The Intelligent Transportation Society of America (ITS America)

Challenges in Deploying and Achieving the Full Potential of Transit ITS; a Discussion Paper

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Notice

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16. Abstract.

Transit Intelligent Transportation Systems (ITS) technologies have been developed and refined over the last 20 years, and provide many potential benefits to transit systems to enhance the effectiveness and efficiency of the services to their clients.

However, at the same time, discussions at meetings and workshops in recent years indicate that there continues to be significant challenges faced by transit agencies in deploying Transit ITS and in reaping the many potential benefits offered by these systems. These discussions offer many insights into the challenges, and suggest various avenues that might be pursued to help transit systems move more quickly up the Transit ITS learning curve and address the challenges.

This Discussion Paper will provide a high level strategic discussion of the many organizational and technical challenges facing transit systems, and develop suggestions aimed at the transit industry on possible avenues for addressing these challenges.

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GLOSSARY

AFC	Advanced Fare Collection
APC	Automatic Passenger Counting
APTS	Advanced Public Transportation System
AI	Artificial Intelligence
AVL	Automatic Vehicle Location
CAD	Computer-Assisted Dispatch
ICM	Integrated Corridor Management
IT	Information Technology
ITS	Intelligent Transportation Systems
MSAA	Mobility Services for All Americans (program of USDOT)
RTPI	Real-Time Passenger Information
SE	Systems Engineering
TCIP	Transit Communications Interface Profiles
TSP	Transit Signal Priority
USDOT	United States Department of Transportation

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1. INTRODUCTION:

1.1. BACKGROUND

The Intelligent Transportation Society of America (ITS America) is the nation's largest organization dedicated to advancing the research, development and deployment of Intelligent Transportation Systems (ITS) to improve the nation's surface transportation system. Its Vision is to save lives, time and money and sustain the environment through the research, development and broad deployment of interoperable Intelligent Transportation Systems (ITS).

ITS America has been engaged in a long-term project to support the U.S. Department of Transportation (USDOT) in a range of activities related to research, development, and dissemination of information on ITS and its application to public transportation modes. It has been asked to develop strategic discussion papers on key topics that might help identify and understand challenges and barriers to ITS deployment as well as suggest recommendations for action, and thereby help to achieve the full range of potential benefits that can be derived from the deployment of ITS by the public transportation industry.

These discussion papers build on the knowledge gained from a range of experts, including practitioners in the field, consultants, suppliers, and researchers, through workshops, listening sessions, and interviews, and supplemented by the review of pertinent literature.

1.2. THE ISSUE: CHALLENGES IN DEPLOYING TRANSIT ITS

Transit ITS technologies have been developed and refined over the last 20 years, and provide many potential benefits to transit systems to enhance the effectiveness and efficiency of the services to their clients.

However, at the same time, discussions at meetings and workshops in recent years indicate that there continues to be significant challenges faced by transit agencies in deploying Transit ITS and in reaping the many potential benefits offered by these systems. These discussions offer many insights into the challenges, and suggest various avenues that might be pursued to help transit systems move more quickly up the Transit ITS learning curve and address the challenges.

This Discussion Paper will provide a high level strategic discussion of the many challenges facing transit systems, and develop suggestions aimed at the transit industry on possible avenues for addressing these challenges.

The methodology included direct feedback from transit managers: Two productive listening sessions have been held to discuss challenges facing transit systems; the first was held in November 2013, and another in May 2014. These provided considerable insights. In addition, ITS America had organized in 2005, a Summit of Transit General Managers to specifically discuss challenges related to the deployment of Transit ITS (see Appendix). The comments from all these discussions were reviewed and synthesized.

1.3. TRANSIT ITS IS WELL DEPLOYED AND OFFERS MANY BENEFITS

Transit ITS is widely used by the industry with over two thirds of buses in the U.S. equipped with ITS technologies.

In addition, for those transit agencies that use ITS technologies, it is perceived to be critical for the service they provide since it plays a crucial role in ensuring:

- Reliability of service, through incident management and service restoration,
- Security and safety, through real-time Automatic Vehicle Location (AVL) and rapid response by emergency services,
- Customer relations, through credible investigation of complaints, and
- Enhanced information to customers, through the provision of real-time information.

For many agencies, Transit ITS offers promising potential for further enhancing service quality and reliability through the use of ITS data for planning and management, and big data.

In many respects, Transit ITS technologies are also the gateway for the transit industry to the future in its various forms:

- Mobility on Demand,
- Connected Vehicles, and
- Automated and Autonomous Vehicles.

1.4. MANY ORGANIZATIONAL AND TECHNICAL CHALLENGES

However, there is a widespread perception among transit agencies that ITS faces a large number of challenges, and is very far from achieving its potential.

The next sections will provide a very comprehensive overview of the many challenges that have been identified through the many discussions and the research involved in the preparation of this discussion paper, which will then help identify potential initiatives that could be recommended to make more effective use of the full potential of Transit ITS.

These can be summarized as follows:

- ITS is Poorly Understood by Policy Boards and Senior Management

- ITS Projects are Technically Complex to Plan and Procure
- ITS Projects Are Complex to Deploy
- Many Operations and Maintenance Challenges Exist Even Once Deployed
- Challenges Exist in Achieving Full System Potential

2. ITS IS POORLY UNDERSTOOD BY POLICY BOARDS AND SENIOR MANAGEMENT

There was general agreement that the most challenging issue limiting the ability to deploy and fully utilize Transit ITS was the lack of understanding and interest with respect to ITS by policy boards and senior management, and the fact that ITS was not perceived to be a strategic resource. There were a number of related aspects to this challenge, namely:

- Poor understanding and lack of interest,
- The potential benefits to be derived from ITS are poorly defined or understood, and
- The costs are equally hard to define.

2.1. POOR UNDERSTANDING OF ITS AND LACK OF INTEREST

2.1.1. Definition Problem

Transit ITS suffers from a *semantics* challenge that makes it hard to define in people's minds what is ITS. Terms include: Computer-Assisted Dispatch / Automatic Vehicle Location (CAD / AVL), Advanced Public Transportation Systems (APTS), ITS, etc. The various terms used create confusion. It is now viewed as a *suite of tools*, but needs better packaging.

2.1.2. General Lack of Interest by Senior Managers and Policy Boards

Policy boards and senior managers of transit systems need to continuously focus on ensuring sufficient funding to operate and expand the transit system, and building the stakeholder coalition to do so. Technology is for the most part a secondary concern, and they are often not very interested in ITS. There is therefore a need to motivate them by providing more information about the potential benefits of ITS (and the potential risks as well).

2.1.3. Lack of Education about ITS by Senior Managers and Policy Boards

In parallel to the general lack of interest, there is also a lack of education about ITS specifically aimed at policy board members and senior management. There are few tailored sources of information or professional development sessions anywhere, and for the most part, the topic of technology is rarely included in sessions or workshops by trade associations aimed at policy boards and senior management.

The problem of the lack of education is compounded in the risk-adverse transit industry, by the "spectacular failure" problem. Knowledge of anecdotal information on failures tends to travel more widely through the industry, and remains in the minds of senior management, discouraging investment in ITS.

2.2. BENEFITS OF ITS ARE POORLY DEFINED OR UNDERSTOOD

There is a lack of definition or widespread knowledge concerning the benefits to be derived from Transit ITS. Considerable effort was made in the 1990s when ITS technologies first appeared to define the benefits that the technologies would provide, but there have been few efforts in recent years to identify and document the benefits that have been achieved. For example, even the recent USDOT update on *Benefits, Costs, and Lessons Learned*[1] only identifies rather limited benefits related to signal priority, pre-trip inspection, traveler information, and scheduling software. These benefits would hardly justify the investment of millions of dollars in the minds of senior management and policy boards.

Transit agency staff must therefore internally try to identify potential benefits as part of the building of business cases, with only access to limited sources of information. This makes it difficult to gain senior management support for investment in Transit ITS. There is need to better define the return on investment and business case.

Decision makers need to understand technology at a higher level and connect them to business results. Technical staff needs to focus their messaging to senior staff on the benefits / processes that management understands, not the technology itself.

In addition, it is often easier to document the benefits for some ITS components, such as video surveillance, than for others, such as customer information. For example, there has been little research to really understand the impacts of real-time information on customer behavior or ridership.

[1] http://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/

2.3. COSTS ARE ALSO HARD TO DEFINE

Not only are benefits difficult to define, but costs are as well. There are several reasons for this:

- ITS are inherently complex systems, involving many components and modules that are integrated into a configuration that is not standardized and is unique for each deployment based on the context-specific systems engineering and concept of operations.
- There are no commercial off-the-shelf products.
- The Transit ITS supplier market is not stable, with considerable market entry, acquisitions and mergers, and exit of suppliers over time. As a result, the bid price for each supplier for any given procurement will depend on the specific market situation at the time of the procurement.
- Experience has shown that, as with most complex systems, actual costs rarely match predicted costs.
- There are also many hidden internal costs for acquiring specialized expertise to operate and maintain the systems.

2.4. CONSEQUENCES

As a result of all of the above factors, there is a general problem that the real costs and benefits, after deployment, rarely match what was loosely described in the business case (if there is one), and this hurts the credibility of investing in ITS in the minds of policy boards and senior management. In addition, horror stories will tend to propagate discretely from manager to manager through the industry, making it that much more difficult to build the case for investing in, and even more so for expanding, ITS systems

The consequences of all of the above are significant, including the following:

- Lack of senior support for funding, and funding is always the primary challenge,
- Lack of leadership in planning and deploying complex long-lasting projects,
- Lack of senior support for the lengthy technical needs assessment required in Systems Engineering,
- Lack of support for technology and Information Technology (IT) in general, and
- Lack of investment in internal ITS expertise within transit agencies.

3. ITS PROJECTS ARE COMPLEX TO PLAN AND PROCURE

ITS projects are complex to plan and procure for a number of reasons:

- Many Technical Challenges,
- Need for Vision, Leadership, and Expertise,
- Competition for Funding,
- Organizational Challenges, and
- ITS Project Planning Challenges

3.1. MANY TECHNICAL CHALLENGES

Transit ITS systems are technically challenging for a number of reasons:

- There are no off-the-shelf commercial solutions. It is not like purchasing a commercial software package.
- Standards exist, such as the Transit Communications Interface Profiles (TCIP), but are still not extensively used. As a result, there is no "plug and play" to integrating different components and modules.
- In most cases, the Transit ITS involves the integration of various systems, including existing legacy systems (e.g. scheduling software).
- The procurement is required to be vendor-neutral. However, in many situations, new ITS modules must be integrated with existing legacy systems; in these cases, given the lack of use of ITS standards (e.g. TCIP), partnerships with the existing legacy system supplier may be desirable, but is often not allowed by procurement regulations.
- Ideally, ITS technologies should enable both backward compatibility with legacy systems, as well as forward compatibility to future enhancements, that may in some case not yet have been identified. Ensuring backward and forward compatibility becomes extremely difficult given the lack of widely used ITS standards in the industry.
- Integration of products from different suppliers will always be challenging.
- The complexity and lengthy design and deployment horizon of these systems, and the changing conditions of the supplier market, will always make the management of supplier contracts challenging.
- Technologies often change faster than the time it takes for procurement processes to run their course.

3.2. NEED FOR VISION, LEADERSHIP, AND EXPERTISE

3.2.1. Challenge of Vision, Leadership, and Commitment

Transit ITS are complex systems to design and deploy. To succeed, they require:

- A vision of the technologies, their role, and how they will be incorporated into the organization's fabric, processes, and culture,

- A "roadmap" from senior management that outlines the building blocks of the entire system; this might enable a more incremental approach to deployment, with deployment of ITS components as needed based on their priority,
- Sustained leadership from senior management and an internal champion, and
- Commitment over the long-term from senior management and the policy board.

3.2.2. ITS Technical Expertise

The systems are also technically complex, and therefore require considerable internal technical expertise.

However, there is a lack of ITS expertise in the transit industry in general, and therefore in many transit systems. Transit agencies must therefore rely rather extensively on external consultants to assist in the design, procurement, and project management for these systems.

3.3. COMPETITION FOR FUNDING AND DIFFICULT BENEFIT-COST EVALUATION

Transit ITS projects involve substantial investment and must compete for funding with other capital and special projects. The frequent lack of interest by policy boards and senior management often place ITS projects at a disadvantage. In addition, as mentioned before, both costs and benefits are difficult to ascertain in advance.

Ideally, ITS procurement should also take into account the life cycle of the system. Unfortunately, it is very difficult to assess life cycle costs for a number of reasons:

- Transit agencies often retain ITS technology far beyond the system's point of obsolescence for lack of funding for system upgrade or replacement.
- In addition, it is often difficult to obtain from ITS suppliers objective assessments of the life cycle costs; in some cases the suppliers are recent arrivals to the industry and do not know the life span of the technology; in others, they do not want to compromise the potential sale of systems.

As a result of the above, it is difficult to prepare an accurate benefit-cost evaluation and to calculate the return on investment, which makes it all the more challenging for the competition for funding.

3.4. ORGANIZATIONAL CHALLENGES

In addition, there are sometimes significant organizational challenges that make more difficult the planning and procurement of Transit ITS projects. The two most common challenges relate to the relationships between: 1) ITS and IT, and 2) Operations and Planning.

3.4.1. ITS vs. Information Technology (IT)

ITS projects involve a complex set of both hardware and software components, as well as many inter-related databases, several of which interface with other enterprise databases. The IT department will naturally be a major internal stakeholder, which raises the question how to define the relationship between ITS and IT.

This raises many questions:

- How should the ITS project be managed during planning, during deployment, and on an ongoing basis? Should it be managed under the IT Department or as a separate special project?
- How to balance the technical IT aspects that the IT department is responsible for versus the business needs that the IT department is not really in a position to assess and define?
- What are the relative ITS versus IT skills that will be required with respect to: implementation, data quality, system administration, Infrastructure support, etc.

There is no simple or one-size-fits-all solution, and the answers will depend on the specifics of each agency context, related to corporate culture, organizational structure, staff resources, expertise, past project history, etc. In all cases, there will be need for an internal process that is collaborative.

3.4.2. Internal Alignment Between Operations and Planning

It will be equally important to consider organizational dynamics between the Operations and Planning dimensions of the ITS project.

Transit ITS projects are typically operations-driven, with major focus on integrated voice and radio communications, dispatching, real-time operations and safety / security incident management.

However, the longer-term significant benefits from ITS may be created by the use of data by the planning department. Unfortunately, many projects are deployed primarily for operations-driven objectives, so the use of ITS data is often an afterthought, after the Systems Engineering has been completed, and it is too late to structure the project. Again, there is need to consider the organizational dynamics, and develop a collaborative process.

3.5. ITS PROJECT PLANNING CHALLENGES WITH RESPECT TO SYSTEMS ENGINEERING

Since ITS projects are challenging to plan and procure, they require a sophisticated approach. Systems Engineering (SE) provides a valuable and systematic process for planning and procuring complex systems like ITS, and its use is in fact a federal requirement to enable the use of federal funds for funding ITS projects. SE helps to: ensure the best possible design to meet needs, minimize problems over the course of procurement and deployment, and takes into account the operations and maintenance needs over the life of the system. It also helps minimize the risk of the previously-mentioned "spectacular failure".

However, SE, though valuable, is daunting for most transit agencies for several reasons:

- There is no tradition of SE in the transit industry.
- There is a lack of people in transit agencies that have been trained in SE.
- SE is only rarely needed since it is applied only for major complex capital infrastructure and ITS projects.
- The requirements assessment and compliance / requirements mapping processes are very complex and daunting for anyone that has never used them before.
- Senior management too often believe that ITS is an off-the-shelf system, and do not understand the need for the systematic (and lengthy) SE needs assessment and design process.
- The Mobility Services for All Americans program of USDOT illustrated the significant challenge of SE for small transit systems in particular.
- There is a lack of documentation on challenges and best practices related to the use of SE in transit.
- Given the lack of internal expertise to conduct SE, transit agencies will require the use of expensive consultants.

If transit agencies do not have the internal expertise to properly conduct SE, it also creates a dilemma for suppliers bidding on ITS projects to either:

1. Include the cost of the SE that they know will be required to develop a proper system design, which will in turn inflate the system price (and most likely result in a loss to a lower-bid supplier), or
2. Not include the cost of the SE, which will lead to a poorly designed system and possible system failure, or lead at the very list to a conflict situation between supplier and transit agency over different interpretations of design requirements and performance (as well as lead to possible legal suits).

4. ITS PROJECTS ARE COMPLEX TO DEPLOY

There are many challenges in successfully deploying Transit ITS projects given their inherent complexity. These include:

- Tasks to Conduct SE Process
- Internal Technical Challenges
- Unforeseen Technical Challenges
- Human and Organizational Issues

4.1. TASKS TO CONDUCT SE PROCESS

Fulfilling the SE Process involves many and complex tasks.

In addition to the formal steps involved in the SE Process, there are many tracking documents that assist in the management of the ITS planning process. The following are suggestions of valuable tracking documents[2]:

- Action Items List
- System Implementation Plan
- Communication Plan
- Change Management Plan
- Risk Management Plan
- Quality Assurance Plan
- Milestone Approval

In addition, some experts suggest that the following steps in the SE process merit special attention:

- It is important to carefully document the status and amendments resulting from testing, verification, and validation of requirements for ITS projects.
- Acceptance Testing is an important step, but contractors often resist the extra time required for thorough testing.
- It is also important for the agency's senior management to commit to thoroughly testing systems before introducing them to operations

4.2. INTERNAL TECHNICAL CHALLENGES

As in any complex technical system deployment, there can be challenging internal technical challenges. Experts have suggested the following three merit special attention:

- Installation issues: New hardware needs to be installed in the garage and on the vehicles; the latter requires taking the vehicles out of service. It is a challenge to

[2] Mishra, S., *How to Have Successful Transit ITS Implementations: Lessons Learned from the Field*, Presentation to Passenger Transportation Systems and Services Committee, October 2014

plan how to minimize the disruption to service. In addition, there may be union-related issues to address.

- Data preparation and integrity: The agency will need to assemble, or perhaps even collect for the first time, data for the new ITS (e.g. geo-coded bus stop inventory). Internal challenges include data fragmentation and validation of the data's quality.

- Involvement of maintenance department: The new system and its various components will need to be vetted with the maintenance department in order to ensure that it is properly maintained and that it is kept fully effective. This important step is often overlooked.

4.3. UNFORESEEN TECHNICAL CHALLENGES

In addition, complex projects that entail a lengthy duration for design and deployment suffer unforeseen risks. Three noteworthy challenges are as follows:

- Lack of due-diligence at the design stage can cause problems down the road.
- Underdeveloped products by suppliers may fail to meet design requirements.
- The need for interface or integration with third party systems may cause not only technical challenges, but also latent costs for unanticipated license fees.

4.4. HUMAN AND ORGANIZATIONAL ISSUES

Human and organizational issues may also affect deployment. Examples include:

- Inter-departmental issues over system ownership or infrastructure support,
- Midstream staffing changes of key personnel at either the agency or at the supplier. It may be difficult to find qualified replacement staff, and will certainly entail delay, not only to find the staff, but also to bring them up to speed on the project.

5. MANY OPERATIONS AND MAINTENANCE CHALLENGES EXIST ONCE DEPLOYED

Not surprisingly, there are many challenges related to system operations and planning, even once the systems are deployed. These are as follows:

- Technical Challenges
- Organizational Challenges
- Operational Challenges
- Challenges Related to Ongoing Relations with Suppliers

5.1. TECHNICAL CHALLENGES

Some of the challenges that have been encountered in systems operations and maintenance relate to the following aspects:

- Integration of various systems,
- Integration of components and systems originating from different suppliers,
- Proprietary technology, which may make difficult the development of interfaces,
- Maintenance of large volumes of data,
- Speed of the server and communications when using a hosted solution, etc.

5.2. ORGANIZATIONAL CHALLENGES

In some cases, organizational challenges are even more difficult than the above-mentioned technical ones. The following are challenges identified from experience.

- **Organizational Lead for ITS Operations**. The organizational responsibility for ITS may transition to a different department after deployment. This may result in a lack of continuity, and a loss of technical and organizational knowledge, as well as changes in vision and standard operating procedures. Such transitions need to be carefully managed.

- **Organizational Planning and Negotiation to Ensure Ongoing Effective Operations and Maintenance**. Obtaining the resources to ensure ongoing operations and maintenance after the system has been deployed may be an organizational challenge. This involves organizational negotiations over:
    - Staff resources,
    - Assignment of duties for new tasks,
    - Adding necessary IT resources,
    - Ongoing training,
    - Ongoing management of system suppliers,
    - Maintenance resources, etc.

Ideally, these topics should have been addressed during the development of the Concept of Operations in the early stages of the SE process, but this is unfortunately not always the case.

- **Organizational Resistance**. There is always considerable resistance to change by some individuals, and there are few incentives to encourage change; this can sometimes limit interest and investment in innovation such as ITS. Overcoming resistance to change requires both active support by senior management, and a champion. Some of the issues that may need to be addressed are:
    - Ensuring acceptance of change and staff buy-in,
    - Managing human-dimension conflicts between change-resisters and technology enthusiasts,
    - Managing dynamics and potential conflicts between departments, since these strengthen resistance to change,
    - Ensuring the vision of an integrated system is shared, etc.

5.3. OPERATIONAL CHALLENGES

Practical, and often frustrating, operational challenges will abound. Some of these include:

- Creating basic staff comprehension of the new technologies, which often relates to insufficient training,
- Difficulty in getting staff to give up old habits and operating procedures,
- Getting end-users (operators, mechanics) to document operating problems in sufficient detail,
- Ensuring operator compliance with log-ons,
- Managing the need and process if multiple operator log-ons are required.

Over time as new technologies are added on to vehicles on an ad-hoc basis, one ends up in some cases requiring bus operators to sign on to multiple devices; when this does not occur, the systems are ineffective. Retrofitting a single log-on mechanism after the fact is complex, but may be necessary. New systems will incorporate mechanisms to avoid this problem.

Ensuring effective operational control may be a particular operational challenge. Control room staff may be facing new tasks, procedures, and interfaces between complex systems

5.4. CHALLENGES RELATED TO ONGOING RELATIONS WITH SUPPLIERS

Ongoing relations with suppliers will often be critical in ensuring smooth system operations and maintenance, but may face some of the following challenges:

- Warranty disputes,
- Lack of support,

- Lack of training, and
- Discovery after-the-fact of valuable features provided to other transit agencies by the same supplier, which is particularly frustrating, and highlights the need for due diligence and consultant support during the SE process.

In addition, it will be necessary to manage ongoing relations with suppliers as part of the effort to keep the system up-to-date to the extent possible. Given the rate of technological change, there is a need to try and plan for an economical way to keep the system up-to-date.

From the suppliers' point of view, there is need for a more explicit definition for measuring system reliability and downtime. This is often poorly defined. System downtime may have nothing to do with the ITS technology per se as in the case when the backbone enterprise architecture or firewall security software is being upgraded. Having a more standardized definition of system reliability may improve relations with suppliers.

6. CHALLENGES EXIST IN ACHIEVING FULL SYSTEM POTENTIAL

The previous sections outlined challenges to plan, procure, deploy, operate, and maintain an ITS. However, there are other potential benefits that might be derived from an ITS beyond its more typical use for communications, security, and incident management. The following section outlines challenges with fully utilizing ITS to its full potential:

- Transit ITS Data is a Valuable Resource but has Many Challenges
- Organizational Reluctance to Build on ITS to Revise Business Practices
- Lack of Industry Standardized Methodologies
- Unfulfilled or Under-Explored Benefits

6.1. TRANSIT ITS DATA IS A VALUABLE RESOURCE BUT HAS MANY CHALLENGES

There is great potential to use the data produced by ITS technologies to create information that is valuable for planning and management. This information can be used to enhance the agency's effectiveness and efficiency, and move towards more data-driven decisionmaking.

A few key examples include use of CAD/AVL or Automatic Passenger Counting (APC) data to:

- Measure on-time performance and improve service reliability for customers,
- Provide valuable data on the distribution of actual running times by month, day, time of day, which can be fed into the scheduling system in order to reduce recovery time, and thereby save operator hours,
- Monitor dwell time at intersections in order to select where Transit Signal Priority (TSP) would be of most benefit,
- Build ridership profiles by stop in order to identify key markets and transfer locations for route design, and where shelters should be located,
- Identify recurring patterns of missed runs, overloads, early departures, etc.

However, there are significant challenges in using ITS data for planning and management. These include:

- Lack of rights to the data in some cases because ownership is proprietary to suppliers,
- Data quality,
- Lack of internal expertise or supplier-provided tools to match, clean, and maintain data,
- Lack of internal expertise or supplier-provided tools to analyze data to create information and standardized reports, and
- Data management challenges such as:
    - Inventory of internal databases and their mapping to business processes,

- Creation of a data warehouse,
- Data interoperability requirements, etc.

A separate Public Transportation ITS Discussion Paper is exploring the uses and challenges related to Transit ITS data in more detail.

6.2. ORGANIZATIONAL RELUCTANCE TO BUILD ON ITS TO REVISE BUSINESS PRACTICES

In addition to the valuable information that can be produced by Transit ITS, the systems can be used to rethink the agency's way of doing business. The introduction of technology introduces change, and with it, the opportunity to rethink processes in ways that take full advantage of the technology's capabilities.

This requires however an openness to change, which may not exist, or may be resisted internally. In addition, it requires a process to map ITS data against internal business processes, and then adjust, or develop new standard operating procedures.

This applies to the above-mentioned use of ITS data for planning and management. But it also applies to the operational control function:

- Are the full capabilities of the ITS being used by the operations control staff?
- Does the system use a decision-support system (such as might result from the federally-sponsored Transit Operations Decision Support System project) to assist control room staff?
- Has the introduction of ITS been used to develop standardized service restoration strategies?
- Have other opportunities for new business processes been analyzed? An example might be to integrate ITS and accident investigation / reporting processes.

In general, there has been little industry-wide exploration and documentation of how ITS might be used to modify business processes, though it certainly happens internally.

6.3. LACK OF INDUSTRY STANDARDIZED METHODOLOGIES

The potential use of the full potential of ITS technologies is also hindered by a lack of standardized methodologies, where one observes individual transit agencies struggling internally over and over on industry-wide topics of concern. The most obvious examples are the need to develop standardized methodologies for:

- Measuring the accuracy of Real-Time Passenger Information (RTPI) systems,
- Measuring the accuracy of APC systems, and
- Measuring the performance and effectiveness of TSP systems

6.4. UNFULFILLED OR UNDER-EXPLORED BENEFITS

In addition to the above, one observes a number of applications related to Transit ITS that have been deployed on an ad-hoc basis across the industry. These include:

- Connection protection
- Yard management
- Vehicle health monitoring
- Real-time proactive control
- Integration of fixed-route transit with flexible and demand responsive transit
- Real-time demand responsive service for the general public

And the future should also enable more advanced applications that do not yet exist at all, such as envisioning a decision support system using artificial intelligence and predictive analytics to recognize as they develop bunching and other patterns that will disrupt service reliability, and then suggest potential strategies. There is anecdotal evidence that such concepts are being deployed in Europe.

7. ITS AS GATEWAY TO THE FUTURE

The future appears to be increasingly technologically driven, and ITS is the transit agency' s gateway to this future. In the shorter-term ITS technologies will be interfaced with systems from other agencies to develop multi-agency or regional portals or systems. In the longer term, ITS is increasingly moving into new arenas of connected vehicles, and vehicle automation.

7.1. APPLICATIONS REQUIRING MULTI-AGENCY DATA INTEGRATION

The future will see a growing trend towards interfaces, coordination, and integration of ITS technologies between different agencies. Examples include:

- Regional Real-Time Passenger Information Portals and Displays
- Multi-Agency Connection Protection
- Multi-Agency Advanced Fare Collection
- Transit Signal Priority
- Integrated traffic and transit control centers
- Integrated Corridor Management

Multi-agency coordination and / or integration of technologies will bring about new inter-organizational challenges.

7.2. SPECIAL PROBLEMS IN DEPLOYING TRANSIT ITS IN MULTI-AGENCY REGIONS

There will be an increasing need for technical interfaces and / or integration between systems operated by different agencies, but this need will be challenging for several reasons:

- Lack of use of TCIP standard,
- Lack of scalability of legacy systems,
- Lack of ITS strategic plans
- Lack of participation in Regional ITS Architecture process, etc.

In this regard, there is need for more formal thinking within transit agencies, that should take the form of an ITS Strategic Plan, to explore future needs and requirements in an increasingly multi-agency environment. There is also a need for more active transit agency participation in the Regional ITS Architecture process; participation to date mostly consists of providing a wish list of potential internal projects.

7.3. FUTURE TRANSFORMATIONS TO TRANSPORTATION INDUSTRY WILL BE TECHNOLOGY-DRIVEN

Finally, urban transportation is likely to be transformed, largely through technology. Future transformations on the horizon relate to:

- Big Data,
- Mobility on Demand,
- Connected Vehicles (among vehicles, infrastructure, and individual persons), and
- Automated and Autonomous Vehicles

Unfortunately, the transit industry appears poorly positioned to be a full partner in these future transformations. Significant challenges echo previously mentioned challenges, and include:

- Lack of interest in ITS,
- Lack of technology vision,
- Lack of knowledge,
- Lack of internal expertise,
- Lack of interaction / coordination with respect to organizations involved in big data, shared-use mobility, and connected vehicles.

8. RECOMMENDATIONS

The former sections provided a comprehensive overview of the challenges related to deploying and achieving the full potential of Transit ITS. An analysis of these suggest several avenues and potential initiatives that the transit industry might consider, as a whole, or individually, to address the identified challenges. These recommendations are organized under the following categories:

- Expand Dissemination of Transit ITS Best Practices
- Research, Documentation, and Dissemination of Benefits of Transit ITS
- Other Areas Requiring Research and Development
- Other Recommendations

8.1. EXPAND DISSEMINATION OF TRANSIT ITS BEST PRACTICES

There is a great need to focus more attention on Transit ITS "Best Practices". This includes:

- Expand outreach of existing resources
- Develop new mechanisms to share information using electronic means
- Develop "user groups" of agencies using common ITS technologies, such as:
    - Archived ITS data
    - TODSS
    - TSP
    - Vehicle Health Monitoring

8.2. DOCUMENTATION AND DISSEMINATION OF TRANSIT ITS BENEFITS AND BUSINESS CASE

There is a great need to identify and document benefits and costs in order to assist in the preparation of more credible business cases that are persuasive to policy boards and senior management:

- Research to identify and document benefits
- Research to identify and document costs in more credible fashion
- Research to identify and document transformation of business processes resulting from Transit ITS
- Research and document return on investment and business cases of systems and components
- Research on the causes of "spectacular failures". This might provide some guidance on how to enhance SE to minimize even further the risk for such failures
- Develop novel mechanism to disseminate information to senior managers and policy boards
- Develop innovative executive training mechanisms aimed at senior managers and policy boards

8.3. OTHER AREAS REQUIRING RESEARCH AND DEVELOPMENT

In addition, there is need for Research and Development (R&D) in a number of other topic areas.

8.3.1. Standardized Methodologies and Tools

There is need for R&D to develop standardized methodologies and tools on the following topics:

- Research to develop automated diagnostic tools to determine causes of data problems when they occur (e.g. on-board sensors, downloading failures, data matching problems, etc.)
- Measuring accuracy of RTPI systems
- Measuring accuracy of APC systems
- Standardized definition of system reliability to clarify supplier responsibility
- Measuring effectiveness of TSP systems
- Potential role of ITS in performance-based planning and management
- Potential Role of ITS with respect to FTA requirements related to asset management and safety

8.3.2. Research and Demonstration Related to Unfulfilled Benefits of ITS

R&D would be valuable to expand best practices, and / or to encourage achieving potential benefits in the following areas:

- Research to understand the slow adoption of TCIP
- Research to document best practices with respect to the use of SE in transit ITS
- Research to develop simplified SE process that is more manageable for small to medium transit systems
- Transit Signal Priority
- Use of AVL / APC data for business intelligence
- Connection protection
- Yard management
- Vehicle health monitoring
- Real-time proactive control
- Integration of fixed-route transit with flexible and demand responsive transit
- Real-time demand responsive service for general public
- Decision support systems using AI and predictive analytics

8.4. OTHER RECOMMENDATIONS

- It would be valuable to develop a national database that provides an inventory of which agency is using which ITS technologies (with supplier). (Note: The USDOT Deployment Database is based on a survey that only happens every 3-4 years, and does not include suppliers.)

- Surveys of transit agencies are duplicative and not shared. More centralized technology scans might be useful, or develop mechanisms to share surveys
- Consider developing Frequently Asked Questions and specification matrix
- Pursue the potential use of the TCRP Transit IDEA Program for R&D on the above topics.
- Develop mechanisms to engage vendors in dialogue about challenges and recommendations (e.g. workshop?)
- There is a need for more training on Transit ITS

APPENDIX: GENERAL MANAGER SUMMIT ON ITS, MAY 3, 2005, PHOENIX

On May 3, 2005 the American Public Transportation Association and ITS America hosted a "GM Summit" in Phoenix in conjunction with the ITS America Annual Meeting. Over 20 transit leaders participated in a discussion led by Utah Transit Authority GM, John Inglish. The GM's represented all levels of technology commitment, from those who have no ITS to ITS trailblazers.

Pre-meeting survey:

Previous to the May 3 meeting, GM's were requested to complete a short questionnaire on ITS for transit. Though it cannot be considered a representative sample for the industry, the results are thought-provoking.

In response to the statement, "I have plenty of information about advanced technology," 10 respondents said YES and eight said NO. In response to the statement, "I am interested in implementing technology as quickly as I can," 10 responded YES and five said NO.

Respondents ranked the following statements from **most** important to **least** important:
1. I don't have sufficient funds for maintenance.
2. I don't have enough money for the initial investment.
3. I don't have the staff expertise to maintain the technology.
4. I don't have the staff expertise to procure the technology.
5. I am waiting for standards to be developed.
6. The benefits of technology do not outweigh the cost.
7. My Board has no interest in technology.
8. Technology will not help us with our core mission.

And finally, survey respondents were asked to complete the statement, "If we want to improve public transit with technology we need…" The results were:

If we want to improve public transit with technology we need…

- Champions to lead the way!
- More resources
- Adequate grant funding to get projects up and running
- Ongoing funding to support maintenance and system support
- Understanding of true costs and benefits
- To understand the value vs. cost
- Compelling business cases with return on investment (ROI)
- To ensure that the technology is proven, stable, and works as requested
- Not to be paying for R&D during implementation
- Non-proprietary software
- Reliable off-the-shelf solutions at lower cost and less complexity to maintain
- To know what has worked and is considered off-the-shelf
- The commitment from the Board and the public
- Operational people to become more technology knowledgeable
- Improved information sharing among agencies
- Standards for assessing new technology and how it will be implemented into a system

- All agencies to agree to move forward with a "Technology Commitment" so that everyone would be moving in the same direction.
- Enterprise-wide transit technology (accounting, scheduling, applicant tracking, etc.)
- AVL/GPS real time integrated transit operations: on-board passenger counters, digital recorders and policies in place to evaluate success.

Meeting discussion:

Survey results were distributed to the GM Summit participants and a lively discussion followed. The participants identified barriers to ITS transit implementation, ideas for resolving those barriers, and some products that they feel warrant further attention.

Barriers to ITS Transit Implementation

- Need to articulate a technology vision
- Cooperation from other transportation authorities/modes -- lack of coordination
- Implementation trauma -- too many things going on
- Too much R&D -- reinventing the wheel
- Training
- Need for GM involvement -- high level focus -- champions
- Not enough off-the-shelf products
- Supply side capacity -- interest
- Onerous procurement requirements
- Managing expectations (on-going costs higher than expected)
- Understand business needs -- define needs for vendors
- Fragmented approach to projects
- Systems constantly retailored to meet specific desires of transit systems
- Cost/benefit not well articulated
- Very short shelf life
- Legacy systems
- Better is evil of good (new, improved software module causes failure)
- Managers abdicate to technologists -- core mission
- Buy America?
- No plug and play
- No restraint in industry

Ideas for Resolution

- Standardize performance/certification (APTA best practices evaluation/ "consumer reports")
- Executive technical training (NTI, GM's Conference, Workshops, etc.)
- Centralizing of systems
- Business opportunity/public private partnerships
- Consortium purchases (APTA/FTA)
- Product lines (7-10 high priority products)
- Showcase projects
- International experience
- Peer-to-peer workshops

Desired Product Lines:

- Electronic Fare Collection
- Passenger counting
- AVL
- Communications
- On board surveillance (security)
- Information systems (passenger ratings)
- IVR
- Scheduling systems
- Asset management systems (maintenance, etc.)
- Over 50 guests observed the discussion and most were excited by the results. For many who serve the industry, it was the first time they had heard an organized discussion among reluctant ITS customers. The meeting opened the door to uniting the industry with new understanding.
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Discussion participants were:

Dave Boggs, Executive Director, Valley Metro/RPTA
Dave Colquhoun, Manager, Transit Planning, Calgary Transit
Gregory E.Cook, CEO/Executive Director, Ann Arbor Transportation Authority
Debbie Cotton, Deputy Director, Regional Technology Services, City of Phoenix, Public Transit Department
Robert L. Doty, Director, Rail Transportation, Acting COO, San Mateo County Transit District
Ken Driggs, Retired, Valley Metro
Ginger Gherardi, Executive Director, Ventura County Transportation Commission
Fred Gilliam, President/CEO, Capital Metropolitan Transportation Authority
John M.Inglish, General Manager, Utah Transit Authority
Paul Jablonski, CEO, San Diego Metropolitan Transit System
Lawrence W. Jackson, President and CEO, Long Beach Transit
Anthony V. Johnson, Executive Vice President/COO, Fort Worth Transportation Authority
Bryan Jungwirth, Deputy Executive Director, Valley Metro
Teri W. Mantony, Deputy General Manager, Administration and Development, Golden Gate Bridge, Highway and Transportation District
William W.Millar, President, American Public Transportation Association
Mary JoMorandini, General Manager, Beaver County Transit Authority
Stephanie Negriff, Director, Santa Monica's Big Blue Bus
Richard Ober, Beaver County Transit Authority
C. Mikel Oglesby, General Manager, SunLine Transit Agency
Dick Ruddell, President/Executive Director, Fort Worth Transportation Authority
Paul P.Skoutelas, CEO, Port Authority of Allegheny County
Jack L. Stephens, Deputy Executive Director, South Florida Regional Transportation Authority