized privacy standards, which have been developed jointly with organizations such as the ACLU. The privacy standards should require that all probe-based technologies (cellular geolocation, toll tag tracking, and instrumented vehicles) be designed in a manner that ensures the absolute privacy of the vehicles and passengers being tracked. The standards should ensure that raw data that permits the recreation of individual vehicle trajectories is not archived. They should also recommend against the archiving of video data. Significant additional detail must be added to these high level requirements.

Liability

Liability associated with the INFOstructure is unlikely to be any different from that of existing traffic management and traveler information systems. To date few problems have been experienced in each of these areas. However, it is important to anticipate the possibility that, with the use of real-time in-vehicle information system errors will have an impact on travelers to which liability can be associated. It is recommended that the INFOstructure avoid any potential liability problems through the execution of agreements

with organizations to which data is provided that assigns any liability to the receiving organization.

TECHNICAL ISSUES

It is equally important to consider the technical issues to be addressed during the planning for the INFOstructure implementation. Technical considerations will have an impact not only on the system design, but may also influence the selection of an organizational alternative.

Architecture

The National ITS Architecture should be considered during the initial phases of planning for the INFOstructure. However, since the National ITS Architecture is intended to serve as the basis for local or regional system implementations, it is most applicable to the local INFOstructure as opposed to its national implementation. The National ITS Architecture provides guidance related to the user services and systems to be included in the implementation and should certainly be used during the system planning phase of the INFOstructure development. Since its primary use is for the local version, the ITS Architecture should be individually applied within each jurisdiction in which it is being implemented.

Many different physical architectures are candidates for the national INFOstructure. The selected architecture will determine the performance of the system including response times, security, accessibility, reliability and cost. The architecture will also be influenced by the selected organizational approach. Representative architectures for the national INFOstructure and their applicable organizations are shown in Table 2.

Table 2. Relationship Between National Architectures and Organization

Architecture	Description	Organization			
		Locally Led	Federally Led	Laissez Faire	Partnership
Existing System	Data collection integrated into existing ATMS systems which are connected to a national INFOstructure network	X	X	X	
State Based	Dedicated INFOstructure computers in each state interconnected into national network	X	X		
Regional	Regional INFOstructure computers interconnected into national network		X		X

While it is possible to debate the details of this table, the fact remains that organization will have a significant impact on architecture. Similarly, system cost and ease of

implementation will also be influenced by architecture. For example the integration of the INFOstructure into existing traffic management systems is likely to present a host of interfacing, formatting and response time issues that could lead to significant additional expense.

Standards

No matter which architecture is selected, there will be a need for common data dictionary and data transfer standards. The flexibility found in the ITS standards currently under development cannot be accommodated. The national INFOstructure must be capable of providing rapid reliable response to queries from any system, anywhere in the US. Providing this capability requires total agreement on all protocols, data elements and communications formats.

Several existing ITS standards are applicable (at least in principle) to the INFOstructure development. These include the Traffic Management Data Dictionary (TMDD), and NTCIP computer-to-computer standards. However, these standards are currently under development, and must reviewed for applicability to this project. Optional usage must be eliminated to ensure 100% conformance among the INFOstructure participants.

Performance

Performance is a broad term that can include data quality (accuracy and precision), availability (percent time that the system is operational), timeliness and many other measures. There is a tendency within the ITS community to specify performance without a complete understanding of the requirements of the application, or the cost implications of the specification. The performance specifications shown in Table 3 are shown as a starting point for the discussion of these issues.

Table 3. Possible INFOstructure Performance Requirements

Measure	Application	Requirement	
		Local Implementation	National Implementation
Speed Accuracy	Traffic Management	5-10%	5-10%
	Traveler Information	20%	20%
Volume Accuracy	Traffic Management	10%	n/a
	Traveler Information	n/a	n/a
Timeliness	All	Delay < 1 minute	Delay < 5 minutes
Availability	All	99.9% (approx. 10 hrs./yr.)	99% (approx. 100 hours per yr.)

While these values could be debated, they demonstrate the importance of considering local and national implementations separately.

Legacy Systems

Traffic surveillance, weather and pavement monitoring has been installed on many miles of urban interstate. Even though this installation is far from complete, consideration should be given to its use as an element of the national INFOstructure. (By definition, this equipment already constitutes an implementation of the local INFOstructure.) The challenge is to develop interfaces with the legacy systems to which the existing field equipment is currently connected. The use of this legacy equipment must be addressed on a case-by-case basis to determine whether it can meet the performance criteria and standards of the overall system.

In its ultimate form of implementation, the creation of the national INFOstructure, exclusively through the interconnection of legacy systems is a first step of the locally led alternative shown in Table 1. The challenge of this alternative is the identification of an adequate number of systems that can satisfy the technical requirements of the national system.

NEXT STEPS

It is clear from this discussion that immediate attention should be paid to the selection of an organizational alternative from Table 1 that will meet the funding and technical requirements of a national INFOstructure. It is important to avoid the pitfall of business-as-usual just because it is convenient. While this alternative might be the most attractive for institutional reasons, it does not necessarily provide the required levels of funding (particularly for operations and maintenance) and rapidity of implementation.

In addition to the selection of the most appropriate organizational approach, it will be necessary to select an architecture, privacy guidelines, and to address the institutional issues identified earlier in this paper. It is also necessary to begin the definition of performance requirements and standards to which the INFOstructure will be developed.

While it will be necessary to review and refine these elements once specific participants have been identified, this “first cut” will be extremely useful to organizations considering participation in the INFOstructure development.