I.T.S. CHALLENGES AND SOLUTIONS FOR SMALL & MEDIUM AGENCIES

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Abstract:
The authors' experience during oversight of over 100 ITS projects indicates that many small and medium-sized agencies are not able to maintain sufficient in-house ITS expertise to implement many ITS projects. The expertise needed includes traditional project-management skills, plus systems-engineering skills for the technology aspects. This can result in projects that are over budget, and/or late, and/or do not achieve their objectives. Some agencies succeeded by ***hiring a separate contractor*** or ***sharing in-house IT staff*** to perform Project Management and Systems Engineering functions. This paper identifies the ingredients for their success, and problems they encountered. It also explores other innovative solutions to this problem.

Keywords: ITS, Project Management, Systems Engineering.

Disclaimer: All statements in this paper are solely the opinions of the authors and do not necessarily represent the policies or opinions of the U.S. Department of Transportation.

I.T.S. CHALLENGES FACING SMALL & MEDIUM-SIZED AGENCIES

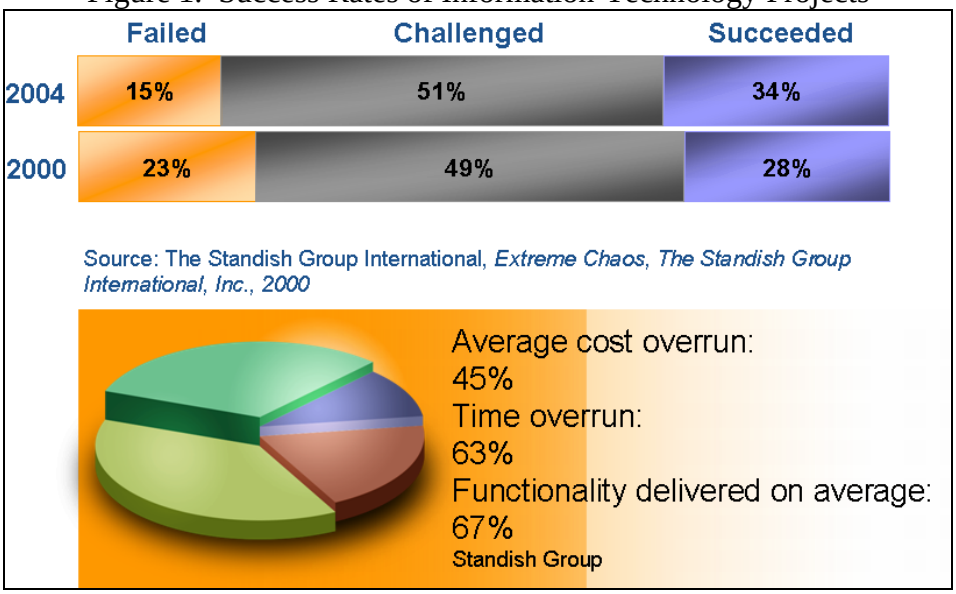
In the course of their normal duties as ITS Engineers for FHWA, the authors have performed detailed oversight for over 100 federally-funded ITS projects. Many of these projects were executed by small or medium-sized local agencies. Some of these agencies have found it difficult to implement complex ITS projects successfully. In this paper, a "successful" project is defined as including **all** of the following outcomes:

(1) completed within the original budget
(2) completed within the original schedule
(3) achieved all of the ***expected*** capabilities.

Based upon this definition, a significant number of ITS projects implemented by these small- and medium-size were ***not*** fully successful. .

ITS projects are comparable in some ways to those of the Information Technology (IT) field, which is also heavily dependent upon technology. The track record for **IT** projects is summarized in Figure 1 below. We are not aware of a comparable study in the **ITS** field.

Figure 1. Success Rates of Information-Technology Projects



What are the "Risk" Factors?

Our experience, like others in the ITS field (e.g. NHI course: "Managing High-Technology Projects in Transportation") points to certain patterns that can predict success and failure. The highest ***risk*** of failure correlates with the following project factors:

- Multi-Jurisdictional or Multi-modal
- New Software Creation
- New Hardware Integrated with new or Existing Software
- New Technology Applications
- New Interfaces - especially to external systems
- System Requirements not well understood or documented

Projects with ***none*** of these factors had a much higher likelihood of success. Projects with one or more of these factors had an increased risk. With multiple factors present, the risk appears to grow.

To illustrate, a few examples of low-risk ITS projects are:

- Adding four Dynamic Message Sign (DMS) that are identical to the existing 40 – using exactly the same specifications, interfaces, operating procedures, etc. (i.e., with ***no changes*** to the system).
- Adding 20 CCTV cameras that are identical to the existing five cameras – with ***no changes*** to the system or how it's used.
- Adding 50 new loops that are identical to the existing 200 – once again, with ***no changes*** in technology or interfaces or usage
- Installing the existing parking management system at 2 new garages – again with ***no changes*** in the system design, technology, or usage

At the other end of the risk spectrum, examples of high-risk ITS projects are:

- **Multi-jurisdictional or multi-modal system implementation**. Because of the external interfaces, these projects generally include substantial software development. For example:
  - A traveler information system that collects data from multiple agencies or modes
  - A Bus Traffic Signal Priority system involving the City Traffic Department and Regional Transit, or one that crosses multiple cities.
- **The first stage of an "umbrella" system implementation**. During this first stage, the overall system framework is designed, plus the first implementation of that framework. For example:
  - New Traffic Signal Coordination system design plus instrumentation at a small number of signals within an eventual larger network
  - A Bus-Signal Priority system along one arterial, with expansion to other arterials in the same city in subsequent project(s).

  As discussed above, subsequent stages that expand the initial implementation by replicating the same elements would often be a lower-risk ITS project.

How Can Risk be Managed?

We contend that many challenges to ITS projects are because the agency staff did not ***adequately assess the project's risk***, and did not ***properly manage the projects***. But what does "properly manage" mean here? It includes three elements:

1.) Using Good Project-Management Practices
2.) Tailoring the Project-Management Approach to ITS
3.) Dedicating Sufficient Time to the Project-Management Effort

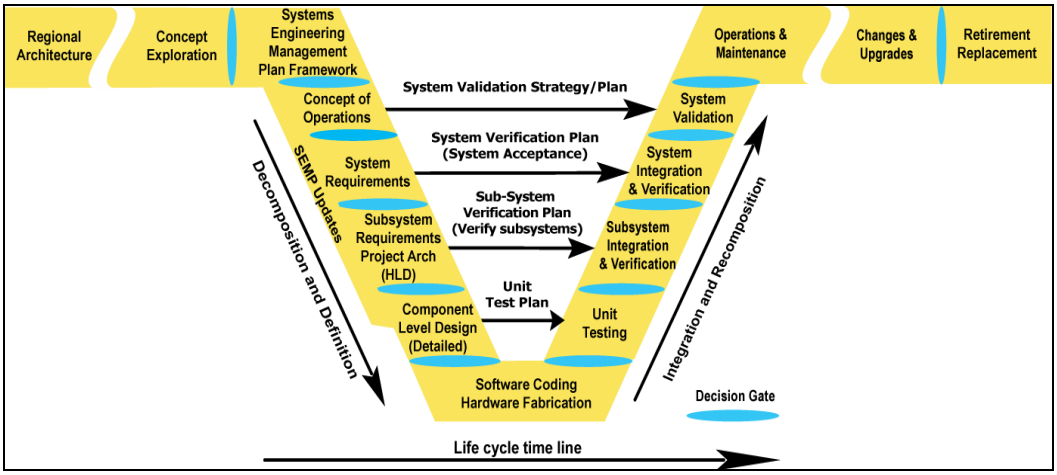
Using good project-management practices

There are project-management practices that are common across a wide range of "projects" (not just ITS projects). Perhaps the most widely-recognized information source on this is the "Project Management Body of Knowledge" (PMBOK) by the Project Management Institute. All ITS projects should be executed using these good project-management practices. Many state DOTs and other larger agencies have institutionalized such standard practices via procedures documents. Many small/medium traffic and transit agencies have not.

Tailoring the project-management approach to *ITS*

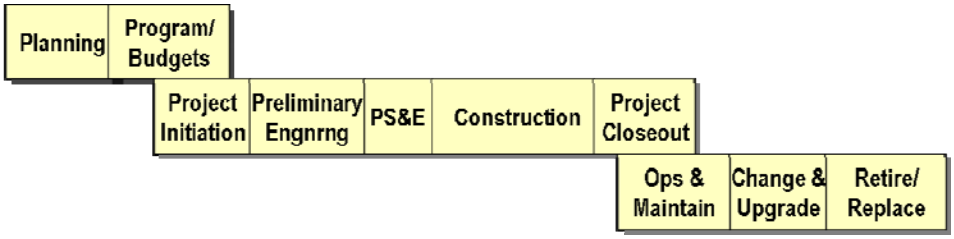
In addition to the general PMBOK practices that are applicable to a wide range of projects, there is a specific process and associated technical management practices that is recognized as "best professional practice" for organizing and managing ***most*** higher-risk ITS projects. In the ITS profession, the process is often called the "Systems-Engineering V Process" and technical aspects are managed thru the Systems Engineering Management Plan (SEMP). This process is represented graphically in Figure 2. Note that there are several variations on this same "V" theme, but this diagram is the most commonly used in the ITS domain.

Figure 2. Systems Engineering "V" Process



We contend that essentially all high-risk ITS projects should use this V process. We further contend that low-risk ITS projects do ***not*** need to use this V process. In most cases, it will be sufficient to use the "traditional" project-management process used for construction projects, as represented in the diagram below.

Figure 3. The "Traditional" Project-Management Process for Construction



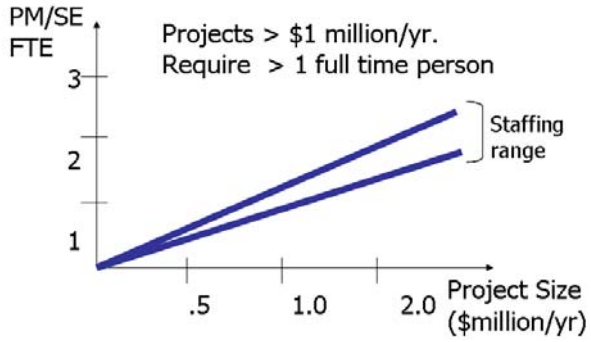
The most widely-recognized information sources on the V process for ITS are the following two documents. The first is better for a beginner and the second is better for a practitioner.

- Systems Engineering for Intelligent Transportation Systems – An Introduction for Transportation Professionals (SE Handbook), published by FHWA. The document can be accessed at: http://ops.fhwa.dot.gov/publications/seitsguide/index.htm
- Systems Engineering Guidebook for ITS - originally published by Caltrans and FHWA, now available as a PDF file and also as an interactive version on the web. It can be accessed at: http://www.fhwa.dot.gov/cadiv/segb.

Dedicating Sufficient time to the Project-Management Effort

The third necessary ingredient for success in managing ITS projects relates to the time spent. Staffing levels needed for ITS projects vary widely with cost and complexity of the project. The USDOT/NHI training course ***Managing High-Technology Projects in Transportation*** recommends a "rule of thumb" staffing level for ITS projects of roughly one full-time-equivalent (FTE) per $1 million of annual project costs. This rule-of-thumb is shown graphically in Figure 4.

Figure 4. Recommended Project-Management Time for ITS



Why is such a "high" staffing level needed? Because there are many tasks that need to be performed. Especially for high-risk projects, almost all of the project-management and systems-engineering tasks shown in Table 1 below will have to be performed by agency staff (or their representatives).

Table 1.

***Project Manager's Responsibilities*:**

1. Develop RFP
2. Contract negotiations
3. Conduct risk analysis
4. Requirements walk-thru
5. Internal coordination
6. Document activities
7. Review documentation
8. Inspect work
8. Review deliverables
9. Acceptance tests
10. Lead project meetings
11. Contract management
12. Review invoices
13. Coord. stakeholders
14. Contribute to website
15. … and more …

What Problems Will Small and Medium Agencies Confront?

There were multiple explanations behind the ITS challenges discussed above, but we observed one recurring factor – lack of qualified staff. Most small and medium-sized traffic and transit agencies find it difficult to maintain staff expertise in two key ITS areas: Managing Technology-Dependent Projects, and Systems Engineering. For these agencies, we observed three interrelated reasons for this:

1.) Not enough ITS activity to justify a full-time staff position.
2.) High turnover of technical staff.
3.) Difficulty in obtaining ITS training when needed.

These three challenges are discussed next.

Not enough ITS activity to justify a full-time staff position

Small/medium agencies often execute only one ITS project at a time, sometimes with months or years between ITS projects. That workload usually does not require one full-time person. The recommended staff levels are easier to reach at larger agencies, which often have several ITS projects underway, with a combined "burn-rate" above $1 million of expenses per year. For small and medium agencies, whose ITS-project burn rate is well below $1 million/year, this creates a dilemma – at what point can they justify hiring one full-time ITS specialist? Several possible answers are discussed below. Furthermore, what ***type*** of ITS projects justify hiring a ITS specialist? For example, a high-risk project to design and implement a

new city-wide traffic-management system will require much more project-management time than a low-risk project that is adding 20 dynamic message signs to a system that contains 10 identical signs. Moreover, for the traffic-system project the need for this ITS staff expertise would likely continue beyond implementation into operations and maintenance. This leads to the second reason for insufficient ITS staff at small/medium agencies.

High Turnover of Technical Staff

Experienced "*techies"* and systems engineers can usually earn more in the private sector. Computer hardware, software and telecommunications technology is rapidly advancing. Talented people in these fields are a valuable commodity in the private and public sector. (Every techie's dream is to work for Google.) Small/medium agencies rarely can pay the "big bucks" to compete in this marketplace. Finally, most small/medium agencies do not offer a career path for a technology specialist, so professional advancement requires changing jobs. Thus, these public agencies are often an "entry point" for technology-based careers.

Difficulty Obtaining ITS Training When Needed

In many cases, existing staff do not have all the ITS knowledge, skills and abilities needed. Information Technology (IT) training is often available locally – usually at a high cost – at many colleges and trade schools. But ***ITS*** training is usually ***not*** readily available locally. Internet-based ITS training (sponsored by USDOT) ***is available*** – at low or moderate cost – to meet this training need (e.g., through NHI, NTI, CITE, etc.), but we were dismayed to find that most local agencies had not yet taken advantage of these readily-available and comprehensive offerings. It would be valuable to conduct a study to determine the reason(s) for this. Anecdotal evidence points to several possible reasons:

- Too much noise, telephones ringing, and other distractions at the office
- Too many interruptions by co-workers (especially when there is no door to close)
- Too many pressing deadlines (training is easy to postpone)
- Lack of peer interaction to maintain focus on learning
- Management's perception of employee use of time

In summary, most small and medium agencies appear to <u>not</u> have adequate "ITS" staff. As a result, the agency allocates too little staff time to Project Management and Systems Engineering functions, which are essential to the success of ITS implementation projects. We found very few agencies that approach the recommended staffing level of one FTE per $1,000,000 of project expenditures per year. In addition to not allocating enough time, many small and medium agencies assign administrative staff or civil engineers to manage these ITS projects. As a result, these non-ITS folks often either fail to perform some of these necessary project-management and systems-engineering functions, or they have the contractor do them. ***The consequence is that the public agency's interests are not fully protected.*** This is because (as Mark Twain would say) "the fox is guarding the chicken coop."

At the same time, ***the contractor's interests are also put at risk.*** For example, one common symptom of inadequate public-agency project-management staffing is failure to review essential documents or deliverables in a timely fashion. In ITS projects, subsequent work frequently depends heavily upon the contents of these deliverables. Best professional practices often dictate that subsequent steps ***should not begin*** until a given deliverable is deemed satisfactory. (In Systems Engineering lingo, these are called "Control Gates" because they can prevent movement forward.) But very few contractors are able to "enforce"

this good professional practice on their client, and the resulting miscommunication often produces dissatisfaction and/or disputes in later steps – when the client realizes that the project is going in the wrong direction.

SOLUTIONS TO THE I.T.S. STAFFING CHALLENGES

The previous sections articulated the challenges facing small and medium traffic and transit agencies. While there is no "silver bullet" solution, there are several potential solutions. Depending upon their local circumstances and preferences, each agency should identify the solution that is most appropriate.

(1) Spend the money required to maintain in-house ITS staff
(2) Share technical staff with other units within the same agency
(3) Share ITS staff between two or more agencies.
(4) Hire a consultant to perform ***some*** of these functions
(5) Hire another ***agency*** to perform some of these functions

These possible solutions are discussed next.

Maintain in-house ITS technical expertise

Even when there is not a need for a full-time ITS specialist on staff, the consequences of not having one may still provide ***economic*** justification for funding a full-time ITS position. For example, in a project with a $500,000/year burn rate, roughly one-half FTE would be needed and the other half-FTE would be "surplus" time. Many understaffed projects have ***avoidable*** cost overruns of 20% or more. If our example $500,000/year project has a 20% overrun, the additional cost would be $100,000/year. This is ***twice*** the cost of that "surplus" time (assuming that surplus time is "wasted"). But productive tasks can often be found to utilize some of that surplus time (e.g. performing system maintenance or perhaps operations).

Share Technical Staff with Other Units in the Same Agency

For municipal traffic and transit agencies, the Information Technology (IT) department of the city or county may have an IT specialist that can be assigned on a part-time basis to support the transit department's ITS project activities. One example is *Santa Monica Big Blue Bus*, which is a department of the City of Santa Monica, CA. The City's IT department assigned one of their technical staff part-time to manage the technical design and implementation of their ***Smart Bus*** project. This approach usually requires that the IT specialist obtain the transit/traffic and ITS knowledge required. In addition to on-the-job training to learn this, there are numerous distance-learning opportunities available to meet most of these learning needs (e.g. thru NHI, NTI, CITE, ITE, ITSA, etc.).

Share ITS Staff with Other Agencies

This third option requires an interagency arrangement to share a full-time ITS specialist between similar agencies. This could be implemented via a cooperative ("pooled-fund") agreement between agencies, or it could be lead by a regional agency (e.g. MPO, State DOT). Some regions have a university that could serve as this lead agency. In California, the Local Technical Assistance Program (LTAP) has provided "Field Engineers" to perform certain (non-ITS) services for public agencies. (See http://www.techtransfer.berkeley.edu/engineers/)

This cooperative model could also lead to establishing a centralized repository of expertise, training and professional-development materials, as has been done by the California LTAP.

Hire a Consultant to Perform *Most* of the Project Management Functions

In California, we refer to this role generically as the "Systems Engineer" because this person will usually perform ***most*** of the Systems Engineering functions and ***some*** of the Project Management functions. It is critical to note that there ***must*** remain some Project Management functions and some technical decisions that ***will*** require leadership by agency staff. Some examples are: reviewing and approving the Concept of Operations, reviewing/approving the System Requirements, obtaining and coordinating participation of most stakeholders, etc.). These required leadership roles for agency staff will change during the phases of the project. This is illustrated in Figures 5, 6, and 7, which show the three major phases of the Systems Engineering V Process below.

Figure 5

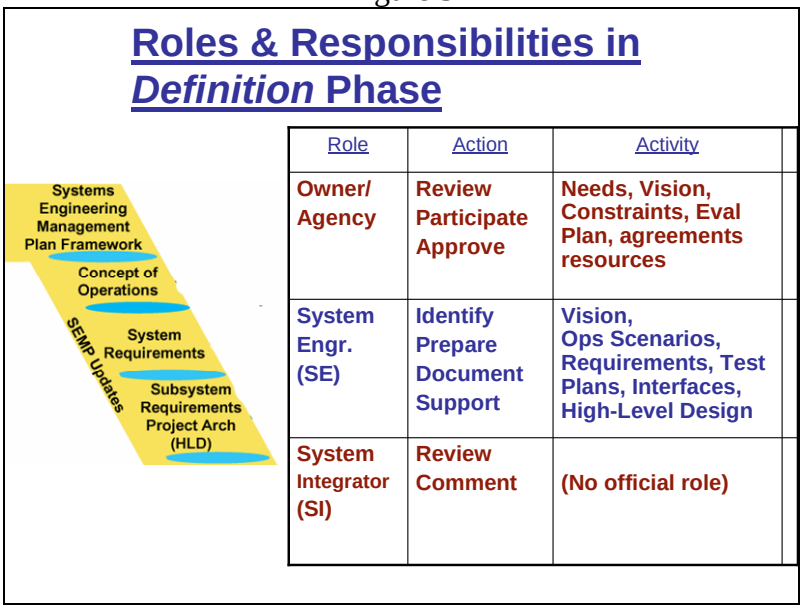


Figure 6

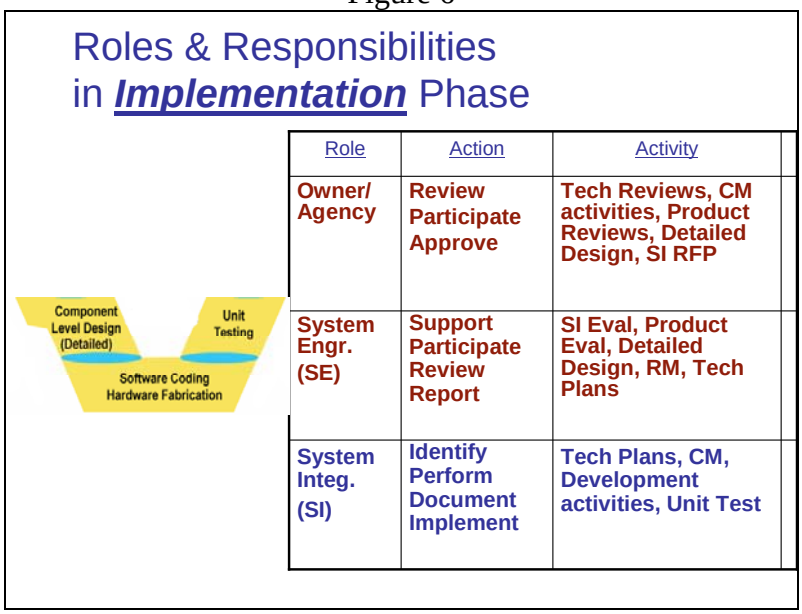


Figure 7

Roles & Responsibilities
in ***Integrate & Test*** Phase

Role	Action	Activity
Owner/ Agency	Review Participate Approve	Integration Plan/ Support, Training, Test Plans & Procedures
System Engr. (SE)	Support Participate Monitor Report	Integration reviews, training, doc review, test procedures, tests, RM
System Integ. (SI)	Perform Document Implement	Integrate, Test, Resolve Defects, Verification, Config. Mgmt, Reqmts. Mgmt.

In this "outsourcing" approach, the amount of time and the specialized technical knowledge required by agency staff can be much smaller than would be required if all of these functions were performed entirely in-house. But there will remain certain functions that the public agency ***must*** perform. Adequate staff time and talent ***must*** be dedicated to those functions, or the ITS project will be at risk.

Hire Another Agency to Perform Some Project-Management Functions

Analogous to hiring a contractor for assistance, it may be possible for a small agency to "hire" a larger, more-experienced agency to perform some of the necessary project management functions. One example of this comes from Los Angeles. Metro, a large transit agency with substantial experience and technical expertise as an established FTA grantee, will often assist small transit agencies with limited resources in some of the project management functions for implementing projects. Metro in such cases serves as the grant applicant and assists the smaller agency with project development and project management functions that include: the grant application process, the required environmental review, meeting all Federal requirements, managing the procurement or construction process, filing the required status update and financial reports, requisitioning the FTA for grant funds, and conducting the appropriate project close-out. Metro typically charges a 5% fee for these services.

CONCLUSIONS

By their nature, certain types of ITS implementation projects entail higher risk than traditional transportation construction projects. The highest-risk projects are those that involve new hardware/software systems or subsystems, and those that involve multiple agencies. Undertaking these higher-risk projects require public agencies to provide competent leadership in two key areas: Systems Engineering and Project Management.

Systems Engineering talents are critical, especially during the *Concept of Operations* and *Requirements Definition* steps at the beginning, and then during the *Testing*, *Training*, and *Initial Operations* steps near the end. Those Systems Engineering talents can be obtained in several ways, and the cost of doing so is generally much less than the "costs" of not doing it.

All projects – technical and non-technical – require good **project management**. High-risk ITS projects require good project management skills, plus knowledge of the risks unique to high-technology projects. The former requires a certain amount of staff time, and the latter requires specialized skills. Several options to meet the time and skills requirements are:

1. Developing/maintaining the staff in-house
2. Sharing staff within the same agency
3. Sharing staff with another agency
4. Hiring a contractor to perform ***some*** (but not all!) of the required functions.
5. Hiring another public agency to perform some project-management functions.

Options 3 and 4 present an opportunity for LTAP, universities, and perhaps state DOTs or MPOs to really improve the success rate of small/medium agencies with their ITS projects. We challenge these organizations to take leadership on this technical-assistance role.

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