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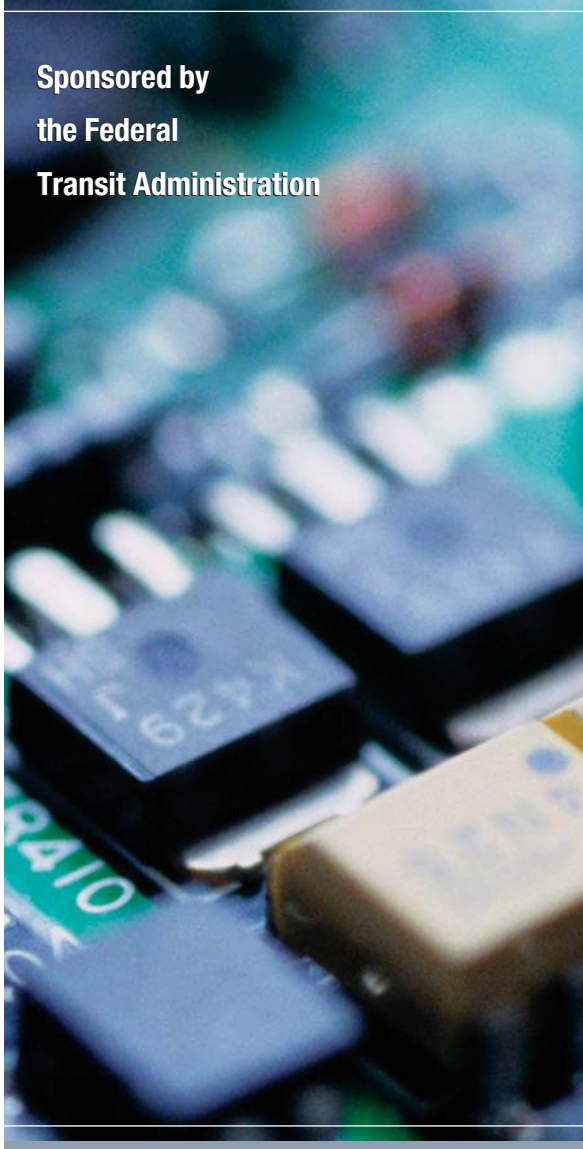

e-Transit: Electronic Business Strategies for Public Transportation
Volume 9

Transit Enterprise Architecture and Planning Framework

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TCRP REPORT 84

e-Transit: Electronic Business Strategies for Public Transportation Volume 9

Transit Enterprise Architecture and Planning Framework

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213—Research for Public Transit: New Directions,* published in 1987 and based on a study sponsored by the Urban Mass Transportation Administration—now the Federal Transit Administration (FTA). A report by the American Public Transportation Association (APTA), Transportation 2000, also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of TCRP includes a variety of transit research fields including planning, service configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S. Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academies, acting through the Transportation Research Board (TRB); and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at any time. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products.

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. The TCRP results support and complement other ongoing transit research and training programs.

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The members of the technical panel selected to monitor this project and to review this report were chosen for their special competencies and with regard for appropriate balance. The report was reviewed by the technical panel and accepted for publication according to procedures established and overseen by the Transportation Research Board and approved by the Governing Board of the National Research Council.

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Ms. Paula Okunieff of ConSysTec was the Project Principal Investigator. The other authors of this report are Nancy Neuerburg of N-Squared Associates, Bruce Eisenhart of ConSysTec, Edward Thomas of AEGIR, and Susan Sharp of Sharp & Company.

As a project team, we can say with gratitude that without WMATA's staff contribution and resources, this effort would be far smaller in scope, with fewer, less well-developed deliverables. WMATA, particularly Jamey Harvey, not only contributed their Enterprise Architecture Process (EAP) for reference, they also contributed their IT governance model, additional guidance, and the time and effort of both in-house staff and contractors to update and support the workshops. In large part, the benefits of the end product are due to their contribution.

FOREWORD

By Gwen Chisholm Smith
Staff Officer
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TCRP Report 84: e-Transit: Electronic Business Strategies for Public Transportation documents principles, techniques, strategies, and processes that are used in electronic business strategies for public transportation. *TCRP Report 84* is being published in multiple volumes; *Volume 9: Transit Enterprise Architecture and Planning Framework* presents multi-faceted methods, tools and examples within a framework to help agencies successfully implement technologies. It helps show the connections between their business and the technology, assists with building the business case for specific investments, highlights different financing options, provides guidance on an enterprise-wide approach to create more efficient and effective system deployments, and provides a method to show the benefits of a technology investment. The report provides a framework that incorporates five systems management disciplines: Enterprise Architecture Planning, Business Case Methodology, Systems Engineering, Financial Implementation Methods, and Post-Implementation Assessment. The Transit Enterprise Architecture Planning (TEAP) Framework incorporates best practices in applying these disciplines from the transit industry practices as well as from other commercial and government sectors into an integrated approach to assist agencies in implementing information technologies (IT) and intelligent transportation systems (ITS) technologies to better meet their business goals and objectives and operational needs. This report describes and provides guidance on how to implement the Framework.

New information and communication technologies are revolutionizing the way services are delivered and organizations are structured. Electronic business processes change the ways organizations operate and conduct business. Opportunities to lower operations and maintenance costs and improve efficiency have changed relationships between transit agencies and their suppliers and customers, and electronic business processes are likely to change industry structures in the long term.

The declining costs of communications, data storage, and data retrieval are accelerating the opportunities spawned by the Internet and other information and communications technologies. Choosing and sequencing investments in technologies, processes, and people to reduce costs and increase productivity present challenges to the transit manager, who must weigh the costs, benefits, and risks of changing the ways services are delivered. To assist in meeting such challenges, TCRP Project J-09 produces a multiple-volume series under *TCRP Report 84*. The research program identifies, develops, and provides flexible, ongoing, quick-response research designed to bring electronic business strategies to public transportation and mobility management.

Transit Enterprise Architecture and Planning Framework is the ninth volume in the *TCRP Report 84* multiple-volume series. In this volume, the authors from Consensus Systems

Technologies, N-Squared Associates, AEGIR and Sharp & Co. describe the TEAP Framework. They drew from transit agencies and other government and commercial businesses that employ best practices, to develop this Framework that is applicable to transit agencies, large or small, and of different modes. The research team synthesized the information collected from a state of the practice scan, and developed a model for an effective and consistent approach to transit enterprise architecture planning (TEAP) that may be used by transit agencies to assist with many aspects of implementing technology projects.

The report provides practical guidance, models, templates, and examples for large and small projects, simplifying the complex procedures related to the multiple stages of the technology investment. The report includes materials targeted to different audiences including information that can be readily used by transit executives, senior managers and program managers in their IT and ITS planning and decision making.

Volumes issued under *TCRP Report 84* may be found on the TRB website at http://www.trb.org/Publications/PubsTCRPProjectReportsAll.aspx.

CONTENTS

Note: Many of the photographs, figures, and tables in this report have been converted from color to grayscale for printing. The electronic version of the report (posted on the Web at www.trb.org) retains the color versions.

EXECUTIVE SUMMARY

Transit Enterprise Architecture and Planning Framework

The Transit Enterprise Architecture and Planning (TEAP) Framework project sought to provide transit agencies with a roadmap and tools to successfully implement Information Technology (IT) and Intelligent Transportation System (ITS) technologies that meet their business needs. The systems management areas that compose the TEAP Framework include the following disciplines:

- Enterprise Architecture and Enterprise Architecture Process (EA/EAP)
- Business Case Methodology (BCM)
- Funding Implementation (FI)
- Project Systems Engineering (SE)
- Post-Implementation Analysis (PIA)

Project Overview

The objective of the project was to identify key elements and develop a coherent framework that is critical to successfully deploying IT (specifically ITS) projects. The resulting framework should adopt best, streamlined practices from the broader IT industry and showcase good examples from the transit industry. Furthermore, the resulting research should provide resources and building blocks that other public transportation organizations could share, borrow, and learn from each other.

The project was divided into two phases. In Phase I, the tasks consisted of doing research to understand the current state of the practice and developing the preliminary TEAP Framework, guidance and tools that compose the roadmap for developing successful IT/ITS projects. The Framework guidance and tools were placed on a wiki website, www.tcrp-teap.pbworks.com. Specifically, the Framework helps:

- Guide an agency's planning process and investment criteria,
- Improve its understanding of risks and risk management,
- Verify and validate compliance with its needs and stakeholder requirements,
- Better manage system project implementation, and
- Enhance the measurement of results and benefits.

The Phase II objectives focused on refining the Framework materials and developing enterprise architecture-related building blocks for the transit industry so that they can more quickly create their own agency-specific enterprise architectures. Transit enterprise architecture templates and tools were created by adapting an existing transit enterprise architecture developed by the Washington Metropolitan Area Transit Authority (WMATA)

into a more generic Reference Enterprise Architecture for Transit. The TEAP Framework's enterprise architecture materials and tools were the focus of the Phase II evaluation and pilot efforts by transit agencies.

Phase I Results

Phase I tasks consisted of preparing a research synthesis and developing the preliminary TEAP Framework, guidance, and tools. Part of the Phase I research focused on understanding the current state of the practice in transit, that is, how transit agencies and transportation authorities currently understand, apply, and use each of the five disciplines that compose the TEAP Framework. Building on the project research and best practices, the project fused these disciplines into a coherent TEAP Framework that showed their interrelationships, flows, and synergies. A wiki website was developed to store the project results. As guidance for transit was developed, it was made available on the website, including a Guidance for Transit Managers document. A summary of these Phase I results is included below.

Research Synthesis

The research included a task to identify best practices in the IT industry and the current state of the practice for transit providers with respect to the five disciplines, as well as how they fit together within an agency. A literature search was conducted, and surveys were developed to interview transit professionals in a range of different transit agencies. To provide a reasonable sample of agencies for the telephone interviews, a group of 14 transit agencies and three DOTs was selected for interviews. The results of the surveys are included in Appendix B. In summary, the synthesis found that application of each of the five disciplines is growing, but lags behind other vertical industries. Many large transit agencies are currently developing more formal methods and procedures to implement all of the included disciplines. The most difficult of the five disciplines for agencies to implement is the enterprise architecture, and very few agencies have the resources or time to implement even part of an enterprise architecture.

TEAP Framework Overview

The Framework helps transit professionals understand the financial, operational, and management impacts of technologies, to help them better meet their enterprise business process needs and corporate objectives. The Framework helps guide an agency's IT/ITS planning process, improve its understanding of risks, better manage the project implementation effort, validate and verify compliance with its needs, and measure results and benefits.

Specifically, the TEAP Framework guides transit in:

- Planning how information, services, and technology will connect across an enterprise to support business processes, solve problems, and measure performance;
- Promoting information sharing across agency and institutional barriers;
- Ensuring that IT/ITS projects are defined and staged in a way that delivers the best value and supports successful project implementation, operations, and maintenance;
- Ensuring that the benefits and costs of proposed IT/ITS projects are understood across the project's lifecycle (including operations and maintenance) and that resources are available to support the program;
- Specifying IT/ITS projects to maximize the IT/ITS investment decisions across the organization;

- Ensuring that IT/ITS projects meet stakeholder needs: requirements are explicitly described, risks are identified and mitigated, and the system development process is managed to ensure that correct operations and requirements are met; and
- Describing the leadership and processes that ensure that the organization's IT group supports and extends corporate strategies and objectives.

The Framework is composed of five System Development disciplines as follows:

- **Enterprise Architecture Planning (EAP),** which is used to model the organization's policies, structure, locations, business processes, information, applications, and technologies, and their relationship to each other (i.e., the organization's blueprint);
- **Business Case Methodology (BCM),** which describes how well a project fits into the organization's stated priorities, as well as the risks, benefits and costs, and estimated return on investment (ROI);
- **Funding Implementation,** which investigates alternative approaches for how to pay for IT/ITS projects;
- **Systems Engineering (SE),** which is used to help design and manage an IT/ITS Project implementation; and
- **Post-Implementation Analysis (PIA),** which provides a method to assess whether the implementation met project and agency goals and achieved a meaningful (estimated) ROI and to review the project implementation experience for lessons learned.

Figure 1 shows the flow of these five TEAP components.

TEAP Wiki

Outreach, transfer, and sustainability of the Framework depends on communicating and sharing the best ideas and efforts with other transit professionals. Building on best practices from the transit industry and other industries, a *wiki,* or collaborative website, was developed to document the recommendations for the Framework, as well as provide a forum and space for transit professionals to share and exchange their approaches to implementing elements of the Framework. The resources collected during the synthesis tasks were made available on the wiki so that transit staff could find a collection of existing resources that explain the multitude of approaches that are available through National Transit Institute (NTI), American Public Transportation Association (APTA), Federal Transit Administration (FTA), and other outreach efforts.

The medium that presented the TEAP Framework needed to address three major needs:

- Develop guidance on the TEAP that targeted multiple audiences (without intimidating any of them by the size of the document).
- Present the material using a medium that was logical, easy to use, and allowed for seamless linkage to show the relationships between the elements (and external resources).
- Provide the industry with a site where collaboration and information navigation was intuitive and easy to use while preventing spamming and misuse of the site.

The research team populated the site with the Framework Guidance and EA/EAP Guidebook. The site lays out the Framework Guidance in a systematic way, with sections targeting different audiences, from executives and senior managers to program managers and technical practitioners (see Table 1 for details).

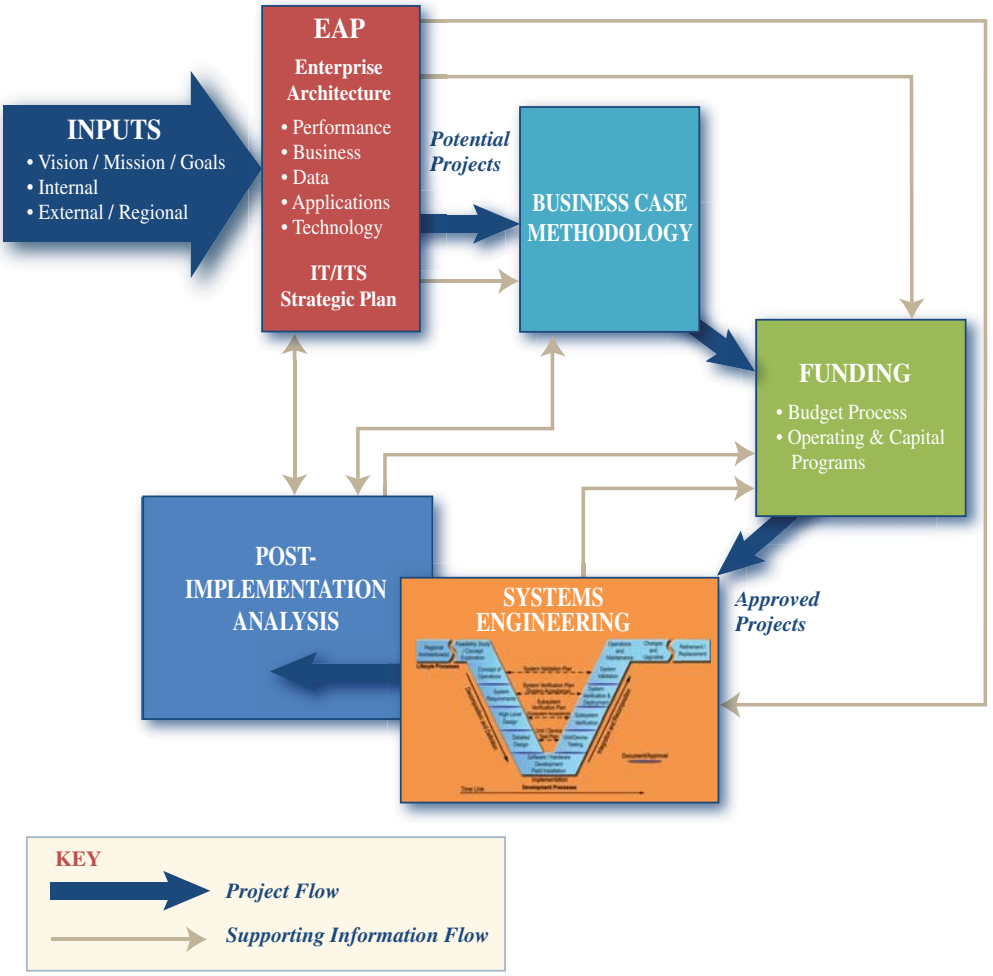


Figure 1. Five components of TEAP.

Guidance for Transit Managers

A short executive report was developed for executive and senior managers (see Guidance for Transit Managers in Appendix A), which included a high-level summary of the Framework and a checklist for managers to assist them with their management oversight of technology projects. Targeted for transit professionals who desire only a short synopsis of the content of the Framework, the report includes a brief description of each of the five disciplines, their benefits, and the synergistic relationships between them. In addition, a general set of roles for transit managers is included, as well as checklists that are specific to each of the TEAP Framework elements. The checklists are designed to assist transit managers in enabling their staff and the transit organization to effectively assess, acquire, and enhance IT/ITS systems. The Guidance for Transit Managers report is available on the wiki and in Appendix A.

Phase II Results: Reference Enterprise Architecture for Transit

Phase II focused on generating a Reference Enterprise Architecture for Transit, and validating this architecture with transit agencies of different sizes, modes, and organizational structures.

Table 1. TEAP Framework Wiki.

TEAP Framework Wiki	Description	Audience
Guidance for Transit Managers	A high-level description of the TEAP Framework, including the purpose and benefits associated with each Framework element and the interrelationships. In addition, the guidance includes a checklist that enumerates the roles and responsibilities of transit managers with respect to each of the elements. This section includes a self-contained, downloadable version that can be printed and read in hard copy.	Transit executive and senior managers.
TEAP Framework Guidance: • **Executive Summary** • **EA/EAP** • **BCM** • **Funding** • **Project SE** • **Post-Implementation**	A detailed description of each TEAP Framework element, including: information on the what, why and benefits of the element; best practices and streamlined approaches; and additional resources, including references, tools, and examples from the Information Technology (IT) and transit industries.	Program managers and transit professionals who want to learn more about the topics.
Transit EAP Guidebook	The Transit EAP Guidebook details step-by-step how to develop a transit enterprise architecture (as-is and to-be). The Guidebook shows how to customize the Reference Enterprise Architecture for Transit to represent the drivers, business processes, information, applications, and technologies in your organization. The Guidebook is an interactive and extendable "space" on the wiki to describe a Reference Enterprise Architecture for Transit, and to include related terms and techniques for implementing a transit enterprise architecture. It includes models, templates, examples, and benefits associated with each step.	Program managers and transit practitioners who are tasked with implementing an EAP and maintaining the as-is and to-be enterprise architectures.
State of the Practice Synthesis Results	A summary of the State of the Practice Synthesis related to the five elements of the TEAP Framework.	All
Other Resources	How-To Guides Glossary and Acronym List FAQs About the Project and the Wiki Site Map Improvement Page	All

The general purpose of an enterprise architecture is to understand the connections between your organization's business processes and stakeholders (users, upstream providers, and downstream recipients); this information is used to measure performance and make decisions, as well as to develop applications and technology that enable the services and generate the information. Most transit agencies support similar business processes, information views, applications and technologies. The models that represent each layer do not differ greatly either. This provides an opportunity for the industry to describe a generic reference that may be customized based on the particular agency, rather than having each transit agency start from scratch. A reference architecture defines the common elements found in each of the four enterprise architecture levels and their typical relationships to each other.

The Reference Enterprise Architecture for Transit was developed from a comprehensive, albeit high-level, existing enterprise architecture (EA) developed by the Washington Metropolitan Area Transit Authority (WMATA). The WMATA EA presented a starting point that detailed some of the complexities of large transit agencies (with several modes), yet may

be scaled down to smaller organizations. To ensure that the WMATA EA represented the diverse transit industry, a team of transit IT experts from more than a dozen transit agencies representing small, medium, and large agencies; covering urban/suburban/rural transit; and supporting different modes were brought together to review and walkthrough the architecture. In addition, several EA experts from other sectors were included in the expert-peer review group. As other agencies heard about the Reference TEAP, they too asked to participate in reviewing, piloting, or commenting on elements of the architecture.

Three workshops were conducted for the participants to review, recommend, and agree to changes regarding the proposed Reference TEAP. The first workshop highlighted a presentation from the Chief of Architecture from WMATA, Jamey Harvey, on the WMATA EA. Mr. Harvey described the EA organization (metamodel), content, and general principles he used at WMATA. The second workshop focused on how to make the architecture more generic and what segment to select for review and refinement (development of one or more "solutions"). The result of this second workshop was the selection of the fare management area for review. Prior to the final workshop, research team members interviewed different agencies that were developing typical and new solutions for fare management. The models included closed systems that most agencies currently implement, an open payment system, and the emerging mobile/branded card payment system.

Several transit agencies reviewed the resulting artifacts; some agencies applied their existing systems to the model or solutions to validate them. The results of these pilots are described in Chapter 6. The final reference architecture, the four fare management solutions, streamlined implementation guidance (with tools and templates), and approach for incorporating solutions were included in the Phase I wiki site.

CHAPTER 1

Introduction

Project Objectives

The Transit Enterprise Architecture and Planning (TEAP) Framework project sought to provide transit agencies with a roadmap to successfully implement Information Technology (IT) and Intelligent Transportation System (ITS) technologies that meet their business needs. The systems management areas that compose the Framework include the following disciplines:

- Enterprise Architecture and Enterprise Architecture Process (EA/EAP)
- Business Case Methodology (BCM)
- Funding Implementation (FI)
- Project Systems Engineering (SE)
- Post-Implementation Analysis (PIA)

Using methods and techniques promoted by these five disciplines, a transit agency will have a roadmap for planning, assessing, developing, and evaluating their IT/ITS projects. To that end, the TEAP Framework project's objectives include:

- Understanding the state of the practice with respect to the transit industry's application of five major IT/ITS system management disciplines (including enterprise architecture, business case methodology, funding implementation, project systems engineering, and post-implementation analysis);
- Developing an approach to integrate the five IT/ITS system management disciplines into a coherent Framework;
- Providing guidance to transit professionals with different levels of technical background about the Framework, its elements, and their relationships;
- Developing guidance and tools to help agencies implement the Framework elements, particularly the Enterprise Architecture Planning element; and
- Validating the approach with transit agencies.

The result of the project is a set of tools and guidance on the five disciplines, collected into a one-stop website that allows collaboration among peers and industry-driven updates as the approach evolves over time. The portal is implemented as a wiki website at http://tcrp-teap.pbworks.com.

Transit Enterprise Architecture and Planning (TEAP) Framework Objectives

The roadmap incorporates five system management development methods into a coherent Framework. Each of the methods is complex and requires different skills to accomplish. Understanding how to implement each element of the Framework and then to connect the different sections required that the project be divided into two phases. The Phase I objective included identifying the best practices of the wider IT industry and the state of the practice for transit, then synthesizing and proposing a Framework to bring these disciplines together. Near the end of Phase I, the Project Team identified critical components of the Framework that were missing from the transit industry and could not be substituted with IT best practices. To that end, in Phase I, the tasks consisted of understanding the current state of the practice in order to develop the preliminary Framework, guidance, and tools that compose the roadmap to developing successful IT/ITS projects. Specifically, the Framework helps:

- Guide an agency's planning process and investment criteria,
- Improve its understanding of risks and risk management,
- Verify and validate compliance with its needs and stakeholder requirements,
- Better manage system project implementation, and
- Enhance the measurement of results and benefits.

The Phase II objectives focused on developing building blocks for the industry so that they could realistically and more quickly create the foundation of the Framework, the Enterprise Architecture. This was accomplished by adapting an existing

enterprise architecture developed by the Washington Metropolitan Area Transit Authority (WMATA) as a reference for transit. This reference is the cornerstone of the TEAP Framework and was applied by one or more agencies to validate the guidance for its application.

Final Report Scope

TCRP Report 84 Volume 9 provides a summary of the outputs of the project. This report is composed of an executive summary and six chapters with the following scope and objectives:

- Executive Summary: This section provides a short overview of the project and its results. The section is most appropriate for transit managers to obtain an overview of the TEAP.
- Chapter 1, Introduction: This chapter provides the objectives of the project and the scope of the final report.
- Chapter 2, Research Approach—Methodology: This chapter provides a summary of the methodology used by the research team for the development of the project outputs.
- Chapter 3, State of the Practice: This chapter summarizes the first output of the project—a review by the transit community of the state of the practice in the use of the five systems management areas that compose the Framework. The chapter provides context for the development of a TEAP that is specific to transit.
- Chapter 4, Development of the TEAP Framework: This chapter describes the TEAP Framework that was developed and presents resources and tools to support application of the Framework. The chapter presents the Framework roadmap, including its benefits and how to implement it.
- Chapter 5, Reference Enterprise Architecture for Transit: This chapter goes into greater detail regarding the reference enterprise architecture and the different solutions for applying fare management application models. The example and templates contained in this chapter describe how a transit agency can adapt the reference TEAP to represent their business processes, information, application, and technology investments.
- Chapter 6, Evaluation and Next Steps: This chapter presents lessons learned from independent transit agencies that either used the TEAP or reviewed the wiki site and its content.

CHAPTER 2

Research Approach—Methodology

The Transit Enterprise Architecture Planning (TEAP) Framework project consisted of two phases. This chapter provides a description of the project tasks, including the methodology used to perform them.

Phase I: Development of the TEAP Framework

The Phase I research focused on understanding how transit agencies and transportation authorities currently understand, apply, and use each of the five system development methods that compose the TEAP Framework. Building on their methods and best practices, the project fused these practices into a coherent framework that showed the connectedness and flow of each development method. As described above, the project objectives involved describing the Framework for several audiences including executives, senior managers, practitioners, and program managers. In addition, detailed guidance would also include a technical audience such as the chief information or technology officers and their staff. Further, the means and channels used to disseminate the findings and Framework had to be collaborative and evolving because the Framework technologies and methods change quickly. A paper report, such as this, may be used as a reference once in a while, but it cannot be used as a tool that facilitates community exchange and extensions. To that end, the means of documenting the Framework was also selected as part of the Phase I effort.

The first part of this phase consisted of gathering information from the literature and interviews on the state of the practice related to the five framework planning areas:

- Enterprise Architecture and Enterprise Architecture Planning (EA/EAP);
- Business Case Methodology (BCM) for identifying, justifying, and selecting ITS projects
- ITS Funding Implementation, focusing on program investment strategies and their relationship to IT Governance;
- Systems Engineering (SE) related to its benefit and role in a project's success, as well as its relationship to the funding and project approval process; and
- Post-Implementation Analysis (PIA) including goals, approaches, and key issues.

> A *wiki* is a collaborative website where wiki members may edit, review, upload documents, and add their comments. The TEAP wiki is open for anyone to view, but available only to members to edit.

During the interviews and literature search, the research team collected examples of performance measures used in post-implementation analyses, highlighted different methodologies and approaches, and developed an annotated bibliography of relevant transit publications and tools/resources in the IT industry. The results of the research synthesis are described in Chapter 3.

Building on best practices from the transit industry and other industries, a *wiki* or collaborative website (see sidebar) was developed to document the recommendations for the Framework. The resources collected during the synthesis tasks were inserted into the wiki as a portal to find existing resources that explain the multitude of approaches that are available through NTI, APTA, FTA, and other outreach efforts. Another critical product that was developed for the wiki was a high-level summary of the Framework for executive and senior managers (see Appendix A). This guidance document explains the need to implement all or part of the Framework, describes the Executive's role with respect to IT governance, gives details on how to use the enterprise architecture to justify and measure successful implementations, and identifies and provides links to a rich set of resources that may be used to establish the TEAP Framework.

In addition to the high-level summary, the wiki was divided into sections that highlighted the five planning areas and other pages that contained the synthesis results or provided help for technical and non-technical wiki readers and editors. A site map is also included. Each planning area includes discussions on:

- What, why, and benefits;
- Best practices; and
- Resources about the topic related to transit and other IT communities.

Several interviews and webinars were conducted to evaluate different aspects of the guidance and wiki site. The research validation effort focused on obtaining stakeholder feedback on multiple facets of the Framework, guidance, and tool concept. Much of the feedback is reflected in the organization and material included in the current site.

A **Solution (or solution architecture)** in enterprise architecture is a cross-cutting segment of an architecture that allocates functions, information, applications, and technology in different configurations to solve specific problems and develop requirements, usually through the design of specific information systems or applications. For example, there are different commercial tools to implement different approaches to fare management, such as (regional vs. agency) smart cards, mobile devices, and open payment systems. Typically, there will be different types of solutions (approaches for implementing applications and technologies) for every major system in the transit enterprise. Each solution may affect relationships among the business processes and information views.

Phase II: Reference Transit Enterprise Architecture Process

The Phase II effort focused on refining the guidance, specifically the enterprise architecture components. The state of the practice revealed that though many organizations wanted to develop enterprise architecture models, they did not want to expend the huge effort it required. Other industries, particularly public sector organizations, deal with this obstacle by developing reference models that may be used as a template. WMATA offered their existing enterprise architecture planning (EAP) model as a starting point for the reference model. So the Phase II effort focused on adapting the WMATA EAP for use as a generic reference enterprise architecture for transit.

Part of the development and validation process of the reference TEAP involved convening a peer review panel, composed of experts in enterprise architecture and transit IT domains. Through a series of workshops and interviews, the panel selected a segment of the transit enterprise for which to develop detailed *solutions* (see sidebar). The expert panel selected the fare management architecture segment and four solutions architectures. In addition, the WMATA EAP was updated to reflect a "generic" transit agency. Additional guidance was developed for transit staff that explained how to use and customize the reference TEAP and fare management solution architecture models. Detailed examples were also included in the guidance materials. These are described in Chapter 5.

One or more transit agencies were solicited for piloting the reference TEAP and addressing how the solution architectures could help them develop "as-is" and "to-be" architecture models. Guidance was developed for most of the agencies, and several of them used the templates to validate the approach. Results from these pilots were solicited and documented in Chapter 6. In addition, several of the expert panel members who attended the workshops and reviewed the reference TEAP and wiki were interviewed about enhancing the wiki. Results of these interviews are also included in Chapter 6.

CHAPTER 3

State of the Practice

To develop an assessment of the state of the practice, the research team reviewed available industry literature and conducted telephone interviews with a sample of transit agencies as well as several state DOTs. The literature search and interviews covered the five major elements included in the TEAP Framework:

- Enterprise Architecture and Enterprise Architecture Planning (EA/EAP)
- Business Case Methodology (BCM)
- ITS Funding Implementation (FI)
- Systems Engineering (SE)
- Post-Implementation Review (PIR)

To provide a reasonable sample of agencies for the telephone interviews, a group of 14 transit agencies and three DOTs was selected for interviews. Survey protocols were developed for the interviews. A standard set of interview questions was administered to all the agencies. In addition, some agencies were asked more detailed questions on some Framework areas, if the screening questions discovered issues to probe further and if time was available. The first column in Table 2 shows the agencies and state DOTs that were interviewed. Several agencies were asked more detailed questions about their experience with the Framework areas. The checked columns in Table 2 represent the agencies that were surveyed in more detail on selected topics. The "General" column refers to the standard questions asked of every interviewee.

Summary of Results

Interviews included questions from the general survey as well as more detailed surveys for each of the five Framework areas. The following sections summarize the findings.

Enterprise Architecture and Enterprise Architecture Planning (EA/EAP)

The scan of the transit industry revealed limited adoption and understanding of EAP. Overall, few "lessons learned" emerged through the industry scan because few organizations engage in planning and documenting their EA. Industry literature related to transit ITS technology deployment is rife with examples about how the lack of enterprise architecture planning is limiting success in system deployments.

Among the organizations interviewed, most of the Chief Information Officers (CIOs) or IT managers were familiar with the concept, particularly if they came from other industries. However, few had the resources or management support to undertake a comprehensive enterprise architecture planning process. Fewer were versed on the "segment architecture" approach currently applied by other industries. WMATA and Miami-Dade Transit were the two transit agencies that said they were working on EAP. Details of these two implementations are described in the *State of the Practice Synthesis* (see Appendix B).

Business Case Methodology (BCM)

The screening survey included questions about the organization's use of a BCM, verified terminology, and asked about the use of a Return on Investment (ROI) analysis and other cost-related analyses in justifying an IT/ITS project. Additional follow-up questions were asked of a subset of respondents. The details of the responses and resources are available in the *State of the Practice Synthesis* (see Appendix B). This section includes several questions and a summary of the general responses. In addition, the section elaborates on several organizations that have a process in place to apply business case analysis as part of their IT/ITS project approval process.

Table 2. Transit agencies and state DOTs interviews for industry scan.

Agency	General	EA/EAP	BCM	Funding	Systems Eng.	PIR
C-Tran	✓					
Hampton Roads	✓				✓	
Iowa DOT	✓					
Kansas DOT	✓					
King County Metro	✓		✓			✓
Lynx	✓		✓		✓	
MARTA	✓		✓	✓		✓
Miami-Dade	✓	✓				
NY State DOT	✓					
Paducah	✓				✓	
RIPTA	✓					
River Bend	✓					
SEPTA	✓			✓		
TriMet	✓		✓			✓
UTA	✓		✓	✓		✓
Wichita	✓				✓	
WMATA	✓	✓				

Does your organization have a process for proposing, justifying, and approving an IT or ITS investment (a BCM)?

Approximately one-half of the organizations had some sort of process, whether it was IT/ITS-specific or the general agency budget approval process, for proposing, justifying, and approving IT/ITS investments. Only a few of the agencies had an IT/ITS-specific process that provided templates and guidance for staff that needed to initiate and justify a project. Some respondents said their organization used consultants to build the justification for a project. Another said, "Nobody in our organization formally requires a BCM process, we have standard budget justification forms, but no official BCM document or process. However, we end up doing some of a BCM's steps to justify the project to the management and Board as part of the budget process, and because it's helpful."

TriMet. The public transportation agency for the Portland, OR, metropolitan region (TriMet) felt that the BCM should be simple, clear, flexible, and understood by all the stakeholders. Flexibility was important, so the business case could be scaled based on the size and complexity of the project to ensure it would be used for all projects and not be skipped because of an onerous process. Basic templates are available for the Project Charter, the Planning Report (which is shown in Appendix A), Alternatives Analysis, and other aspects of justifying the project. They stated that the analysis should consider all the system life cycle stages, including feasibility, design, development, implementation, operation and maintenance, and the end of the life cycle when the system is terminated or replaced.

Further, TriMet has a project sponsor for each project, with ". . . responsibility for approving budget, schedule and scope changes, deciding the issues to be presented to other stakeholders and for accepting the final work product. The sponsor is typically the most senior person from the business unit needing the work who will stay informed of and involved in the project." In their BCM, the project sponsor has a quick reference document with checklists to help them in their role of facilitating the project's success. Examples of some of the project sponsors' checklists, which help them do their job, are included in the *State of the Practice Synthesis* (Appendix B).

WMATA. WMATA is working on the development of an Enterprise Architecture and also has a project management methodology that it uses. As a result, their BCM includes a reference to the Enterprise Architecture. The project management methodology includes a Business Plan Initiation (BPI) process, although the process does not always require a justification for all projects. The BPI feeds into the capital planning framework for all projects. A streamlined form for the Business Plan Initiation Review process and instructions for completing the form are included in the *State of the Practice Synthesis* (Appendix B). The form summarizes all the project justification documents.

King County Metro (KCM). Over the last 15 years, King County Metro has used a couple of different processes for developing a business case. Currently, KCM must use King County government's process for justifying and approving IT/ITS projects. The process is described in a 69-page document titled, "Project Manager Guide to PRB Reviews," which also references other documents for additional guidance (*1*). Two tables from the Guide, which show the suggested deliverables for Phase I (called Project Planning) and for Phase II (called Project Development), which in King

County's process includes the "business case," are included in the *State of the Practice Synthesis* (Appendix B). The Project Planning phase is typically completed as a preliminary request for funding to further build the business case in Phase II. King County employs a gated process, with funding released by project phase.

Does your organization use the term "Business Case Methodology"?

Only one respondent said that the term "Business Case Methodology" was used in his or her organization. A few respondents wanted to know what the term meant before answering the question. Terms that were used for their agency's process for approving IT/ITS projects included Business Case, QBC or Quantified Business Case, Phased Gate Review, and BPI or Business Plan Initiation. In a Phased Gate Review process, a management review event occurs between specified project phases to determine if the project should proceed "through the gate" to the next phase.

Does your BCM vary by type of system or IT/ITS project? If so, how?

Of those agencies with a BCM, all allowed for lesser detail in describing the business case, depending on the size and perceived risk of the project. Some skipped steps when they knew the project was required. Others were acutely aware of the costs of doing the analyses and wanted to keep the level of effort commensurate with the estimated project costs, complexity, and risks.

King County provided the only form for determining the level of oversight a project might require, which drives the number and detail level of the forms to be submitted. The four categories of factors used to determine project risk rating are project size, project manager experience, team experience, and project type. The Project Size factor rates the project on size, primarily based upon onetime cost estimates and, secondarily, on project duration. The Project Type factor rates the technical complexity of the work being undertaken.

If yes, does the BCM consider: (Operations and maintenance costs and requirements, agency architecture, regional ITS architecture, integration options, other enterprise-wide thinking)?

All the business case methodologies took into consideration operations and maintenance costs. The business case methodologies also considered one or more aspects of the agency architecture and/or the regional ITS architecture. One of the King County BCM forms had a checklist of technical outcomes which included "Leverages and/or extends integration architecture." WMATA's Business Plan Initiation form includes "Implement Authority-wide Integration" as an IT priority.

In your organization, what have been the benefits and issues pertaining to completing a BCM?

TriMet felt that the BCM helps with ensuring a common understanding of the project and helps manage expectations. High-level documentation of the project from the BCM and project management process is available for stakeholders to access (they have it in a database).

Standardization of the steps helped simplify training on the process, helped readers quickly find information, and helped somewhat with comparisons between projects.

At Metropolitan Atlanta Rapid Transit Authority (MARTA), the head of IT said, "You are relating what you want to do to the business needs, costs, and impacts. You *show* why the project should be done, not just providing an opinion or gut feel."

Issues pertaining to the BCM included finding the time and resources to do the analyses. Finding the data to do the ROI was also cited as an issue. A concern was stated that sometimes, for some projects, the process can take so long that the user requirements and technology options change before the project is started.

Does your organization usually perform a Return on Investment (ROI) analysis as part of the IT/ITS project justification process?

A majority of the respondents said their agency had conducted an ROI analysis on one or more IT/ITS projects. More than one respondent was unclear on the difference between a cost-benefit analysis and an ROI analysis. "ROI analyses" were conducted on key projects at some agencies that did not have a BCM. Conversely, the existence of a BCM at an organization did not mean that an ROI analysis was always completed on a project, although some level of cost analysis was always done.

Other cost-related analyses completed when a new project is being justified.

Many of the agencies completed some form of a cost-benefit analysis. For a subset, Total Cost of Ownership was calculated. King County has a process for completing a "Quantified Business Case." Another said, "they consider if the overall cost exceeds the benefits."

Does your agency have a formal process for comparing and selecting among different proposed IT/ITS projects?

If a respondent said their organization did not have a BCM, they were not asked this question. Mostly the answer to this question was "no," although several said that having a standard form for proposing projects helped with the comparison process. TriMet said they had a three-category classification of projects, which are Mandatory, Highly Recommended, and Discretionary. Others said that their organization had tried different approaches but did not currently have a repeatable process in place.

MARTA is pleased that the selection of projects is done through the IT Governance committees, which include transit management. At their agency, users prioritize all the IT projects. This relatively new process "ended the old user complaints about IT pushing them."

IT/ITS Funding Implementation

Transit agencies are applying the full range of financing mechanisms to make IT/ITS investments from large enterprise technology replacement projects to small automated vehicle location (AVL) projects. Pay-Go is the primary financing mechanism used by most transit agencies. However, comingling of funds and public-private partnerships (PPP) are starting to be used more frequently.

For example, Salt Lake City Utah Transit Authority (UTA) co-mingled $12.3 million to acquire an account-based fare collection system and a performance reporting system. WMATA is pursuing a public-private partnership to finance, design, implement, operate, maintain, and manage content of a streaming video advertisement and passenger information system called "The Metro Channel." Southeastern Pennsylvania Transportation Authority (SEPTA) is another transit agency considering an ITS public-private partnership, in their effort to replace an antiquated fare collection system.

Table 3 summarizes how 12 transit agencies participating in the survey financed their IT/ITS projects.

Systems Engineering (SE)

In order to determine where transit agencies stand on understanding and use of Systems Engineering (SE) for ITS project development, a portion of each transit agency interview was devoted to the use of SE. For several of the agencies that had recent experience with the systems engineering process, an additional set of interview questions was posed to assess whether the agencies had seen benefits from their use of the Systems Engineering process, particularly the process recommended by the U.S. DOT guidance. The discussion below highlights the key findings from the interviews.

Table 3. Transit agency funding of IT/ITS projects.

Funding Approach	Number of Agencies Using Funding Approach, N=12
Debt Financing	5
Capital Lease Financing	2
Public-Private Partnerships	3
Credit Enhancement	2
Pay-Go	12
Co-mingling	12

Source: TCRP Project J-09, Funding Implementation Survey (January 2009).

Use of the SE Process by Transit Agencies

Almost all of the agencies interviewed indicated they used some type of development process or did some aspects of the SE process. Only two answered "no" or "not really" to the basic question, "Do you use a Systems Engineering Process for project/system development?" A closer examination of the interview responses shows that about one-half of the agencies could be described as having a development process, and of these only a couple are really using the SE process. Why the discrepancy? There are several key reasons:

- **Low level of knowledge of the SE process among agency personnel.** In several cases, the agency response was that we do whatever parts of the process the contractor provides. It seems in some cases the agencies are content to rely solely on whatever level of expertise the contractor provides. In one or two of the agencies they specifically hire a contractor to be their system engineer, providing the SE expertise that they lack.
- **Existing project management or system development processes.** Several of the agencies that could be considered more advanced (based on the number and scope of their ITS deployments) have a definite process orientation, but in most cases this orientation is strong on project management (or in one case business management) but not strong in the technical development process that systems engineering represents. Because of the project management focus, these agencies have a structured view of tracking the project's progress against cost and schedule. They may also have detailed consideration of such cross-cutting activities as risk management. However, what these processes lack is the technical development process, with its Concept of Operations (focusing on the stakeholder needs and the operational scenarios of the systems), formal requirements definition, design tradeoffs, and verification against requirements. They each cover parts of these activities (most often the requirements definition), but not all of them.

- **Transit agencies have in general not been required to use the SE process.** Although FTA policy on ITS projects requires an SE analysis for each project using federal funds, the requirements do not cover the full range of the SE process, and can be met by cherry picking info from a far less systematic development process. Two of the agencies interviewed were required to closely follow the U.S. DOT SE process. They were developing systems under the Mobility Services for All Americans (MSAA) Initiative grant. The initial phase of these projects developed the Concept of Operations and functional requirements for the system, caused each agency to become knowledgeable of the U.S. DOT SE process and required the agency to utilize the process in the project development. As will be discussed below under "Benefits of Using the SE Process," both agencies felt it was a worthwhile exercise and plan on using the SE process for future efforts.

Benefits of Using the SE Process

The question posed to transit staff was, "Have you derived benefits from using the Systems Engineering process?" The answer was a resounding yes. Some of the benefits they identified were:

- Using the process helped the agency and the other stakeholders go through each step rather than jumping to the end.
- The SE process helps the agency keep the project on schedule and budget. It allows the agency to have better visibility into the contractor's progress through the outputs.
- Using the process saves the agency a lot of trouble at the backend of the project because the surprises are minimized.
- The Concept of Operations made the agency and the rest of the stakeholders more aware of how the parts of the system will integrate and work together.

Post-Implementation Analysis (PIA)

The transit agencies that were surveyed had varying levels of understanding of post-implementation analysis, or as it is called in other industries, Post Implementation Review (PIR). In addition, post-implementation analysis (PIA) was called different things in the various agencies, so additional prompts and follow-up questions were needed to clarify what was being discussed.

Does your agency have a PIA or evaluation phase for IT/ITS projects?

With the exception of a few of the transit agencies that were surveyed, most of the respondents described relatively little consistent PIA activity. In a few cases, PIR was confused with system acceptance or project closeout activities. The majority of the agencies surveyed did not have a formal PIA process. Of those that did, it was only sometimes or informally followed by a subset of those respondents. One respondent said their reports had varying levels of formality, but they usually included lessons learned, performance goals, and comparisons against initial model forecasts.

Terms used to describe PIA activities or processes included post project assessment, benefits realization step, evaluation, feedback, earned value management analysis, and validation. When the transit agency's PIA had some form of specified procedures, it was generally because the organization's central IT staff had a System Development Life Cycle (SDLC) methodology that included a post-project-closeout analysis step.

An interesting, related comment from MARTA was that they have hired staff to be an in-house, independent verification group that analyzes a new system prior to system acceptance (they complete the SE verification process step). This group and process have "paid off in dividends."

King County Metro has extensive, detailed documentation and requirements for how project managers will run their IT/ITS projects and document their activities. More information about the process and the Benefits Realization Report that is due a year after project close-out is in the *State of the Practice Synthesis* in Appendix B.

What is the time frame for measuring/evaluating the results of the IT/ITS project?

The time frame for completing PIAs varied, but most were completed within 1 year of system acceptance.

The Utah Transit Authority (UTA) has an interesting approach that includes two phases. First, it obtains feedback on the system from the customer within 30 days of system acceptance. UTA is certified in and applies International Organization for Standardization (ISO) 9001 Quality Management Standards, so this feedback is part of a regularly followed process. UTA strives to monitor, measure, and report on whether the project met the agreed-upon quality, schedule, and budget expectations defined in the scope, while acknowledging that all categories are subject to change requests that can modify expectations to the scope.

UTA has another regular post-implementation practice, although there is no form for it. An IT supervisor or the project manager always checks back on the new system, generally after it's running for 3 to 6 months (maximum 1 year) to see if anything else could have been done differently. They look for lessons learned or needed system adjustments, as well as using it as an opportunity to keep up with changing business needs.

The King County Metro Transit Signal Priority (TSP) team completes its "before" and "after" data collection efforts

immediately surrounding a new installation to have as similar as possible "before" and "after" operating conditions (usually 2 weeks before and 2 weeks after).

Who or what is the driver for having a PIA?

A variety of reasons were given for doing a PIA. Some agencies cited policy or practice. Another said ISO standards and procedures, as well as it being critical for providing good customer service. Other answers included the following:

- Federal requirements
- Usually we think it is the right thing to do
- Grant requirements
- When a project manager pushes for it
- When it is a problematic project or one with lots of conflicts
- When someone promised cost savings and now we have to find them
- We have to justify why it cost so much
- We want the lessons learned to improve practices and procedures
- We want to know how to improve the system in the enhancement phase and if it is needed

How are the results used?

The most common answer was that the lessons learned were valued for improving future projects. The results were also used to guide the next set of enhancements for the new project or to identify new business requirements.

The Utah Transit Authority used the PIR process for several purposes. Documenting PIR results from all of the IT/ITS projects "allows you to go back and see what you did and learn from errors." From an IT perspective, "one of the best values is the alignment of the requirements and the deliverables (was it that the client changed their mind or that resources changed?). Feedback helps you clearly know what the clients think. It's time consuming, but good. It just takes lots of time."

The TSP team at King County Metro uses the evaluation results in a number of different ways. They use the feedback for adjusting and fine-tuning the TSP system, for TSP staff training and education, and for determining whether or not to shut down a location with poor performance. In addition, the analyses have helped them contribute to the industry's knowledge about TSP in talks, papers, and during the development of the Transit Communications Interface Profile (TCIP) standards. Finally, they use the evaluation data to help determine where to put the next TSP installation, where to do improvements, to estimate how much time each vehicle spends on every block of the street and to provide the data to others in the organization who want it. One of the biggest benefits is that it helped build tools, such as the TSP Interactive Model (cost-benefit model), for creating more effective installations.

Does your agency apply the PIA process to all or some of its IT/ITS projects?

Three of the agencies said they do some PIA regularly after an IT/ITS project has passed systems acceptance. Most said they would try to do more in the future.

What are the biggest issues in completing the analyses?

For those agencies that completed post-implementation analyses, time, money, gathering data, and motivation were issues in completing the work. For some, after the project was over, they felt pressure to either work on enhancements or move on to a new project. Another said that it is a struggle to obtain data for a good ROI analysis; they use the cost/benefit analysis portion of the ROI more as a planning tool for deciding between implementation options.

CHAPTER 4

Development of the TEAP Framework

Building on the best practices from the research synthesis and literature survey, plus input from numerous transit agencies and workshops, the Transit Enterprise Architecture and Planning Framework project created the TEAP Framework, which includes guidance and tools for transit for successfully implementing IT/ITS projects. The Framework and tools are described in detail on the project's wiki website at www.tcrp-teap.pbworks.com. For each of the five key elements of the Framework (Enterprise Architecture Planning [EAP], Funding Implementation Methods, Business Case Methodology [BCM], Systems Engineering [SE], and Post-Implementation Analysis [PIA]), the wiki has a section on the "What, Why, and Benefits" of the element, a section on "Best Practices," and a section on "Additional Resources" such as references, examples, and tools. In addition, the Framework guidance describes the relationship among the Framework areas. As it is defined, the Framework incorporates and supports many aspects of IT governance.

The TEAP Framework, as illustrated in Figure 2, shows how the elements flow and relate to each other at a high level. When the Framework elements are used together, the value of the Framework is much greater than individual elements. In particular, the information modeled in the enterprise architecture (EA) improves the speed and validity of the business case and the systems engineering process. It also improves the accuracy of the funding and post-implementation analysis efforts.

For example, when a business case is needed to implement an asset management/work order system that includes passenger facilities, the EA shows how many applications depend on the current and up-to-date information contained in the bus stop inventory that is managed and continuously updated by the system. The EA shows the critical functionality of the asset management system, payback in productivity, relationship to corporate objectives, and impact on staff resources and business processes. With respect to the SE process, the system description; needs, roles and responsibilities; interface requirements; key system requirements; and impact on transition may be generated from querying the EA model. With information from the EA, the SE analysis can be completed significantly more quickly and accurately.

This chapter is divided into two parts. The first part provides an overview of the TEAP Framework. The second part describes how the TEAP Framework wiki supports transit agencies in learning about the Framework and tools, implementing more successful IT/ITS projects, and finding other agency-related work examples.

TEAP Framework Overview

The Framework helps transit professionals understand the financial, operational, and management impacts of technologies, to help them better meet their enterprise business process needs and corporate objectives. The Framework will also help guide an agency's IT/ITS planning process, improve its understanding of risks, better manage the project implementation effort, validate and verify compliance with its needs, and measure results and benefits.

Specifically, the TEAP Framework guides transit in:

- Planning how information, services, and technology will connect across an enterprise to support business processes, solve problems, and measure performance;
- Promoting information sharing across agency and institutional barriers;
- Ensuring that IT/ITS projects are defined and staged in a way that ensures best value and supports successful project implementation, operations, and maintenance;
- Ensuring that the benefits and costs of proposed IT/ITS projects are understood across the project's lifecycle (including operations and maintenance) and that resources are available to support the program;
- Specifying IT/ITS projects to maximize the IT/ITS investment decisions across the organization;
- Ensuring that IT/ITS projects meet stakeholder needs: requirements are explicitly described, risks are identified

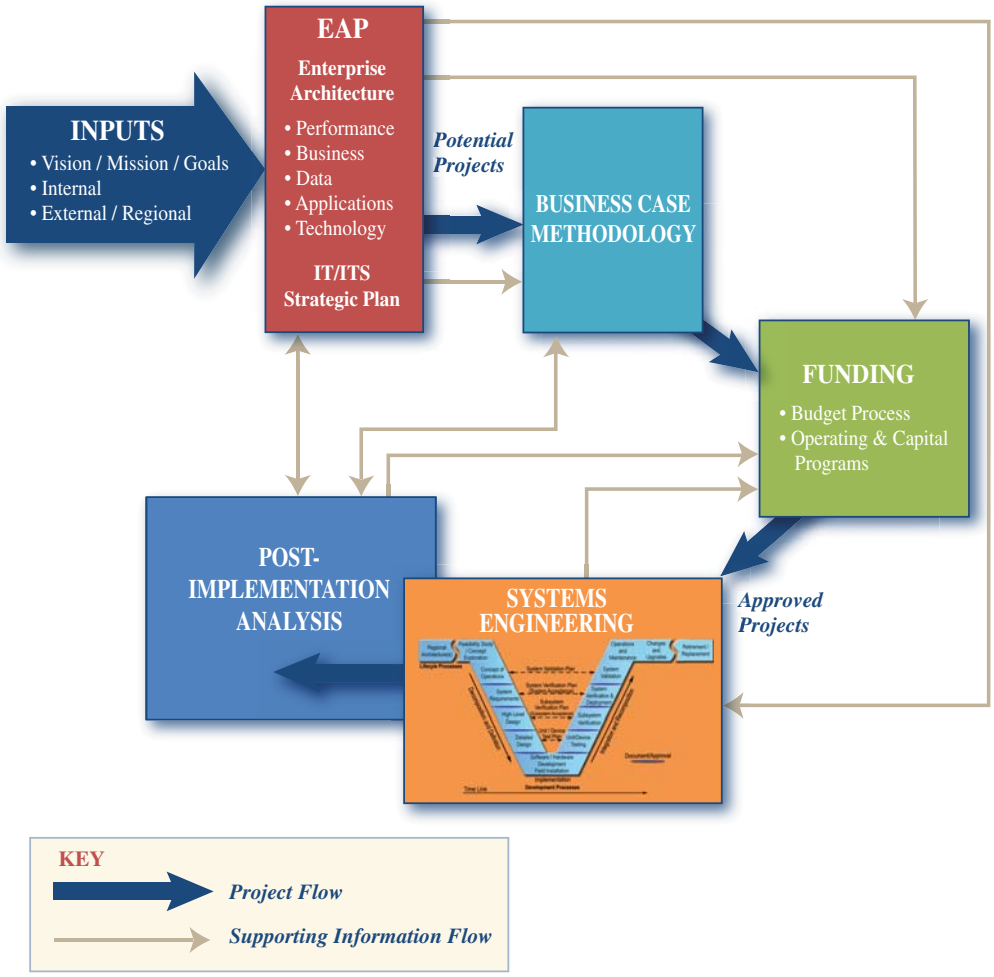


Figure 2. Transit enterprise architecture and planning framework.

and mitigated, and the system development process is managed to ensure that correct operations and requirements are met; and

- Describing the leadership and processes that ensure that the organization's IT group supports and extends corporate strategies and objectives.

What are the TEAP Framework elements?

The TEAP Framework comprises five elements, shown in Figure 3. They provide tools for planning, developing, deploying, and evaluating the systems and technologies that best meet an organization's objectives. These key elements of the Framework are:

- Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) development process (developing the blueprints);
- Business Case Methodology (BCM) (how well does this project fit into the stated priorities; what are the risks,

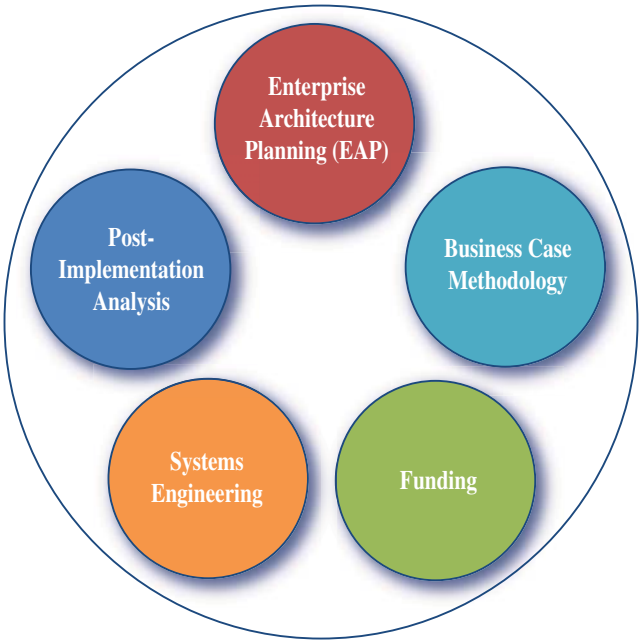
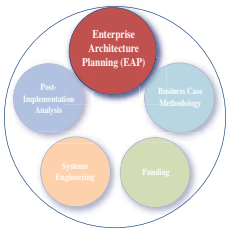


Figure 3. TEAP Framework elements.

benefits and costs, and estimated return on investment [ROI]);
- Funding (how to pay for IT/ITS projects);
- Systems Engineering for helping to design and manage an IT/ITS Project implementation; and
- Post-Implementation Analysis (PIA) to assess whether the implementation met project and agency goals and achieved a meaningful (estimated) ROI and to review the project implementation experience for lessons learned.

Looking at each element in more detail clarifies the role each plays and how they work together to create a successful TEAP Framework.

Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) Overview



The Enterprise Architecture Planning (EAP) process is a set of activities used to develop the Enterprise Architecture (EA) models, diagrams, and descriptions. The process relies on stakeholder input to document the agency's current performance measures, business processes, data, applications, and technologies, reflecting the organization's "as-is" architecture. Next, a "to-be" architecture is developed that documents where the organization wants to be with respect to its business in the future. A 4- to 5-year horizon works best here. It consists of the corporate mission, goals, objectives, and the business processes, data, applications, and technologies that are needed to support that vision. The third step describes the gap between the present ("as-is") and the future ("to-be") and how to close it. The EAs, both the "as-is" and "to-be" architectures, are composed of four or five models (Business, Data, Applications and Technology, plus in some approaches a Performance model) that are depicted in one or more diagrams, policy statements, procedures, inventories, or other pieces of information. The term used to describe these is "artifact."

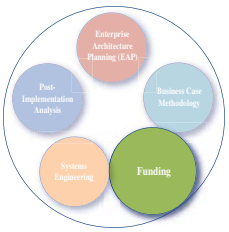
Business Case Methodology (BCM) Overview

A BCM is a formal analysis used to justify and capture the reasoning for initiating a project. The TEAP Framework includes information on how to implement a BCM at a transit agency and guidance on how to build an appropriate business case for a technology project.

The business case typically reviews and verifies that:

- The proposed investment has value and importance
- The project will be properly managed
- The organization has an adequate plan and the capability to deliver the benefits
- The organization's resources are working on the highest value opportunities
- Projects with inter-dependencies are undertaken in the optimum sequence (*2*).

Funding Implementation Overview

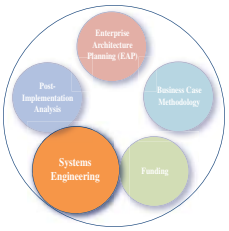


IT/ITS Project Funding Implementation discusses approaches for obtaining and making use of various sources of funding for IT/ITS projects. Like IT projects in general, transportation IT and ITS projects are delivered through public leveraging options like bond financing, public-private partnerships, co-mingled funding, and a variety of federal, state, and local funding sources.

Transit agencies are using many of these financing mechanisms to access the various sources of capital for IT/ITS projects. Historically, buy (pay-as-you-go), borrow (issue bonds), or lease were the primary financing mechanisms used by transit agencies. Since the 1990s, there has been more creative use of these traditional mechanisms and the introduction of public-private partnerships. Financing mechanisms, particularly four categories—debt mechanisms, capital leasing financing, equity and partnerships, and credit enhancements—have been important.

Based on a modest survey of transit agencies, it was found that no single financing method works for all situations; rather, financing decisions need to be tailored to the specific project, region, and financial circumstance.

Systems Engineering (SE) Overview



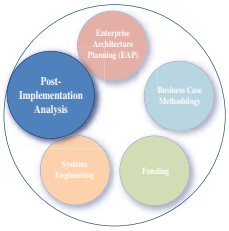
Systems Engineering (SE) is a discipline that helps ensure that customer needs are implemented in the system that is developed. Customer needs are defined by those who have a vested interest in the system, such as a user, a manager, or someone impacted by the operations of the system (e.g., recipient of information or process coordination partner).

Customer needs drive the system requirements, or what the system should do. For example, if there is a need to measure

ridership at stops for each trip and an Automated Passenger Counting (APC) system is being proposed to do the counting, then there must be a corresponding system requirement for the APC system to count boardings and alightings at each stop by trip identifier. The SE process ensures that the requirement is described in the design and consequently implemented in the software and that data is collected, stored, and reported in a format that supports its use as a performance measure. The steps prescribed by the SE process ensure a structured approach to track customer needs throughout the development stages of an IT/ITS project.

U.S. DOT recognized the potential benefit of the SE approach for ITS projects and included requirements for the use of the SE process in the FHWA Final Rule 940/FTA Policy on ITS Architecture and Standards that was enacted on January 8, 2001.

Post-Implementation Analysis (PIA) Overview



Post-Implementation Analysis (PIA) or Post Implementation Review (PIR), as it is commonly called in the IT field, is conducted at the final stages or right after a project has been completed. "The purpose of the PIR is to evaluate how successfully the project objectives have been met and how effective the project management practices were in keeping the project on track" (*3*). This information can be used to improve project management processes and guide where the next set of investments should be made. The PIR and associated ROI analyses can also help demonstrate how the project made a difference and identify lessons learned.

The PIR is *not* the testing and verification activities that are typically performed in a project acceptance or closeout phase. For example, an Automatic Vehicle Location (AVL) system may have to be accepted from a vendor if it performs according to the requirements in the Request for Proposals (RFP), passes the test plan, and satisfies the SE verification process. However, the system may not perform the way the users want. Perhaps the business changed or the project was specified ambiguously and/or incorrectly in the RFP and System Requirements. The PIA plan is also sometimes called a Validation Plan.

In summary, the PIR occurs after the IT/ITS system has been incorporated into the business and assesses how well the project meets the users' needs, what needs to be done next, and how well the implementation process went. Developing and sharing lessons learned can continuously improve the agency's project acquisition and management processes.

How do the TEAP Framework elements relate?

As illustrated in Figure 2, the TEAP Framework elements build on the models, analysis, and reports generated in the previous stage. The Framework value is greater than the sum of its parts. It also improves the quality and completeness of the downstream products. A well-developed business case helps ensure that a project gets funded and that the funding is at the appropriate level. It also helps ensure that the plan and resources are available to gather baseline data needed to prove that the project made a difference during the PIA. Information from the systems engineering steps can help decision makers advance a project effectively through funding "decision gates."

During the course of this project more transit agencies began focusing on IT project management and governance of these projects. IT staff began to realize the importance of creating a solid foundation on which to make good business decisions on funding, operating, and maintaining technology deployments. In order to show a solid return on investment and measure success, it is essential to understand the connections, bottlenecks, and stresses across the enterprise. The foundation of this information is represented in the EA. Therefore, making the EA process less costly and time consuming became a need of the TEAP Framework.

TEAP Framework Wiki Overview

The medium that presented the TEAP Framework needed to address three major areas—audience presentation, interactivity, and collaborative environment. The specific needs that were addressed included:

- Develop guidance on the TEAP that targeted multiple audiences (without intimidating any of them by the size of the document).
- Present the material using a medium that was logical, easy to use, and allowed for seamlessly showing the relations among the elements (and linking to external resources).
- Provide the industry with a site where collaboration and information navigation was intuitive and easy to use while preventing spamming and misuse of the site.

The Framework and element descriptions, best practices and resources needed a medium where the relationships between the elements were visible, and the connections to additional resources and tools were seamless. A website by its nature proved to be the best medium to present the information. The materials were accessible and various audiences could easily find guidance that was commensurate with their knowledge and responsibilities. Yet in recognition of the changing nature of the topic, and the need for transit professionals to collaborate, a user-driven website was needed. A wiki allows users

with permission to contribute and work together in a loosely connected community. The wiki format provides a means of directly soliciting new and updated guidance from registered users on their questions, recommendations, approaches, and practices. The format enables "trusted" writers to contribute and share information in a transparent environment on best practices and new methods. Also, using a wiki to store the project's findings allows for ongoing updating and expanding of the content.

Target Audience and Wiki Sections

There are several open source wiki applications and numerous information service providers (ISP) that provide a wiki "in the cloud." The research team, in order to focus on the content rather than the technology, elected to use an ISP. The site (http://tcrp-teap.pbworks.com) allows cutting and pasting from word processing documents, uploading of different file formats, display of graphics, and application of several html and Java script functions. All changes are recorded and ascribed to the user who made the change providing robust configuration management functionality.

The research team populated the site with the TEAP Framework Guidance, tools, and a Transit EA/EAP Guidebook. The site lays out the Framework Guidance in a systematic way with sections targeting different audiences, from executives and senior managers to program managers and technical practitioners (see Table 4).

TEAP Guidebook

Guidebook Purpose and Scope

The Transit Enterprise Architecture Planning (TEAP) Guidebook differs from the TEAP Framework in that the Framework describes general benefits, best practices, and

Table 4. TEAP Framework wiki sections.

TEAP Framework Wiki	Description	Audience
Guidance for Transit Managers	A high-level description of the TEAP Framework, including the purpose and benefits associated with each Framework element and their interrelationships. In addition, the guidance includes a checklist that enumerates the roles and responsibilities of transit managers with respect to each of the elements. This section includes a self-contained, downloadable version which can be printed and read in hard copy.	Transit executive and senior managers
TEAP Framework Guidance: • **Executive Summary** • **EA/EAP** • **BCM** • **Funding** • **Project SE** • **Post-Implementation**	A detailed description of each TEAP Framework element, including: information on the "What, Why and Benefits" of the element; "Best Practices" and streamlined approaches; and "Additional Resources" with references, tools, and examples from the IT and transit industries.	Program managers and transit professionals who want to learn more about the topics
Transit EAP Guidebook	The Transit EAP Guidebook details step-by-step how to develop a transit enterprise architecture (as-is and to-be). The Guidebook shows how to customize the Reference Enterprise Architecture for Transit to represent the drivers, business processes, information, applications, and technologies in your organization. The Guidebook is an interactive and extendable "space" on the wiki to describe a Reference Enterprise Architecture for Transit, and to include related terms and techniques for implementing a Transit Enterprise Architecture. It includes models, templates, examples, and benefits associated with each step.	Program managers and transit practitioners who are tasked with implementing an EAP and maintaining the as-is and to-be enterprise architectures
State of the Practice Synthesis Results	A summary of the *State of the Practice Synthesis* related to the five elements of the TEAP Framework.	All
Other Resources	How-To Guides Glossary and Acronym List FAQs About the Project and the Wiki Site Map Improvement Page	All

resources for the five system development disciplines, while the TEAP Guidebook describes details related to how to implement a Transit Enterprise Architecture by customizing the Reference Enterprise Architecture for Transit and other resources. The Guidebook describes the terms and techniques used by transit and other architecture experts. The Guidebook may be seen as an evolving process; as more transit agencies develop architectures, concepts, techniques, and resource materials, the resources and guidance in this section will grow. The site allows for extensions and conversations among practitioners as the experience developing TEAP grows in the industry.

Guidebook Audience and Prerequisites

The TEAP Guidebook targets transit staff who understand both the transit enterprise domain and basic organization of an Enterprise Architecture Process (EAP). (The materials presented in the TEAP Framework section on EAP should provide enough background to the reader to understand the Guidebook method.)

Guidebook Organization

The Guidebook is inserted into the "Best Practices" page of the TEAP Framework, EA/EAP section of the wiki. The Best Practices page is used as a launch pad into the pages that constitute the Guidebook. The need to make the material interactive and the huge amount of material that is contained in these pages makes it efficient to document the material exclusively on a website and not compile it into a voluminous paper document.

The Guidebook is divided into two major parts:

- Description of the Reference Enterprise Architecture for Transit
  - Including solutions for different segments of the architecture
  - Instructions on augmenting or changing the reference architecture
  - Instructions for customizing the various models in the architecture and changing the relationships between entities in different models (e.g., measures and information)
- Streamlined process and guidance on applying the Reference Enterprise Architecture for Transit
  - Where do you start?
  - Step by step directions for getting started
  - How do you drill deeper into the details of your enterprise?

The Reference Enterprise Architecture for Transit is described in Chapter 5. The streamlined process is described in further detail in the following sections.

Streamlined Process for Developing a Transit Enterprise Architecture

A recurring theme during the state of the practice review was the lack of resources needed to create the enterprise architecture. Transit professionals needed a more effective way of collecting and organizing their information without marshalling their entire IT staff for the effort. Some transit staff indicated that they did not even know where to start. Based on this feedback, the wiki includes a section on how to get started. The development of the Reference Enterprise Architecture for Transit provides building blocks to accelerate development of a high-level TEAP. The streamlined process uses the Reference Enterprise Architecture for Transit to develop templates (which may be populated) and guidelines on how to collect information to populate or edit the templates.

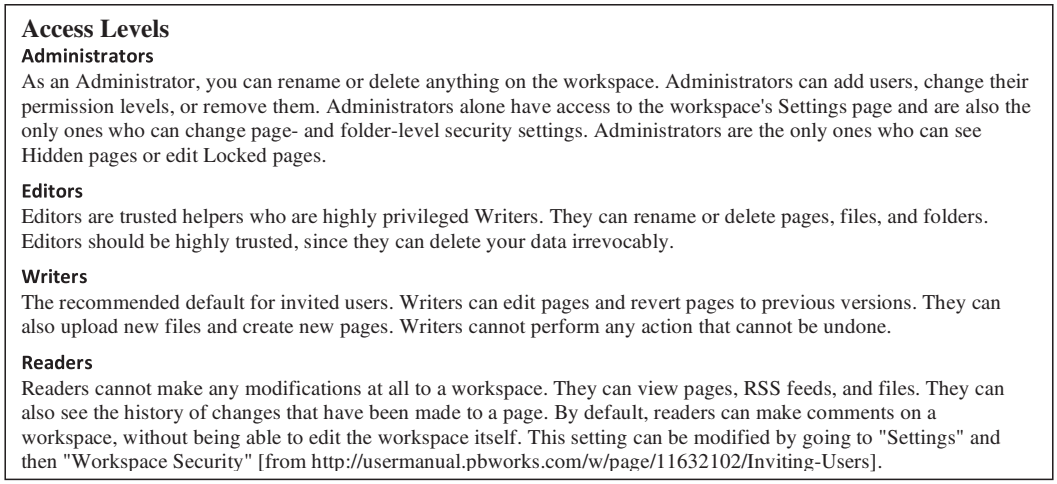
The Reference Enterprise Architecture for Transit provides transit agencies with a basic starting point that they can use to customize their organization. It contains descriptions of the business processes, information views, types of transit applications, and similar devices and technologies used by the industry. It also builds the connections and dependencies between the architecture drivers (goals, measures, standards, regional agreements) and the enterprise architecture.

The entities and relationships are captured in a metamodel (see Chapter 5). The metamodel is a way of classifying the entities in transit and showing how they relate. Similar to a database, the metamodel is the database schema and the reference model is the content of each table in the model.

The streamlined approach describes how to edit or collect/populate each layer of the Reference Enterprise Architecture for Transit using a template or worksheet included with the instruction. Examples from existing agencies are included with the guidance. Suggestions for additional data collection fields are included in the discussion. Moreover, the streamlined approach includes a section on purpose that describes examples of "what if" scenarios. Additional information about the streamlined approach may be found in Chapter 5.

Wiki Site Review and Validation

The research team addressed the wiki's usefulness as a tool for the industry at several stages of the project. As a part of the project's validation task, a group of transit professionals, some of whom participated in the research synthesis process and others who did not, were asked to participate in up to three webinars to discuss the wiki. During the webinars, team members walked through the site, asking questions and describing the functionality. Participants consistently found the site intuitive and useful. The results of these workshops were incorporated into the latest version of the site. The full report may be found in Appendix C. Additional improvements to the wiki



Access Levels

Administrators

As an Administrator, you can rename or delete anything on the workspace. Administrators can add users, change their permission levels, or remove them. Administrators alone have access to the workspace's Settings page and are also the only ones who can change page- and folder-level security settings. Administrators are the only ones who can see Hidden pages or edit Locked pages.

Editors

Editors are trusted helpers who are highly privileged Writers. They can rename or delete pages, files, and folders. Editors should be highly trusted, since they can delete your data irrevocably.

Writers

The recommended default for invited users. Writers can edit pages and revert pages to previous versions. They can also upload new files and create new pages. Writers cannot perform any action that cannot be undone.

Readers

Readers cannot make any modifications at all to a workspace. They can view pages, RSS feeds, and files. They can also see the history of changes that have been made to a page. By default, readers can make comments on a workspace, without being able to edit the workspace itself. This setting can be modified by going to "Settings" and then "Workspace Security" [from http://usermanual.pbworks.com/w/page/11632102/Inviting-Users].

Figure 4. Wiki access levels.

were also made based on the pilot results, which are described in Chapter 6.

Vision for Augmenting the Wiki (Guidebook and Reference TEAP Artifacts)

The wiki site is critical to presenting the research because it provides a forum for transit professionals to share their experiences with each other and enhance the Guidebook based on new lessons learned and experiences. During the validation workshops, participants were asked who should be able to update and change the wiki and its content. The participants unanimously agreed that editors of the wiki should monitor and agree on its content (see Figure 4 for description of user roles and access levels).

There are two approaches for submitting wiki content and changes: through comments or by adding to/changing a wiki page. Any user may submit a comment at the bottom of most wiki pages. Some pages are locked and may be changed only by someone with administrator-level access. Other pages may be created and/or changed and documents can be uploaded by users with editor- and writer-level access.

CHAPTER 5

Reference Enterprise Architecture for Transit

Purpose of a Transit Enterprise Architecture Process Reference Model

As described previously, the general purpose of an Enterprise Architecture (EA) is to understand the connections between your organization's business processes and stakeholders (users, upstream providers, and downstream recipients); this information is used to measure performance and make decisions, as well as develop applications and technology that enable the services and generate the information. Most transit agencies support similar business processes, information views, applications, and technologies. The relationships between the models that represent each layer do not differ greatly either. This provides an opportunity for the industry to describe a generic reference that may be customized based on the particular agency, rather than having each transit agency start from scratch. A reference architecture defines the common elements found in each of the four EA levels and their typical relationship to each other.

In addition, organizational drivers also contain common elements. Most transit agencies include a hierarchy of staff and mission/goals/objectives that drive performance measures. The challenge in developing the reference architecture comes in describing application and technology models. These change and evolve continuously; different vendors may present vastly different solutions. The reference architecture handles these challenges by modeling different solutions at the application and technology levels. Together with the business process and information view elements and relationships, the different *solutions* (see sidebar in Chapter 2) using typical application and technology categories and types provide the building blocks for developing EA models customized to represent each transit agency. The application categories and types may include generic systems such as workforce management, financial management, customer relationship, customer information, and maintenance management. Typical technology components include data/processing servers, routers, modems, networks, and other devices.

Methodology Used to Develop the Reference Enterprise Architecture for Transit

The Reference Enterprise Architecture for Transit was developed from a comprehensive, albeit high-level, existing EA model developed by WMATA. The WMATA EA, which includes several modes and references to other transit management systems, presented a starting point that details some of the complexities of large transit agencies, yet may be scaled down to smaller organizations.

To ensure that the WMATA EA represented the diverse transit industry, a team of transit IT experts from more than a dozen transit agencies of varying sizes, including urban/suburban/rural agencies, and supporting different modes, were brought together to review and walkthrough the architecture. In addition, several EA experts from other sectors were included in the expert peer review group. (See Table 5 for a list of participating organizations.) As other agencies heard about the Reference TEAP, they too asked to participate in reviewing, piloting, or commenting on elements of the architecture.

Three workshops were conducted for the participants. The first workshop highlighted a presentation by the Chief Architect from WMATA, Jamey Harvey, on the WMATA EA. Harvey described the EA organization (metamodel), content, and general principles he used at WMATA. The second workshop focused on how to make the architecture more generic and what segment to select for review and refinement (development of one or more "solutions"). The result of this second workshop was the selection of the fare management area for review. Prior to the final workshop, team members interviewed different agencies that were developing typical and new solutions for fare management. The models included closed systems that most agencies currently implement, open

Table 5. TEAP peer review panel.

List of Participating Organizations in the Reference TEAP Peer Review Panel
Cape Cod Regional Transit Authority
C-Tran
Dallas Area Rapid Transit (DART)
EA Works
FTA Headquarters
King County Metro
Miami-Dade County
New Jersey Transit
New York City Transit
PACE
EA Expert (retired)
TriMet
Utah Transit Authority
VIA—San Antonio
WMATA

payment system, and the emerging mobile/branded card payment system.

In the final workshop, the discussion centered around how to represent different fare management configurations, and how to generically represent applications and technology components. The results of these discussions and the workshop recommendations were posted on a private wiki site for which all participants had writer-level access. Several transit agencies reviewed the resulting artifacts; some agencies applied their existing systems to the model or solutions to validate them. The results of these pilots are described in Chapter 6. The final reference architecture, the four fare management solutions, streamlined implementation guidance (with tools and templates), and approach for incorporating solutions were included in the Phase I wiki site.

What Is in the Reference Enterprise Architecture for Transit?

The reference architecture is composed of several sets of entities, including the following:

- Metamodel—Model that shows the organization of the Reference Enterprise Architecture for Transit
- Reference Enterprise Architecture for Transit—Model that shows the reference architecture, including all the entities and relationships
  - Diagram of the model
  - Templates and tools that explicitly define the four EA layers, and the institutional and technical drivers of a Transit Enterprise Architecture
- Fare Management Solutions—Four different configurations/solutions for implementing the fare management segment of the Reference Enterprise Architecture for Transit
- Streamlined EA Process—Streamlined approach for collecting information to customize the reference architecture to meet a transit agency's enterprise

These topics are overviewed in the sections that follow. The wiki contains the details and in-depth descriptions of the models, tools, and process.

TEAP Metamodel Overview

As discussed in the beginning of this chapter, an important aspect of the reference architecture, or any EA in general, is the entities that compose the EA and their relationship to each other. The TEAP metamodel (see Figure 5) is a very close replica of WMATA's EA metamodel; it shows the institutional and technical architecture drivers in the vertical box (on the left), and then the four typical enterprise architecture layers (business, information, applications, and technology) in the horizontal boxes on the right side of the diagram. Some entities are fully contained within other entities; for example, a business domain includes several business functions which specializes the functions into business processes. The links between the Information View and Business Process, or Information View and Measure indicate that there is a connection (perhaps dependency) between the paired entities. The metamodel is the foundation of the enterprise and does not readily change. Perhaps the most important aspect of the metamodel is to describe the general relationships between entities. The reference architecture can then use this model to describe entities and their specific relationship to each other. For example, an Information View element called *ridership* may be linked to a Measure called *monthly ridership statistics.*

An Access database and Excel spreadsheets were developed that represent the entities and relationships described by the metamodel diagram. Transit agencies may use these as templates to collect information about their organization.

Overview of the Reference Enterprise Architecture for Transit

The Reference Enterprise Architecture for Transit is the content that is inserted into the TEAP metamodel. Based on the metamodel, the reference model is divided into several sections:

- Architecture Drivers including
  - Vision/Mission
  - Transitional Processes
  - Locations
  - Standards
- Business including
  - Business Domain
  - Organization

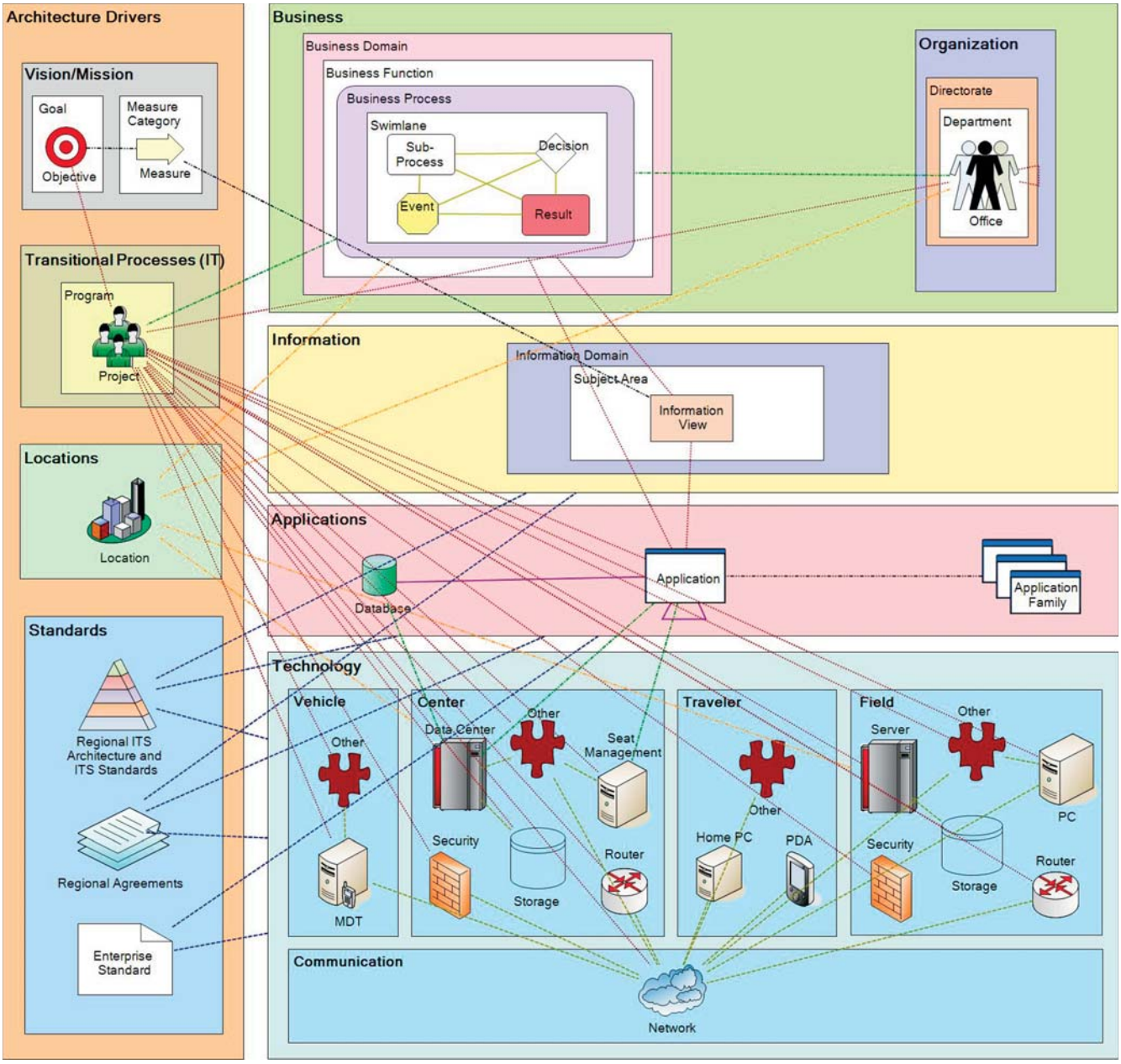


Figure 5. TEAP metamodel. (Source: Adapted from WMATA Enterprise Architecture, June 2009. Licensed under a Creative Commons Attribution-ShareAlike License [CC BY-SA].)

- Information
- Applications (and related databases) and Application Families
- Technologies related to their ITS System/Center association or Communication

Each of these layers includes a model that depicts the entities and relationships and a table with descriptions for each of the entities. The descriptions are contained in a spreadsheet and database. The database describes the relationships between entities (within a layer or between layers).

Architecture Driver Layer Overview

The architecture drivers are composed of four major areas including mission, transitional processes, locations, and standards.

Mission. The mission topic describes the mission, vision, goals, and related objectives. The vision/mission drives the corporate goals, and for each goal there are one or more measurable objectives. Performance measures may be categorized by different classification schemes. For example, organizations may classify their (performance) measures based on safety,

customer service, and productivity. Each measure is related to one or more objectives (and *vice versa;* each objective may be related to one or more measures). A typical performance measure may be "monthly ridership statistics." A corporate goal is to increase ridership while the objective may state: increase ridership on new routes by 2 percent per quarter over the next 2 years.

Transitional Processes. The transitional processes entity lists the programs and specific IT projects planned or active that effect change to the architecture. This category may also be seen as a "Project Portfolio" or it may describe areas related to an IT strategic plan. This is the link that connects the TEAP to the TEAP Framework elements (i.e., business case, funding, systems engineering, and PIR). Additionally, the project and/or program models connect to almost every entity. The transitional processes help keep track of "to-be" elements in the architecture.

Locations. The locations entity is a means of assigning a "location" to the physical technologies and assets. It is also a means of categorizing these things using the National ITS Architecture centers and system nomenclature by categorizing it by a type—mobile/vehicle, field, center or traveler. The information contained in a locations table may include the following:

- ITS Type (Mobile/Vehicle, Field, Center, Traveler)
- Grouping (e.g., Facilities, General, Mobile, Offices, Stations)
- Location Name
- Description
- Address
- Telephone
- Latitude
- Longitude

A locations table entry is associated with each technology entry. For example, a server is located in a facility such as the agency headquarters and the backup server may be located in a data center located at an offsite facility.

Standards. The standards entity is composed of IT and ITS standards; IT policies (such as branding, privacy, security); and other regional agreements that drive business processes, information, applications, or technology. Any regional agreements that share networks may include a Level of Service agreement. The network would be linked to the Level of Service agreement. Applications that implement a Transit Communications Interface Profile (TCIP) standard dialog would link to the Profile Information Conformance Specification (PICS). Each of the three entities contained in the Standards entity may link to Information, Application, or Technology entities.

Business Layer Overview

The business layer includes the business processes and organizational structure. These entities are inextricably linked.

Business Process. Business process entities are composed of the business domain, functions, and processes. Each business domain, function, and process is described from a high level. The TEAP uses WMATA's approach for classifying the enterprise. There are three domains: administration functions, operations and service level functions, and then cross-cutting, executive, and interagency (e.g., security, safety, and customer service) functions. The reference architecture summarizes the enterprise to the business process level; however, many agencies create flow charts that describe business processes to more detailed levels, down to specific operating procedures, subprocesses, decision points, and events (triggers).

As mentioned above, the Reference TEAP includes three major Business Domains:

- Enterprise Administration Domain—Supports back-office and other administrative functions
- Integration Domain—Supports cross-cutting, executive, and customer functions
- Transit Management Domain—Supports operations, maintenance, and support related to providing the service to the customer

Organizational Structure. The organizational structure is composed of directorates, directorates are composed of departments, and departments are composed of offices. If the levels of an organization need more than three levels, then offices may be composed of one or more offices.

Information Layer Overview

The information layer is composed not of specific databases and data sets, but of the "data dictionary" clustered into critical data sets. The information layer includes the information domain, subject area, and information views in a hierarchical relationship. Many information domain entities correspond to business functions with the same name, such as:

- Enterprise Asset Management
- Human Capital Management
- Financial Management
- Operations Management and Supply Chain
- Safety
- Enterprise Management
- Customer Service
- Security

The reference architecture also contains aggregated domains where subject areas and information views are logically grouped together including:

- Transit Domain Information—aggregates information from the four modes: rail, bus, paratransit, and vertical (elevators/escalators)
- Integration Information—which includes cross-cutting information, executive, and customer information
- Core Data—which contains critical information for multiple processes

The core data is critical to operations of the business. It contains fleet information, transit gazetteer and network information, service schedules and operational performance, incidents, and more.

Applications Layer Overview

The applications layer includes three major entities: an application family, applications, and databases. An application family contains one or more applications, and applications include one or more databases. A database may be used by one or more applications. Additionally, an application may exchange information with another application.

Because there are many off-the-shelf and custom tools that transit agencies use, the Reference TEAP designates a set of categories and types of tools in lieu of commercial or open software products. The list is based on the TCIP system types as well as common systems that are available off-the-shelf. The list is documented in the wiki at: http://tcrp-teap.pbworks.com/TEAP_Applications.

Technology Layer Overview

The technology layer contains information on the technologies that store data and software, network equipment, sensors/performance monitoring devices, control equipment, and other devices. The TEAP metadata model creates classes of technology types that are resident in different environments. The environments correspond to the National ITS Architecture System and center domains: vehicle/mobile, field, center, and traveler. In addition, communications is a connection among these technology environments. The classes of technologies include the following:

- Communications—Network
- Center—Data center, other technologies, seat management, storage, route, security
- Vehicle—MDT (computer), other technologies (router)
- Field—Router, personal computer, other technologies, security, server, storage
- Traveler—personal computer, PDA

In addition, the router "device" category included in each layer is a way to show which technology entities are connected to each network. This convention provides a way to depict and analyze physical network models. However, the relationship between applications and technologies shows the *logical relationship* among the enterprise elements. This relationship is essential to determine performance, capacity, and critical infrastructures that support corporate business processes.

The Reference TEAP does not include a category for each personal computer in an agency. Typically, agencies have standard configurations for their equipment, servers, and other technologies; these can be stored and reused to describe the technology layer using the seat management convention in the model. Seat management is used to describe these types of configurations (and the number of PCs with this configuration) and is associated with a location of a "center." The PC may be used in the same way, but associated with a field location. The mobile data terminal (MDT) is defined as the on-board computer. To that end, there may be more than one device on-board designated as an MDT. In developing one of the pilots, we reviewed an approach for documenting servers and personal computers located at transit stations. The relationship between the seat management (center) and personal computer (field) is a means of tracking the configurations and software licenses of field equipment.

TEAP Solutions for Fare Management

Solutions in the fare management segment are described for four alternative configurations. The entities and relationships are explicitly defined for the four EA layers—business processes, information, applications, and technologies. In reviewing a number of representative fare management configurations, we found that the relationships among TEAP Business Processes and Information Sets are fairly stable from implementation solution to implementation solution, particularly since they revolve around the Financial Management function. On the other hand, the solutions (and connections) for applications and technology may differ greatly depending on bundling of application functions, and adoption of methods, services, and technologies. The term "solution architecture" is used in the IT industry to describe different ways of implementing applications and technologies to enable similar business processes and generate comparable information sets. The approach used to generate alternative solutions for the TEAP was to model four configurations that are typical or emerging in the transit industry for the fare management area. The four solutions are:

- Closed Fare Management System (with partners)
- Closed Fare Management System (used by partners)
- Mobile Fare Payment System
- Open Fare Payment System

Table 6. Streamlined processes for developing an "as-is" transit enterprise architecture.

Step	Streamlined Processes for the TEAP
1	**Describe Locations.** Identify physical locations of entities owned or used by your organization. This includes passenger facilities, third party fare outlets and information kiosks, transit vehicle and equipment depots, and staff facilities.
2	**Describe the Organization.** This is a list of the organizational structure and staff of your organization. The positions in the organization chart will be linked to their roles and responsibilities within the business processes.
3	**Complete Mission, Vision, Goals.** Describe the mission, vision, goals.
4	**Review and Edit the Business Process View.** At a minimum, search and replace "AGENCY" for the name of your agency.
5	**Review and Edit the Information View.** At a minimum, search and replace "AGENCY" for the name of your agency.
6	**Application Inventory.** Collect an inventory of your applications.
7	**Technology Equipment Inventory.** Collect an inventory of your servers, networks, communications devices, and other technologies.

The models were developed so that an agency may grab the templates and content of a model, revise the names of processes and information to map to their organization's terminology, relate the application categories and types to their application products, and assign the specific technology vendor to each of the technology components.

Each fare management solution is described by an enterprise model (with the key components of each level and their connections) and a spreadsheet with several sheets that describe the entities or the relationships (associations) between entities. The spreadsheet files contain a separate sheet (tab) for business process, information, application, and technology views. In addition, there are sheets that relate the business processes to information sets, another sheet that relates the business processes to application categories and types, and so on.

These fare management solution spreadsheets and templates may be used as building blocks to apply to your organization's EA. Moreover, because emerging fare management solutions are described, an agency migrating from a Closed System to an Open Payment System can use both models and describe the gaps, processes, data flows, and organizational changes that will be affected by the transition.

Streamlined EA Process

The streamlined process was developed for describing a specific "as-is" (current) EA (see Table 6). It describes how to get started, that is, how to begin to populate an EA that describes a specific organization. The processes to maintain, update, and transition to a future architecture are left as a future research effort. Moreover, the "to-be" or future architecture is typically recommended on a per-project basis since it requires alternatives and business case analyses to understand costs and impacts. The addition of *solutions* enables migration to new models, applications, and technologies as they evolve in the industry (e.g., IT, ITS, and transit).

Details including templates, purpose, examples, and methods for each step are described in the TEAP Guidance pages. Each step includes a page where practitioners may provide additional guidance, assistance, and tools to address new challenges.

CHAPTER 6

Evaluation and Next Steps

Evaluation Phase Goal

The primary goal of the evaluation phase was to obtain transit agency involvement in reviewing, using, and helping to improve the Transit Enterprise Architecture and Planning (TEAP) Framework content on the TEAP wiki.

Specific objectives of this phase were to:

- Further improve the TEAP wiki's usefulness based on transit industry feedback.
- Create a generalization or reference enterprise architecture (EA), with tools and templates, and publish it on the wiki.
- Develop an approach for transit agencies (large and small) to apply the reference EA as a building block to expedite their particular EA process.
- Identify other potential improvements to the wiki that can be incorporated in the future.

Pilot Approach

A multi-faceted approach was used to obtain transit input to further refine and add resources to the wiki site, and in particular, create a Reference Enterprise Architecture for Transit based on transit agency input. Although two agencies were specified at the panel meeting to participate in the pilot activities, the team chose a multi-faceted approach because of early concerns about the availability of transit agencies with the capability to take on the additional workload of implementing an enterprise architecture planning (EAP) pilot. It was likely that participation in a targeted EAP development effort for the pilot, without having planned for it in the previous budget cycle, would be difficult. Steps were taken to obtain broader input into the evaluation effort.

The implemented approach consisted of the following key steps:

- Develop improved materials and provide a training workshop to facilitate transit learning and involvement.
- Work with WMATA to review, assess, and enhance their EAP documents for transit review, generalization, and testing. Using transit-specific examples in the wiki and workshops would make it easier for the examples to be understood, rather than using general EAP industry examples. Pilot products and lessons learned could also be obtained from this step of working with WMATA.
- Conduct a series of EAP workshops to obtain transit input on existing materials and potential new ones. This would allow the participation of a broader range of transit agencies in the review, testing, and development of transit EAP materials, reference architecture, and tools.
- Develop a Reference Enterprise Architecture for Transit with one or more segments of a full EA. The areas were selected by the transit participants in the workshops.
- Work with a smaller transit agency to do a more in-depth pilot (originally to be Cape Cod Regional Transit Authority [CCRTA], then recruitment efforts occurred with other agencies as well).
- Conduct interviews with a set of transit agencies that reviewed and worked with the wiki and EAP materials to obtain additional feedback and ideas. (Core questions can be found in Appendix A).

In order for the small-agency pilot to be a success, it was agreed at the TCRP panel meeting that the agency selected would need to fulfill certain roles and responsibilities.

These responsibilities included:

- Working with the TEAP project team to define a clear and concise set of objectives, scope, and schedule for the pilot.
- Assigning resources sufficient to meet the TCRP 09-13 project schedule and making their staff available to the TEAP project team.

- Allowing the pilot results to be published by the Transportation Research Board.

Peer Review Webinars/Workshops

Four webinars were conducted to obtain transit industry input in the development of a preliminary Reference Enterprise Architecture for Transit for the TEAP wiki. The webinars included a training session and three workshops.

The first workshop highlighted a presentation by the Chief Architect from WMATA, Jamey Harvey, on the WMATA EA. Harvey described the EA organization (metamodel), content, and general principles he used at WMATA. The focus of the peer review discussion was on the following three areas:

- WMATA's taxonomy for a Transit Reference Enterprise Architecture Business Process Model.
- WMATA's taxonomy for a Transit Reference Enterprise Architecture Data and Application Model.
- A governance structure and organization as a set of roles and responsibilities that apply to a generic set of transit provider stakeholders.

The second workshop was focused on how to make the architecture more generic and what segment to select for review and refinement. The result of this second workshop was the selection of the fare management area for review.

Prior to the final workshop, the research team interviewed different agencies that were developing existing and new solutions for fare management. The models included the typical, closed systems that most agencies currently implement, open payment system, and the emerging mobile and regional branded (smartcard) payment system.

In the final workshop, the discussion focused on how to represent different fare management configurations, and how to generically represent applications and technology components. The results of these discussions and the workshop recommendations were posted on a private wiki site to which all participants had writer-level access. Several transit agencies reviewed the resulting artifacts; some agencies applied their existing systems to the model to validate it. The results of these pilots are described in the next section entitled "Pilot Agencies."

The final reference architecture, the four fare management solution architectures, updated streamlined TEAP, templates, guidance, and approach for incorporating solution architectures were included in the Phase I wiki site.

Pilot Agencies

Originally, the Phase II Project Plan specified the recruitment of at least one agency that would apply a segment of the reference EA. The project team contacted a range of agencies that had expressed interest in the pilot during Phase I. They then worked with a subset of agencies, including Cape Cod Regional Transit Authority (CCRTA), Dallas Area Rapid Transit (DART), Westchester County, and Chicago Transit Authority (CTA) to begin the pilot testing effort of a segment of the reference EA. None of the agencies were able to complete the pilot activities that they desired to do because of time and internal resources issues. A range of planning efforts and custom product developments went into either aborted starts or ongoing efforts. In the end, the research team met feedback and product development goals through trading-off the depth of the agency pilot test for the broader involvement of more agencies.

The pilot agencies that spent time and effort with the project team beyond the workshops to review, sometimes test, and to comment on the project's wiki, EAP materials, and models are summarized below. Additional information about their involvement in the pilot effort and their contributions to the project follows.

- WMATA: Feedback on wiki elements, review and modification of their implemented EAP materials to generate TEAP products, training and discussion with other transit staff, collaboration with the project team on material development, assistance with workshops
- CCRTA: Review of wiki materials, provision and discussion of ARRA project documents for project, preliminary planning efforts
- DART: Pilot planning, preliminary data collection for field location, technology and applications
- CTA: Review of wiki content, preliminary application of Reference TEAP and mapping of Fare Management System, participation in the pilot interviews, provision of materials
- King County Metro: Review of wiki content, active workshop contributions, pilot interview, provision of materials
- UTA: Provision of fare documents and an overview for the team in a teleconference, working on assessment of the "Open Payment Fare Management System" against the solution model, wiki content assessment and discussion, workshop and pilot interview participation
- Avolution EAP Software: Validation of TEAP reference architecture using EA modeling software to ensure valid and accurate relationships

Washington Metropolitan Area Transit Authority (WMATA)

For the evaluation phase, WMATA agreed to have its EA undergo peer review and to help create a new Reference Enterprise Architecture for Transit, which could be piloted by a

transit agency. Mr. Jamey Harvey, Chief Architect at WMATA, prepared and led a workshop laying out the details and motivation behind WMATA's EA model. WMATA agreed to participate and put forward their architecture for several reasons, first and foremost because they wanted their efforts to be shared by the industry. A secondary reason is because they saw the value in transit experts reviewing and commenting on their approach. Moreover, they saw the benefit in creating a community of enterprise architecture experts in the transit industry to move the industry forward. As new technologies, applications, and business needs change and evolve, new solutions need to be developed, and consequently, models that represent these business needs will be developed and incorporated into the next generation "to-be" architecture models. Finally, he hoped that other agencies would work on different segments of the architecture and share their development efforts as well. It is too much work to create a transit EAP for just one agency.

Cape Cod Regional Transit Authority (CCRTA)

Initially, CCRTA staff volunteered to work with the TEAP project team to pilot the EAP related models at CCRTA. At first, we discussed that the TEAP Framework project could help CCRTA begin to develop their own EA using the templates that are included in the EA/EAP Guidebook sections of the wiki, and the new ones developed as part of the Reference TEAP.

The plan was for the research team to follow-up with CCRTA to evaluate the successes and challenges encountered by the staff in using the reference enterprise architecture model and templates offered by the TEAP wiki.

In the Phase II Work Plan, the original intent was to accomplish the following:

> . . . introduce the CCRTA staff to EA for transit and EAP methods. They will review the elements of the prototype Transit Reference Architecture with CCRTA and provide guidance on how they might customize the business architecture. In addition, the Project Team will train CCRTA staff how to populate databases for four EA models using a set of "templates" (technology, application, data and business process) that document the reference architecture. (These activities may be changed in the Pilot Scope of Activities plan.)

The research team reviewed the summaries of CCRTA's projects and began the process of developing the scope of the pilot activities with CCRTA staff. Unfortunately, CCRTA decided that their project deadlines were too tight to add EAP activities related to the projects and withdrew from the pilot effort.

Dallas Area Rapid Transit (DART)

DART was very interested in piloting aspects of the EA model and spent a significant amount of time with the research team defining what would occur in the pilot. The team worked with DART's Director of Technology Program Management to begin drafting a Memorandum of Understanding (MOU) for the pilot. Several products were developed for DART staff to use to collect information and insert it into a database management system with the connections among architecture layer components already defined. These included the following:

- Spreadsheet/database (and model) of WMATA's business processes, data components, applications
- Preliminary traceability to TCIP application categories/types
- Draft metamodel and template descriptions that applied to DART
- Changes to the metamodel and templates used that would be used to collect and insert the data collected into the database management system and EAP software
- Guidance on how to apply the TEAP

The research team began developing templates specifically targeted for DART's scope. Several database models, templates, and forms were developed for collecting information; the scope was focused such that the effort could be accomplished in the 6 weeks allocated for the pilot.

Ultimately, DART management had a higher priority for the key staff person who was working with the pilot over the project time period. The work had to be deferred or dropped.

Lessons learned from DART:

- It is difficult to start up an EAP project even with tools
- There is a need for dedicated resources (especially time) to initiate the project
- It is important to have a high-level managerial champion for the project (not just acquiescence as a "nice to have")
- It is critical to have a strong commitment to build EAP over the long run

Chicago Transit Authority (CTA)

CTA recognized the need for a comprehensive, enterprise-wide understanding of their technologies and where they're going. As a result they hired Douglas Dalrymple, who has EAP expertise, as a Senior IT Solutions Project Manager in CTA's Project Management Office (PMO). Doug was excited to be involved in the TEAP pilot effort. Although he did not participate in the workshops he was briefed by J. Harvey (WMATA) and tested Reference EAP materials and partici-

pated in the pilot interviews. We are still working with him by providing guidance on the templates and tools developed for the wiki. Key results of the pilot interview with Doug Dalrymple are included below.

One of the primary reasons for wanting to develop an EA at CTA and participate in the pilot was to develop a good, comprehensive, updated technology strategic plan for CTA. The business and information layers of the EA are particularly important in developing a good strategic plan. Participation in the pilot and use of the wiki were also valuable for gaining more transit contacts and developing a network of transit staff that can share ideas, lessons learned, and work products.

Mr. Dalrymple has already begun the process of incorporating the WMATA governance model from the wiki and modifying it for CTA. The "swim lanes" will be unique to CTA. Further, the TEAP wiki materials have assisted him in starting to build CTA's business layer of their EA. His preliminary results have already triggered valuable discussions and better understanding of complicated processes. He has indicated that the wiki was well structured for this.

Other reasons cited for pursuing the development of an EA are the benefits of having business needs drive the technology investments. Further, an EA gives an enterprise view of what CTA has. The organization needs and wants to understand the costs of their business processes and systems to understand the true cost of ownership. A good EA provides critical documentation of systems and their relationships, so that inevitable retirements of senior staff don't result in a harmful loss of key institutional knowledge. Also, if an agency has old systems, it needs clear documentation so issues and failures can be fixed quickly. Additional details of this effort may be found in Appendix C: Validation Report.

King County Metro (KCM) and the Department of Transportation

Business Solutions Group Supervisor, Stephen Bell, agreed to review and discuss EA materials within the context of his organization, the King County Department of Transportation, which includes KCM. He was an active participant in the pilot workshops, reviewed materials, and participated in the pilot interviews. In addition, he provided some very clear and concise documentation that provides an overview of EAP, which should be integrated into the wiki.

He and his organization are looking at EAP to improve the strategic alignment between business goals and technology. Also, the agency now wants the ability to link the cost of an investment with its performance effectiveness. He felt that given the increasingly complex technology and business environment at the organization, a tool like EAP can help manage the increasing complexity. The EA would serve as a map to help get a handle on the complexity and it would help an agency gain speed and agility. King County doesn't have an EA, although it strives for an enterprise-wide perspective. They are looking at options and prefer an approach that is conformant to a larger methodology.

In reviewing the wiki, he felt that it provided a lot of knowledge and references, but EAP is a complicated topic and, in general, transit does not know too much about it. Most agencies will not be able to afford an Enterprise Architect. The wiki needs to assist transit in understanding the EAP value proposition and how to get help. In agencies where a lot of people are retiring, the risks from inadequate documentation can be high. EAP helps with the documentation and helps minimize risk. Further, the documentation that arises from an EAP process can help new staff, vendors and consultants to better understand the business.

Some of the features of the wiki that he reviewed and found useful were as follows:

- The enumeration of the transit business areas and common processes.
- Discussion that related EAP, COBIT, and systems engineering, although more could be said about them.
- Seeing ABACUS® outputs that were in the transit domain. (For more information, see the section of this report titled "Testing within EA Modeling Software—ABACUS Enterprise Architecture Software").

He also provided some additional comments on the wiki site and its topics, such as:

- Make it clear why a transit EA is needed. It can be a hard sell because it's complicated.
- An EA improves the ability to see interconnections. Requirements, connections and opportunities will be missed if a new project is done as a silo. Staff can miss issues when a system is complicated, and the EA helps them see the implications, connections, and redundancies.
- Larger agencies need a software tool to help maintain the EA components and relationships.

Utah Transit Authority (UTA)

UTA helped with the development of the TEAP fare management solution model and tools. Toward that goal, UTA presented materials and an overview of their fare architecture and implementation, plus they were active workshop contributors and they participated in the pilot interviews. After being walked through UTA's fare implementation, the TEAP team developed an "open payment" fare management solution model including business, information, application, and technology layers and their interconnections. The model was returned to UTA for review. In addition, other transit agencies

were asked to review the model to ensure its correctness and validity for more than a single agency.

Following the Reference TEAP (and solution model) development, Abraham Kololli, UTA's Information Systems Manager, participated in the pilot interviews to obtain feedback from their review of the process, the reference model, and wiki guidance materials. The interview results are highlighted below.

- For UTA, the goal is the outcome of EAP, which is good accessible documentation, not the EAP process itself. The wiki and the project workshops provided new source materials and ideas for improving what is done at UTA.
- The TEAP wiki can help transit agencies with a number of issues, such as understanding the importance of knowing their business needs before proceeding with technology investments.
- Templates, like some on the wiki, can help you think of or remember critical things as you are planning, implementing, or maintaining systems.
- EA is all about documentation. If "Joe" falls off the face of the earth, what are you able to do with him gone and how quickly can you recover from his absence? It depends on how good your documentation is.
- We have lots of documentation, such as guidance to staff, source safe, source code, and flow charts. A new employee could spend weeks reading and learning before touching any code. We have documentation standards and our documentation is heavily linked to our IT Disaster Recovery Plan, which fits with the overall organization's Disaster Recovery Plan.
- One of the benefits to transit from the EAP models and templates available on the wiki could be much better Disaster Recovery Plans. The tools and information can help an agency create better documentation in their Disaster Recovery Plan, which is crucial.
- The wiki and EAP can help prompt the development of a comprehensive list of "what's out there" and "what talks to what."
- Most agencies don't have the resources that are needed to be devoted to an EAP process, so ways to share efforts and information, such as this wiki, are helpful.
- Some of the additions or improvements to the wiki that were mentioned are:
  - Wish it were national. Wish there were contacts: agency names, staff names, phone numbers for people that are doing these things or are considering it. A possible downside is that people may talk off-line and forget to add to the wiki.
  - Have folders for each of the ITS areas so agencies can figure out who's implemented the type of system or is in development. Could have a place to volunteer one's name.
  - Links to RITA resources and list, if they are not already included.
  - Can have online chats.
  - Some people don't know what a wiki is and how it can be used. The open source crowd knows what it is. With diverse users, you need to determine how to allow more or less access and ability to change the wiki content.
  - Having some generic architecture examples on the wiki for things like Wireless Architectures may cut down on repeat questions to specific transit agencies.

Testing within EA Modeling Software—ABACUS Enterprise Architecture Software

In addition to the transit agencies that helped pilot test and comment on the TEAP wiki and EAP materials, one vendor heard of the project and volunteered time and software tools to help with a different type of pilot testing. The vendor worked in conjunction with WMATA staff and the research team to see if the TEAP Transit Reference EA model could successfully be input into general EAP industry modeling software.

The EA tool, ABACUS, is designed for modeling, understanding, and analyzing complex enterprises across people, processes, and technologies. At the vendor's website, ABACUS is described as:

> . . . a flexible modeling tool that predicts the benefits, effectiveness and cost of alternative strategies. This is achieved through:
>
> - Analyzing an enterprise using metrics such as total cost of ownership, performance and reliability, and performing sophisticated trade-off analysis for guided decision making;
> - Uniting various levels of a complex enterprise into an integrated, hierarchical, single point of truth; and
> - The communication of an enterprise model and analysis using graphs, two dimensional pictures and advanced three dimensional visualisations.

A critical element of any model is to ensure its logical consistency, completeness, and validity. Much of these attributes are testable through functions using a database management system or special-purpose tools. WMATA's EAP is stored in a special-purpose tool (ABACUS) that models and stores architectures. A WMATA staff person and EAP vendor who supports WMATA's EAP model (http://www.avolution.com.au/products.html) volunteered to implement the Reference TEAP into ABACUS. The implementation achieved several objectives:

- Provided additional resources for transit agencies to implement the reference EA.

- Validated the logical consistency of the Reference TEAP (relationships).
- Provided for demonstration of "what if" scenarios and visualizations that were not possible for the project team to present (due to limited project resources).

The TEAP wiki provides several outputs from ABACUS, including its native file format and hyperlinked report of the model. In addition, the TEAP MS Excel files are consistent with the ABACUS TEAP content and serve as templates that provide round-trip editing tools for any EA tool vendor that may wish to enter the transit market.

Summary and Key Findings

The evaluation phase was successful in achieving the primary goal of obtaining transit agency involvement in reviewing, using, and helping to improve the TEAP Framework content on the TEAP wiki. Transit staff participated in the three EA workshops, provided documents, updated and tailored materials for the workshops and the wiki, began the process of testing and customizing EA materials provided via the wiki for their own agencies, participated in follow-up interviews, and contributed ideas and materials for improving the TEAP wiki content.

No single agency was able to do an in-depth pilot and test of the EA materials during the TCRP TEAP project time period. Unfortunately, the current economic troubles in the United States have added even greater stresses on transit agencies, including those that wanted to pilot test the materials and tools. All the transit agencies that agreed to participate in the pilot had less time than they desired to work on it or had to withdraw. Ironically, at times like these, documentation of "as-is" and "to-be," such as EAP provides, is most helpful and valuable in helping maintain, enhance, and develop technologies efficiently. Nonetheless, the time that the transit staff was able to contribute was highly valuable.

The TEAP project's multi-faceted approach that was developed for the pilot, given early concerns about transit agency time availability, worked well in obtaining much valuable transit feedback and developing new tools and reference materials. The pilot feedback was more diverse, coming from many agencies, rather than from one in-depth study. In the evaluation phase, the research team accomplished the following:

- Conducted EA/EAP training workshops.
- Obtained feedback and documents from transit staff.
- Created a generalization of a transit reference enterprise architecture, with tools and templates, and published it on the wiki.
- Developed an approach for transit agencies (large and small) to apply the reference EA as a building block to expedite the EAP.
- Enhanced many parts of the wiki, including the front page.
- Revised and improved the Guidance for Transit Managers.
- Received the transit reference EA model information in ABACUS EA software for review via a donation by a vendor of time, effort, and access to their software tool.
- Gathered many suggestions and other ideas for potential improvements to the wiki that can be incorporated in the future.

The transit participants in the pilot phase felt that the wiki was very valuable and helped with a wide range of transit issues. Some of the benefits they mentioned are summarized as follows:

- The TEAP wiki can help transit agencies with a number of issues, such as
  - developing effective strategic plans and
  - understanding the importance of knowing their business needs before proceeding with technology investments.
- The wiki templates can help you identify critical items as you are planning, implementing, or maintaining systems.
- The EAP models and templates on the wiki can be used to create more effective Disaster Recovery Plans.

In addition, the transit participants gave many suggestions and ideas for potential improvements to the wiki that can be incorporated in the future, such as:

- Develop generic briefing materials for executive managers and board members that help them understand the value of EAP and the need to support EAP efforts.
- Develop information on how to build a business case for EAP, including some examples and key indicators.
- Reinforce the point that the transit business areas have to be involved.
- Include national contact information (agency names, staff names, and phone numbers) for transit agencies that are doing, or are considering doing, EAP or ITS applications. Have it organized by categories.
- Consider having a place for vendors and consultants to list services, tools, and other related products.
- Have some generic project architecture examples on the wiki for things like Wireless Architectures and some ITS applications.
- Investigate the possibility of online chats.
- Ensure that the wiki contains information on the benefits of forming an IT Steering Committee, including benefits to the organization as well as to the participants on the committee.

- Continue to add examples of how other transit agencies do things, such as how they use a good business plan to drive the technology plan.
- Advertise the wiki and steer more agencies and transit staff to it.

Conclusion and Final Comments

The state of the practice survey and the pilot results demonstrated the transit industry's overall difficulty in finding the needed resources and time to fully develop all the elements of the TEAP Framework within most transit agencies. Return on investment (ROI) data are still elusive with respect to EA efforts because there are so few agencies that have the resources to implement and measure the concrete benefits of implementing and maintaining an EA. All the transit staff that participated in this project wanted to make further progress in the TEAP Framework areas at their agencies and they generously helped improve the relevance and quality of the products and tools produced by this project.

They recognized that transit EA information is valuable for many purposes. The creation of the solution architectures helped show the benefits of creating generic transit templates and providing examples. One of the benefits of having EA information about a transit agency's technology and business environment is similar to a renovation/rehabilitation project having blueprints. Having an accurate building blueprint accelerates deployment and mitigates risk when building on to or fixing a problem in the facility.

Finally, the transit staff felt that the wiki makes the information about the TEAP Framework more accessible and easier to update on an ongoing basis. Further, it enables the transit community to share ideas, approaches, and tools to become more successful.

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Abbreviations and Acronyms

ADM	Architecture Development Method
AFC	Automated Fare Collection
ANSI	American National Standards Institute
APC	Automatic Passenger Counter
APTA	American Public Transportation Association
APTS	Advanced Public Transportation System
ATIS	Advanced Traveler Information System
AVL	Automated Vehicle Location
BC	Business Case
BCM	Business Case Methodology
BPI	Business Plan Initiation
BSI	Bus Stop Inventory
CAD	Computer Aided Dispatch
CIN	Consumer Information Network
CIO	Chief Information Officer
CIS	Customer Information System
COTS	Commercial Off-The-Shelf [software]
CSF	Critical Success Factors
DB	Data Base
DBA	Data Base Administrator
DBMS	Data Base Management System
EA	Enterprise Architecture
EAP	Enterprise Architecture Planning
EIA	Electronics Industries Alliance
FAA	Federal Aviation Administration
FEA	Federal Enterprise Architecture
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GPS	Global Positioning System
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers

INCOSE	International Council on Systems Engineering
IR	Incident Report
IT	Information Technology
IT/ITS	Information Technology/Intelligent Transportation System
ITS	Intelligent Transportation System
IVBSS	Intelligent Vehicle-Based Safety Systems
ISO	International Organization for Standardization
KCM	King County Metro Transit (headquartered in Seattle)
MARTA	Metropolitan Atlanta Rapid Transportation Authority
MDT	Miami-Dade Transit
NASCIO	National Association of State Chief Information Officers
NTCIP	National Transportation Communications for Intelligent Transportation Systems Protocols
O&M	Operations and Maintenance
OS	Operating System
PC	Personal Computer
PIR	Post-Implementation Review
PROI	Public Return on Investment
PMO	Project Management Office
RACI	Responsible, Accountable, Consulted, Informed
RFP	Request for Proposals
RITA	Research and Innovative Technology Administration of the U.S. DOT
ROI	Return on Investment
RT	Real Time
RTS	Real Time System
SDLC	System Development Life Cycle
SE	Systems Engineering
SEPTA	Southeastern Pennsylvania Transportation Authority
TCIP	Transit Communications Interface Profiles
TCRP	Transit Cooperative Research Program
TCO	Total Cost of Ownership
TEAP	Transit Enterprise Architecture and Planning
TOGAF	The Open Group Architecture Framework
TSP	Transit Signal Priority
TriMet	Tri-county Metropolitan Transportation District of Oregon
U.S. DOT	United States Department of Transportation
UTA	Utah Transit Authority
WAN	Wide Area Network
WMATA	Washington Metropolitan Area Transit Authority

APPENDIX A

Guidance for Transit Managers

TABLE OF CONTENTS

1 Introduction

Transit has become more and more dependent on the successful operation and interaction of its automated systems. Managers in all areas of transit are incorporating Information Technology (IT) and ITS systems to improve system performance and provide critical information for effective decision-making and the efficient provision of transit service. Those systems increasingly interact with systems managed by other areas within the transit organization, necessitating a higher degree of systems thinking and planning. In general, successful transit IT/ITS projects can no longer be implemented with only the attention of the IT department.

Many of the issues associated with poor implementations of technology projects can be avoided if transit managers from all business areas step forward and take a leadership role in ensuring that their organization and the IT/ITS project teams implement the key principles and elements of the Transit Enterprise Architecture and Planning (TEAP) Framework.

This Guidance for Managers addresses:

- A TEAP Framework Executive Summary (Section 2.1) that briefly describes the benefits of the Framework and its five elements, and provides a few examples of how the elements interrelate and increase their value to transit. Read this section to gain a better understanding of how using the Transit Enterprise Architecture and Planning Framework can improve your agency's IT/ITS project outcomes.
- Manager's Roles & Checklists (Section 2.2), which provides guidance on manager's roles and steps that transit managers can undertake to help improve the likelihood of success of IT/ITS projects and to improve the value of transit IT/ITS investments. Use this section to help assess issues and to point to specific actions that can be taken to improve the process of selecting, defining and implementing IT/ITS projects.

2 TEAP Framework Executive Summary

The goal of the *Transit Enterprise Architecture and Planning (TEAP) Framework* project is to provide transit agencies with a roadmap, based on a Transit Enterprise Architecture and Planning Framework, to successfully implement IT/ITS systems that meet their business needs. Among other benefits, the Framework and its elements help an agency leverage its IT/TS investments and maximize their value to the organization.

2.1 What does the Framework do?

The Framework helps transit professionals understand the financial, operational and management impacts of technologies, to help them better meet their enterprise business process needs and corporate objectives. The Framework will also help guide an agency's IT/ITS planning process, improve its understanding of risks, better manage the project implementation effort, validate and verify compliance with its needs, and measure results and benefits.

Specifically, the TEAP Framework guides transit in:

- Planning how information, services, and technology will connect across an enterprise to support business processes, solve problems, and measure performance;
- Promoting information sharing across agency and institutional barriers;
- Ensuring that IT/ITS projects are defined and staged in a way that ensures best value and supports successful project implementation, operations, and maintenance;
- Ensuring that the benefits and costs of proposed IT/ITS projects are understood across the project's lifecycle (including operations and maintenance) and that resources are available to support the program;
- Specifying IT/ITS projects to maximize the IT/ITS investment decisions across the organization;
- Ensuring that IT/ITS projects meet stakeholder needs: requirements are explicitly described, risks are identified and mitigated, and the system development process is managed to ensure that correct operations and requirements are met; and
- Describing the leadership and processes that ensure that the organization's IT group supports and extends corporate strategies and objectives.

2.1.1 What are the TEAP Framework elements?

The TEAP Framework comprises five elements, shown in Figure 1. They provide tools for planning, developing, deploying, and evaluating the systems and technologies that best meet an organization's objectives. These key elements of the Framework are:

- Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) development process (developing the blueprints);
- Business Case Methodology (how well does this project fit into the your stated priorities; what are the risks, benefits and costs, and estimated return on investment [ROI]);
- Funding (how to pay for IT/ITS projects);
- System Engineering for helping to design and manage an IT/ITS Project implementation; and
- Post-Implementation Analysis to assess whether the implementation met project and agency goals and achieved a meaningful (estimated) ROI and to review the project implementation experience for lessons learned.

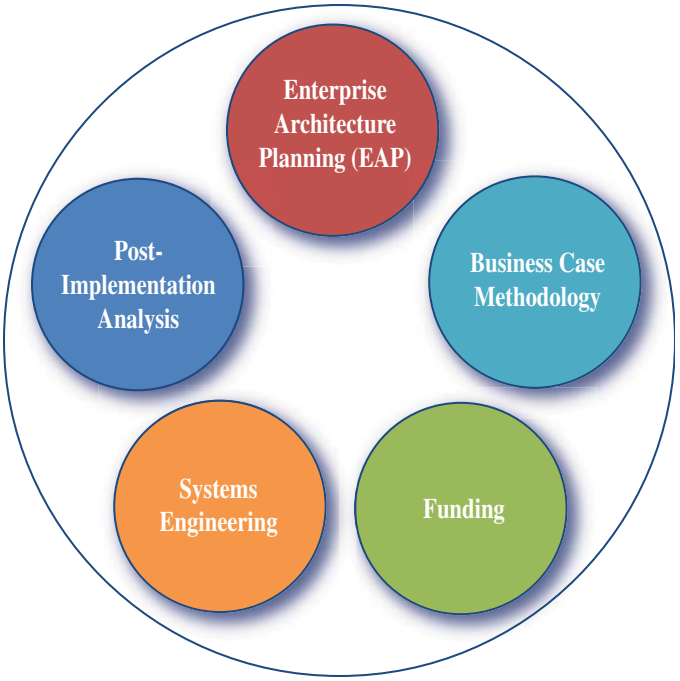
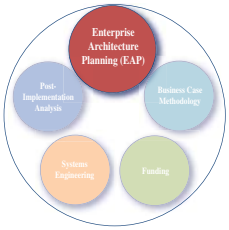


Figure 1. TEAP Framework elements.

Looking at each element in more detail clarifies the role each plays and how they work together to create a successful TEAP Framework.

2.1.2 Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) Overview



The *Enterprise Architecture Planning* process is a set of activities used to develop the Enterprise Architecture models, diagrams and descriptions. The process relies on stakeholder input to document the agency's current performance measures, business processes, data, applications, and technologies, reflecting the organization's "as-is" architecture. Next, a "to-be" architecture is developed that documents where the organization wants to be with respect to its business in the future. A four to five year horizon works best here. It consists of the corporate mission, goals, objectives, and the business processes, data, applications, and technologies that are needed to support that vision. The third step describes the "gap" between the current ("as-is") and the future ("to-be") and how to close it. The Enterprise Architectures, both the "as-is" and "to-be" architectures, are composed of four or five models (Business, Data, Applications and Technology, plus in some approaches a Performance model) that are depicted in one or more diagrams, policy statements, procedures, inventories or other pieces of information. The term used to describe these is "artifact."

The *Enterprise Architecture* is a dynamic repository of knowledge, in an organized framework. By providing an overview of the current status and the future desired state of the business and technology, it facilitates the coherent planning and development of technology purchases ahead of time, to optimize the use of resources and the value of the investments.

The Enterprise Architecture links projects to business strategy by associating critical business processes, organizational resources, and service performance with supporting applications, data, and technologies. EA models can generate insight into cost savings and productivity increases because they link resources and costs that apply to the business, information used for decision making, applications and technologies. Put into practice, this element might show how cuts in staffing may impact an IT system's effectiveness since technology enhancements may not be efficient if there are limited staff resources to support the information needed by the IT solutions. For example, a bus annunciation system relies on maintaining a high quality bus stop inventory with accurate locations of each bus stop by trip/pattern/route. If there are cuts in staff or resources, and the inventory is not maintained then the Annunciation System will not provide accurate information to riders. The EA models the business needs and shows the linkages to the information sources, applications, and infrastructure components.

Guidance for transit managers related to EA/EAP is included in Section 2.2.2.

2.1.3 Business Case Methodology Overview

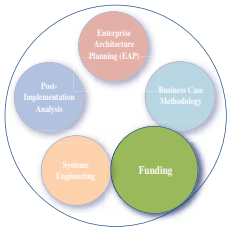
A Business Case Methodology (BCM) is a formal analysis used to justify and capture the reasoning for initiating a project.

The business case typically reviews and verifies that *(1):*

- The proposed investment has value and importance
- The project will be properly managed
- The organization has an adequate plan and the capability to deliver the benefits
- The organization's resources are working on the highest value opportunities
- Projects with inter-dependencies are undertaken in the optimum sequence.

Guidance for transit managers related to BCM is included in Section 2.2.3.

2.1.4 Funding Overview



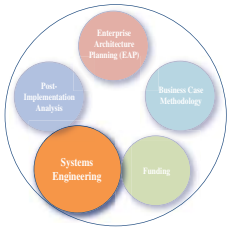
IT/ITS Project Funding discusses approaches for obtaining and making use of various sources of funding for IT/ITS projects. Like IT projects in general, transportation IT and ITS projects are delivered through public leveraging options like bond financing, public-private partnerships, co-mingled funding, and a variety of Federal, state and local funding sources.

Transit agencies are using many of these financing mechanisms to access the various sources of capital for IT/ITS projects. Historically, buy (pay-as-you-go), borrow (issue bonds), or lease were the primary financing mechanisms used by transit agencies. Since the 1990's, there has been more creative use of these traditional mechanisms and the introduction of public-private partnerships. Financing mechanisms, particularly four categories—debt mechanisms, capital leasing financing, equity and partnerships, and credit enhancements—have been important.

Based on a modest survey of transit agencies, it was found that no one financing method works for all situations, rather financing decisions need to be tailored to the specific project, region and financial circumstance.

Guidance for transit managers related to IT/ITS funding is included in Section 2.2.4.

2.1.5 Systems Engineering Overview



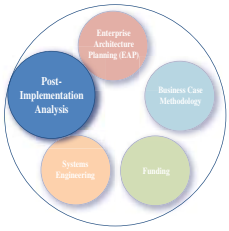
Systems Engineering (SE) is a discipline that helps ensure that customer needs are implemented in the system that is developed. Customer needs are defined by those who have a vested interest in the system, such as a user, a manager, or someone impacted by the operations of the system (e.g., recipient of information or process coordination partner).

Customer needs drive the system requirements, or what the system should do. For example, if there is a need to measure ridership at stops for each trip and an Automated Passenger Counting (APC) system is being proposed to do the counting, then there must be a corresponding system requirement for the APC system to count boardings and alightings at each stop by trip identifier. The systems engineering process ensures that the requirement is described in the design and consequently implemented in the software and that data is collected, stored, and reported in a format that supports its use as a performance measure. The steps prescribed by the Systems Engineering process ensure a structured approach to track customer needs throughout the development stages of an IT/ITS project.

US DOT recognized the potential benefit of the systems engineering approach for ITS projects and included requirements for the use of the systems engineering process in the FHWA Final Rule/FTA Final Policy on Architecture and Standards that was enacted on January 8, 2001.

Guidance for transit managers related to SE is included in Section 2.2.5.

2.1.6 Post-Implementation Analysis Overview



Post-implementation analysis or Post Implementation Review (PIR), as it is commonly called in the IT field, is conducted at the final stages or right after a project has been completed. "The purpose of the PIR is to evaluate how successfully the project objectives have been met and how effective the project management practices were in keeping the project on track." *(2)* This information can be used to improve project management processes and guide where the next set of investments should be made. The PIR and associated ROI analyses can also help demonstrate how the project made a difference and identify lessons learned.

The PIR is *not* the testing and verification activities that are typically performed in a project acceptance or closeout phase. For example, an Automatic Vehicle Location (AVL) system may have to be accepted from a vendor if it performs according to the requirements in the Request for Proposal (RFP), it passes the test plan, and satisfies the systems engineering verification process. The system, however, may not perform the way the users want. Perhaps the business changed or the project was specified ambiguously and/or incorrectly in the RFP and System Requirements. The post-implementation analysis plan is also sometimes called a Validation Plan.

In summary, the PIR occurs after the IT/ITS system has been incorporated into the business and assesses how well the project meets the users' needs, what needs to be done next, and how well the implementation process went. Developing and sharing lessons learned can continuously improve the agency's project acquisition and management processes.

Guidance for transit managers related to Post Implementation Analysis can be found in Section 2.2.6.

2.1.7 How do the TEAP Framework elements relate?

Figure 2 below shows the TEAP Framework and how the framework elements relate to each other at a high level. By using the Framework elements together, the value of the Framework is much greater than the sum of its parts. For example, the information in the Enterprise Architecture can

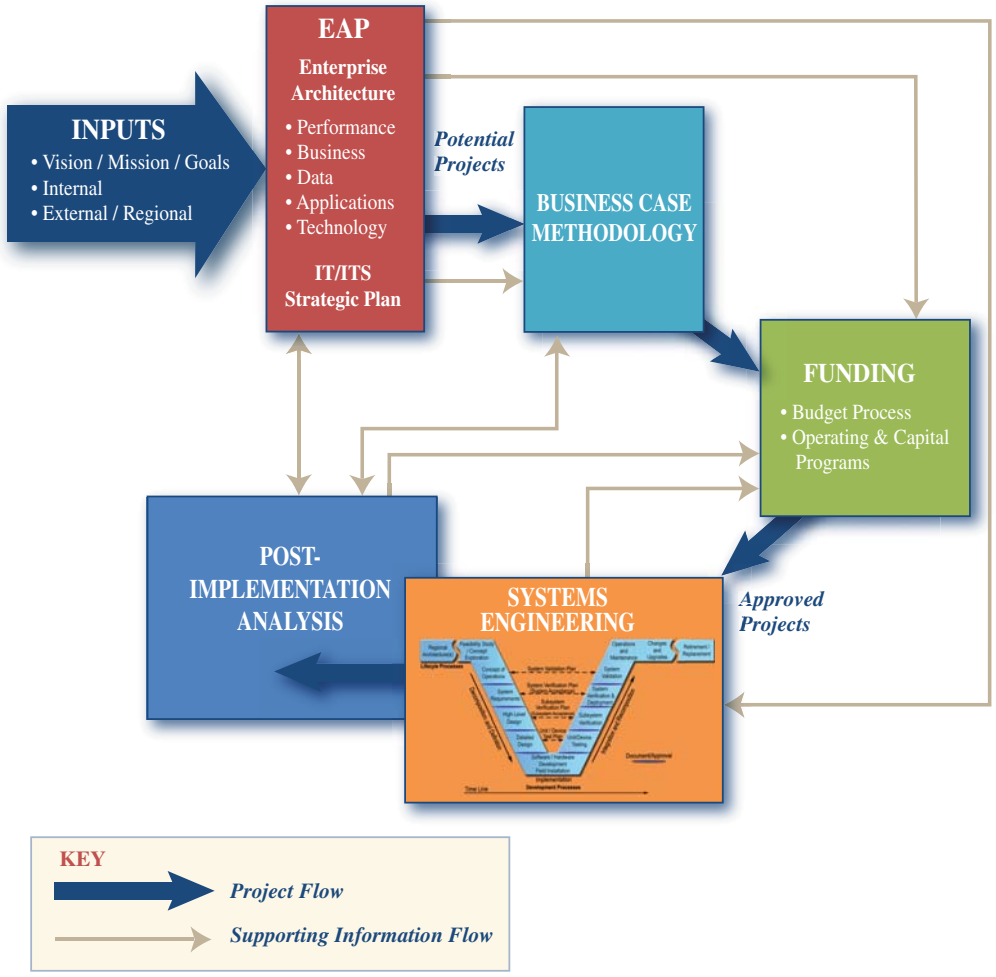


Figure 2. How Framework elements relate.

improve the speed of developing the Business Case Methodology and the project requirements in the Systems Engineering process. It also improves the quality and completeness of those products. A well developed Business Case helps ensures that a project gets funded and that the funding is at the appropriate level. It also helps ensure that the plan and resources are available to gather baseline data needed to prove that the project made a difference during the post-implementation analysis. Information from the systems engineering steps can help decision makers advance a project effectively through funding "decision gates."

2.1.8 Growing Need for TEAP Framework Knowledge & Skills

As competition for limited resources increases, the need for skills in building a good business case, arranging funding, using EAP to improve the value of the investment, managing projects with good systems engineering practices, and proving value with post-implementation analysis, will increase.

2.2 Manager's Roles & Checklists

This section is intended to assist transit managers in enabling their staff and the transit organization to effectively acquire, assess and enhance IT/ITS systems. A general set of roles for transit managers are included as well as checklists that are specific to each of the TEAP Framework elements.

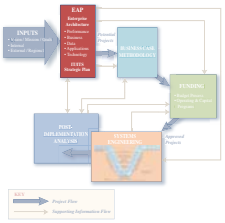
2.2.1 Key Roles for Managers

Key roles for all the members of the transit management team are to:

- Ensure a common vision for the organization and communicate goals and priorities. If vision and goals are not clear, scarce IT resources may be spent on less critical projects.
- Ensure that IT/ITS systems support the agency's operational needs. The organization's goals should be one of the drivers of the IT/ITS project's goals, objectives, and requirements.

- Be champions of integration and an enterprise-wide perspective when IT/ITS projects are being developed. Without management championship of an enterprise-wide perspective, the focus of staff and projects will be more "stove-piped," resulting in a loss of resource leveraging, missed issues that cause problems later in the project life cycle, and the loss of potential efficiencies.
- Provide oversight and encourage staff as they implement technology solutions that take into consideration enterprise-wide needs and issues. Staff will likely need both training and encouragement as they adopt new system development approaches.
- The transit General Manager and the head of Information Technology have particular responsibility for ensuring that an integrated, agency-wide approach is taken for developing data and information systems solutions. *(3)*

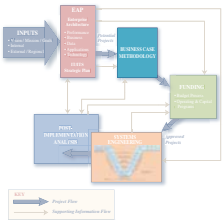
2.2.2 EA/EAP Checklist for Managers



All transit managers can both support and gain benefits from fostering thinking with an enterprise-wide perspective and from developing an Enterprise Architecture at their organization. Included below is guidance for transit managers on actions related to EA/EAP they can take that will benefit their organization and/or the transit agency as a whole.

- Have more effective IT staff and IT/ITS project team members by increasing the availability of knowledge about your business goals and processes through actions such as:
  - Providing educational tours of your business area to IT and IT/ITS project staff.
  - Working with other transit managers and groups to allocate time and resources for identifying and documenting the business relationships and dependencies between the groups.
  - Supporting the development and documentation of the EA Business Architecture that helps team members from different groups and new staff understand how the business works ("as-is") and how it is planned to work in the future ("to-be").
  - Helping communicate an *Enterprise Architecture Vision* for the agency that promotes the move towards enterprise standards for performance metrics, information, software, and hardware.
- Foster the mind-set in your organization that data is a corporate asset requiring governance discipline and management procedures such as standardization, quality control, documentation of issues and other metadata (information about data), data security, preservation, and appropriate access.
  - Support the development of an Enterprise-wide Data Architecture by providing staff support to help with the definition of current and future data requirements, data dependencies with other systems and groups in transit, and other needed information.
  - Ask staff if data standards are available, or can be developed agency-wide, that streamline data maintenance activities.
  - Only approve data set development in your organization after ascertaining throughout the organization if other requirements can be incorporated that may allow cost sharing and that maximize the value of the effort and data to the organization. As the enterprise-wide Data Architecture is developed, this review and coordination task gets quicker and easier.
  - Create a grass-roots advocacy for key data sets by advocating data "owners" and "custodians," and provide a forum where their issues may be addressed.
- Ensure that your business area has a complete inventory of all the technology systems and applications that are needed to run your business. Typically, an inventory may exist of systems supported by the IT department, but other critical spreadsheet and database applications developed within the business area may exist that are not inventoried nor understood by more than one person.
  - Take actions to reduce operating risks due to systems that are undocumented, poorly backed-up, or dependent on only one individual.
  - Ask staff to move towards greater standardization and version control of software and hardware.
  - Understand licensing restrictions of third party software and its interfaces; this becomes critical when application data is needed for downstream applications.
- Promote alignment of project development and procurement efforts with the "to-be" EA transition plan or "gap" analysis. The EAP transition plan may also specify the development of standards and templates for hardware, software, interfaces, and data. These standards will enable faster deployment and more effective management of the system's lifecycle.
  - Ensure that the procurement process reviews the project specifications and procurement criteria against the EA IT standards.
  - Establish a role for appropriately appointed IT staff on every project with a technology component to ensure alignment with the Enterprise Architecture Vision.
  - Ensure that the description of potential impacts is based on a review of the EA linkages among business strategies, business processes, information, applications, and technology.

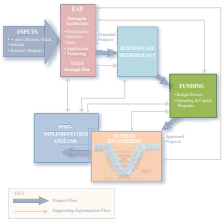
2.2.3 Business Case Methodology Checklist for Managers



This section provides guidance for transit managers related to the Business Case Methodology (BCM).

- If your organization does not have a BCM, work with the IT Manager and the other transit managers to have a formal analysis process developed or acquired, even if it is a simple one. Support the development process by providing goals, guidance and a thoughtful review.
- Make sure that the transit executive management team understands and owns the BCM because it plays a critical role in investment decision making and how their proposed projects will be understood and judged.
- Ideally, the management team should review the process and ensure that it is unbiased and contains the information needed by the IT department, the transit business areas, finance and budget, and other key stakeholders.
- Further, the transit management team should review and guide policy and practices concerning how flexible the BCM should be. For example, should the BCM be modified to have a simpler form for less expensive and less risky projects?
- Review the Business Case for proposed projects and determine if a project meets agency goals, adequately addresses risks, and is financially viable before it is allowed to start.
- Provide oversight of proposed projects throughout their lifecycle and ensure that the business case is updated at agreed-upon project steps or phases. As the project moves through phases, estimates can be updated as additional information becomes available and assumptions pertaining to scope, schedule, and budget get confirmed or disproved.
- The business area manager for the proposed project (e.g., Manager of Operations, Manager of Customer Services, etc.) and the IT Manager should jointly assume accountability for the validity of the assumptions and project approach.
- Ensure that the metrics used in the Business Case are business-relevant and matter to key stakeholders.

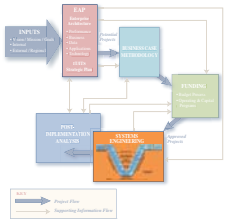
2.2.4 Funding Checklist for Managers



This guidance for transit managers relates to considerations for managing or overseeing IT/ITS funding issues.

- Prioritize proposed IT/ITS projects, taking into consideration the agency's goals and the project development dependencies with other IT/ITS projects.
- Develop a "gated approach" to requesting and releasing IT/ITS project funding that fits the needs of your organization and the size and importance of the project. A "gated" approach helps reduce risk and continually refines the project scope, schedule, and budget so a project is not held accountable against early, poorly refined estimates. One example of such an approach would be to:
  - Require the development of a preliminary Business Case for a proposed project.
  - If the Business Case makes sense, the project passes through a "gate" when the management team releases funding to develop functional requirements, a preliminary concept of operations, and refined scope, schedule, and budget information.
  - Review the new materials from the prior step; if all still looks good, the project passes through another "gate" when the management team releases funding to develop the project implementation approach, including further refinements to the scope, schedule, and budget.
  - Review the implementation approach materials from the prior step and determine if additional information is needed by the management team before releasing the project and funds through this "gate" into the implementation phase.
  - The IT Manager and the Business Area Manager for the project should continue to monitor the project's progress and expenses throughout the project's life cycle.

2.2.5 Systems Engineering Checklist for Managers



This section provides guidance to transit managers relative to the use of systems engineering for project development. The guidance is designed to help managers ask questions to better understand what is occurring during the planning and development of an IT/ITS project and to provide better oversight and support to the projects, whether they are run by consultants or by transit staff.

General Guidance

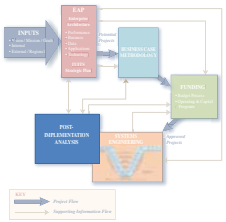
- Identify personnel within the organization who have systems engineering experience.
- If the agency does not already possess it, put plans in place to obtain the necessary knowledge and skills pertaining to the systems engineering process, whether it is high level training for managers or more detailed training for project managers.
- Define a process for reviewing proposed projects to determine to what degree the systems engineering process is needed for each project.

Project-Specific Guidance

As a manager, ask the following questions with respect to each agency IT/ITS project, then provide guidance and support as needed to help ensure the success of the project.

- Is it a low-risk or high-risk project? If the project is high risk, then use of the systems engineering process is essential to its success.
- Has the agency assigned a project manager who has experience with the systems engineering process?
- Have the stakeholders who will be affected by the project been identified and are they participating in the project development steps?
- Have stakeholder needs been identified and documented (e.g., in a Concept of Operations)?
- Ensure that all the transit managers understand the Concept of Operations for a new project. Additional stakeholder needs and issues may be uncovered during the management team meeting to review the Concept of Operations.
- Have system requirements been defined, traced to the needs, and documented?
- Did the design of the project consider alternatives rather than assuming a solution?
- Is there a plan to verify that the system requirements are met by the completed system?
- Has there been planning for Operations and Maintenance? This might first be documented in the Concept of Operations and then described more completely in an Operations and Maintenance Plan.

2.2.6 *Post-Implementation Analysis Checklist for Managers*



This section provides guidance to transit managers relative to the use of Post-Implementation Analysis. The guidance focuses on management activities that ensure that the benefits of completing post-implementation analyses are realized. A number of the steps also improve the value and success of other phases of an IT/ITS implementation.

- Ensure that a realistic Post-Implementation Review (PIR) Plan or Project Validation Plan (depending on the terminology used by the agency) is developed before the systems development is started so appropriate "before" data can be collected.
- Ensure that financial analyses, such as ROI with cost, benefit, and Total Cost of Ownership considerations are completed during the development of the Business Case. These analyses can be used to assess whether the completed project met or exceeded the original expectations.
- Provide motivation, oversight, and the resources necessary to collect the data.
- Ensure that the project verification steps in the systems engineering process, which verify that requirements are met, are completed before system acceptance and project closeout.
- After project closeout, ensure that the PIR data collection plan is underway, so the post-implementation analyses can be completed.
- Request and review the post-implementation analysis report.
- Follow-up to make sure appropriate system and process improvement recommendations are implemented.

3 References

1. Description derived from http://en.wikipedia.org/wiki/Business_case [November 20, 2008]
2. From the Washington State Department of Information Services, Information Services Board, Project Management Framework, Closure-Post Implementation Review, http://isb.wa.gov/tools/pmframework/projectclosure/postimplementation.aspx
3. *Best Practices for Using Geographic Data in Transit: A Location Referencing Guidebook,* Paula Okunieff, Nancy Neuerburg, and Teresa Adams, 2003

APPENDIX B

State of the Practice Synthesis

TABLE OF CONTENTS

1 Introduction

1.1 Scope of State of the Practice Synthesis

This document, the state of the practice synthesis for the *Transit Enterprise Architecture and Planning Framework* project, consists of the deliverables for the following five project tasks.

- Task 1: State of the Practice—Enterprise Architecture
- Task 2: State of the Practice—IT/ITS Funding Implementation
- Task 3: Transit Agency Situational Analysis: State of the Practice—Business Case Methodology
- Task 4: State of the Practice—Systems Engineering Implementation
- Task 5: State of the Practice—Post Implementation Analysis

The five tasks relate to important disciplines that contribute to the successful planning, funding, development, and deployment of transit Intelligent Transportation Systems (ITS) projects. Chapter 2 includes an overview of the methodology used to develop the syntheses, which included a review of the literature and interviews with transit agencies and the Department of Transportation (DOT) for a few States. The syntheses developed for the five tasks are included in Chapters 3 through 7.

The purpose of the synthesis tasks was to obtain a better understanding of current industry knowledge and practice in the five topic areas, as well as to observe the state of readiness for transit to adopt industry best practices. Subsequent deliverables will address and recommend best practices within a framework that blends these five disciplines into a seamless, consistent Framework.

1.2 Project Overview

The *Transit Enterprise Architecture and Planning Framework* project seeks to provide transit agencies with a roadmap, based on a Transit Enterprise Architecture and Planning (TEAP) Framework, to successfully implement Information Technology (IT) and ITS technologies that meet their business needs. The project includes a preliminary assessment of the industry and tools available (the synthesis tasks) and the development of a framework and a process, supported by tools to assist agencies in implementing IT/ITS technologies. The Framework and tools will help transit professionals understand the financial, operational and management impacts of technologies, to help them better meet their enterprise business process needs and corporate objectives. The Framework will also help guide an agency's planning process, improve its understanding of risks, and validate and verify compliance with its needs, better manage the project implementation effort, and measure results and benefits.

The project consists of two phases. During Phase I, the Research Team will complete the syntheses and develop the details of the framework for improving ITS project deployments. As early Phase I deliverables, the syntheses describe current industry practice through a review of the literature and interviews with transit industry professionals, and identifies industry readiness for adopting best practices in the five specific disciplines associated with deploying ITS projects. In subsequent deliverables, the Transit Enterprise Architecture and Planning Framework will be described. It will include a high level overview for an executive management audience, details on how to develop an enterprise architecture that aligns technology investments with business needs, guidance on how to show the relationships among ITS business processes, performance, information, services and technology, and examples and templates. During Phase II, key aspects of the TEAP framework will be field tested and demonstrated through the EA/EAP tool(s) implementation.

1.3 Background

The five disciplines addressed in the syntheses, which will be included in a framework for successfully deploying transit ITS projects, are often poorly understood and executed in transit as well as other industries. This is due to several factors:

- Lack of time and resources for training on the topics
- Lack of time, resources and corporate support for implementing the disciplines
- Lack of materials that tailor the topics for transit to make them relevant rather than complex and theoretical

As competition for limited resources increases, the value and need for skills in building a good business case, arranging funding, using EAP to improve the value of the investment, managing projects with good systems engineering practices, and proving value with post-implementation analysis, will increase.

Further, in transit as well as other industries, the relationships between the five disciplines are typically not well laid out and understood. In Task 4 of this project, the Framework and relationships will be described. An enterprise-wide framework approach to project planning better enables the identification of the impacts on people, systems and technologies over the lifecycle process, as well as the meeting of agency requirements. Specifically, a Framework guides transit in:

- Planning how information, services and technology work together across an enterprise to support business processes, solve problems, and measure performance;

- Promoting information sharing across agency and institutional barriers;
- Ensuring that IT/ITS projects are defined and staged in a way that ensures best value and supports the successful implementation, operations and maintenance;
- Ensuring that the benefits and costs of proposed IT/ITS projects are understood across the project's lifecycle (including operations and maintenance), and resources are available to support the program;
- Specifying IT/ITS projects to maximize the IT/ITS investment decisions across the organization;
- Ensuring that IT/ITS projects are described to meet stakeholder needs, requirements are explicitly described, risks are identified and mitigated, and the system development process is managed to ensure correct operations and requirements are met; and
- Describing the leadership and organizational structures and processes that ensure that the organization's IT sustains and extends corporate strategies and objectives *(1)*.

1.4 The Synthesis Topic Areas

The five synthesis topic areas provide tools for planning, developing, deploying, and evaluating the systems and technologies that best meet an organization's objectives. These topic areas, which will become part of the Framework, are:

- Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) development process (developing the blueprints);

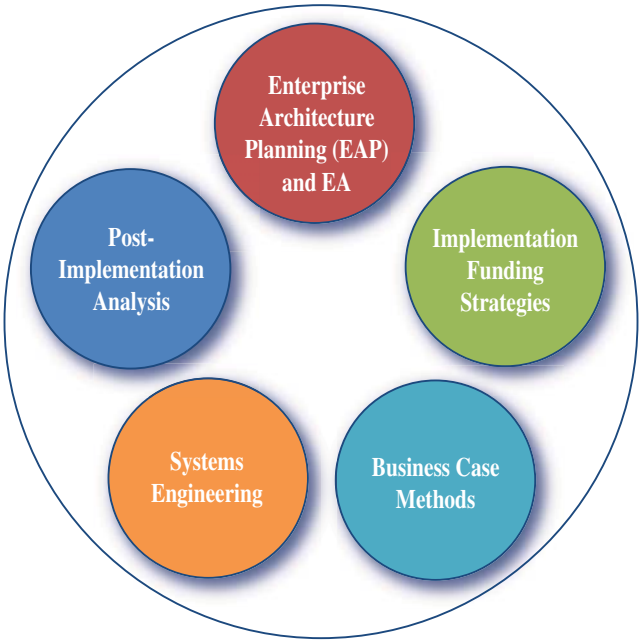


Figure 1. Synthesis topic areas.

- ITS Implementation Funding (how to pay for it);
- Business Case Methodology (how well does this project fit into the your stated priorities; what are the risks, benefits and costs, and estimated return on investment [ROI]);
- System Engineering for helping design and manage an ITS Project implementation; and
- Post-Implementation Analysis for assessing system performance (including reviewing the experience for lessons learned) and meaningful (estimated) ROI.

These topic areas and concepts are described in Chapters 3 through 7. The following highlights the intent and scope of each chapter.

1.4.1 Enterprise Architecture (EA) and Enterprise Architecture Planning (EAP)

The *Enterprise Architecture Planning* process is a set of activities used to develop the Enterprise Architecture models, diagrams and descriptions. The process typically is stakeholder driven where the current performance measures, business processes, data, applications and technologies that are used in the organization are documented. The next step consists of documenting where the organization wants to be with respect to its business in the future, about four to five years. The organization consists of the corporate mission, goals, objectives, and the business processes, data, applications and technologies that are needed to support that vision. This is called the "to-be" architecture. A third step is a description of how to get there or a description of the "gap" between the current ("as-is") and the future ("to-be"). The Enterprise Architecture, both the "as-is" and "to-be" architectures, are composed of four or five models (depending on which Methodology is used—see Chapter 3 Appendix A) that are depicted in one or more diagrams, policy statements, procedures, inventories or other "artifact."

Chapter 3 on EAP/EA describes various IT industry approaches to EAP processes and EA artifacts. The transit industry does not have a track record in EAP (with only two agencies having documented their enterprise-wide EA); however, some transit agencies are deploying segments of their architectures, through enterprise data, enterprise applications, or during their business case and systems engineering processes. These examples will be discussed in greater detail in Chapter 3.

1.4.2 ITS Implementation Funding

Chapter 4 on ITS Implementation Funding discusses guidelines for obtaining, analyzing, and making use of various

sources of funding for IT/ITS projects. Like IT projects in general, transportation IT and ITS projects are delivered through public leveraging options like bond financing, public-private partnerships, comingled funding, and a variety of Federal, state and local funding sources.

Transit agencies are using many of these financing mechanisms to access the various sources of capital for IT/ITS projects. Historically, buy (pay-as-you-go), borrow (issue bonds) or lease were the primary financing mechanisms used by transit agencies. Since the 1990's, creative use of these traditional mechanisms and introduction of public-private partnerships has occurred. Chapter 4 discusses financing mechanisms; in particular, the section describes four categories: debt mechanisms, capital leasing financing, equity and partnerships, and credit enhancements.

Chapter 4 discusses ITS implementation funding and analyzes the best method for obtaining the necessary funds for the selected implementation. Based on the surveys conducted, no one financing method works for all situations, rather financing decisions need to be tailored to the specific project, region and financial circumstance.

1.4.3 Business Case Methodology

A Business Case Methodology (BCM) is a formal analysis used to justify and capture the reasoning for initiating a project.

The business case typically reviews and verifies that *(2):*

- The investment has value and importance
- The project will be properly managed
- The firm has the capability to deliver the benefits
- The firm's dedicated resources are working on the highest value opportunities
- Projects with inter-dependencies are undertaken in the optimum sequence."

Chapter 5 discusses some of the different business case methodologies for justifying IT/ITS investments. Each of the methodologies use somewhat different techniques for building the business case and determining return on investment, total cost of ownership, value of investments, risk factors, impacts, and opportunities. Some best practices and critical success factors associated with developing a good business case and business case methodology are included in the chapter.

1.4.4 Systems Engineering

Systems Engineering is a discipline that attempts to ensure that customer needs are implemented in the system that is developed. Customer needs are defined by the stakeholders or people who have an interest in the system, as a user, a manager, or as someone impacted by the operations of the system (i.e., recipient of information or process coordination partner). Customer needs drive the system requirements, or what the system should do. For example, if there is a need to measure ridership at stops (boardings and alightings) for each trip, then there is a corresponding requirement for the Automated Passenger Counting (APC) system to count boardings and alightings at each stop by trip identification. The systems engineering process must ensure that the requirement is described in the design, and consequently implemented in the software, data collected, stored and reported in a format that is consistent with its use as a performance measurement. The steps prescribed by the Systems Engineering process ensure a structured approach to track the need throughout the development stages.

U.S. DOT recognized the potential benefit of the systems engineering approach for ITS projects and included requirements for the use of the systems engineering process in the FHWA Final Rule/FTA Final Policy on Architecture and Standards that was enacted on January 8, 2001. Chapter 6 discusses the major steps that comprise the Systems Engineering analysis process and the results of the transit industry scan that shows the limited understanding and implementation of the policy by transit agencies.

1.4.5 Post-Implementation Evaluation

Post-implementation analysis or Post Implementation Review (PIR), as it is commonly called in the IT field, is conducted after a project has been completed. "The purpose of the PIR is to evaluate how successfully the project objectives have been met and how effective the project management practices were in keeping the project on track *(3).*"

Chapter 7 discusses what a PIR is and is not. The PIR is not the testing and verification activities that are typically performed in a project acceptance or closeout phase. As an example, the AVL system selected to meet the goal of increasing ridership may have to be accepted from a vendor if it performs according to the requirements in the Request for Proposal, it passes the test plan and the systems engineering verification process.

The system, however, may not perform the way the users want. Perhaps the business changed or it was specified ambiguously and/or incorrectly. The PIR occurs after the IT/ITS system has been incorporated into the business and assesses how well the project meets the users' needs, what needs to be done next, and how well the implementation process went. Developing and sharing lessons learned can continuously improve the agency's project acquisition and management processes. The current practice in the industry, recommended practices, and a checklist for managers is included in Chapter 7.

2 Synthesis Methodology and Industry Scan

To develop an assessment of the state of the practice, the research team reviewed available industry literature and conducted telephone interviews with a sample of transit agencies as well as several state DOTs. The literature search and interviews covered the five major elements to be included in the Transit Enterprise Architecture and Planning Framework:

- Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA);
- ITS Implementation Funding;
- Business Case Methodology;
- Systems Engineering for ITS Project implementation;
- Evaluation for post-implementation measurement including assessing meaningful (estimated) ROI and performance.

The literature search focused on innovative approaches in the IT and transportation industries, and in particular, transit. Sources included professional journal articles, guidebooks, and tools that are available on the web, including several reports published by the Transit Cooperative Research Program (TCRP).

To provide a reasonable sample of agencies for the telephone interviews, a group of 14 transit agencies and three DOTs was selected for interviews. Survey protocols were developed for the interviews. A standard set of interview questions was administrated to all the agencies. In addition, some agencies were asked more detailed questions on some Framework elements, if the screening questions discovered areas to probe further, and if time was available. The first column in Table 1 shows the agencies and state DOTs that were interviewed. Several agencies were asked more detailed questions about their experience with the Framework topics. The checked columns in Table 1 represent the agencies that were surveyed in more detail on selected topics.

3 Findings on Transit Enterprise Architecture Planning and Enterprise Architecture

This chapter presents methodologies for planning and documenting an Enterprise Architecture (EA) and discusses the transit survey findings. Developing an enterprise architecture is often perceived to be an arduous, expensive and lengthy process performed by outside consultants who spend many months at an organization and then provide a huge report with countless diagrams and, tables that ends up sitting on a shelf. The scan of the practice for Information Technology (IT) and transit ITS shows that this was often the practice in the past. Today, however, many industries have created useful templates for documenting an Enterprise Architecture, including the business processes, data, performance measures and technology characteristics of their industry. The process of creating an EA has also been improved by new shortcuts and segmenting the enterprise into smaller, more manageable chunks. Industries are now starting to realizing substantial cost and time savings through Enterprise Architecture Planning (EAP).

The development of an enterprise architecture has shown significant benefits in planning for information technology programs and obtaining important information about the business. In "The Value of Enterprise Architecture," *(4)* the author reported savings in several areas:

- "Savings of 60% of the man-day efforts needed for collection, processing, validation and reporting on the elements of the enterprise architecture—a task done continuously for reasons such as SOX, risk management, data protection, user satisfaction etc. These savings alone can finance an EA program
- "A 10% increase in deliverables from investments in IT projects by architecturally checking projects in the preparation phase to ensure potential risks are identified and mitigated and also to avoid architectural conflicts during the execution of IT projects.
- "A 10% reduction in yearly operating costs by the discovery of redundancies or excessive spending in the IT support to business and by standardizing the architecture, which not only leads to cost reduction but also to increased business and IT flexibility and agility."

For example, when a manager wants to save costs by eliminating an ancient data reporting system, it is important to know what parts of the agency access data it manages, which applications depend on it, and which customers or users would be affected.

This chapter is divided into two sections. First, it discusses the discipline of Enterprise Architecture Planning and the evolution of the leading methodologies. These are formal methods that describe detailed steps, products and building blocks that an organization uses to develop an Enterprise Architecture.

The second part of the chapter discusses how transit currently approaches Enterprise Architecture Planning (EAP) and the development of Enterprise Architecture. While few transit agencies have enterprise architecture planning processes in place or have developed an enterprise architecture in the formal sense, there are ways that organizations are employing "enterprise thinking" in making technology investment decisions. The brief scan shows that the majority of transit IT professionals are not making use of available industry tools to

Table 1. Transit agencies and state DOTs interviews for industry scan.

Agency	Standard Interview	EAP/EA	Funding	BCM	Systems Eng.	PIR
C-Tran	✓					
Hampton Roads	✓				✓	
Iowa DOT	✓					
Kansas DOT	✓					
King County Metro	✓			✓		✓
Lynx	✓			✓	✓	
MARTA	✓		✓	✓		✓
Miami-Dade	✓	✓				
NY State DOT	✓					
Paducah	✓				✓	
RIPTA	✓					
Riverbend	✓					
SEPTA	✓		✓			
TriMet	✓			✓		✓
UTA	✓		✓	✓		✓
Wichita	✓				✓	
WMATA	✓	✓				

develop segments of the enterprise architecture, and they miss capitalizing on the lessons and benefits of "enterprise thinking."

3.1 Main Purpose of an Enterprise Architecture

Enterprise Architecture is a structure that provides executive managers visibility into the overall relationships among their people, processes, technologies and performance. It enables executive managers to plan their technology investment decisions to better meet corporate business needs and processes.

The Enterprise Architecture benefits organizations by:

- Identifying where to reduce IT costs and complexity, by increasing the visibility of information flows and relationships between data, systems, technologies and business processes
- Increasing business value and effectiveness through improved technology deployment

The proliferation of servers and operating systems that started over two decades ago was one of the earliest drivers of enterprise architecture. Organizations started to have new problems as they accumulated different servers, operating system products and versions, database products, and varieties of personal computers with different variations of desktop software. Soon IT could not keep up; IT staff often didn't know all the software and hardware varieties used throughout the company. The lack of technology planning generated inefficiencies in the workforce and in the production of needed information. Agencies needed to hire experts to

maintain all of their equipment; they needed to send their people to training on all the platforms they supported; they needed to add specialists to their PC help desk to support the variety of applications.

Most agencies now have hardware and software inventory lists that document every computer, applications, infrastructure software and peripherals, as well as a set of systems specifications and standards for software/products used for databases, operating systems, web applications, application development and more. The inventories and standards are typical of the elements contained in a "Technology Enterprise Architecture" layer. Building the lists and standardizing the technology was driven by the need to align the technologies and future investments with the corporate resources (staff, skills) needed to support them.

The current methods used to plan for and document enterprise architectures take this concept further. In addition to a "Technology Enterprise Architecture" layer, a typical EA includes three to four other interrelated architecture "layers." In a Government Technology article *(5),* the author states, ". . . one of the key things to know about enterprise architecture is that it is not 'just an IT matter'—it involves the discussion and clarification of business processes and procedures. There is no sense building applications and an infrastructure that simply automate disorganized or inefficient processes, so defining and documenting business processes are key components of a full enterprise architecture undertaking."

The Business Architecture describes the business and includes details on business processes, work flows, and roles and responsibilities needed to meet the business goals and objectives of the organization. It describes the "who, what, where, why, when and how" business processes are accomplished. The Business Architecture helps project developers understand the business, identify stakeholders, find dependencies, and generally expedites the information gathering tasks needed to develop requirements.

The Data Architecture describes the data and data structures used by a business and its technology applications. It includes the meaning and relationship of information, information on data integration needed by the organization, and answers the questions of who, what, where, why, when and how the data is managed. A Data Architecture can help a transit agency minimize ITS project delays due to missing or misunderstood data, such as when a trip planning system is purchased and its operation is delayed because accurate bus stop data is not available.

The Services Architecture, which used to be called Applications Architecture, describes the organization's technology services and applications, such as web services, Automated Passenger Counters, customer information systems, inventory systems, Human Resource systems, etc. The Services Architecture contains other information about the applications, such as the flow and delivery of information among subsystems, application versions, and restrictions on use. It helps identify integration opportunities and problems, system dependencies, gaps in functional coverage, the status of systems, and helps ensure that the development and enhancement of applications align with the business strategies of the organization.

The Performance Architecture is a relatively newer part of an EA. It is a standardized framework to measure the performance of major IT investments and their contribution to program performance. It includes Mission Goals and Objectives and Performance Measures.

There are numerous examples in transit, where an EA would have eliminated ITS project delays and cost overruns. For example, there are instances where transit agencies procured automated passenger counting (APC) systems, only to realize that they are missing the people or processes to locate, track and update the data required as input to the system. Had an Enterprise Architecture been in place, it would have shown the connections among the business processes, data sets and technologies. It would have revealed the missing processes and data from the onset, allowing for better planning and budgeting, and successful project delivery.

Typically, the Enterprise Architecture (EA) is composed of three major parts:

- Current or "As Is" EA
- Future or "To Be" EA
- Gap Analysis with transitional EA models

The Enterprise Architecture begins by describing the people, processes and technologies in use ***today.*** It documents current processes, technologies and adopted standards and identifies problems, bottlenecks and missing linkages among the enterprise elements. Next, the Enterprise Architecture of the ***future*** identifies how to resolve these problems and structure an organization where business goals are addressed by clearly defined processes, consistent data, easy to use applications and "well oiled" technology solutions. The Gap Analysis defines a transitional program that identifies the stages necessary to move towards the future enterprise.

The Enterprise Architecture Planning process is the work that is done to develop and update the Enterprise Architecture. The process is driven by many factors, including mapping the corporate vision, customer expectations and stakeholder needs to the EA.

The enterprise architecture planning process reveals the pieces and connections to all parts of the business, so that all the stakeholders along the activity chain see the flows of data, work and outcomes. By doing this, other groups within the organization may benefit from the processes being implemented, such as a process to manage bus stops, or they may

find a group already doing similar processes. The processes and technologies employed to manage bus stops may be elevated to an enterprise activity, thereby aggregating contributions from multiple departments, benefiting multiple users, eliminating redundancies by creating a single bus stop inventory source and improving corporate effectiveness through adoption of standard operating procedures.

The main purpose of an Enterprise Architecture Planning Process (EAP) is:

- To engage key stakeholders and IT staff in understanding the connections and dependencies among various parts of the business and work together to improve the Enterprise's overall effectiveness by reducing redundancies, leveraging technology investments for multiple processes, and building a seamless information infrastructure.
- To prioritize enterprise information technology needs with respect to the organization's strategic goals and objectives, particularly as the needs relate to technology investment decisions (build, operate and maintain).

The key benefits of an EAP include:

- Ensuring there is consensus among key decision makers about the organizational objectives, needs, priorities and business processes, and how they are served by the technology investments;
- Ensuring that there is an awareness about how the decisions related to technology investments such as business processes that operate and maintain the technology investment (including the lack of investment) impact the organization, its people, objectives, needs, priorities, and assessment capabilities.

Although the different Enterprise Architecture (EA) and Enterprise Architecture Planning (EAP) methods in the industry have similar categories and major processes, the industry is not consistent in the meaning of terms, classifications, and scope of EA and EAP. A more detailed discussion of the definitions can be found in the Appendices of this chapter. In addition, the appendices include a discussion on how the term "framework" is used with respect to EAP/EA.

3.2 General Approach to EAP/EA Used by Other Industries

This section describes two well-known, non-proprietary approaches to EAP/EA, the Federal Enterprise Architecture (FEA) and The Open Group Architecture Framework (TOGAF). The two approaches are introduced to show some similarities and differences, and to help the reader gain additional familiarity with common EAP/EA concepts and terms. Some structure and content for this project's Transit Enterprise Architecture and Planning Framework will come from these two EAP/EA approaches. In addition, there are dozens of other hybrid approaches and even these two approaches have influenced each other over the past decade.

The TOGAF, derived from the Department of Defense approach, is typically used as a set of templates with step-by-step instructions for developing, planning for and implementing a segment of an enterprise architecture. The FEA was originally a set of four reference architecture models and a process to build a plan to move from the current architecture representation to a future architecture vision; as it evolved, the reference architecture models grew into a taxonomy that could be used as building blocks to describe segments of the enterprise; the planning process became a practical roadmap that involved developing a transition plan, incorporating core services, building a business case, and developing an implementation plan based on a systems engineering process.

3.1.1 Federal Enterprise Architecture (FEA)

The FEA has grown into a multi-faceted program to define methods, tools and assessment strategies for the Federal government to develop Enterprise Architectures that describe business processes for improvements in key areas. In their own words:

> . . . the FEA is entirely business-driven. Its foundation is the Business Reference Model, which describes the government's Lines of Business and its services [including financial, HRM, etc. and cross-cutting profiles like geospatial] . . . The outcome of this effort will be a more citizen-centered, customer-focused government that maximizes technology investments to better achieve mission outcomes. *(6)*

Figure 2 shows the business-driven model. The agencies share similar functions ("lines of business") such as Financial, Human Resources, and Homeland Security. They also are in need of integrated, cross cutting services ("profiles") such as geospatial, security and records management. This three-dimensional model shows the inter-relationships and shared functions among the Federal government departments. When the effort began, the focus was on a development process. The result was an EAP process as shown in Figure 3.

The EAP process for each Federal agency to develop Current and Future architectures, document their standards and policies, and develop transitional plans was daunting. To support the planning process, the FEA working groups developed three Reference Architectures *(7)* that described Performance Measures, high level Lines of Business, and a Data Reference Model *(8)* that could be used as a reference or tem-

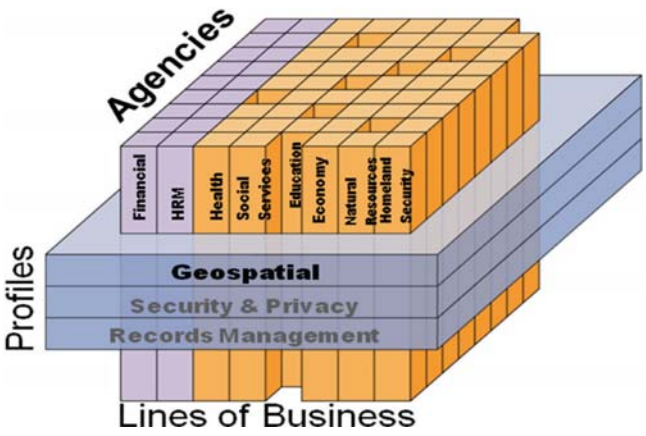


Figure 2. FEA Business Reference Architecture. Source: FEA Guidance

plate upon which the Government Departments could build their structures. By 2005, that effort was substituted with a new approach. The new emphasis was on scoping the development into smaller, manageable segments.

The new approach using Segment Architectures was established in 2007, with the publication of the Federal Segment Architecture Methodology (FSAM) Practice Guidance document *(9)*. According to the FSAM Overview:

> A segment architecture is a detailed results-oriented architecture (baseline and target) and a transition strategy addressing a vertical or horizontal portion (or segment) of the enterprise. *(9)*

Today, the FEA is composed of

- Five-layer reference model (performance, business, information, services, technology)
- Segment architecture process and guidance
- Taxonomy for cataloging assets that are part of the EA
- Process for creating an enterprise architecture
- Transitional process for migrating from pre-EA (current) to post-EA (future)
- Built in approach for measuring progress and success (through the performance model)
- Self-assessment approach for determining success of using the EA to drive business value

The approach seems to have paid off; several agencies have published detailed operational concepts and business processes,

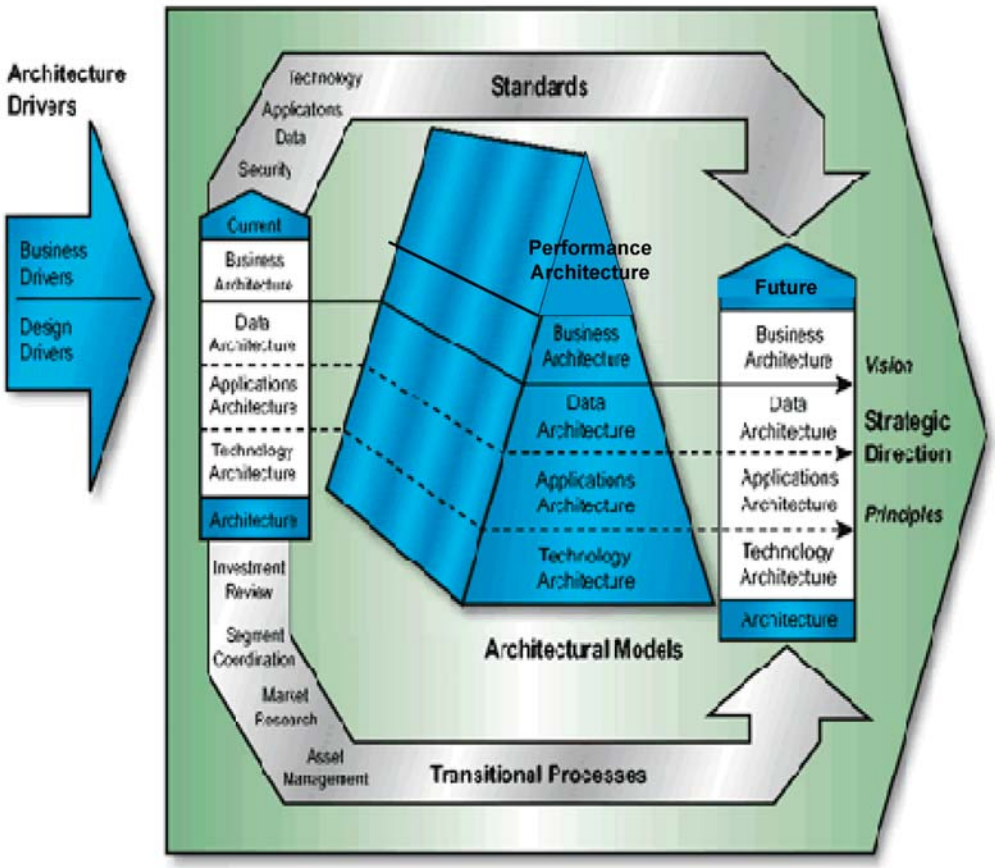


Figure 3. FEA Enterprise Architecture Framework from Version 1.1. Source: Version 1.1 FEA Enterprise Architecture Framework

requirements, data models and dictionaries, services and tools that are tied to their performance metrics.

This approach may help the transit industry define a manageable process to allow it to reduce the complexity of the transit enterprise into parts that can address core processes and priority areas. However, the industry is missing a reference architecture (business, performance and data) which could serve as a template to define the "lines of business" and the cross-cutting functions.

3.1.2 The Open Group Architecture Framework (TOGAF)

TOGAF is a set of resources and process guidance for developing Architectures. The Framework is composed of three major parts

- Architecture Development Method (ADM) Cycle
- Enterprise Continuum
- Resource Base

The ADM is a set of guidelines that describes and guides developers through an enterprise architecture process that "meet[s] the business or IT needs of an organization." *(10)* The Framework guidance emphasizes the need to scope the cycles through the architecture. The ADM, illustrated in Figure 4, is cyclical, starting at the preliminary phase and cycling through steps A through H at ever increasing levels of detail. The cycle may be scoped by detail or process.

The general Framework is comprised of a set of processes, tools, and building blocks for any industry, public or private, to use to develop an enterprise architecture. The cyclical nature enables a means of reducing the complexity, either by developing increasing levels of detail for the four architecture models specified by the method, or using a "segment" approach, similar to the one introduced by the FEA approach.

The TOGAF approach depends on using a set of building blocks. It offers many resources to contribute to the Architecture development. TOGAF calls this part of the Framework the **Enterprise Continuum.** The Enterprise Continuum is described as a "virtual repository" of methods, patterns and solutions that help build an organization's Architectures. The FEA reference architecture documents would be considered an industry representation of its core business, performance and data. The **Resource Base** is composed of standards, policies and solutions (like open "web services") that are available for the industry to procure off-the-shelf, or integrate into their industry applications. These ADM, Enterprise Continuum and Resource Base are explained in more detail in this Chapter's Appendix C.

The TOGAF model provides a framework for planning the Enterprise Architecture. Although many of the solutions, templates and processes may be applied to transit, it is missing the tailored content, business and performance taxonomy that links the model to transit.

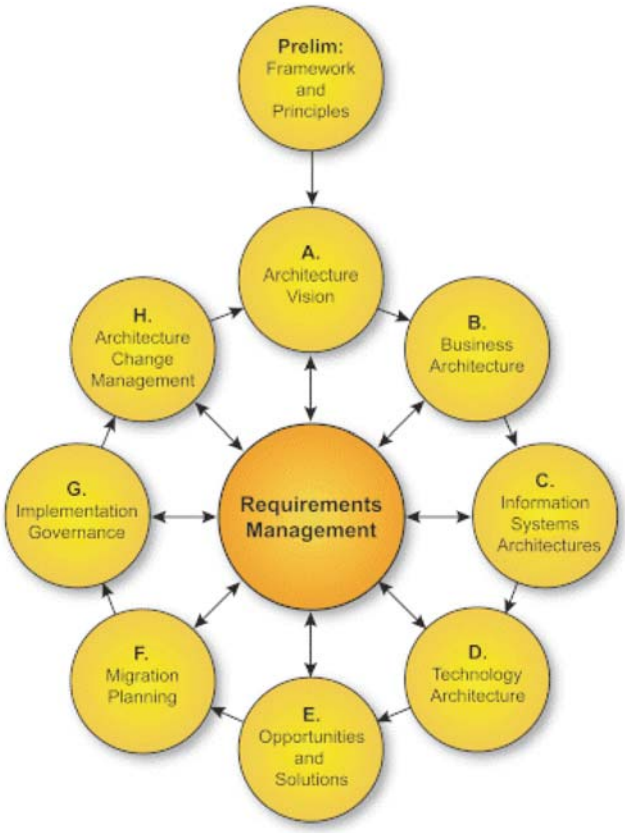


Figure 4. TOGAF architecture development method cycle. Source: TOGAF Version 8.1.1

3.1.3 Industry Implementation Approaches

There are hundreds of articles, workbooks, tools and guidelines for developing Enterprise Architectures. The materials range from overviews to dense documents that could double as door-stops. The organizations described in this section documented their approach, recording and organizing their vision, goals, and business practices.

3.1.3.1 National Association of State CIO (NASCIO) NASCIO develops many tools for State and local government information technology managers to deliver better services to their constituents. One initiative they undertook in 2004 was to publish an Enterprise Architecture Toolkit *(11)*. The toolkit is a step by step process on how to build an Enterprise Architecture including identifying stakeholders, listing roles and responsibilities, collecting information on template forms for each architecture domain and, finally, techniques for program management, EA lifecycle management and governance (see Figure 5).

The Toolkit is organized into several books dealing with Architecture domains: Business, Information, and Technol-

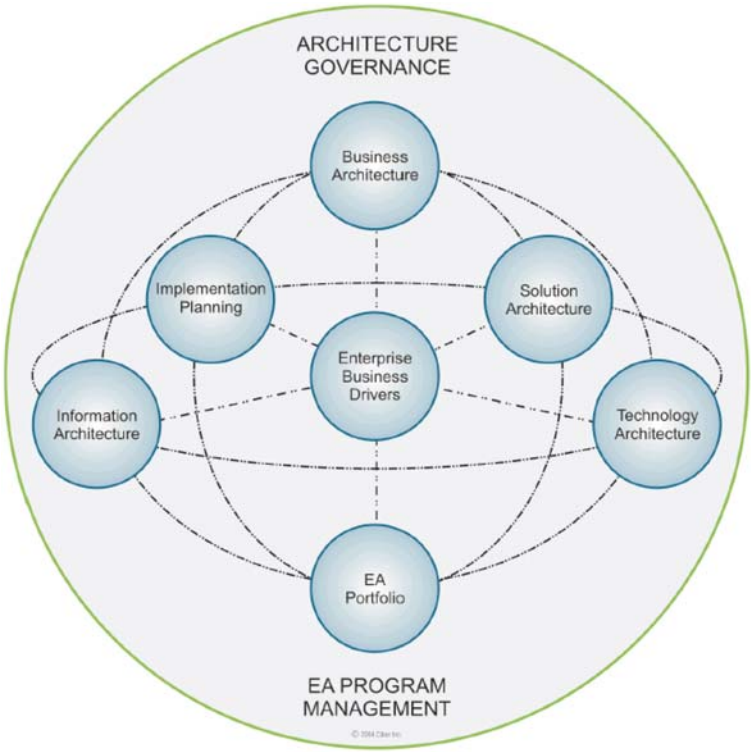


Figure 5. NASCIO enterprise architecture process model. Source: [NASCIO Toolkit].

ogy. Similar to FEA and TOGAF, the NASCIO methodology includes a fourth domain, a Solutions Architecture, which describes requirements, design and approaches for implementing the conceptual architecture models. The EA Portfolio is the inventory documenting the characteristics of the four domains. The projects that derive from the domains are also contained in the Portfolio. The entire process is subject to a formal Architecture Governance process which falls under the purview of the Executive in Charge (e.g., CIO), wherein technology projects are prioritized and verified for conformance to the policies of the EA Program. Some states that developed an Enterprise Architecture require all project requests and business justifications to be tied to the business process, data and technology described in the Enterprise Architecture. The business case serves as a check on the procurement process to ensure the consistency, integration and staging of the project with the state's mission and goals.

3.1.3.2 Michigan Enterprise Architecture Framework Guidelines A concise document, the Michigan Enterprise Architecture Framework Work Plan Guidelines *(12)* describes the process for Michigan state agencies to develop a statewide architecture. The Guidelines include three sections. The first section describes the process model; it includes ". . . eight process activities and coordination and integration requirements. The materials are based upon and in part excerpted from the Gartner EA Process Model, particularly 'Gartner Enterprise Architecture Process: Evolution 2005' ". *(12, p.4)* The second section describes the EA Framework. The Michigan approach defines the term Framework as "structure." The Framework is a description of the drivers, "requirements, enterprise architecture viewpoints (business, technology, information and services), enterprise solution approach and requirements, and governing, managing and accountability." The framework section is derived from three sources: "Gartner Enterprise Architecture Framework: Evolution 2005", "Architecture Frameworks: Some Options", and "NASCIO EA Development Tool Kit," Version 3.0. The final section describes the Work Plan and includes best practices and guidelines for developing the EA.

3.1.4 Lessons Learned on EA/EAP from Other Industries

Several lessons may be learned from the scan of other industry best practices with respect to developing a Framework that includes EA/EAP. The lessons include the following:

- Reduce the complexity of EAP process;
- The Enterprise Architecture process is cyclical, each cycle should focus on a limited scope of the business or level of detail;

- Provide resources (templates and building blocks) that EAP facilitators and EA developers can use to expedite the process;
- Provide a check on corporate projects to ensure that the EA (driven by corporate goals and core processes) was used in project scoping, development and deployment activities.

The following activities or approaches support the implementation of the four lessons:

- Develop an overall, high level structure that may be used as a template to build an enterprise architecture.
- Create a taxonomy (terms and definitions) of core business, performance and data that are related to the transit business. The taxonomy, like a reference architecture, may be used as a resource to help agencies build an enterprise architecture.
- Develop a repository of enterprise "artifacts" that may be used as examples of procedures, guidelines, policies, and standards that apply to the different architecture models.
- Build an enterprise architecture in manageable segments, tied to priority and core business processes.
- Develop outreach materials to educate the industry on the benefits and uses of an enterprise architecture.
- Develop a governance structure that reviews the proposed project's role within the enterprise (performance, business, information, services and technology).

3.2 Transit Approaches to EAP/EA

The scan of the transit industry revealed limited adoption and understanding of Enterprise Architecture Planning and Enterprise Architecture. Among the organizations we interviewed, most of the CIOs or IT managers were familiar with the concept, particularly if they came from other industries. However, few had the resources or management support to undertake a comprehensive enterprise architecture planning process. Fewer were versed on the "segment architecture" approach currently applied by other industries.

3.2.1 Transit EAP/EA: Lessons Learned from the Literature

TCRP Report 84 Volume 5: Concept for an e-Transit Reference Enterprise Architecture

The TCRP J-09 Committee published a research paper [Report 84 Volume 5 *(13)*] that looked at how the disciplines of Enterprise Architecture and Systems Engineering work together to help the industry "quickly assess the impacts of potential opportunities of changes and new developments." *(13, p. 2)* A recommendation was presented to develop a Transit Reference Enterprise Architecture.

The report described a development process *(13, p.4)* that was based on similar paradigms of the architecture development methods:

- Capture the "As Is 'Transit Today' "
- Describe the vision for the "To Be 'Transit of the Future' "
- Document the "typical sequence of actions and their impacts" or implementation plans for transitioning from current to future.

Advanced Public Transportation Systems: The State of the Art Update 2006

Another study, sponsored by the US DOT, the State of the Art Report *(14)*, described a few Enterprise Architecture development efforts in the transit industry. In particular, the report identified a specific challenge/lesson that was learned from organizations that performed a formal or informal internal enterprise architecture:

> Integration of technology cannot occur without the integration of business objectives and policies of the departments and/or agencies that are expected to cooperate in an ITS project. *(14, p. 50)*

The statement reiterates the need to overlay a "governance" structure around the development of the enterprise architecture to ensure that executive manager and stakeholder participation and buy-in are incorporated into the development of the future architecture.

Other Literature about Transit ITS

Few lessons learned emerged through the industry scan because few organizations engage in planning and documenting their enterprise architecture. Industry literature related to transit ITS technology deployment is rife with examples about how the lack of enterprise architecture planning is limiting success in system deployments. The transit literature identifies the issues, such as:

> Concentrate on the soft side [planning and business processes] of the system—this is where success is really achieved . . . Ensure that staff . . . understands how to use the data. Think long-term, and ensure that data structures can be integrated with downstream applications. *(15, p. 24)*
>
> Underestimating the degree to which advance planning was needed . . . Ensuring support from IT, maintenance, and other parts of the organization . . . Adapting business practices and operating procedures. *(16 p. 35)*

These studies do not explicitly point to a solution such as Enterprise Architecture Planning; this may be because there is a lack of understanding and guidance about how Transit EAP helps executive managers run their organizations more effectively. The 2006 State of the Art Report identifies key

obstacles to deploying Transit ITS that pinpoints areas where Enterprise Architecture or even "enterprise thinking" will directly benefit transit agencies:

> Key obstacles [to deploying Transit ITS] include:
>
> - The stand-alone nature of most individual technology deployments limits the benefits that could be provided by business-oriented, enterprise-wide technology strategies;
> - Most technology-based applications require continuous cooperation and coordination between and among many different departments, agencies, and jurisdictions that are often difficult to achieve;
> - Limited resources and gaps in education and training in the integration, use, and maintenance of technologies and the standards necessary for interoperability and data sharing make it difficult for transit professionals to keep up with technological developments and opportunities;
> - Fast-paced changes in technologies put deployment efforts at risk. *(14, p. 6)*

3.2.2 General State of Enterprise Architecture Adoption by Transit Agencies

As reflected in the *State of the Art Report Update 2006* (SOA), few organizations are following a formal method to develop an Enterprise Architecture. The industry scan reflected the same results. There are two areas that may provide lessons for the industry. Progress toward enterprise development in transit, particularly Transit ITS, is occurring in Enterprise Data and GIS.

The SOA Report discussed Enterprise Data as a key ingredient towards integration. Several organizations have made significant strides in developing and implementing "enterprise data models" including TriMet, King County Metro, UTA, and other organizations that were not interviewed as part of this scan. Still, in the most recent publication *Synthesis on AVL for Bus Transit (16),* when asked, "What was the biggest way in which your bus AVL system has not met expectations the agency had when the decision was made to deploy?", a significant number of responses cited the "[h]igh level of effort required for data management and reporting," *(16, p. 36)* "data integrity," and core data processing, exchange and archiving issues related to ITS bus systems. These problems emerge when information does not conform to a consistent set of standards and policies across the enterprise. Organizations that have developed data policies (e.g., quality, reporting and maintenance), data dictionaries and enterprise data models and have ensured that vendor products conform to their data standards have had a much easier time deploying, operating and maintaining ITS.

The SOA Report also identified Geographic Information Systems (GIS) as an area that is supporting enterprise services and data architecture development. There are a number of potential reasons for the development of an enterprise GIS approach. Factors include:

- Availability and adaptation of geospatial standards that promulgate an enterprise approach; most of these standards incorporate transit (geospatial) feature descriptions and relationships, as well as location services needed by transit business processes. The standards and products that conform to these standards constitute the building blocks needed to describe the EA GIS segment.
- Literature and tutorial materials directly relevant to transit. These include vendor materials, case studies published by TCRP and an industry-developed Guidebook on Best Practices for Using Geographic Data in Transit: A Location Referencing Guidebook. The latter work includes a section that describes a taxonomy for the business processes, data and functions (services) that comprise the Transit Enterprise GIS architecture domains.
- Availability of training and conference opportunities that promote enterprise approaches for deploying GIS in transit.

Many agencies see a single enterprise software tool such as Resource, Asset or Maintenance Management Systems (RMS, AMS, MMS) or a Customer Relations Management System (CRM) as an enterprise architecture. Certainly, these tools are solutions for critical business processes. However, they are no substitute for developing the four or five layered enterprise architecture, as exemplified by the difficulty that many agencies still encounter when deploying ITS such as Computer Aided Dispatch/Automated Vehicle Location (CAD/AVL), Automated Passenger Counters (APC), and Customer Information Systems/Trip Planners.

3.2.3 Miami-Dade Transit

Miami-Dade Transit (MDT) initiated an enterprise architecture planning process in 2002. The project lasted about 18 months including the development of the Transit Mission and Goals through the development of the IT/ITS Strategic Plan. Consultants were hired to develop the Enterprise Architecture in coordination with IT staff.

As illustrated in Figure 6, the project tasks were modeled after the FEAF method (see Chapter 3 Appendix B for a more detailed discussion of the FEAF), gathering information on the business environment, documenting the current "as is" architecture domains (business, data, applications and technology), developing stakeholder-driven target architectures, understanding the gap between the current and target and describing how the IT organization needed to adapt to the changes. Finally, the IT 2003–2006 Strategic Plan was developed and a subset of the plan was extracted to define the IT/ITS Strategic Plan.

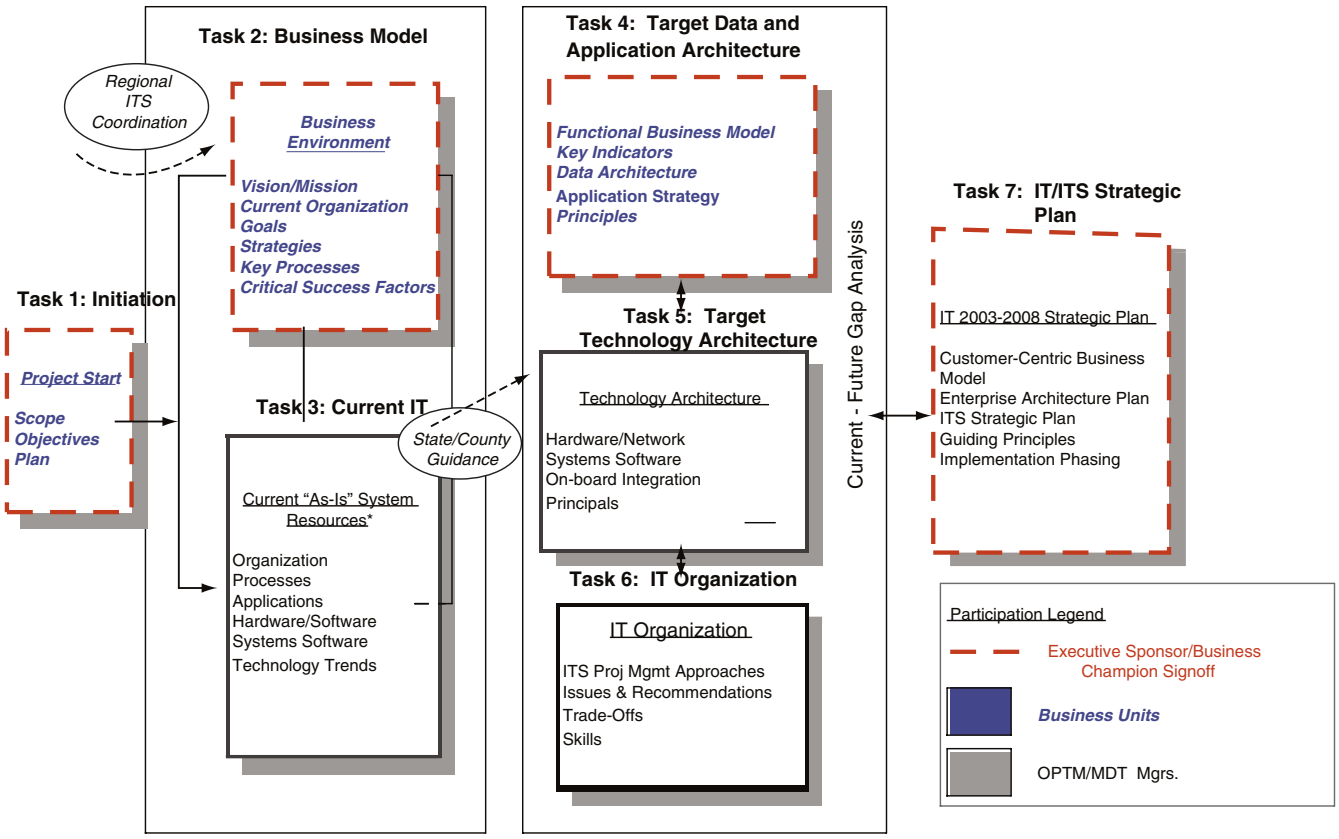


Figure 6. MDT enterprise architecture planning process and project tasks. Source: MDT.

The Business Architecture was divided into several segments. Figure 7 shows how the six major corporate goals (Maximize Use & Efficiency, Educate Community, etc.) drive the business processes (Service Implementation, Service Management, etc.). The goals are traced from the business processes to the other architecture domains and eventually to the strategic plan, showing the impact, dependencies, and overlap among the projects in meeting those goals. Table 2 describes the six segments that were included in the architectures. In addition to linking the corporate vision to the business, the Environment described stakeholders (internal and external); their roles and responsibilities were described and mapped to the detailed process level.

The Enterprise Architecture business process products used Unified Modeling Language (UML). Use Case and Activity diagrams and were cataloged in tables. MDT developed some very detailed activity diagrams to model specific processes within their organization. The more detailed business processes that were related to ITS used the Transit Communications Interface Profiles (version 1.1) business areas and functional descriptions as a reference and taxonomy for more detailed segmentation of the business processes. The internal infrastructure business processes (e.g., finance, human resources, payroll and procurement) were modeled after the organization hierarchy.

The current technology, applications and data sources were documented in lists. There was significant difficulty in developing a detailed data architecture because many of the data sources were closed and subsumed by the proprietary applications, and even the interfaces were covered by intellectual property restrictions. To that end, the data architecture identified core datasets and the development of a centralized data model was identified as a high priority project in the strategic plan.

Where appropriate, linkages were made between the MDT EA (including the on-board/vehicle subsystems) and the Regional ITS Architecture. The business architecture and data flows were mapped to the Regional ITS Architecture MDT subsystems and architecture flows. The high-level mapping depicted in Figure 8 shows the transit ITS and back office subsystems assignments to the National ITS Architecture Subsystems: Center, Roadside, Vehicle and Traveler Systems.

The gap analysis and corporate goals drove the sequencing and scope of the projects included in the strategic plan. The strategic plan is being used as a roadmap to help MDT and the IT staff build out the architecture.

3.2.4 Washington Metropolitan Area Transit Authority (WMATA)

WMATA has the most history with developing Enterprise Architectures. In 2001, they initiated an effort which resulted

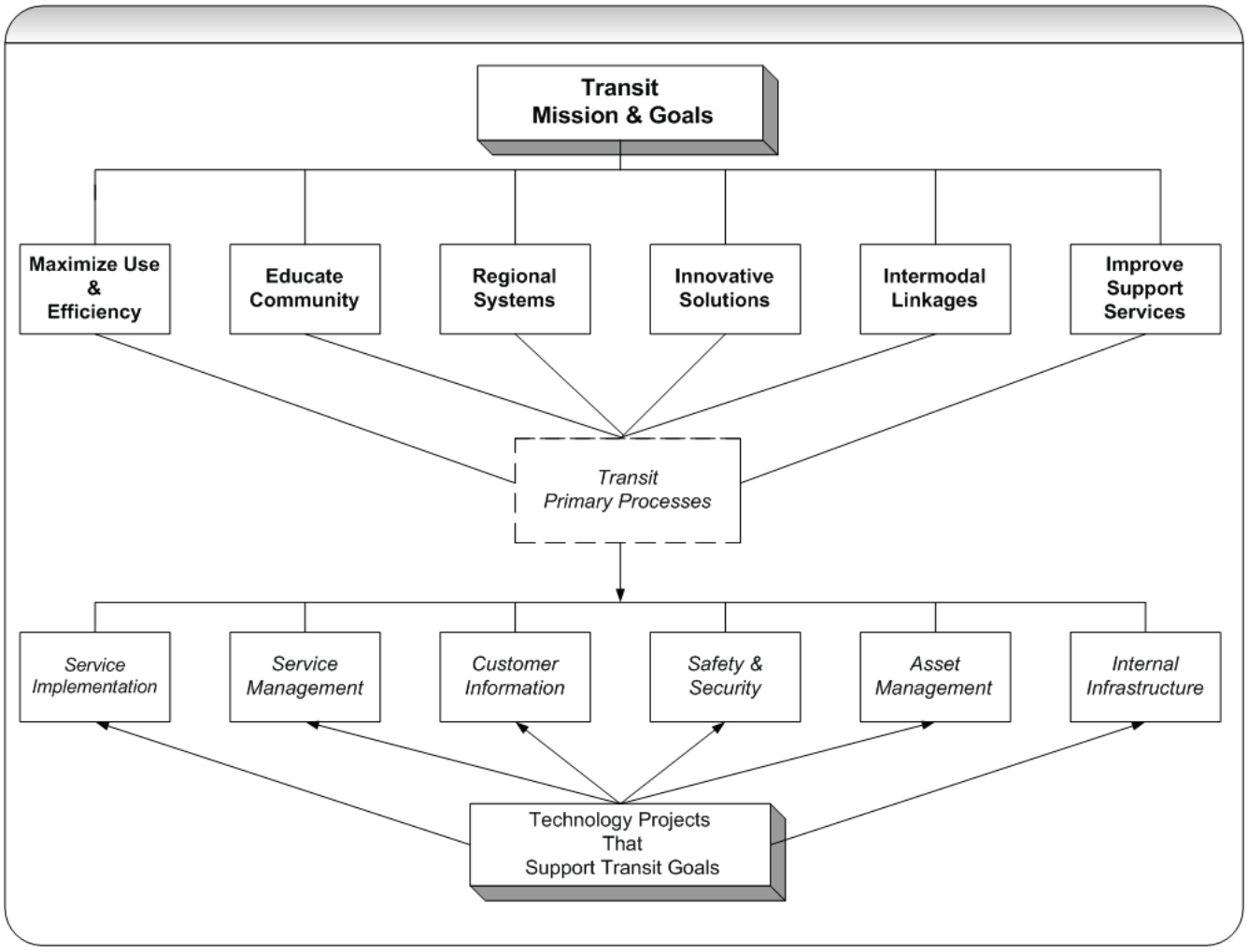


Figure 7. Relationship between MDT goals and primary processes. (Source: MDT Strategic Plan [17].)

in the published report "Renewing Technology Infrastructure at the Washington Metropolitan Area Transit Authority: Assessment of the Current Enterprise Architecture." *(18)* The assessment was comprehensive, although it did not cover the architecture of on-board revenue and non-revenue vehicles and linkages between the back office and on-board systems. Some of the recommendations on the "administrative" side of the business were implemented, including payroll, finance and customer relations management software. Following this effort, there were small efforts to develop "project" architectures for technology areas, for example, on-board bus and customer communications segment architectures.

In 2007, WMATA hired a chief Enterprise Architect, who restarted the comprehensive enterprise architecture development effort. Although currently under development, WMATA is applying a cyclical effort by first developing a structure that defines the segments of their business and then drilling into the details of each segment. Figure 9 shows the high level Enterprise Architecture.

The Business Architecture is composed of three *domains:*

- Enterprise Administration
- Integration
- Transit Management

Each domain is composed of Functions, and Functions contain Processes; Table 3 shows the relationship between Domain and Function. The excerpt in Figure 10 shows the ITS Traveler processes: Remote Traveler Support Functions for Rail and Bus and Personal Information Access. These processes are derived from the National ITS Architecture.

A process such as the *Remote Traveler Rail Support Processes* is a snapshot of the business, information, application and technology architecture views, as well as the organization that participates in the business processes. The Remote Traveler Rail Support Processes crosses organizational lines including groups supporting customer operations, marketing, police,

Table 2. MDT enterprise business process segments.

Segment	**Description** *(17, Vol 1, p. 1-18 to 1-20)*
Service Implementation	Understanding the service needs of current and potential customers, developing a service plan and translating the service plan into deliverable service are complex processes. Many of the functional areas in the transit industry, including rail, bus and paratransit, rely on the information generated in this process. In particular, schedule information is used in a wide range of operational, customer information and on-board applications.
Service Management	The transit industry is always looking for ways to gain efficiency improvements in the process of managing daily operations. In particular, bus and paratransit operations can benefit if system applications streamline or eliminate manual processes. A new generation of transit operator support systems can provide increased flexibility in the assignment of resources and improved reporting capabilities.
Customer Information	Many transit agencies spend significant resources in the process of providing customer information. Information is developed and distributed via paper timetables, bus stop signs, on-board signage, customer information operators, the Web, etc.
Safety and Security	Protecting the safety and security of employees and passengers is extremely important for many reasons. Public perceptions of safety and security at transit stops and on the transit vehicles affect the likelihood of attracting and retaining customers. Both passengers and operators like to know that help is close at hand in the event of an unsafe situation on a vehicle. Applications such as CAD/AVL, security cameras, emergency alarms and better communications will enhance actual, as well as perceived, safety and security. Safety and security incident tracking systems help prevent incidents and deploy resources more effectively.
Asset Management	Work order, facility management and inventory systems are crucial to maintenance efficiency and controlling costs. Effective management of asset replacement programs ensures that information, systems and infrastructure can be replaced at the end of their useful life without interrupting transit service and reliability.
Internal Infrastructure	The higher level Internal Infrastructure process includes functions such as human resources, finance, payroll, risk management, procurement and managing information technologies and core data.

and public relations. The process is defined as "support of patrons while using the WMATA Metrorail transit system." The information view (IV) supports maps, schedules, fares, alerts, emergency voice communications, etc. The application view (AV) includes Channel M, Incident Management, Passenger information Display server, among other applications. The technology that supports the business process includes signs, intercoms, and other technologies.

Finally, there is a direct connection between the business process and the performance measures by which the services are evaluated. In the ITS Traveler Function area, the WMATA Scorecard measures customer satisfaction for the modes: bus, rail and vertical (elevators and escalators).

At WMATA, the Enterprise Architecture is used to drive technology investments. In the corporate publication, "Professionals' Guide to Information Architecture Standards and Services", General Manager John Catoe wrote in the preface *(19, p. 3):*

> This guide . . . describes our architectural approach to developing new technology systems . . . Standardizing our information technology infrastructure is our strategy to take Metro into the future . . .

The guide includes the hardware, application and infrastructure software versions used throughout the organization; the guide also includes a scorecard (as depicted in Figure 11) showing the maturity of the IT Capabilities with respect to the organization's goals (with the darker shaded boxes on the right being most mature and the shaded boxes on the left being least mature). The Information Technology Capability Pyramid shows the progress towards meeting the goals of the future Enterprise Architecture. In addition, the Guide provides a corporate awareness about the transit enterprise, standards and policies and "stewardship" over IT resources. The procurement process includes governance over the selection of technology standards to monitor conformance with the direction of the IT enterprise.

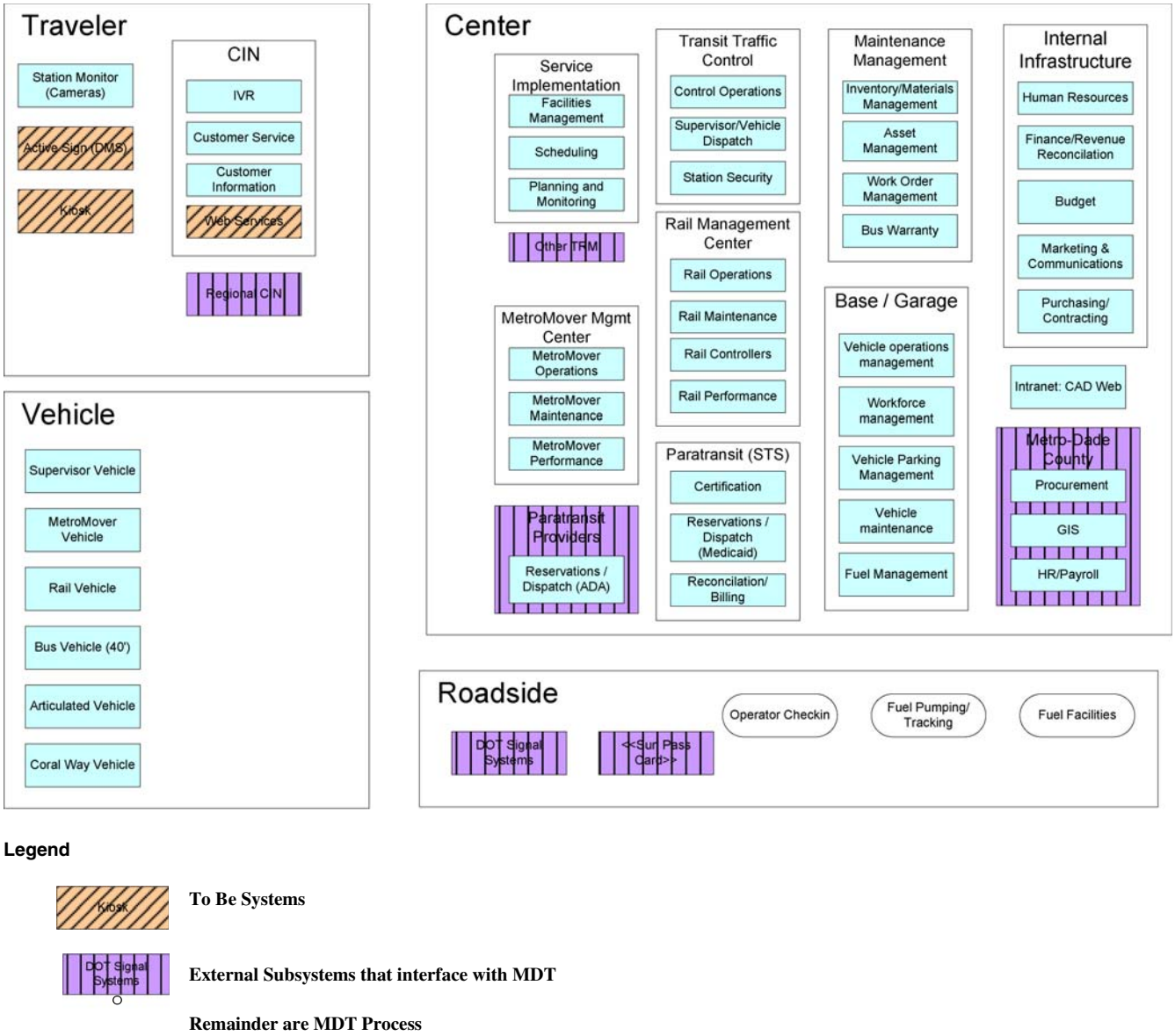


Figure 8. MDT current EA allocated to Regional ITS Architecture model. (Source: MDT Strategic Plan [17].)

3.2.5 Other Transit Approaches to Enterprise Architecture Planning

Agencies use several approaches that support "enterprise thinking" either across an architecture level or between architecture levels.

- Bottoms up inventory
- Segment Architecture (cross cutting or vertical) like GIS
- Enterprise data
- Project architectures

3.2.5.1 Current Application and Technology Architectures through Inventories A first step to developing an "as is" architecture is documenting a list of all the applications, both software and hardware (versions, models, maintenance schedules and license agreements). In addition, these agencies are defining application and technology standards for their organizations. For example, agencies are consolidating their databases around a certain manufacturer's version (Oracle 11i, SQL Server 2008, PostGresSQL), running their critical infrastructure on a certain operating system, or turning to Open Source Software as their first choice for infrastructure software. MARTA developed several Technology Architecture models from 1998 through to their current system. These standards and their current technology and applications may be documented as a set of inventories. As seen in many of these inventories, a spreadsheet is used to identify the owner's organizational unit, IT steward(s), related software or hardware, manufacturer and version. Additionally, other attributes related to technology component perform-

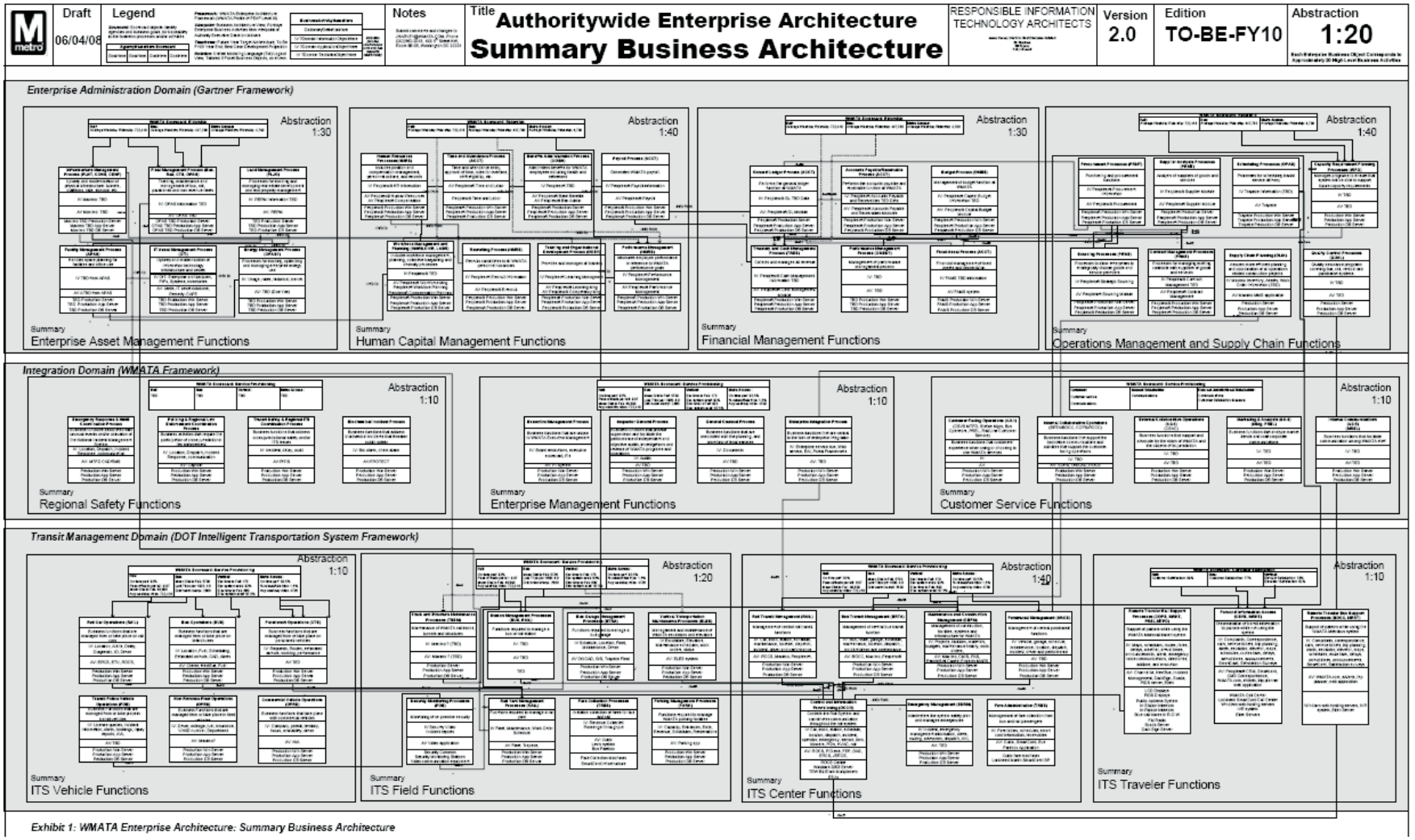


Figure 9. WMATA Summary Business Architecture. (Source: Adapted from WMATA Enterprise Architecture, June 2009. Licensed under a Creative Commons Attribution-ShareAlike License [CC BY-SA].)

Table 3. Relationship between WMATA domains and functions.

Domain	Functions
Enterprise Administration (based on the Gartner Framework)	Enterprise Asset Management Human Capital Management Financial Management Operations Management and Supply Chain
Integration (based on the WMATA Framework)	Regional Safety Enterprise Management Customer Service
Transit Management (based on the U.S. DOT National ITS Architecture Framework)	ITS Vehicles ITS Field ITS Center ITS Traveler

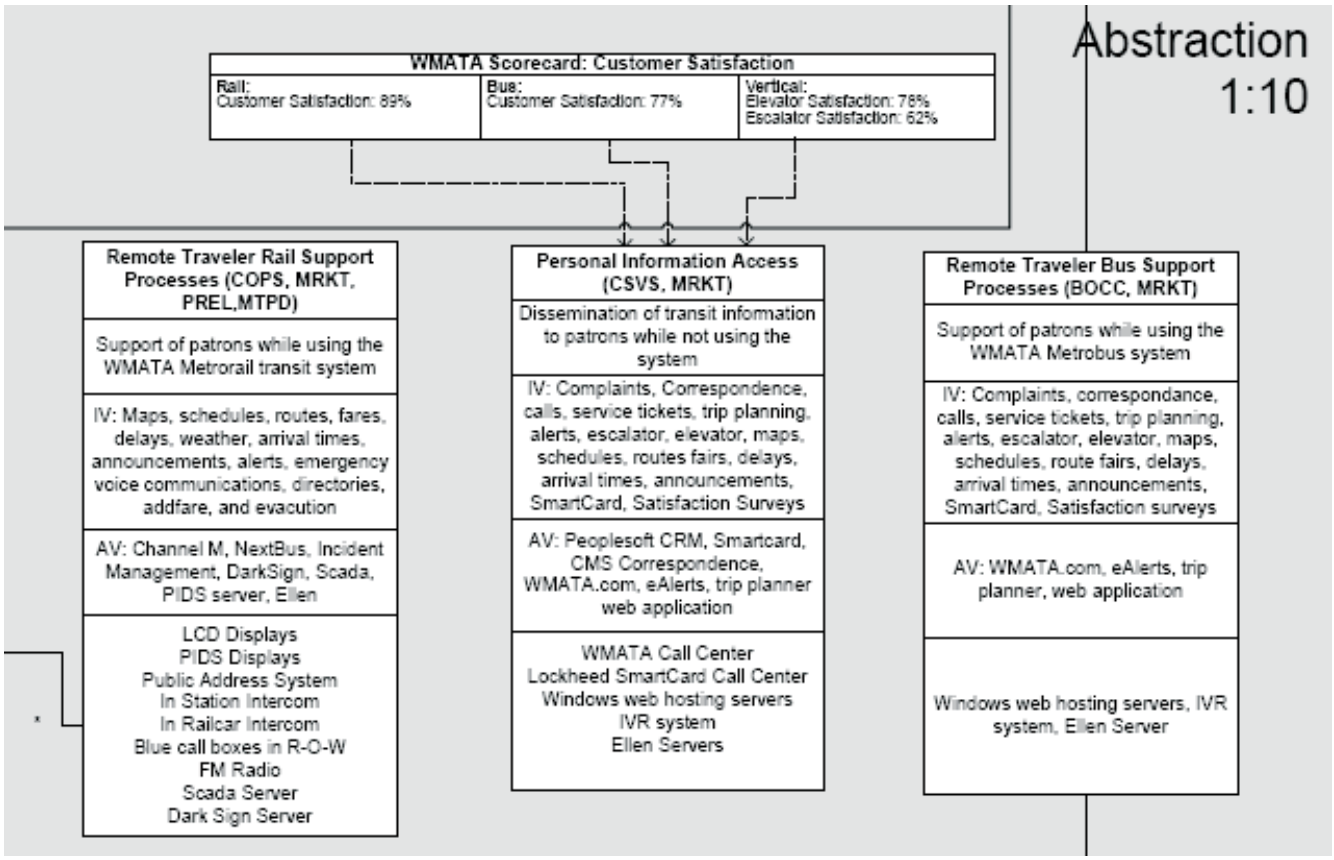


Figure 10. ITS traveler functions from WMATA business architecture. (Source: Adapted from WMATA Enterprise Architecture, June 2009. Licensed under a Creative Commons Attribution-ShareAlike License [CC BY-SA].)

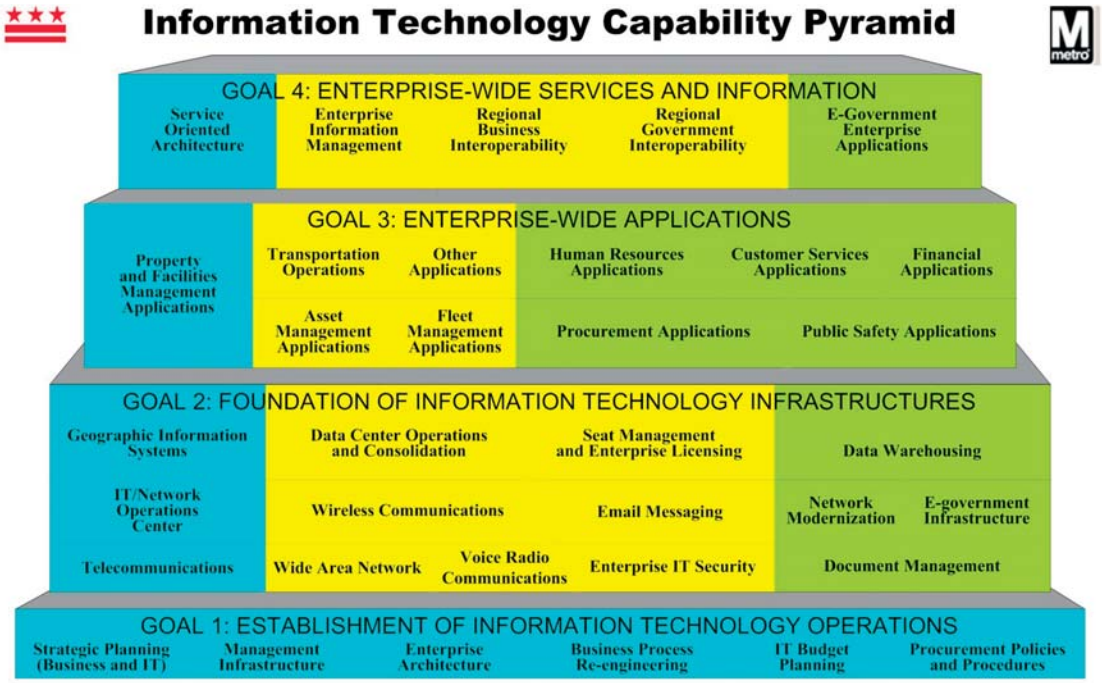


Figure 11. WMATA IT maturity capability pyramid [from Oct 30, 2007]. (Source: Professionals' Guide [19].)

ance may be included in the table. The attributes may include elements of behavior, cost, reliability and capacity. The next step would be to link the technology, software and applications lists, relating them to each other and the organization, referencing OS software to servers, servers to their location and applications to the server and OS software (and version).

Some methodologies describe the "as is" architecture as a "bottoms up" approach to architecture, meaning that it is the act of unearthing what exists. Using this approach, any documentation collection of current capabilities, services, processes and existing standards describes part of the "as is" architecture. The documentation may be as simple as a spreadsheet that includes the agency standards and internal procedures. Most medium to large size agencies have a centralized list of their applications, software and infrastructure. Perhaps missing from the inventories are the connections among the infrastructure elements, applications and software and the linkages to the business processes, objectives and goals.

3.2.5.2 A Cross-Cutting Segment Architecture Development: Geographic Information Systems (GIS) As described in the FEA, the Segment Architecture is a process to investigate a section of an overall EA that is either a vertical business area (e.g., line of business) or a cross-cutting area. Since the early 1990's, the transit industry has been developing GIS enterprise architectures, an example of a cross-cutting area. In July, 1992, Seattle Metro (aka King County Metro) published a comprehensive Phase I study *(20)* detailing the cross-cutting business processes, functions and supporting applications, geographically related data elements and organizational impact on meeting those needs. A Phase I second study, published in 1993 *(21)*, described the alternative hardware, software and applications that support the business processes. The analysis segregated the analysis into "infrastructure" (technology), "GIS Software" and "Software" (applications) and "Data" (data), anticipating the divisions promoted by subsequent EAP methodologies. In hindsight, the early King County Metro Phase I studies followed the FEA Federal Segment Architecture Methodology through to its implementation, even as it continues to evolve to today.

There are several transit agencies that have implemented enterprise GIS architectures. The early work of Seattle Metro, which was widely disseminated, may have contributed to the early adoption of this architectural segment. The work was used to help develop a comprehensive Guidebook on Geospatial data management from planning through implementation, operations and maintenance *(22)*. Though not a reference architecture or step by step guide to developing a segment architecture, the Guide provides building blocks to develop a business process model, identify geospatial and location services and identify core data needed to fully describe a GIS enterprise architecture. Furthermore, the enterprise approach to a Geospatial enterprise architecture has been aided by the Geospatial industry. The Industry promotes and vendor products support open specifications and standards, which drives standardization in all industries that use the tools; in

addition, Google has made access to map data (through KML) and geospatial functions free and available.

3.2.5.3 Enterprise Data: Centralized Database Many agencies aspire to develop a centralized database of core data (or a distributed set of databases with seamless sharing of information). An enterprise database, similar to ones developed by BART, TriMet, King County Metro, Long Island Rail Road and UTA, supports the development of IT/ITS applications as well as other downstream applications. These agencies can develop "homegrown" applications and services that better support their business processes. Some organizations, like MARTA, are developing robust data warehouse applications. MARTA's warehouse application drives a "dashboard" that displays up-to-date performance information showing up-to-date operational performance data. Very few have actually developed an enterprise data architecture or centralized database. The development, operations and maintenance effort to manage a database of this sort requires staff with specific skills and resources to ensure data integrity.

Several artifacts contribute to the development of a Data Architecture and ensure a comprehensive description of the data infrastructure. These include:

- Data principles with respect to treating Data as a resource and asset.
- Business and logical (physical) data model
- Data dictionary for core data including naming conventions, unambiguous definitions, and unique identifiers
- Data management process models
- Data interoperability requirements
- Data lifecycle needs
- Data security needs
- Data reporting requirements and aggregated data descriptions (particularly for performance measures)
- Metadata needs

(Note: this list is based on several data management and data enterprise architecture descriptions which include these and additional products.)

In developing their data architecture, Miami Dade Transit defined six key Data Principles *(17, Appendix A, p. A-3)*.

> "The six key principles identified by MDT staff are:
>
> 1. Avoid duplicating the development and maintenance of data and datasets
> 2. For a core data element, establish a single point of management, collection, "cleaning", and define an authority or "a system of record" to ensure data consistency and completeness throughout organization
> 3. Create enterprise awareness of critical data (understand processes that depend on data)
> 4. Create an awareness of the value and cost of data throughout the organization
> 5. When creating core data, determine priority order based on overall criticality to application, operations, and the number of users
> 6. Consider security, including access requirements and restrictions."

Agencies that develop and implement a core database have fewer problems deploying data-driven ITS systems than most agencies. One reason is that their data is consistent and supported by their business processes. Furthermore, they have developed tools to support their internal customers that help make their agencies more adaptable. Finally, they have control over how and who can use critical data.

3.2.5.4 Project Architectures and Enterprise Solutions Transit agencies are migrating to enterprise-wide applications through open "services" or interfaces that help distribute key information in a timely manner. Some agencies are undertaking comprehensive studies of the needs and requirements for these applications (the sections on System Engineering and Business Case Methodology will discuss the processes related to these types of applications in more detail). The planning work related to developing these enterprise applications may be described as a vertical segment of the enterprise architecture process. Although the industry scan was limited, the related vertical architectures included:

- Travel Management Coordination Centers (for regional and statewide human service and community transportation)
- Computer Aided Dispatch and Automated Vehicle Location (CAD/AVL) systems
- Bus Rapid Transit (limited to data, services and technology—communications and related project linkages)
- Data and Service Architectures related to customer communications on transit service
- Maintenance Management (to enhance predictive maintenance processes)
- Human Resources

The enterprise applications tend to be costly, which hampers smaller agencies that have limited resources. Many applications target areas outside the scope of transit ITS projects, such as personnel (HR), finance and equipment maintenance. The IT industry is providing solutions for smaller agencies through the Internet. For example, Hampton Roads Transit is migrating some of its applications to "cloud" computing or "software as a service" solutions, that is, Internet-provided services that are free or may be acquired for a minimal fee. Other organizations, for example, Long Island Rail Road and TriMet, use open source software products. More open source software products are available for enterprise applications. In addition to the well-known operating system

(LINUX), web server (Apache) and web browser (Mozilla) software, new open source software tools like Customer Relations Management *(23),* Enterprise Resource Planning, Mobile Computing and Communications (including Voice Over IP) are being offered by application service providers.

3.3 Next Steps

The lesson learned from this review is that Enterprise Architecture Planning is difficult without the necessary building blocks that other industries enjoy. Several approaches to planning and implementing the Enterprise Architecture are available, including NASCIO and TOGAF; it is the description of the high level business processes, data and services models and their relationships that are missing from the industry literature. Agencies generate hundreds of pages of documents that may be shared, however, there are no tools or web sites to post these models, policies, examples and documents. There are many TCRP and FTA reports on Performance Measures, Transit ITS technologies and their cost/benefits that are not categorized by a formal taxonomy, and thus they are hard to access and use. The industry would benefit from a formal wiki site, with hyperlinks to show the relationship among the five FEA architecture models.

Chapter 3 Appendix A: Enterprise Architecture Definitions from the Literature

Although the major processes and categories are similar throughout the different Enterprise Architecture (EA) and Enterprise Architecture Planning (EAP) methods, the industry is not consistent in the meaning of terms, classifications, and scope of EA and EAP. This section describes definitions of Enterprise Architecture and Enterprise Architecture Planning. In addition, this Research study asserts a "Transit Enterprise Architecture and Planning Framework". Many of the definitions in the following sections discuss their method or model as a "framework." To that end, this section defines the term framework to broaden our understanding of the term with respect to this research.

Enterprise Architecture

The scope of "enterprise architecture" varies by methodology. Across different definitions, the common factor is that the enterprise architecture is a formal description of the system (in this case the "enterprise" is not just a single application such as a resource management system). Although each EA Methodology definition differs on what is implied by *enterprise,* each consistently includes people, processes and technology. In addition, the Enterprise Architecture is described from various viewpoints, from the business owner, operations manager to the developer and line staff.

The Enterprise is typically composed of four to five interconnected architectures (these were presented in the introduction):

- Performance Measures,
- Business Processes,
- Information,
- Services (applications), and
- Technology.

For example The Open Group Architecture Framework (TOGAF) describes Business, Information, Application, and Technology *(10)*. The Federal Enterprise Architecture describes five architecture views as described in the side bar *(6)*.

The Federal Enterprise Architecture (FEA) Enterprise Architecture Models

The **Performance Architecture** is a standardized framework to measure the performance of major IT investments and their contribution to program performance. It includes Mission Goals and Objectives and Performance Measures.

The **Business Architecture** includes details of processes, work flows, roles & responsibilities needed to meet the business goals and objectives of the organization. It describes the "who, what, where, why, when and how" business processes are accomplished.

The **Data Architecture,** a conceptual data model that describes the meaning and relationship of information, includes information on integration issues associated with enterprise data; it also answers the questions of who, what, where, why, when and how the data is managed.

The **Services Architecture** describes application req'ts, and the flow and delivery of information among subsystems. It records the application versions, restrictions on use and other information on applications and interfaces.

The **Technical Architecture** describes technical information on security, communications, and infrastructure policies and standards associated with the deployment of technology. An agency may specify database, desktop and server equipment and software, network protocols, as well as, define security and privacy policies.

The relationships among these architectures are typically described as seamless and interconnected where the Corporate Vision, mission and objectives (*Performance Measures*) drive the need to implement *Business Processes;* Business Processes are driven by decisions that people make using good *Information;* Information is generated from Applications and Automated Processes (*Services*); Applications run on *Technology*.

The Federal Enterprise Architecture (FEA) defines Enterprise Architecture as a description of information, services and technology that work together to solve and measure business needs.

> [Enterprise Architecture is] . . . information, services and technology across an enterprise, that work together to solve and measure business needs and processes. *(24)*

The National Association of State CIOs (NASCIO) describes enterprise architecture as a methodology for "designing government processes." Their description is closer to one used for Enterprise Architecture Planning.

> Enterprise Architecture is the management discipline for designing government processes and technology investments for success. *(25)*

The IEEE definition for "architecture" is derived from Steven Spewak, who standardized an approach for enterprise architecture planning. It defines an architecture as a framework that includes people (environment), processes and technology.

> The fundamental organization of a system embodied in its components, their relationship to each other, and to the environment, and the principles guiding its design and evolution. (Definition for Architecture-*26)*

The Open Group Architecture Framework (TOGAF) definition [TOGAF 8.1.1 Glossary] assumes the word architecture has two distinct meanings, both a system description as well as a plan for implementing it.

> Architecture (10, Glossary) has two meanings depending upon its contextual usage:
> 1. A formal description of a system, or a detailed plan of the system at component level to guide its implementation.
> 2. The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time.

A ***Reference Enterprise Architecture*** has a different meaning then enterprise architecture. A *Reference Enterprise Architecture* is a taxonomy and set of relationships described by an industry to define its core business. Many industries have developed a reference architecture to standardize functions, services, and critical performance measures, as well as to promote interoperability and off-the-shelf tools that meet their business needs. The Federal Enterprise Architecture has three reference architectures—Performance, Business and Data. In addition, each Federal Department is tasked to define more detailed Lines of Business (e.g., business processes) which will add to this taxonomy. Additionally, some agencies are driving the reference architecture to increasing levels of detail by developing Concept of Operations descriptions (for example, personnel management) or specifications for cross-cutting functions (such as geospatial services) that will ensure interoperability across the Federal government.

Enterprise Architecture Planning

Methods that define Enterprise Architecture Planning are consistent in their understanding of the term's meaning. It is a process to develop (1) a set of enterprise element descriptions, and (2) a plan to implement the systems that compose the architecture descriptions. Steven H. Spewak, in his groundbreaking book *Enterprise Architecture Planning: Developing a Blueprint for Data, Applications, and Technology*, lays out a method for implementing the planning process. Spewak defines EAP as follows:

> Enterprise Architecture Planning is the defining architectures for the use of information in support of the business and the plan for implementing those architectures. *(27)*

The NASCIO also defines the term EAP similarly:

> The processes necessary to direct or guide initiatives, to ensure that performance aligns with the enterprise, to enable the enterprise business by exploiting opportunities, and to ensure resources are used responsibly and architecture-related risks are managed appropriately. *(11)*

The FEA and TOGAF (which uses the term Architecture Development Method (ADM) cycle) both apply Systems Engineering and Program Management planning processes to the EAP. The method used in the FEA and TOGAF frameworks will be discussed in the section below.

Framework

The word framework is used differently depending on which Enterprise Architecture methodology is described. Generally, framework is used to describe "a structure." In the last decade it is evolving to mean a set of processes that are used to implement an Enterprise Architecture.

The use of the term to mean structure is nowhere more evident than in its earliest use by the father of Enterprise Architecture, J. A. Zachman. Zachman defined the enterprise architecture framework as a set of products and terms that are

associated with the cells in a matrix where the rows describe the perspectives of major players of the enterprise (planner, owner, designer, builder, subcontractor, and enterprise), and its columns refer to "what, how, where, who, when, why," or "data, function, network, people, time and motivation." Later in life, as described by Roger Sessions in [1], Zachman described his work ". . . as it applies to Enterprises . . . [as] a logical structure for classifying and organizing descriptive representations of an Enterprise." *(28, p. 11)*

In his paper from 2007, Sessions describes Architecture Framework as a structure that consists of artifacts (documents, reports, analysis, models or other physical description) or products that describe parts or perspectives of an Enterprise Architecture. He states that an Architecture Framework is:

> A skeletal structure that defines suggested architectural artifacts, describes how those artifacts are related to each other, and provides generic definitions for what those artifacts might look like. (Definition for Enterprise Framework from *28*)

This definition is similar to the definition that the US DOT uses to define the National ITS Architecture, "reference architecture framework" for the transportation system. The US DOT defines Architecture as:

> A framework within which a system can be built. Requirements dictate what functionality the architecture must satisfy. An architecture functionally defines what the pieces of the system are and the information that is exchanged between them. An architecture is functionally oriented and not technology-specific which allows the architecture to remain effective over time. It defines "what must be done" *not "how it will be done." (29, Glossary)*

TOGAF defines a framework as a set of processes that support the development of an architecture. The TOGAF method is a framework as described by its name. This definition is closer to the one that describes this research Transit Enterprise Architecture and Planning Framework.

> A tool for assisting in the production of organization-specific architectures. An architecture framework consists of a Technical Reference Model, a method for architecture development, and a list of component standards, specifications, products, and their inter-relationships which can be used to build up architectures.

Similar to TOGAF, when the Federal government launched the enterprise architecture development program in 1998, it named itself the Federal Enterprise Architecture Framework (FEAF). FEAF consisted of both the structure of the different models of the enterprise architecture based on the Zachman framework as well as an adaptation of the methods advocated by Spewak's EAP methodology. In 2002, the Federal program renamed the FEAF methodology to Federal Enterprise Architecture (FEA).

Chapter 3 Appendix B: FEA Segment Architecture Description

A Segment Architecture is a prioritized section of the Federal Enterprise Architecture that contributes to describing a critical part of the Enterprise Architecture at a greater level of detail. For example, the Federal Geographic Data Committee (FGDC) describes its three lines of business *(30):*

- Identify common geospatial requirements, responsibilities, and capabilities across [the] government
- Allow for improved coordination of acquisition and operations to government-wide benefit
- Encourage the geo-enablement of appropriate government business processes to improve access to location-based data and services

This Segment Architecture methodology (depicted in Figure 12) is defined by FSAM in the following five steps:

1. Determine Participants and Launch the Project: Project charter
2. Define the Segment Scope and Strategic Intent: Performance Architecture Model
3. Define Business and Information Requirements: Business and Information Architecture Models, Business Rules and high level Requirements (concept of operations)
4. Define the Conceptual Solution Architecture: The combined systems, services, and technology architectures that support the target performance, business, and data architectures developed in the preceding process steps.
5. Author the Modernization Blueprint: The Sequencing and Transition Plans.

The segment development steps are preceded by defining the strategic drivers (e.g., policy directives) and high level reference business architecture models and conforming to requirements defined by cross-cutting Segment Architectures. The FEA assumes that Government agencies that develop a Segment Architecture will use the Reference Architecture models as a building block, taxonomy and checklist.

The outcome of the FGDC initial cross-cutting segment architecture effort has been to develop a Profile *(31),* that is:

> . . . a tool for chief architects to determine how and where place-based approaches and associated geospatial resources fit into their enterprise architectures as they implement the FEA reference models.

The document also lists standards and service components (e.g., web and location-based services) that should be supported in Federal procurements across the agency to facilitate interoperability.

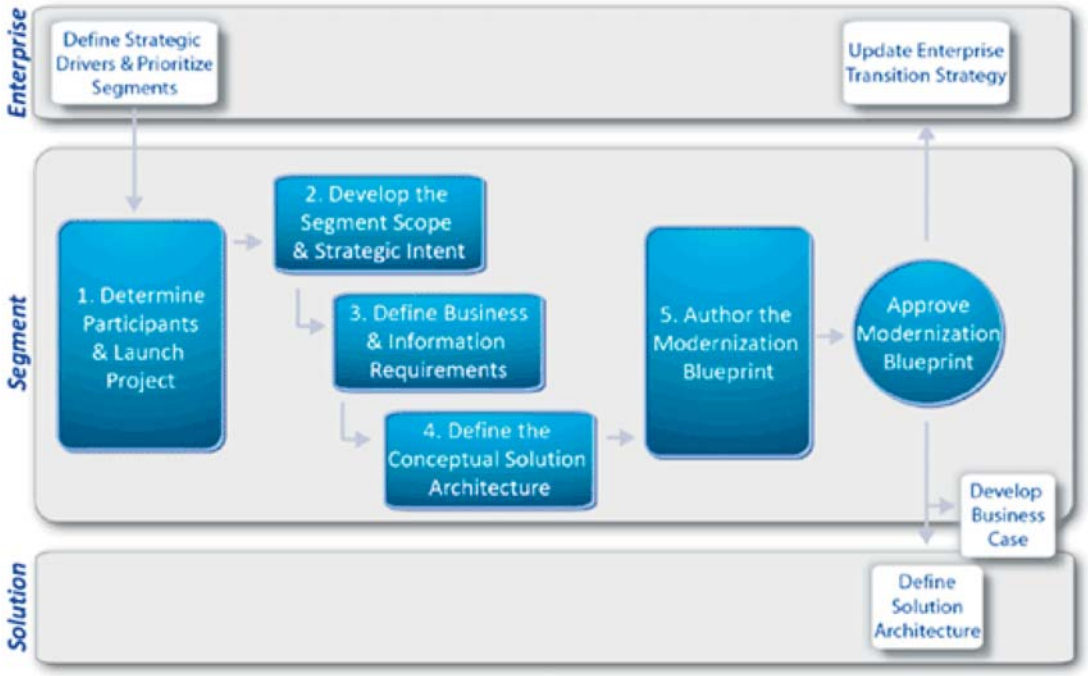


Figure 12. FSAM high-level overview. Source: FSAM.

Chapter 3 Appendix C: Description of The Open Group Architecture Framework (TOGAF)

Domain descriptions are performed in Phase B through D. In each of these Phases, the current and future architectures are described and validated with key stakeholders, and the model conforms to existing standards, policies and procedures. In addition, developers identify the "gap" between the current and future architectures. Additional contributions are made to the requirements and gap matrix at each phase. Gaps that may exist at the Business Architecture stage include *(31, Part II, Phase B):*

- People gaps (e.g., cross-training requirements)
- Process gaps (e.g., process inefficiencies)
- Tools gaps (e.g., duplicate or missing tool functionality)
- Information gaps
- Measurement gaps
- Financial gaps
- Facilities gaps (buildings, office space, etc.)

The ADM includes phases to move an organization towards transitional architectures. These are briefly described below.

Phase E Opportunities and Solutions: This phase includes the exploration of funding implementation methods, alternative analyses (at the four domain levels), an implementation and migration strategy and a detailed Implementation Plan.

Phase F Migration Planning: This phase includes details related to prioritizing the projects that will form the detailed Implementation and Migration Plans.

Phase G Implementation Governance: The objectives of Phase G are to:

- Formulate recommendations for each implementation project.
- Construct an Architecture Contract to govern the overall implementation and deployment process.
- Perform appropriate governance functions while the system is being implemented and deployed.
- Ensure conformance with the defined architecture by implementation projects and other projects. *(10, Part II, Phase G)*

Phase H Architecture Change Management: This phase supports the continual improvement and update of the architecture descriptions, policies and vision to meet the changing requirements of the enterprise.

There are many resources available to contribute to the Architecture development. TOGAF calls this part of the Framework the **Enterprise Continuum.** The Enterprise Continuum is described as a "virtual repository" of methods, patterns and solutions that help build the Organization Architectures. The Enterprise Architecture is composed of a "conceptual" part called the **Architecture Continuum** (see Figure 13), and a product oriented part called the **Solutions Continuum.**

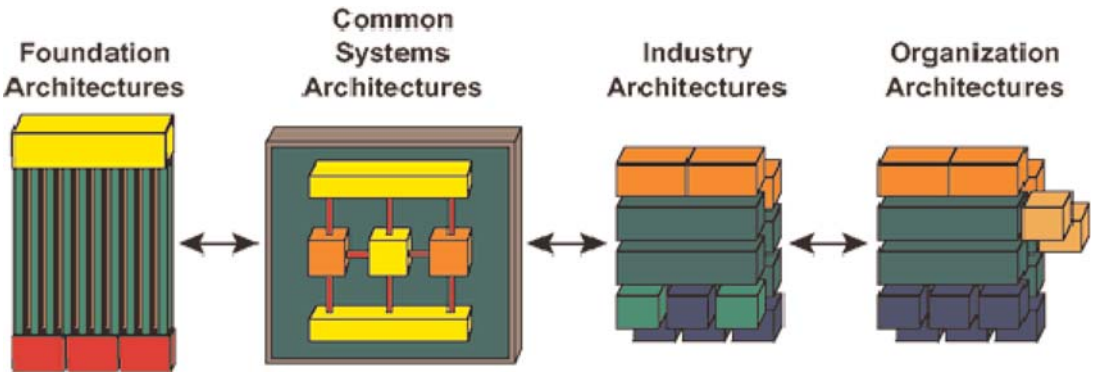


Figure 13. The architecture continuum. Source: TOGAF version 8.1.1.

The Architecture Continuum is a set of building blocks that may be used as a template to help build architectures. The Foundation and Common Systems Architectures are common to most organizations irrespective of market segment. The Industry Architectures describe specific functions and processes of a vertical market or industry. The Retail industry's "Active Store" architecture is an example of an Industry Architecture; the National ITS Architecture is an example of the ITS industry architecture (although it does not follow the TOGAF methodology).

The Architecture Continuum also includes a **Standard Information Base (SIB).** The SIB is an inventory of standards that apply to the parts of the Architecture Continuum.

The **Solutions Continuum** is a set of building blocks for the implementation of the architecture. It is composed of product and system solutions for IT, industry configurations and organizational implementations.

Finally, the **Resource Base** contains resources on governance, boards, contracts, assessment and maturity models and examples of ADM products and required skill sets.

4 Findings on Transit IT/ITS Implementation Funding

Prior to the 1980's, pay-as-you-go was the primary way to fund transportation projects. State and local governments secured Federal transportation funding either through formula or discretionary grants. They would budget the non-federal match with state and local funds. Local and state funds were derived from transportation fees or revenue from a variety of broad-based taxes. The 1980's marked an era of heightened interest in private sector approaches applied to public transportation. Innovative financing became a dominant theme, where traditional financing approaches were used in new and creative ways. Public financing options with a variety of innovations arrived on the transportation scene in the 1990's and have proliferated into the 21st Century.

This chapter compiles information on current ways transit IT/ITS projects are funded. It summarizes literature obtained from a variety of sources (see references at the end of the chapter). Best practice is presented based on a survey conducted with a sample of transit agencies that are known for their progressive use of technology. Their application of technology occurs in electronic fare collection, passenger information, operation control centers, system surveillance, service scheduling, vehicle location, operator safety, substance detection and a variety of business management functions such as accounting, payroll, training, maintenance, purchasing and material storage.

4.1.1 General Findings from the Literature

As we near the second decade of the 21st Century, financial engineering is alive and well in the transportation sector. Infrastructure banks exist at the Federal and State levels. Special provisions for financing technology can be found in Federal tax law. A variety of innovative financing mechanisms are being widely used. Several university business schools offer financial engineering programs to teach students principles and practices involved in structuring, analyzing and making decisions on economically efficient and effective financing approaches. Organizations like the National Association of State Chief Information Officers (NASCIO), Government Finance Officers Association (GFOA), Federal Transit Administration (FTA), Federal Highway Administration (FHWA), the Transportation Research Board (TRB) (through the FTA-funded Transit Cooperative Research Program and FHWA-funded Highway Cooperative Research Program) and the American Public Transportation Association (APTA) are documenting the state-of-the-practice and state-of-the-art in technology financing in general and public transportation technology financing in particular.

4.1.2 General Approach to Implementation Funding

A summary of IT funding experience at the state level is identified in Table 4. As the table implies, IT investments are clearly becoming more competitive with other capital invest-

Table 4. State funding of IT projects.

Funding Approach	Number of States Using Funding Approach, 2008, N=31	Number of States Using Funding Approach, 2003, N=23
User–Fee Revenue	22	NR
Grant Funding	22	NR
Budgeting & Appropriations Strategies	19	18
Leveraged Financing	19	15
Outsourcing & Managed Services	19	16
Procurement Strategies	17	16

Notes: NR represents No Response.
Leveraged financing includes leasing and various types of bond financing.

Source: NASCIO's 2008 and 2003 surveys of innovative funding for IT projects, 2008

ments. According to the NASCIO survey, few states were using user fees and grants to fund IT projects in 2003. However, by 2008, over 70% of the states participating in the survey indicated that they were employing user fees and grant funds to implement IT projects. More innovative and alternative funding approaches appear in the same timeframe. Bond financing and different types of lease financings became more prevalent. In addition, a variety of public-private partnerships and public-public partnerships started commanding greater attention.

An illustrative example of an emerging and innovative public-private partnership is the replacement of the IT systems for the Commonwealth of Virginia Department of Taxation. In 2003, Virginia legislators amended the Public-Private Transportation Act to allow it to be applied to other government programs. The Department of Taxation (TAX) was the first area to make use of the amended authority. It initiated and executed a partnership contract with CGI-AMS to design, implement and operate a new tax revenue collection system with online filing and payment capability. TAX used an enterprise architecture planning framework to develop the new tax collection system as shown in Figure 14. The private contractor raised $71 million to cover the cost of the new system.

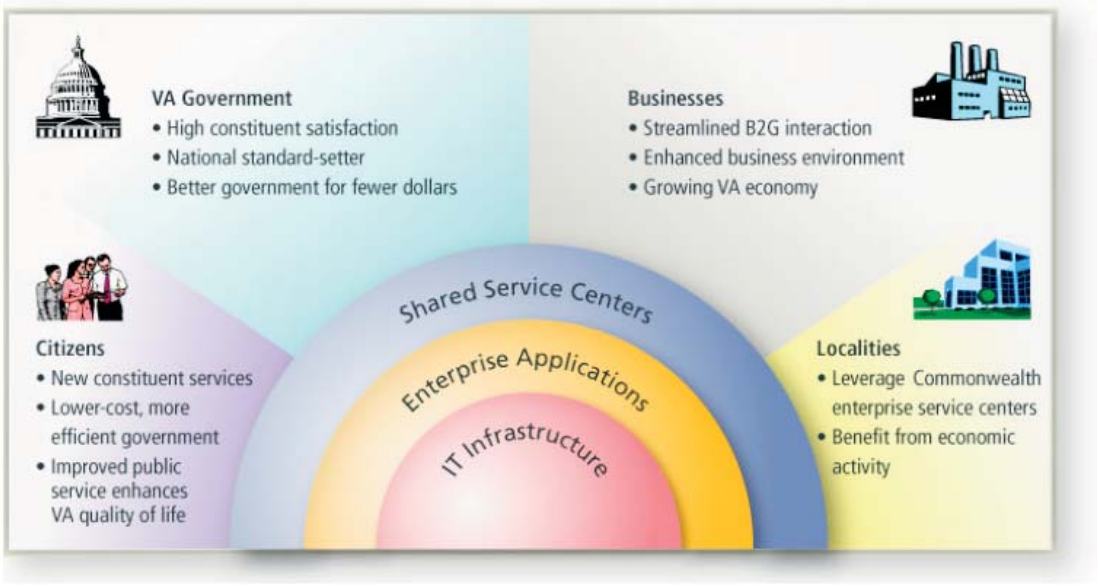


Figure 14. Virginia TAX architecture planning framework. Source: Commonwealth of Virginia Department of Taxation, 2003.

In return, CGI-AMS received 3% of revenue collected from on-line returns over the life of the contract. Risks were shared. The contractor assumed systems integration and operating risks and Virginia assumed revenue risk. Absent the CGI-AMS annual payment, the Commonwealth receives an additional $72 million of revenue.

The Government Finance Officers Association (GFOA) recommends that finance officers achieve a full understanding of the available options when determining if a public-private partnership agreement is a viable and prudent transaction for their jurisdiction. This includes development of an internal policy that defines the government's criteria for making various contributions to or investments in "partnership" arrangements. Early in the process of analyzing a proposed "partnership" transaction, the finance officer should also assess the nature and extent of any outside consulting or financial analysis services that the governmental body requires for its analysis and negotiation of the transaction.

As noted in the Recommended Practice (RP), The Role of the Finance Officer in Economic Development *(32),* finance officers are encouraged to participate in and provide essential information to the "partnership" process. This includes developing the objectives for the partnership, analyzing financial aspects of proposed arrangements, making recommendations to elected officials, advising on procurement issues arising from the solicitation and engagement of non-governmental parties and participating in the negotiation of the development agreement. The finance officer must also determine the total value of the public contribution (participating jurisdiction and others) in the agreement, including non-cash items, to make sure that the public's contributions to and investments in the project are justified and properly compensated. The finance officer must also be mindful of any direct or indirect increased, ongoing public operating costs that may result from the project.

The GFOA recommends that finance officers use the following list as a guide for preparing a comprehensive examination of issues that must be addressed before, during and after the project is determined to be viable and prudent. This list emphasizes that a great deal of due diligence must be completed prior to entering into a contract, since these decisions may have significant and long-lasting ramifications. GFOA recommends taking the following actions when considering public-private partnerships:

1. Research private partners, their business and market;
2. Research the type of transactions being considered;
3. Consult with appropriate professionals about applicable federal and state tax laws;
4. Understand the rights and obligations of each party;
5. Set standards for public financial commitments;
6. Evaluate and disclose the financial and non-financial impacts of the proposals; and
7. Monitor the agreement.

The finance and technology officers involved in a "partnership" should ensure full disclosure and make recommendations that the government's participation in the venture does not bring excessive and unbalanced risk to the public.

4.2 Transit Capital Investment Needs and Funding Approaches

4.2.1 Transit Funding Needs

Given the demand for transit funding, transit agencies are using all forms of funding approaches for state of good repair projects that maintain conditions and performance and for capacity enhancement and system expansion projects that improve conditions and performance. Like IT projects in general, transportation IT and ITS projects are delivered with public leveraging options such as bond and leasing financing, public-private partnerships, comingled funding and a variety of Federal, state and local funding sources. From the report, 2006 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report to Congress, the replacement value of urban transit infrastructure in the United States was $402.7 billion in 2004 dollars *(33)*. This is the cost estimate of replacing all of the transit assets using 2004 dollars. We know that price inflation for IT and ITS projects technology is advancing all the time. For example, it has been said that microprocessors, the heart of most systems, change nearly every 90 days.

In order to maintain the conditions and performance of the Nation's transit system, it is estimated to cost $9 billion per year, as shown in Figure 15. To enhance and expand capacity, an additional $12.8 billion is estimated for a total average annual capital investment of $21.8 billion through year 2024. Of that amount IT, ITS and other systems would require about $1.5 billion per year for maintaining condition and performance and nearly $2 billion per year to improve condition and performance.

4.2.2 Capital Funding Sources

Figure 16 shows that transit agencies receive funding from a variety of sources. They not only receive technology funding from FTA but also from FHWA, state DOTS, local governments and other Federal agencies, such as the Department of Homeland Security (DHS). Transit agencies also make use of a variety of locally generated sources of funds. Since the 1990's, Federal funding continues to account for 50% to slightly over 60% of transit funding. However,

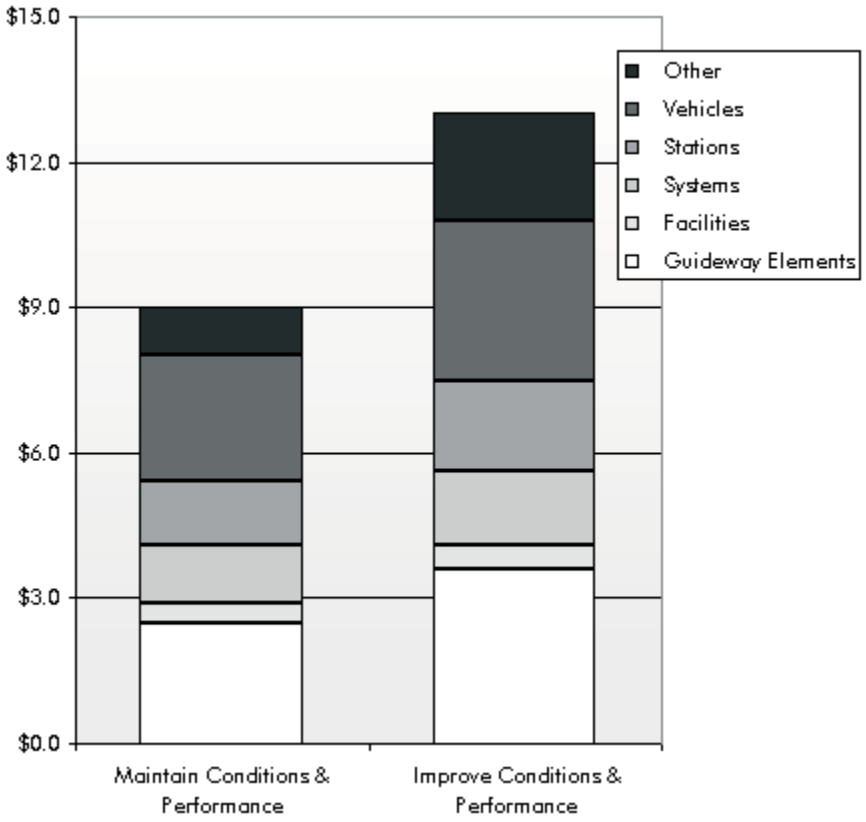


Figure 15. Annual transit capital assets investment needs 2004–2024 ($ in 2004) (34). Source: Transit State of Good Repair: Beginning the Dialogue, October 2008, FTA.

between 2001 and 2005, federal funding experienced a decline. During that period, growth in transit agency-generated funds and state and local funding replaced the federal decline. Transit agency-generated funds led the way. The capital funding sources are defined more specifically as follows:

- **Federal Funds** are funding provided through a number of formula and discretionary programs. The Federal Transit Administration (FTA) distributes the bulk of the federal assistance through its Urbanized Area, Non-Urbanized Area and Fixed Guideway Formula Programs; Discretionary Bus and Bus Facilities, Major Capital Investment,

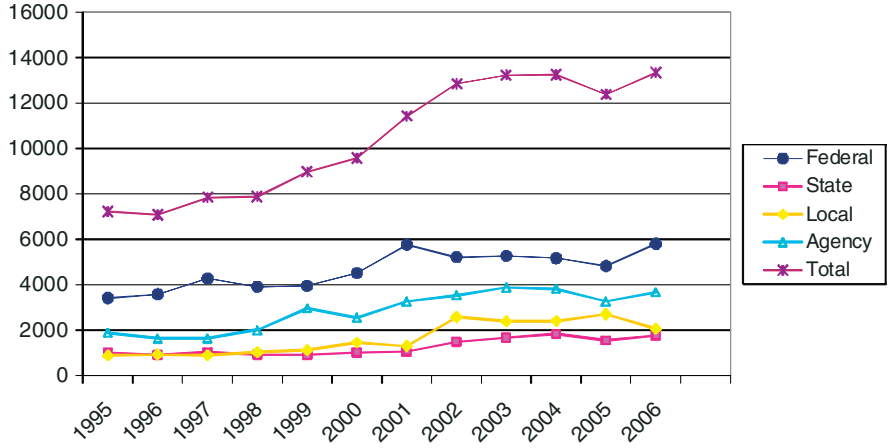


Figure 16. Transit funding sources FY 1995–FY 2006. Source: Transit Statistics, Capital Funding, 2007, APTA.

Planning and Research Programs; and Flexible Highway Funding.

- **Program and Homeland Security State and Local Government Funding Programs.** Under the Flexible Highway Funding Program, the Federal Highway Administration (FHWA) transfers funds to FTA from its Congestion Mitigation and Air Quality Improvement (CMAQI), Surface Transportation (STP) and Interstate Highway Substitution Formula Programs and Research and Technology Discretionary Funds. IT/ITS projects are eligible under each of the FTA, FHWA and DHS formula programs and are funded through earmarks in the various FTA and FHWA discretionary programs.
- **State Government Funds** are obtained from dedicated taxes, general funds, fuel taxes and toll revenue. This includes funding from bond proceeds and infrastructure banks. These state sources are typically used as a match for federal funding and for funding IT/ITS projects. From time to time, some states use specially appropriated funds to support transportation initiatives like congestion management where ITS projects serve as primary tools.
- **Local Government Funds** are derived from similar sources as the states and include sales and property taxes. Local funding sources are also used to match federal funding and can be used for IT/ITS projects.
- **Transit Agency Directly Generated Funds** are revenues generated by or donated directly to the transit agency, including passenger fare revenues, advertising revenues and joint development revenue from leveraged assets, donations, self-imposed taxes, agency bond proceeds, and revenues from creative financing arrangements like cross-border leases and sales leaseback contracts. As observed in the project surveys, transit agencies are starting to make greater use of directly generated funds to pay for IT/ITS projects.

We saw in Figure 15 above that transit agencies need to spend $21 billion per year to keep their systems in a state of good repair and to improve performance. In 2006, an $8.5 billion gap occurred. Consequently, competition for available funding is extremely stiff. IT/ITS projects suffer in this competitive environment because of lingering misunderstanding of their benefits and higher priority capital projects like vehicle replacements, infrastructure rehabilitation and construction of new lines.

4.2.3 Financing Mechanisms

Transit agencies are using a variety of financing mechanisms to access the various sources of capital for IT/ITS projects. Historically, buy (pay-as-you-go), borrow (issue bonds) or lease were the primary financing mechanisms that transit agencies used. Since the 1990's, creative use of these traditional mechanisms and introduction of public-private partnerships have occurred. Today, financing mechanisms fall into four categories: debt mechanisms, capital leasing financing, equity and partnerships and credit enhancements. More detailed definitions of these financing mechanisms are as follows *(35):*

- **Debt**—These mechanisms are also known as leverage financing and include long- and short-term issuances of bonds in the taxable and tax-exempt markets as well as direct loans from governmental and non-governmental sources.
- **Capital lease**—Rather than purchasing an asset outright, the acquiring entity leases the asset over a number of years. While this is not always truly a mechanism to finance the acquisition of an asset, it most certainly is an alternative approach to gain use of the asset over a comparable period of time. Lease payments are made in lieu of payments of principal and interest. In many instances in which a lease-to-purchase arrangement is utilized, lease mechanisms do indeed result in full asset ownership.
- **Public-Private Partnerships (PPP)**—These are contractual arrangements where an outside entity invests a certain amount of funds in a capital asset with the expectation of sharing in the profits of its operation or otherwise directly benefiting from its operation or is given access to agency owned assets in the context of more effective management of its assets. *(36)* In the transit arena, this can include IT, ITS, vehicle, joint development and infrastructure projects.
- **Credit enhancement**—These mechanisms are designed to help manage financial risk and include bond insurance, letters and lines of credit, and governmental guarantees used not as stand-alone financing mechanisms but in support of the direct financing techniques. It is important to note that these financing options are not mutually exclusive and that the most innovative project delivery approaches tend to use them in combination. The TEA-21 authorized Transportation Infrastructure Finance and Innovation Act is an example of a federal credit enhancement program.
- **Pay-As-You-Go**—This mechanism is used when a project's schedule can be met with current sources of funds rather than by borrowing or leasing. This financing mechanism is used more widely than the others for most transit capital investments in particular IT/ITS investments.
- **Comingling**—Comingling of funds occurs when funding for one program is used in support of multi-program objectives. Transit agencies are starting to realize that enterprise approaches like comingling of funds, IT/ITS Architecture, and process management improvements are both efficient and effective ways to solve their financing, customer service, operations, and management problems.

These mechanisms are very similar to those used by states to fund their IT projects, as found by the NASCIO surveys.

Table 5. Transit agency funding of IT/ITS projects.

Funding Approach	Number of Agencies Using Funding Approach, N=12
Debt Financing	5
Capital Lease Financing	2
Public-Private Partnerships	3
Credit Enhancement	2
Pay-Go	12
Co-mingling	12

Source: TCRP 09 Enterprise Architecture Planning, Funding Implementation Survey, January, 2009

Technology in general has played an important role in these developments, as noted above. Lease financing and public-private partnerships involving technology projects received incentives from the tax code in the form of Qualified Technological Equipment (QTE) depreciation allowances. Transit technology in particular is helping to lead the way towards expanded and innovative use of these financing mechanisms. Table 5 summarizes how transit IT/ITS projects were financed by twelve transit agencies that participated in the project survey.

Transit agencies are applying the full range of financing mechanisms to make IT/ITS investment from large enterprise technology replacement projects to small AVL projects. Pay-Go is the primary financing mechanism used by most transit agencies. However, comingling of funds and public-private partnerships (PPP) are starting to be used more. For example, in 1992 the Sacramento Regional Transit District comingled acquisition of 75 buses, a fare collection system and a radio system in a $32.4 million leveraged lease. Salt Lake City UTA comingled $12.3 million to acquire an account-based fare collection system and a performance reporting system. WMATA is pursuing a public-private partnership to finance, design, implement, operate, maintain and manage content of a streaming video advertisement and passenger information system called "The Metro Channel." SEPTA is another transit agency considering an ITS public private partnership, in their case to replace an antiquated fare collection system. Successful implementation of a public-private partnership requires state government legislation overriding low-bid procurement rules, as occurred in Virginia and demonstrated in projects participating in the FTA Turnkey Demonstration Program of 1993 and 2007, Public Private Partnership Program. *(37)* As of April 2007, 23 states and Puerto Rico have legislation in place that allows varying levels of private sector participation in several types of transportation projects.

4.2.4 Repayment Streams

Payment streams include a mix of broad-based taxes, fare box revenue, non-fare box revenue from joint development, shared-use of assets and advertisements, and a mix of annual Federal formula and discretionary allocations. When debt and lease financing mechanisms are used, the repayment stream must be identified and reserved to meet the obligations. The appropriateness of their use varies with their stability and reliability. Economic and market conditions, political acceptability, federal regulations, revenue generation capacity and technology risks are some of the factors that would be used in deciding with which combination of these repayment streams to secure the financing of an IT/ITS project. For a more thorough treatment of the various sources of repayment see *(38)*.

4.3 Key Findings on Transit Agencies Implementing IT/ITS Funding

Transit agencies are using IT/ITS technologies as tools for improving management and operational functions across their enterprises. Decisions on technology investments are made within the context of the capital planning and programming process. Agencies are employing the whole range of funding sources, financing mechanisms and repayment streams. Comingling of funds is allowing transit agencies to more effectively leverage their IT/ITS investment. In the surveys, we saw where a performance reporting system was added to a radio system upgrade project or where broadband wireless communication was combined with an advanced passenger information system and a new electronic fare collection system. Pay-Go financing secured with federal, state, local and agency-generated sources of revenue remains the mostly widely used financing mechanism for all sizes of transit agencies and for smaller technology projects that do not place extraordinary demands on capital. Bond financing is used by agencies with bond authority and large capital programs that cannot be funded on a pay-as-you-go basis. With the inducements of the Government Accounting Standard Board's rules, transit agencies are also seeking to optimize the value of their assets by leveraging them through public-private partnerships. Several cases were particularly illustrative of the trends in implementation funding of IT/ITS projects.

4.3.1 Salt Lake City Utah Transit Authority (UTA)

UTA recently completed implementation of an upgrade radio system for $6 million, a reliability reporting system for $300,000 and an electronic fare collection system (EFC) for $12 million. The EFC System is an account-based bankcard system with 1400 bus validators and 30 rail station validators.

The Reliability Reporting System was integrated with an existing AVL System and leveraged an extra $2 million dollars invested in the EFC System. These projects were funded with revenues from a dedicated UTA sales tax of 6.45 percent. The IT/ITS Program is allocated $5 million a year in sales tax revenue in accordance with the 30-year long-range plan. These funds are typically used on a pay-as-you-go basis but are also occasionally allocated from bond proceeds.

4.3.2 Washington Metropolitan Area Transit Authority (WMATA)

In 2006, WMATA, through the Department of Planning and Joint Development, issued a request for expressions of interest for a public-private partnership to enhance the communication system; develop and implement a real time streaming video advertisement, passenger information and security alert system; and to upgrade the operations control center with a much-expanded customer information component. The system concept was called the Integrated Customer Communication System (ICCS). The ICCS concept of design and operations estimated funding being derived from a four-fold increase in revenue from dynamic advertisements. With 45 private sector teams submitting expressions of interest, WMATA initiated a procurement for a public-private partnership as an option to finance, design, build, operate and manage content for what is now called "The Metro Channel" (TMC). The TMC procurement does not include the operations control center upgrade or the communication system overhaul. A Neutral Host Communication System was procured in a separate contract. WMATA is planning to implement the first TMC pilots in 10 stations by 2010 and to complete the entire rail and bus system in four to five years.

4.3.3 Metropolitan Atlanta Rapid Transportation Authority (MARTA)

MARTA, like WMATA and many other transit agencies, has recognized that improving customer experience is a high return goal. MARTA decided to use a public-private partnership as a strategy for achieving this goal. MARTA entered into two 10-year public-private partnership contracts to install, operate and manage content of a passenger video display system for its buses and rail cars. The passenger display system provides real time information on transit services, advertisements, news and weather. The bus agreement estimated the generation of $10 million per year, and the rail agreement estimated $20 million. More recently, MARTA implemented an $85 million Enterprise Resources Program of business systems with bond proceeds secured by its one-cent sales tax.

4.4 Constraints on Funding Approaches

Funding approaches for transit IT/ITS projects are influenced by different eligibility requirements, market conditions and risk profiles. Federal funding requirements include architecture planning, systems engineering and purchasing ITS based on full and open competitive procurements. In the survey, the architecture planning and systems engineering requirements were not replicated as conditions for state and local government funding of transit IT/ITS projects. However, debt service caps, sunset provisions and credit worthiness were identified as local and state government constraints driven by the marketplace. With rapid changes occurring in technology and in the marketplace, risk surfaced as a constraining factor in financing transit technology projects. Evidence of these constraints is described below.

4.4.1 Eligibility Requirements

In late 1989, the USDOT initiated development of a National ITS Architecture as a framework for integrating the flow of information between different systems (ITS). Figure 17 presents an overview of the current version of the National ITS Architecture. ITS technologies were categorized into four subsystem classes: Travelers, Centers, Vehicles and Field infrastructure systems. In sponsoring the National Architecture, the USDOT wanted to promote cost-effective technology decision-making, to facilitate seamless transportation across and between transportation modes and to encourage smart procurement of new technologies when using federal funding. In essence, the federal government wanted its funds to be used to buy open, integrated and interoperable systems rather than customized, closed, proprietary systems.

The Federal Transit Administration (FTA) and the Federal Highway Administration (FHWA) conducted town hall meetings in metropolitan areas around the nation. The feedback confirmed the technical need for architectures based on actual regional ITS systems that would use the single National ITS Architecture as a template. The National ITS Architecture was codified in the last three Transportation Authorization Bills: ISTEA, TEA-21 and SAFETEA-LU. Based on the legal requirements, the FHWA responded by preparing a rule on ITS Architecture and Standards (Rule 940). Because of the different way that FTA operates they created a nearly identical policy for implementing the authorization requirements.

The smartcard experience provides a good illustration of the pitfalls of not using an enterprise architecture approach. FTA funded deployment of the first smartcard system at the Washington Metropolitan Area Transit Authority (WMATA) in 1996. The WMATA system was initially called the Go Card system, owned exclusively by Cubic Transportation, Inc. (Cubic). It evolved into what is now called the WMATA smartcard system. *(39)*

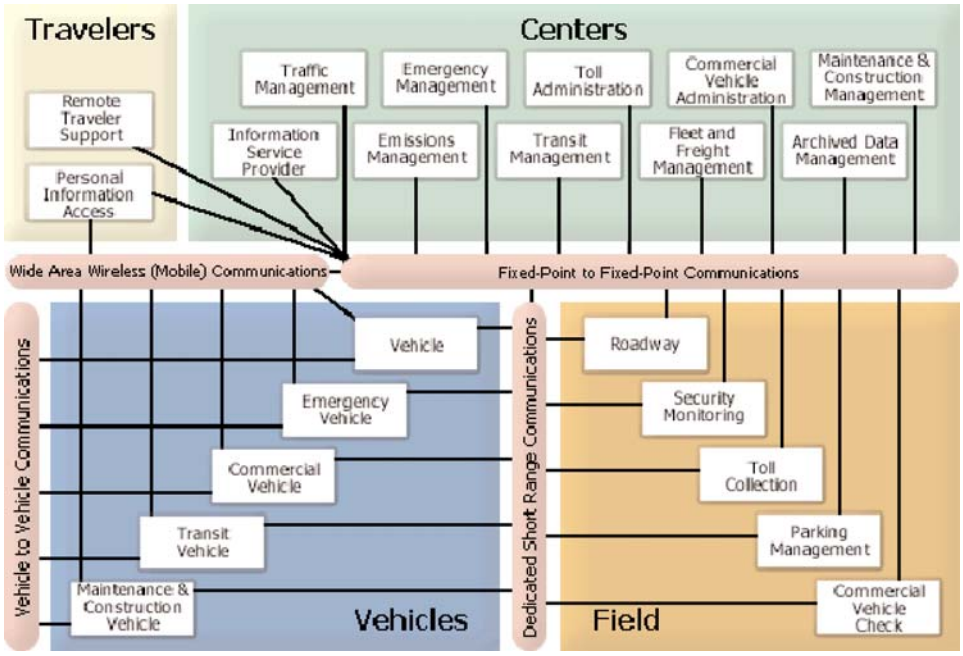


Figure 17. National ITS architecture. (Source: National ITS Architecture [29], "Physical Entities" Page.)

Transit smart card systems involve both proprietary software and hardware. As demonstrated at WMATA and other transit agencies, such closed systems are the antithesis of the National Architecture. These smart card projects have experienced many of the problems that the National Architecture was designed to avoid, including lack of internal agency and regional integration, limited equipment and interagency interoperability, cost overruns, schedule overruns, difficulties changing fare policy and ineffective and unresponsive card management.

While the FTA promoted systems integration in its action, the National ITS Architecture had from its outset limitations in its treatment of subway systems in general and transit fare collection in particular. Subway systems were not directly addressed in the National Architecture (although they were implicitly covered through several interfaces in the architecture). Fare collection was treated primarily from the viewpoint of the transit management subsystem to transit vehicle subsystem (buses and light rail vehicles only) interface, rather than a field or infrastructure system like highway toll collection.

This limitation goes back to the very origins of the ITS Initiative. The initiative itself was originally called the Intelligent Vehicle Highway Systems Initiative. It was changed to ITS at the urging of Gordon Linton, FTA Administrator from 1992–1998. Subway interests saw their systems as too vital and mission critical to be part of the National ITS Architecture and overall Initiative. Today, however, automatic fare collection systems for subway systems are treated as ITS and must comply with the same integration policies and regulations as surface systems like transit buses, light rail transit and highways.

The Federal Highway Administration (FHWA) led the highway industry towards an account-based, multi-state electronic toll collection system as illustrated by the multi-state I-95 EZ Pass. Also, in selecting the account-based approach, highway interests were able to take advantage of data standards and communication protocols developed, tested and certified outside the transportation sector by the banking interest. Today, transit agencies around the world are starting to take notice of the significant benefits afforded by bankcard fare collection systems. Account-based fare collection systems are based on an open architecture, international standards, and certifications approved by the banking industry. They do not require the time, cost and funding needed for customized transit smart card standards.

4.4.2 Marketability

The market for ITS continues to grow in the U.S., as shown in Figure 18. Since 1997, all ITS services experienced significant growth, with emergency management, transit management and electronic payment systems leading the way. Growth in transit management systems was fueled by larger increases in federal transportation funding in TEA-21, a large number of ITS projects in federal appropriations, and transit managers having a better appreciation of ITS benefits to transit operations and management.

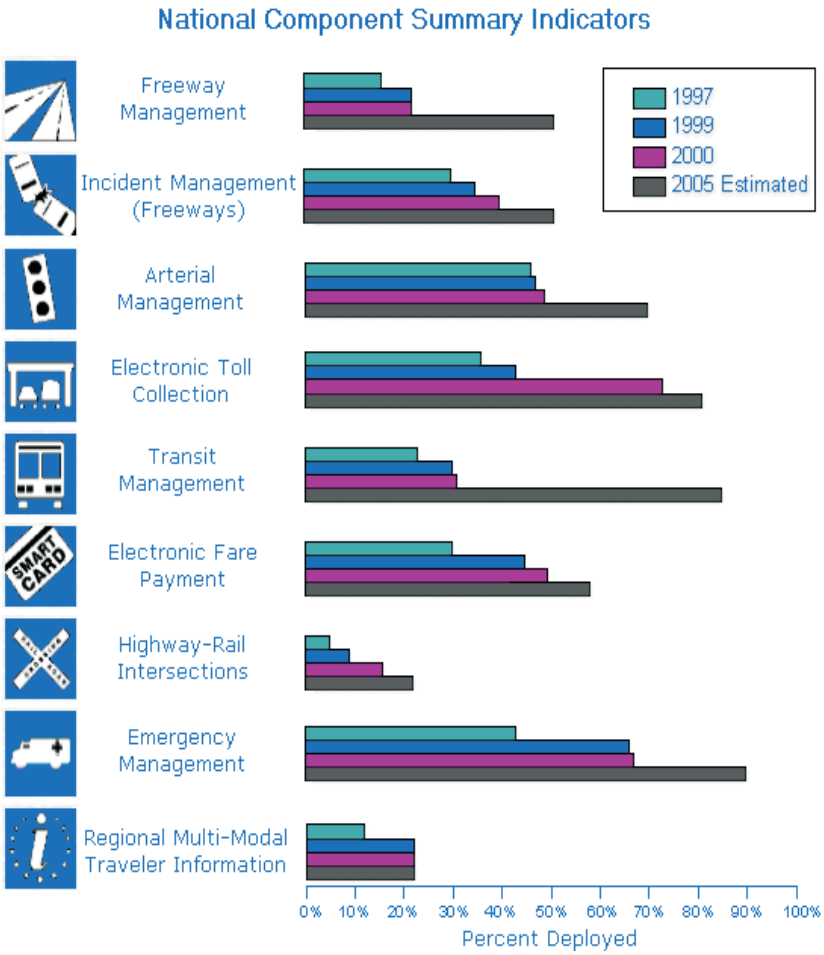


Figure 18. Market for ITS deployments.

4.4.3 Risks and Uncertainties

Risk is inherent in every investment we make. Consequently, it is extremely important that risk be considered carefully in conducting financial planning for technology projects. Ideally, a risk assessment would determine the likelihood that a technology will successfully integrate in accordance with the Enterprise Architecture, cost what the engineering estimate produced, be implemented in accordance with the schedule, be insulated from the vagaries of the economy and marketplace, not experience support problems when things go awry and not end up in court over disputes with the vendor. Unfortunately, technology projects, like most other investments, always bring a variety of risks that could adversely affect a project's scope, schedule and budget. The different types of risks are:

- **Technology risk**—The probability that the technology will not meet the technical requirements of the client and may not be flexible for future changes desired by a client.
- **Economic risk**—The extent to which pledged revenues may not provide an adequate income stream to amortize debt, pay operating expenses and provide an adequate return to investors.
- **Completion risk**—As a counterpart to the risk of revenue streams being insufficient, there are the risks that construction costs will exceed initial cost and schedule estimates.
- **Legal risks**—The potential to violate Federal and state statutory provisions relating to construction and operation of the system and relating to the taxable and/or tax-exempt financing being applied.
- **Management risk**—The ability of the private contractor and the sponsoring agency to successfully manage the project.
- **Financial risk**—This refers to the probability that a debtor (the issuer of the bonds) is unable or unwilling to make timely payments of interest and principal (also known as default risk) and is addressed by the rating agencies in their assignment of bond ratings.
- **Interest rate risk**—The probability that a bond will lose value because of a general rise in the level of interest rates (if interest rates rise, the value of a specific stream of bond payments falls; alternatively, if interest rates fall, there is a gain in value).

- **Reinvestment risk**—Measuring the probability that an investor may buy a bond that yields a certain return (e.g., 10 percent) but may not actually get that return.
- **Liquidity risk**—Capturing the possibility that a bond may not be quickly turned into cash at its fair market value.

The level of risk increases with the complexity of the technology project. As an illustration, a self-contained bus AVL is not as complicated as installation of a paratransit AVL and scheduling system. The latter takes more time, requires more systems integration work and costs more. Similarly, the Salt Lake City upgraded radio system is far less risky than implementation of WMATA's ICCS. An ICCS could hardly be implemented without an Enterprise Architecture, extensive coordination across all of the functions of a transit agency, a more advanced communication system, a more progressive operations control center and an enterprise database. Although these risks can be quite overwhelming, it is critical that they be identified, measured, allocated and mitigated.

5 Findings on Business Case Methodology in Transit Synthesis

Objective of Business Case Methodology (BCM) Synthesis

A goal of this Synthesis is to provide information that can improve the success of justifying and funding IT/ITS projects. The Synthesis will document the state of the practice in the transit industry with respect to the use of Business Case Methodologies to justify the development or procurement of Information Technology (IT) and Intelligent Transportation System (ITS) systems. The Synthesis will provide high level guidance on how to implement a practical and effective BCM. In addition, potential linkages between the BCM analysis and other project stages in the Transit Enterprise Architecture and Planning Framework will be highlighted.

5.1 What is a "Business Case"?

A business case states, as of a certain point in time, the reasons for initiating a project.

The IT Governance Institute says in its guidance document titled, "Enterprise Value: Governance of IT Investments: the Business Case," *(40)* that the business case must provide the answers to the four main questions of:

- Are we doing the right thing? (What is proposed? What are the intended business outcomes?)
- Are we doing it the right way? (How will it be done? What is being done to have it fit with other current and future capabilities?)
- Are we getting it done well? (What is the plan for doing the work? What resources and funds are needed?)
- Are we getting the benefits? (How will the benefits be delivered? What is the value of the project?)

Formal business cases are evaluated to ensure that *(41):*

- "The investment has value and importance
- The project will be properly managed
- The firm has the capability to deliver the benefits
- The firm's dedicated resources are working on the highest value opportunities
- Projects with inter-dependencies are undertaken in the optimum sequence."

A business case is not a static document. It is a collection of assumptions, analyses and predictions of what will occur with a project at that given point in time. As the project moves through phases, additional information becomes available, assumptions get confirmed or disproven, and estimates can be updated. The business case should be updated at agreed upon project steps or phases.

5.2 What is a "Business Case Methodology"?

A business case methodology is a formal analysis process used to develop a business case. It is used to justify and capture the reasoning for initiating a project. For the purposes of this synthesis document, a BCM must have standardized elements and be a documented process, even if it is a simple one.

5.3 Why is having a Business Case Methodology Valuable?

A business case and a business case methodology are valuable to the success of an IT/ITS project and the ability of an organization to demonstrate the benefits of a project. A business case can help to:

- Determine if a project is financially viable before starting and running into trouble
  - What is the project likely to cost and is the funding and budget needed to see it to completion available?
  - Will you get the financial benefits that may be needed?
- Helps decision makers understand and prioritize investment options.
- Demonstrate that the "thinking" and preliminary planning was done
- Helps the various stakeholders understand and agree upon the project elements. Building stakeholder consensus in advance helps decrease project issues, delays, and cost increases during the implementation phase.
- Drive a project to achieve its stated outcomes and performance measures. Specifying anticipated outcomes at the

beginning of a project helps assure that the project stays true to the initial purpose and priorities. The Information Systems Board *(42)* of Washington State believes that "[w]hat gets measured gets managed."
- Defining the desired outcomes and acceptance criteria at the beginning of the project also clarifies the project's scope and provides a starting point for post-implementation demonstration of the achieved benefits and for developing "lessons learned."

The most important role of the business case is to help the project obtain approval and funding. A funding organization, whether it is the Federal Transit Administration (FTA) or the transit agency's budget office, prefers to fund projects with a good business case that makes the decision-makers feel comfortable that the dollars will be well spent. Further, a good business case helps create a project that is more likely to be finished on-time, within budget, and meeting scope requirements. By establishing credibility for successfully completing projects with demonstrable benefits, it increases the odds for obtaining funding on future projects.

5.4 Differences Among Business Case Methodologies

Business case methodologies can be purchased, borrowed from an organization willing to share its methodology, customized from another methodology or developed from scratch. Some of the commercial processes vary in how easily their process steps and templates can be customized.

BCMs vary in the number of analyses proposed as options and in the number of analyses that are required. The next subsection of this Synthesis chapter will include a list of some of the analyses and assumption areas that might be in a business case.

In addition, the guidance and expectations for the level of detail in the analyses can vary greatly. Different BCMs grant different degrees of leeway to the developers of the business case in deciding how much to incorporate in the business case. For example, not all the BCMs include a feasibility analysis as a possible component, although it should be a consideration for some of the new ITS technologies.

An example of a business case study conducted on an emerging technology, "Assessing the Business Case for Integrated Collision Avoidance Systems on Transit Buses," *(43)* included steps that may not be required when implementing a more mature ITS related technology. The study conducted a technology evaluation, cost-benefit analysis, and ". . . assessed the receptiveness among transit operators to use IVBSS products and the willingness of manufacturers to develop them." Assessments of the technology as well as vendor, consultant and internal staff interests and capabilities are important elements of the feasibility portion of a BCM when working with cutting edge technologies.

Some agencies implement BCMs that focus on building a business case that may be approved in one step and then the project goes into the detail requirements, design and development phases. Other BCMs follow a more "gated" process, with a series of approvals and revisions to the business case documents. For example, if a feasibility study provides favorable results, additional funding and resources may be provided to do high-level requirements development, alternatives analyses and complete other required aspects of a business case.

5.5 Examples of Possible Topic Areas in a Business Case

The most common topic areas in a non-complex business case include the following:

- Project Description
- Statement of the problem to be fixed or business need to be met
- Alternatives considered
- Project costs
- Anticipated benefits
- Assessment of the costs and benefits
- Risks and critical success factors
- Recommended project approach
- Anticipated outcomes that can be measured post-implementation

Listed below are some additional areas that can be included in a business case. The list is far from exhaustive and there is some overlap in a few of the categories. Few business case methodologies were described in fewer than 20 pages. In later sections of this report, some comprehensive BCMs are identified and referenced.

- Executive Summary
- Project Background
- Project Description
- Project sponsor, stakeholders and core team
- Linkage to agency goals and objectives
- Environmental Analysis
- Assumptions, constraints and conditions, including critical success factors
- Alternatives
- Business and Operational Impacts
- Technology Assessment
- Project Risk Assessment
- Anticipated funding approach
- Lifecycle cost analysis
- Cost/Benefit Analysis

- Return on Investment (ROI)
- Project Schedule and analysis
- Verification
- Conclusions and Recommendations
- Implementation Strategy
- Review and Approval Process

5.6 Transit BCM Survey Results

The screening survey included questions on the organization's use of a business case methodology, verified terminology and asked about the use of a Return on Investment (ROI) analysis and other cost related analyses used in justifying an IT/ITS project. Additional follow-up questions were asked of a subset of respondents.

Does your organization have a process for proposing, justifying and approving an IT or ITS investment (a business case methodology)?

Approximately half the organizations had some sort of process, whether it was IT/ITS-specific or the general agency budget approval process, for proposing, justifying and approving IT/ITS investments. Only a few of the agencies had an IT/ITS-specific process that provided templates and guidance for staff that needed to initiate and justify a project. Some respondents said their organization used consultants to build the justification for a project. Another said, "Nobody in our organization formally requires a BCM process, we have standard budget justification forms, but no official BCM document or process. However, we end up doing some of a BCM's steps to justify the project to the management and Board as part of the budget process, and because it's helpful."

TriMet

TriMet felt that the BCM should be simple, clear, flexible and understood by all the stakeholders. Flexibility was important, so the business case could be scaled based on the size and complexity of the project to ensure it would be used for all projects and not be skipped because of an onerous process. Basic templates are available for the Project Charter, the Planning Report (which is shown in Appendix A), Alternatives Analysis and other aspects of justifying the project. They stated that the analysis should consider all the system life cycle stages, including feasibility, design, development, implementation, operation and maintenance and the end of the life cycle when the system is terminated or replaced.

Further, TriMet has a Project Sponsor for each project, with ". . . responsibility for approving budget, schedule and scope changes, deciding the issues to be presented to other stakeholders and for accepting the final work product. The sponsor is typically the most senior person from the business unit needing the work who will stay informed of and involved in the project." In their BCM, the Project Sponsor has a Quick Reference document with checklists to help them in their role of facilitating the project's success. Examples of some of the Project Sponsor's checklists, which help them do their job, are included in Table 6.

WMATA

WMATA is working on the development of an Enterprise Architecture and also has a project management methodology that it uses. As a result, their BCM includes a reference to the Enterprise Architecture. The project management methodology includes a Business Plan Initiation (BPI) process, although the process does not always require a justification for all projects. The BPI feeds into the capital planning framework for all projects. Appendix B includes a streamlined form for the Business Plan Initiation Review process, plus instructions for completing the form. The form summarizes all the project justification documents.

King County Metro (KCM)

Over the last 15 years, King County Metro has used a couple of different processes for developing a business case. Currently, KCM must use King County government's process for justifying and approving IT/ITS projects. The process is described in a 69-page document titled, "Project Manager Guide to PRB Reviews," *(44)* which also references other documents for additional guidance. Appendix D contains two tables from the Guide which show the suggested deliverables for Phase I, called Project Planning and for Phase II, called Project Development, which in King County's process includes the "business case." The Project Planning phase is typically completed as a preliminary request for funding to further build the business case in Phase II. King County employs a gated process, with funding released by project phase.

Does your organization use the term Business Case Methodology?

Only one respondent said that the term Business Case Methodology was used in his or her organization. A few respondents wanted to know what the term meant before answering the question. Terms that were used for their agency's process for approving IT/ITS projects included Business Case, QBC or Quantified Business Case, Phased Gate Review, and BPI or Business Plan Initiation. In a Phased Gate Review process, a management review event occurs between specified project phases to determine if the project should proceed "through the gate" to the next phase.

Does your Business Case Methodology vary by type of system or IT/ITS project? If so, how?

Of those agencies with a BCM, all allowed for lesser detail in describing the business case, depending on the size and

Table 6. Project sponsor checklist example.

Sponsor Checklist Examples from TriMet
Project Initiation Phase ☐ Is this project aligned with TriMet's organizational goals? ☐ Is this project a priority for TriMet resources (within an agency-wide context) at this time? ☐ Have all stakeholders (especially those in other divisions) been identified? ☐ Does the project description describe the problem, need or opportunity … and not the solution? ☐ Should this project proceed to the Planning Phase? Immediately or at a future date (given resources and other priorities)?
Planning Phase ☐ Have the business need, scope of the project, and expected outcomes from the project been verified by all stakeholders? ☐ Has cross-divisional input been obtained in identifying alternative solutions? ☐ Will this project comply with national, regional and agency standards … or will an exception need to be made? ☐ Have options been evaluated adequately? ☐ Should this project proceed to the Design Phase? Immediately or at a future date (given resources and other priorities)?
Design Phase ☐ Have you reviewed and approved a project plan (work breakdown structure) for the project? ☐ Have those who will operate and maintain the resulting system participated in defining design requirements? Have ongoing operations and maintenance costs been estimated? ☐ Have impacts on users and business process/organizational changes been identified and change management planning begun? ☐ Does this project raise new safety and/or security issues? ☐ Have you communicated project plans, status and implications to all stakeholders? ☐ Should this project proceed to the Implementation Phase? Immediately or at a future date (given resources and other priorities)?

perceived risk of the project. Some skipped steps when they knew the project was required. Others were acutely aware of the costs of doing the analyses and wanted to keep the level of effort commensurate with the estimated project costs, complexity and risks.

King County provided the only form for determining the level of oversight a project might require, which drives the number and detail level of the forms to be submitted. The four categories of factors used to determine project risk rating are Project size, Project manager experience, Team experience and Project type. The Project Size factor rates the project on size, primarily based upon onetime cost estimates and, secondarily, on project duration. The Project Type factor rates the technical complexity of the work being undertaken. An example of the Project Oversight Rating form is included in Appendix B.

If yes, Does the BCM consider: (Operations and Maintenance costs and requirements, Agency architecture, Regional ITS architecture, Integration options, other enterprise-wide thinking)?

All the BCMs took into consideration operations and maintenance costs. The BCMs also considered one or more aspects of the agency architecture and/or the regional ITS architecture. One of the King County BCM forms had a checklist of technical outcomes which included, "Leverages and/or extends integration architecture." WMATA's Business Plan Initiation form includes "Implement Authority-wide Integration" as an IT priority.

In your organization, what have been the benefits and issues pertaining to completing a Business Case Methodology?

TriMet felt that the BCM helps with ensuring a common understanding of the project and helps manage expectations. High-level documentation of the project from the BCM and project management process is available for stakeholders to access (they have it in a database).

Standardization of the steps helped simplify training on the process, helped readers quickly find information, and helped somewhat with comparisons between projects.

At MARTA, the head of IT said, "You are relating what you want to do to the business needs, costs, and impacts. You *show* why the project should be done, not just providing an opinion or gut feel."

Issues pertaining to the BCM included finding the time and resources to do the analyses. Finding the data to do the ROI was also cited as an issue. A concern was stated that sometimes, for some projects, the process can take so long that the user requirements and technology options change before the project is started.

Does your organization usually perform a Return on Investment (ROI) analysis as part of the IT/ITS project justification process?

A majority of the respondents said their agency had conducted an ROI analysis on one or more IT/ITS projects. More than one respondent was unclear on the difference between a cost-benefit analysis and an ROI analysis. "ROI analyses" were conducted on key projects at some agencies that did not have a BCM. Conversely, the existence of a BCM at an organization did not mean that an ROI analysis was always completed on a project, although some level of cost analysis was always done.

Other cost related analyses completed when a new project is being justified.

Many of the agencies completed some form of a cost-benefit analysis. For a subset, Total Cost of Ownership was calculated. King County has a process for completing a "Quantified Business Case." Another said, "they consider if the overall cost exceeds the benefits."

Does your agency have a formal process for comparing and selecting among different proposed IT/ITS projects?

If a respondent said their organization did not have a BCM, they were not asked this question. Mostly the answer to this question was "no," although several said that having a standard form for proposing projects helped with the comparison process. TriMet said they had a three-category classification of projects, which are Mandatory, Highly Recommended and Discretionary. Others said that their organization had tried different approaches but did not currently have a repeatable process in place.

MARTA is pleased that the selection of projects is done through the IT Governance committees, which include transit management. At their agency, Users prioritize all the IT projects. This relatively new process "ended the old user complaints about IT pushing them."

5.7 Other Approaches to a BCM

A search of the literature shows a diverse set of business case methodologies available for purchase or freely available on the websites of public organizations. Among the various BCMs, terminology varies somewhat, as do the number of steps, plus the line may shift that defines the starting and stopping points of project steps or phases. A number of the most accessible of the free BCMs are described below.

Free templates and explanations are available from the New South Wales Government Chief Information Office. *(45)* The Business Case Template *(46)* includes a useful "3-Point Cost Estimate Table, incorporating the following three cost estimates, Most Likely Cost Alternative, Best Case Scenario (Minimum cost of alternative), and Worst Case Scenario (Maximum cost of alternative)" (Figure 19).

On the South Carolina Division of the State Chief Information Officer website *(47)* there is a 2007 guide for building a business case methodology, titled Business Case Methodology Template. The report covers the following topics:

- When to Use this Template
- Required Business Case Elements
- Cover Page
- Executive Summary
- Project Background
- Project Description
- Environmental Analysis
- Alternatives
- Business and Operational Impacts
- Technology Assessment
- Project Risk Assessment
- Cost/Benefit Analysis
- Project Schedule
- Verification
- Conclusions and Recommendations
- Implementation Strategy
- Review and Approval Process

The September 2006 guidebook titled *Building a Business Case for Shared Geospatial Data and Services: A Practitioners Guide to Financial and Strategic Analysis for a Multi-participant Program (48),* contains clear explanations and examples that are also useful for transit. Further, all transit systems deal with geographic data, so there are some secondary learning benefits.

On its website *(49),* the state of Texas includes an easy to understand Texas Project Delivery Framework, which has hyperlinks to Instructions, Templates and an Excel Workbook for building a business case. The Excel Workbook *(50)* has many potential cost categories detailed. The Workbook also includes a useful Evaluation Factors Spreadsheet that allows the project to be rated on a wide range of categories, such as statutory fulfillment, strategic alignment, agency impact analysis, financial analysis, initial risk consideration and alternatives analysis.

In addition, page 24 of the Business Case Instructions *(51)* contains rating categories so projects can be compared.

3-Point Cost Estimate Comparisons for [Insert Project Name]

		Most Likely Cost of alternative	Best Case Scenario (Minimum Cost of alternative)	Worst Case Scenario (Maximum Cost of alternative)
ALTERNATIVE 1 *[Enter the alternative name if applicable]*	Capital			
	Recurrent			
	TOTAL COSTS	$0	$0	$0
	Benefits / Savings			
	NET COST/BENEFIT	$0	$0	$0
ALTERNATIVE 2 *[Enter the alternative name if applicable]*	Capital			
	Recurrent			
	TOTAL COSTS	$0	$0	$0
	Benefits / Savings			
	NET COST/BENEFIT	$0	$0	$0
ALTERNATIVE 3 *[Enter the alternative name if applicable]*	Capital			
	Recurrent			
	TOTAL COSTS	$0	$0	$0
	Benefits / Savings			
	NET COST/BENEFIT	$0	$0	$0

Figure 19. Business case template. (Source: New South Wales Government [46].)

Another easy to navigate website that provides hyperlinks to guidance on the various parts of Business Case Analysis Report is the Federal Aviation Administration's website at: http://fasteditapp.faa.gov/ams/do_action?do_action=ListTOC&contentUID=7. Figure 20 shows the initial web page for the Business Case Analysis Report. Other useful guidance on proposing and managing IT projects is included on the FAA web pages.

The FAA also has links to documents on the "Investment Analysis Standard Guidance" webpage, *(52)* on the following topics:

- Cost Basis of Estimate
- Cost Estimation Methodology
- Benefit Basis of Estimate
- Benefit Analysis Methodology
- Risk Analysis Basis of Estimate
- Risk Metrics for Initial Investment Analysis
- Risk Analysis Methodology for Initial Investment Decision
- Risk Analysis Methodology for Final Investment Decision
- Work Breakdown Structure

The IT Governance Institute's website at www.itgi.org provides valuable information about building a business case. It is particularly valuable because it puts BCM in the context of IT governance and Control Objectives for Information and related Technology (CobiT), which is a set of best practices (framework) for IT management created by the Information Systems Audit and Control Association (ISACA), and the IT Governance Institute (ITGI). The website also includes a link to the informative document titled, "Enterprise Value: Governance of IT Investments: the Business Case."

Several useful documents address some of the issues that distinguish calculating an ROI for a public sector project, rather than for a "for profit" organization. A StateTech article, *(53)* titled *Evaluating IT Investments,* discusses the concept of a Public Return on Investment (PROI). Two articles from the Center for Technology in Government at the University at Albany are also very helpful. The first article is titled, *Public ROI: Advancing Return on Investment Analysis for Government IT: A Public Value Framework, (54)* which discusses, among other things, what kinds of public value are produced. They called it "a public value framework to emphasize the point of view of the public, not the government, as the basis for the assessment." The second article is titled, *Return on Investment In Information Technology: A Guide for Managers (55),* which discusses business case and ROI development approaches and issues, including potential risk factors in the four categories: political, organizational, technology, and business process.

Another document relevant to calculating ROI for a type of ITS project is the FTA sponsored report titled, *Real-time Bus Arrival Information Systems Return-on-Investment Study (56),* which discusses a methodology for determining the return on investment of real-time information systems for bus services and explores cost-benefit analysis issues. In the

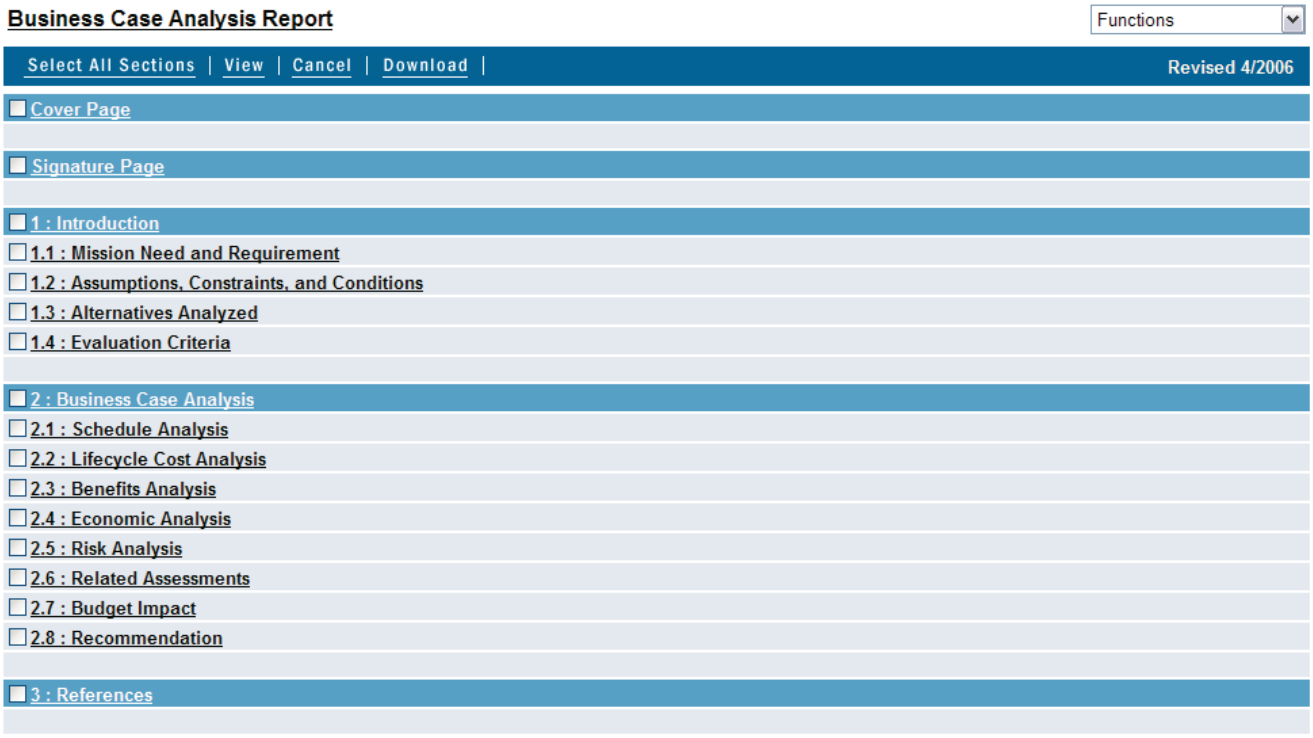


Figure 20. Business case analysis report. (Source: FAA.)

field of Geographic Information Systems (GIS), which supports ITS, the 2006 guidebook titled, *Building a Business Case for Shared Geospatial Data and Services: A Practitioners Guide to Financial and Strategic Analysis for a Multi-participant Program (57),* discusses ROI and benefits from both an agency and regional perspective. The benefits, guidance and approaches are useful for other areas of ITS as well.

5.8 Recommended Practices for BCM

A preliminary list of recommended practices pertaining to creating a BCM and developing a business case is included below. The list of best practices and recommendations will be expanded in Task 4, Transit Enterprise Architecture and Planning Framework Guidance.

Who Should "Own" the Business Case Methodology?

The methodology, including guidelines and templates for conducting a business case analysis, is typically the responsibility of an agency's Project Management Office (PMO). If such an office does not exist, the BCM is either the responsibility of the IT Steering Committee, or, failing to have that committee, the Chief Information Officer. In some organizations, where the IT department has not had the staff or resources, to fully develop policies and procedures, the finance and budget office may impose a more generic BCM for major projects that are requesting funding.

The transit executive management team should understand and own the BCM because it plays a critical role in investment decision making and how their proposed projects will be understood and judged. The standardized process and templates help decision-makers understand a project, its value and risks, how it impacts other parts or the organization, and how it might compare to other investment options. Ideally, the management team should review the process and ensure that it is unbiased and contains the information needed by the IT department, the transit business areas, finance and budget and other key stakeholders.

Further, the transit management team should review and guide policy and practices concerning how flexible the BCM should be. For example, should the BCM be modified to have a simpler form for less expensive and risky projects?

Selecting and Tailoring a BCM

The BCM for the agency is usually selected or developed under the guidance of the Project Management Office or the IT Steering Committee. A number of methodologies, with their associated templates, are commercially available for purchase. They vary in how flexible they are and how easily they can be modified. In addition, there are quite a few processes available from the public sector that can be adopted as a starting framework and then tailored to the needs of a specific organization. By reviewing some of the BCMs listed in this report, agencies can select and customize

components that will best serve their organization and business culture.

In building the business case methodology, use business case best practices and standardize the process, templates and tables of content for the documents. Provide examples. Train staff that quality business cases are living documents that should be updated in the successive project phases as new information becomes available and assumptions become obsolete. Create a collaborative environment to develop the standards. If stakeholders aren't committed to the process, the quality and timeliness of the business case will suffer.

If a Project Management Office is running the BCM, it needs to own the process, not the content. The business area manager needs to stay invested in the development of the business case content.

Who Should "Own" the Business Case?

Building a good business case requires the involvement of a wide range of stakeholders, such as future users of the system; transit managers; finance and budget staff; a range of IT staff with expertise in networks, infrastructure, databases, software development, operations and maintenance; and possibly regional stakeholders. The development of the business case is the responsibility of the assigned project manager, however, the business area manager for the proposed project (e.g., Manager of Operations, Manager of Customer Services, etc.) and the IT Manager may be jointly accountable for the validity of the assumptions and project approach.

Transit agencies may assign responsibility and accountability differently, depending on the resources and abilities within the organization. However, the development of a RACI matrix, which assigns who will be Responsible, Accountable, Consulted and Informed to the key tasks in the process, will significantly increase understanding and effectiveness of the process.

5.9 Business Case and an Enterprise Architecture

How well a technology investment aligns with the enterprise's overall business needs depends, in part, on how well the organization understands the impacts, linkages and opportunities with respect to the businesses, performance goals, information, services and technologies of the organization. An Enterprise Architecture documents the linkages and enterprise architecture planning determines how to move from the current environment to a future one. The availability of Enterprise Architecture facilitates finding the answers to many of the business case questions as they relate to people, process and technology.

5.10 Realizing Benefits

In an InformationWeek article, "Rules To Live By: Benefit Realization—Improving the Yield on IT" *(58),* the author stressed the ". . . importance of effective benefit realization practices. They can go a long way toward driving improved yields of IT investments. The bottom line, benefit realization practices are not cookie-cutter. Rather, they are a specific set of processes, methodology, a toolkit . . . Successful ones are very context-driven and take into account the organization's culture and management style. Don't wait to have everything thought through to perfection, it won't ever be. And most important, make such capabilities part of the organizational DNA. . . ."

The article also recommends that an organization be selective with the benefit realization metrics. It suggests that:

- An analysis should focus on a few, carefully selected performance measures rather than lose focus on the priorities and overwhelming staff with too many measures.
- "Do not use the same level of measurement and process rigor on all initiatives, as you'll risk killing the effort with bureaucracy."
- Use metrics that are business-relevant and matter to key stakeholders.

5.11 Have Buy-in and Get the Sign-offs

A business case consists of a set of assumptions and predictions of what is likely to occur, pertaining to system functionality, costs, schedule, risks and other factors. Having the appropriate stakeholders sign off on their portions of the business case builds awareness of the project details, builds "buy-in," signifies commitment, and documents decision making, assumptions and agreements.

Chapter 5 Appendix A: Planning Report Template from TriMet

Describes the end product and/or outcomes of the project, the constraints within which the project must be implemented, and options for proceeding. Does not include elements of design or descriptions of how the project outcomes will be accomplished.

1. Scope

This is a high level project description, list of stakeholders (users and others), sponsors, team members, and level of effort (estimated total time and/or cost). Scope may differ from Project Charter after discussing these items with all stakeholders. Include the project goal statement.

2. High Level Functional Requirements

A brief description of the current situation and why the new project is necessary. Technical, cultural and or business reasons may drive the change. Example: Our current MMIS system is over 20 years old, is written in Cobol, and resides on the Mainframe. The mainframe is being retired, users demand a GUI interface, and current IT skills sets have evolved past Cobol. Additionally, the MMIS Repair Ticket Processing can be made more efficient with a new system. This may be a paragraph, or refer to a Requirements Document for larger projects.

3. Assessment of Environmental Requirements

A description of the constraints within which the project must operate, e.g. technical standards or architectural guidelines, policy/legal constraints, cultural issues, security requirements, required system interfaces, etc. If an exception to standards may be necessary, include explanation and/or justification. This may be a paragraph, or refer to a Requirements Document for larger projects.

4. Operation Scenarios and Summary of Impacts

This section will detail the various business and IT operation scenarios . . . may include both the "as is" and "to be." It will describe how information or data flows through the system, who is involved in the management of the data and system and at what points. This will include both users and maintainers of the system. If additional IT or business staff are required or reduced, they will be identified in this section. Additionally, this section will identify the life cycle of hardware, required software/hardware licenses, and warranties. This may be a paragraph, or refer to a Business Use Cases document for larger projects.

5. Analysis of Options

A description of the expected benefits and potential risks of alternatives proposed for the project. One of the options should be to "do nothing."

6. Proposed Action

a. **Next Step.** *Describe the next step, e.g. Project Planning, conduct an RFI, defer further action until future date, etc.*
b. **Project Team.** *Name the individuals to be involved in the next step (i.e. core team members only in cases of very large projects).*
c. **Resources Required.** *Estimate the resources required for the next step (internal staff time, cost of contracted services, materials or other expenses).*

7. Approval to Proceed granted by:

_____

Date: _____

Chapter 5 Appendix B: WMATA's Streamlined Form for the Business Plan Initiation (BPI) Review Process and Instructions for Completing it

Business Plan Initiation (BPI) Form

Please Complete Blank White Fields Only

Link to Sample BPI	OR	Link to Instructions on How to Prepare a BPI

CIO BPI-Approved Amount:	**Previous BPIs for this project?:**	No	**If Yes, enter the previous BPI number(s):**
BPI ID No.:			
Project Description Section			
Project Title:			
Project Manager:		Phone #:	
BPI Type:			
[Reserved]:			
Department Supported:			
Performing Department:			
Funding Department:			
BPI Requested Amount:	$		
Funding Source:			

Authority Priority:		**IT Transition Phase:**	
Enter Executive Summary below. Use Alt + Enter for new line.			
Project Scope:			
BPI Scope:			
Expected Benefits:			
Total Project Development & Implementation ***Cost:*** $		***Expected Annual Operations & Maintenance*** ***Cost:*** $	
Approval Section			
Title	**Name**	**Signature**	
AGM-IT/CIO:	Suzanne J. Peck		
IT PMO:	Mary M. Bauer		
IT Program Manager:			

Enterprise Architecture:	Jamey Harvey	
Chief/Office Director		
Project Manager:		

Business Plan Initiation (BPI) Form

CIO BPI-Approved Amount:		**BPI ID No.:**	

Project Cost Section

Development & Implementation Costs

Key Tasks **(Requirements, Design, Testing, etc.)**	**To Date** **Enter date: ___/___/__**	**FY09**	**FY10**	**FY11**	**FY12**	**FY13**	**FY14**	**TOTAL**
TRAINING								
TOTAL DEV & IMPL. COSTS								

Operations and Maintenance Costs

Operations and Maintenance Costs	**To Date** **Enter date: ___/___/__**	**FY09**	**FY10**	**FY11**	**FY12**	**FY13**	**FY14**	**TOTAL**
Software Costs								
Hardware Costs								
Staffing Costs								
Other Costs (ex. Data)								

TRAINING								
TOTAL O&M COSTS								
TOTAL PROJECT COSTS								

Project Schedule Section

Total Project Duration (Development & Implementation):	
Estimated Project Start Date:	
Estimated Project End Date:	

Key Milestones Section

Major Milestones/Tasks (For items covered under this BPI Form)	**Duration (weeks)**

How to Prepare an IT Business Plan Initiation (BPI) Form

IT has established an IT Business Plan Initiation ("BPI") Process that is used for AGM-IT/CIO review and approval of IT and Telecommunications projects. Part of the process includes preparation of a BPI form. This form is designed to ensure a comprehensive process and enhance the IT customer's experience in requesting projects. The BPI form captures information on project scope, schedule, deliverables and budget.

The BPI form allows the AGM-IT/CIO to view the project in the context of IT strategic initiatives and Authority Priorities. It also provides the basis for the PMO and project team to monitor and report progress against plan. The BPI form should be completed as follows:

Page(s) #	Field Name	Information Needed
1 and 2	**CIO BPI-Approved Amount**	Leave blank. The PMO will ensure completion
1 and 2	**BPI ID No.:**	Leave blank. The PMO will ensure completion. The PMO assigns a new BPI ID with each authorized project.
Page 1	**Previous BPIs for this project?**	Select Yes or No. If this is a new project, select no.
Page 1	**If Yes, enter the previous BPI number(s)**	Enter the PMO-assigned number of each previous BPI(s) that is associated with this project.
Project Description Section Provide information to obtain CIO approval's funding amount for the specific period of time that the BPI covers.		

Page(s) #	Field Name	Information Needed
Page 1	**Project Title**	Name the Project
Page 1	**Project Manager**	Identify the project manager assigned to this project.
Page 1	**BPI Type**	Select one: Project, Purchase or Resource
Page 1	**Reserved**	Used as necessary to provide clarity to the project scope
Page 1	**Department Supported**	List all departments/offices supported by this project
Page 1	**Performing Department**	List the department with primary performance responsibility
Page 1	**Funding Department**	List all departments providing funding support to this project
Page 1	**BPI Requested Amount**	Enter the amount of this BPI (not the entire project), just the spending authority for the time period covered by this BPI. The BPI Requested Amount could also be the entire amount of the project, depending on the size of the project.
Page 1	**Funding Source**	List the OMBS funded source code. For example, if IT funded, PE_ITIS_ITI0601.
Page 1	**Authority Priority**	Until further notice, select one of the following: Bus Operations, Rail Operations, Safety, Security, Supports Bus Operations, Supports Rail Operations, Supports Security Initiatives, or Supports Safety Initiatives, All of the Above. If none of the above, leave blank.

Page(s) #	Field Name	Information Needed
Page 1	**IT Transition Phase (PMO Defined)**	These are IT priorities that are imperatives to stabilize, upgrade and improve WMATA's IT services. Each request falls in one of these categories. A drop-down menu is available for selection. 1. Business Unit Application 2. Develop Authority wide Application 3. Stabilize Infrastructure/Implement Sound Management Practices 4. Implement Authority wide Integration 5. Improve Infrastructure
Executive Summary Section		
Page 1	**Project Scope**	Summarize what the entire project will accomplish. It explains why the project should be undertaken. It also helps manage expectations and eliminate scope creep. The Project Scope remains the same (with subsequent BPIs). If necessary, include what will not be done during this project.
	BPI Scope	Itemize what will be done during this period of the project.
	Expected Benefits	List the results and benefits of this project. How will this project improve the current state?
Page 1	**Total Project Development & Implementation Cost**	Enter the total cost to implement this project. Itemize those costs on page 2 and put the grand total here.
Page 1	**Expected Annual Operations & Maintenance Cost**	Enter the average annual Operations & Maintenance (O&M) cost here, after itemizing those costs on page 2.
Approval Section		
Page 1	**Signatures**	The Project Manager/Program Manager should obtain the signatures of all parties, except the AGM/CIO. Signatures should be obtained prior to the BPI meeting with the AGM/CIO.

Page(s) #	Field Name	Information Needed
		Please add fields for the addition of signatories as necessary. For example, multiple AGMs or Office Directors may sign a BPI.
Project Cost Section **Development & Implementation Costs**		
Page 2	**Key Tasks**	List the key tasks, such as Requirements, Design, Testing, Q&A, and Training.
Page 2	**To Date, Enter Date:**	Enter all spending incurred to date (if any) on this project and enter the as of date.
Page 2	**Fiscal Year Columns**	Enter expected development & implementation costs for the fiscal start-year and for each fiscal year that this project will be in development & implementation.
Page 2	**Total Dev & Impl. Costs**	Total both horizontally and vertically all development and implementation costs.
Operations and Maintenance Costs		
Page 2	**Software Costs**	Enter costs to operate and maintain software, including upgrades and replacements.
Page 2	**Hardware Costs**	Enter costs to operate and maintain hardware, including upgrades and replacements.
Page 2	**Staffing Costs**	Include costs of in-house staff and contractor costs to operate and maintain software and hardware.

Page(s) #	Field Name	Information Needed
Page 2	**Other Costs (ext. Data)**	Include other costs, but not the cost of data storage and maintenance.
Page 2	**Training**	Include ongoing training costs.
Page	**Total O&M Costs**	Total both horizontally and vertically, all operations and maintenance costs.
Project Schedule Section		
Page 2	**Total Project Duration (Development & Implementation)**	Enter time (duration – weeks, months, and years) that it will take to develop and implement this project.
Page 2	**Estimated Project Start Date**	Enter estimated project start date.
Page	**Estimated Project End Date**	Enter estimated project end date.
Key Milestones Section		
Page 2	**Major Milestones/Tasks**	List major milestones for the period covered by the BPI. Do not list milestones for the entire project.
Page 2	**Duration**	Enter the estimated time it will take to complete each milestone. Do not provide dates, but durations (i.e., weeks or months.

Chapter 5 Appendix C: KCM's Form for Determining Extent of Oversight Process

Project Oversight Rating Instructions *(59, Appendix B)*

These are instructions for completing a rating form used to assess the risk of IT projects. The four factors used to determine project risk rating are:

1) Project size

2) Project manager experience

3) Team experience

4) Project type

To complete the Self-Rating form, determine the rating for each project evaluation factor.

HIGH = 3 **MEDIUM = 2** **LOW = 1**

Factor 1: Project Size

This factor rates the project on size, primarily based upon onetime cost estimates and secondarily, upon project duration.

Step 1: Rate the project by estimated one-time costs as follows:

Estimated one-time Costs	**Rating**
Greater than $500,000	High
$50,000 to $500,000	Medium
Under $50,000	Low

Step 2: Adjust low and medium ratings in the above upward by one rating level if the estimated time period from project approval to "go live" is greater than twelve (12) months.

Factor 2: Project Manager Experience

This factor rates the risk based on the project manager's experience on similar efforts.

Project Manager	Rating
Has not completed a like project in a project manager role.	High
Has successfully completed one like project in a project manager role.	Medium
Has successfully completed two or more like projects in a project manager role.	Low

Factor 3: Team Experience

This factor rates the risk based on the experience of the project team key staff. The project team consists of all project staff reporting to the project manager, including contractor staff, if applicable.

Step 1: Evaluate the experience of each key staff member, including contractor staff, for completion of like projects in key roles.

Like Projects Completed by at Least 75% of Key Staff	Rating
None	High
One	Medium
Two or more	Low

Factor 4: Project Type

This factor rates the technical complexity of the work being undertaken.

Technical complexity is only appropriate for projects that deliver a solution which impacts the current technical environment through new hardware and/or software. Solution Delivery projects should utilize the table below by performing steps 1 and 2 for table A.

For IT projects that don't impact the technical environment, please use the LOW or 1 rating factor. [Examples of projects that don't impact the technical environment include Plan/Document Delivery projects and Process Improvement projects]

Step 1: Using Table A below, "Elements of Project Type," circle the rating for each applicable element.

Step 2: Assign the rating for this factor based upon the highest rating from among all of the elements circled in Step 1.

Table A: Elements of Project Type

Component	Activity Category	Affected Element	Rating
Hardware	New Install	Local Desktop / Server	Low
		Distributed / Enterprise Server	Medium
	Update / Upgrade	Local Desktop / Server	Low
		Distributed / Enterprise Server	Low
	Infrastructure	Local Network / Cabling	Low
		Distributed Network	Medium
		Data center / Network Operations Center/Wireless/Radio	High
Software	Custom Development	Local Desktop / Server	Low
		Distributed / Enterprise Server	High
	COTS Installation (new)	Local Desktop / Server	Low
		Distributed / Enterprise Server	High
	Custom Update / Upgrade	Local Desktop / Server	Low
		Distributed / Enterprise Server	High
	COTS Update / Upgrade	Local Desktop / Server	Low
		Distributed / Enterprise Server	Medium

Component	Activity Category	Affected Element	Rating
	Infrastructure	Middleware	Medium
		Layered Product	Medium
		DBMS	Medium
Non-technical	N/A	N/A	Low

Computation of the Overall Project Rating

After determining the rating for each evaluation factor, add the total ratings for factors 1-4, and divide by 4. The score will fall into one of two levels:

- Level 1 – Project is subject to a single funding release and to provide monthly monitoring status.
- Level 2 – Project is subject to phased funding releases as defined by the Project Review Board Process and to provide monthly monitoring status – this is the full oversight monitoring process.

All IT projects in PRB oversight, regardless of their risk level, will need to request funding release from the PRB.

Project Oversight Rating Form

Project Name: ___ Project Duration: _____

Brief Project Description: _____

Department: ___ Director Signature: _____

---

1. Project Size:

Estimated one-time costs*	Rating	Score
$		

**Adjusted up a rating for projects longer than 12 months*

2. Project Manager Experience:

Project Manager	Rating	Score
Name:		

3. Team Experience:

Key Project Staff	Rating	Score
Names:		

4. Project Type:

Component	Activity Category	Rating	Score
Hardware	New Install		
	Update/ Upgrade		
	Infrastructure		
Software	Custom Development		

Component	Activity Category	Rating	Score
	COTS Installation (new)		
	Custom Update/Upgrade		
	COTS Update/Upgrade		
	Infrastructure		
Non-technical	N/A		

Compute Project Score:

Total Rating =	

Add the total ratings for #1-4

FINAL Rating =	

Divide Total Rating by four (4)

Assign Level to Final Rating:

Final Rating	Level
2.01 – 3.0	2 – phased funding releases
1.0 – 2.0	1 – single funding release / monthly monitoring status reports

The project Review Board may raise the rating of project oversight based on additional factors such as past project performance by the sponsoring department or substantial risks identified with the project.

Chapter 5 Appendix D: King County Suggestions for Project Review Board Deliverables *(60)*

This appendix contains two tables from King County's "Project Manager Guide to PRB Reviews." The first table shows the suggested deliverables for Phase I, called Project Planning. The second table shows the suggested deliverables for Phase II, called Project Development, which in King County's process includes the "business case".

Typical Elements of Phase I PRB Deliverables

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
Project Plan (Summary Version)	**How the Project will be Managed**	▪ Brief description of the project's: ➢ Charter ➢ Organization and management plan ➢ Communication and project reporting plan ➢ Issue and action item plan ➢ Risk management plan ➢ Quality management plan ➢ Change management plan
	Project Scope	▪ High level overview of: ➢ Project description ➢ What's in scope ➢ What's not in scope
	Summary Schedule	▪ Gantt chart for the entire project with: ➢ Phases ➢ Major deliverables ➢ Major milestones ➢ Dates
	Summary-level Budget	▪ Lifetime by year by account for the entire project with: ➢ Salaries and benefits ➢ Miscellaneous supplies ➢ Consulting ➢ Contract employees ➢ Travel ➢ Training ➢ Printing ➢ OIRM support ➢ Hardware/software ➢ Contingency ➢ Other (specify) ▪ Budget assumptions
	High Level Risk Assessment	▪ High impact risks identified for the project

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
Possible Contract List	**List of Possible Contracts**	▪ Brief description of each contract with: ➢ Estimated amount of each contract ➢ Estimated time period for each contract
Work Plan for Phase II – Project Development	**One Page Summary Describing the Work of the Next Phase**	▪ High level overview of: ➢ Significant project activities ➢ Approach and techniques ➢ Major deliverables description ➢ Major milestones description ➢ Project dependencies ➢ Budget release request for next phase ➢ Begin and end schedule dates for next phase
	Detailed Schedule for Next Phase	▪ Resource loaded Gantt chart with: ➢ Phases ➢ Tasks ➢ Resources (assigned to tasks) ➢ Deliverables ➢ Milestones ➢ Dates
	Detailed Budget for Next Phase	▪ Budget detail (for each item of the budget) ▪ Spending plan ▪ Budget assumptions

Typical Elements of Phase II PRB Deliverables

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
Business Case	**One Page Summary**	▪ High level overview of: ➢ Project objectives ➢ Project description ➢ Significant business needs and requirements ➢ Solution recommendations ➢ Summary costs ➢ Significant quantifiable and non-quantifiable ➢ Financial payback ➢ Project schedule start and stop dates
	Typical Elements	See business case web page http://kcweb.metrokc.gov/oirm/tools_templates/business_case_tools.htm
	Business Needs Driving this Project	
	Project Objectives	▪ Strategic goals and objectives ▪ Business goals and objectives ▪ System goals and objectives

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
	Quantifiable Costs and Benefits for the County	▪ Total development costs by account and year ▪ Quantifiable benefits by year ➢ Hard dollar revenue ➢ Hard dollar reimbursements ➢ Hard dollar cost reductions ➢ Other hard dollar benefits ➢ Soft dollar cost avoidance ➢ Other soft dollar benefits ▪ Operating and maintenance costs by account and year ▪ Payback ➢ Break-even point in years ➢ Net present value ➢ Internal rate of return (IRR) ➢ Return on investment (ROI)
	Quantifiable Benefits for the Public	▪ Hard dollar reimbursements ▪ Hard dollar cost reductions ▪ Other hard dollar benefits ▪ Soft dollar cost avoidance ▪ Other soft dollar benefits
	Cost Benefit Analysis Worksheet	▪ Detailed quantifiable cost and benefit estimates
	Non-Quantifiable Benefits	▪ Project alignment with business strategy ▪ Competitive advantage provided by project for the county or the public ▪ Management information support provided by project ▪ Legislative directive or mandate provided by project ▪ Management information support ▪ Alignment with strategic IT architecture ▪ Other
Project Plan (Detailed Version)	**How the Project will be Managed**	▪ Description of the project's: ➢ Charter ➢ Organization and management plan ➢ Communication and project reporting plan ➢ Issue and action item plan ➢ Risk management plan ➢ Quality management plan ➢ Change management plan
	Project Scope	▪ Project description ▪ What's in scope ▪ What's not in scope ▪ Constraints and Assumptions

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
	Schedule	▪ Gantt chart for the entire project with: ➢ Phases ➢ Tasks ➢ Resources ➢ Deliverables ➢ Milestones ➢ Dates
	Budget	▪ Lifetime by year by account for the entire project with: ➢ Salaries and benefits ➢ Miscellaneous supplies ➢ Consulting ➢ Contract employees ➢ Travel ➢ Training ➢ Printing ➢ ITS support ➢ Hardware/software ➢ Contingency ➢ Other (specify) ▪ Annual by account ▪ Spending plan ▪ Budget assumptions
	Project Control Plans	▪ Organization and staffing plan ▪ Risk Management Plan ▪ Issue and action item management plan ▪ Change (scope) management plan ▪ Communication plan ▪ Quality plan ▪ Vendor management plan ▪ Benefit Realization plan ▪ Summary level implementation plan ▪ Summary level architecture plan
Updated Contract List	**Updated List and Description of Contracts**	▪ Description of each contract with: ➢ Estimated amount of each contract ➢ Estimated time period for each contract ➢ Possible vendors for each contract

PRB Deliverables	Requirements for each Deliverable	Suggested Information Project Managers May Wish to Cover under each Requirement
Work Plan for Phase 3a - Implementation Planning & Solution Design	**One Page Summary Describing the Work of the Next Phase**	▪ High level overview of: ➢ Significant project activities ➢ Approach and techniques ➢ Major deliverables description ➢ Major milestones description ➢ Project dependencies ➢ Budget release request for next phase ➢ Begin and end schedule dates for next phase
	Detailed Schedule for Next Phase	▪ Resource loaded Gantt chart with: ➢ Phases ➢ Tasks ➢ Resources (assigned to tasks) ➢ Deliverables ➢ Milestones ➢ Dates
	Detailed Budget for Next Phase	▪ Budget detail (for each item of the budget) ▪ Spending plan ▪ Budget assumptions

6 Findings on Systems Engineering and Transit

Systems Engineering as a process for system development was first described in the 1950s and was originally created to address the development of large-scale defense systems. Since then it has been broadened into a discipline that is used in all kinds of project developments. Systems engineering can be applied to any system development, whether you are developing a household appliance, building an airplane, or implementing a sophisticated transit management system. As the International Council on Systems Engineering (INCOSE) defines it:

> Systems Engineering is an interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, then proceeding with design synthesis and system validation while considering the complete problem.
>
> Systems Engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems Engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs.

Outside the realm of ITS, the Systems Engineering process is described by standards (such as ANSI/EIA 632-Processes for Engineering a System and ISO/IEC 15288: 2002(E)—Systems engineering—System life cycle processes) and handbooks (INCOSE SE Handbook and IEEE 1220). These documents provide a general description of the Systems Engineering Process and relate it to typical system life cycle phases. As such, these are excellent reference documents for the transit community to consider as they move toward the use of the systems engineering process in the development of ITS systems. However, their generality make them less approachable and less understandable to many within the transit community, who may be better served with documentation that directly relates the basic systems engineering process to transit ITS development.

US DOT recognized the potential benefit of the systems engineering approach for ITS projects and included requirements for the use of the systems engineering process in the FHWA Final Rule/FTA Final Policy on Architecture and Standards that was enacted on January 8, 2001. The Rule/Policy requires a systems engineering analysis to be performed for ITS projects that use funds from the Highway Trust Fund, including the Mass Transit Account. Figure 21 shows an excerpt from the Final Policy that specifies the minimum requirements that the systems engineering analysis must include.

Why has the USDOT instituted this policy? Because there are well documented benefits to using a Systems Engineering process for development of technology-based projects. What are some of the benefits? As described in the Introduction to Systems Engineering mentioned above, some of the benefits (along with references for these benefits) are:

§ 940.11 Project implementation.
(a) All ITS projects funded with highway trust funds shall be based on a systems engineering analysis.
(b) The analysis should be on a scale commensurate with the project scope.
(c) The systems engineering analysis shall include, at a minimum:
(1) Identification of portions of the regional ITS architecture being implemented (or if a regional ITS architecture does not exist, the applicable portions of the National ITS Architecture);
(2) Identification of participating agencies roles and responsibilities;
(3) Requirements definitions;
(4) Analysis of alternative system configurations and technology options to meet requirements;
(5) Procurement options;
(6) Identification of applicable ITS standards and testing procedures; and
(7) Procedures and resources necessary for operations and management of the system.

Figure 21. FHWA/FTA systems engineering analysis requirements.

"Systems engineering reduces the risk of schedule and cost overruns and increases the likelihood that the implementation will meet the user's needs. Other benefits include:

- improved stakeholder participation
- shorter project cycles
- more adaptable and resilient systems
- verified functionality and fewer defects
- higher level of reuse
- better documentation

These assertions have been supported by several studies that have shown that good systems engineering results in better cost and schedule performance. Studies have been performed by the International Council of Systems Engineering *(61)*, Boeing *(62)*, and IBM *(63)*, among others. Figure 22 shows the results of an INCOSE study that collected planned and actual project cost data and systems engineering cost data for 44 projects. The survey indicated that investing in systems engineering improved project cost performance. The responses indicated a 50% overrun on average without systems engineering and a clear trend towards better cost performance results with systems engineering."

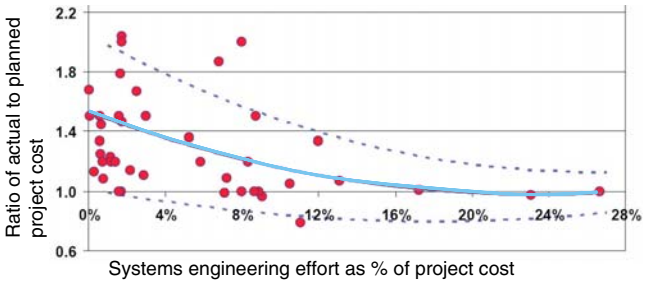


Figure 22. Systems engineering improves project cost performance. (Source: INCOSE.)

In order to provide a description of the Systems Engineering process that is tailored to the transportation community, the USDOT developed two documents:

- Systems Engineering for Intelligent Transportation Systems: an Introduction for ITS Professionals *(64)*, and
- Systems Engineering Guidebook for ITS *(65)*

The first of these is, as it says, an introduction that has the following purpose:

> This guide is intended to introduce you to systems engineering and provide a basic understanding of how systems engineering can be applied to intelligent transportation systems (ITS) projects. The guide leads you step-by-step through the project lifecycle and describes the systems engineering approach at each step in the lifecycle. It describes how to begin implementing the systems engineering approach on your next ITS project and incorporate it more broadly into your organization's business practices.

The second is a more detailed "text book" that provides not only details for each step in the process, but also templates for all of the Systems Engineering deliverables. An on-line version of the guidebook has been recently developed (http://www.fhwa.dot.gov/cadiv/segb/) that not only puts the guidebook information into a hyperlinked format but also provides examples of systems engineering documentation drawn from actual ITS projects across the country.

The following (taken from the first USDOT source above), gives a good description of how the Rule/Policy is applied to the agencies across the country that deploy ITS.

> The Rule/Policy allows each Project Sponsor to use a systems engineering approach that is tailored to fit the needs of each ITS project. As you will see in the following chapters, the systems engineering approach is actually broader than the seven specific requirements identified in the Rule/Policy. If you implement a good systems engineering process, you will meet or exceed the specific systems engineering analysis requirements identified in the Rule/Policy.
>
> The FHWA Division and FTA Region offices determine how the systems engineering analysis requirements in the Final Rule/Policy should be applied to ITS projects in each region and how compli-

ance should be demonstrated by each project sponsor. Federal oversight is provided based on oversight requirements defined in the stewardship agreements with each state. . . . . Contact the ITS specialist in your FHWA Division Office or FTA Regional Office for more information.

These USDOT references describe the systems engineering life cycle through the mechanism of a "V" model (hereafter referred to as the Vee model) that is shown in Figure 23. This model describes the key steps in the overall process, beginning with the creation of a Regional ITS Architecture to define the integration of ITS deployments in a region, and continuing through the life cycle all the way to system retirement or replacement decision. Notice in the diagram that most steps on the Vee have a small oval at the conclusion of the step (identified as Document/Approval in the figure). At each of these steps there is some output of the process that must be reviewed and approved so that development can move to the next step. These "decision points" are one of the key attributes of the systems engineering process.

The Vee diagram and system engineering steps, which support a variety of technology project types, are similar to System Development Life Cycle or Software Development Life Cycle (SDLC) methodologies that have been used in the IT industry for software development. A number of SDLC models have been created, with some common ones being the "waterfall," "spiral," and "rapid prototyping" models. The Vee diagram can be tailored to suit any of these types of development models.

How has the transit industry embraced the Systems Engineering process as described by the USDOT? That was one of the subjects of the interviews and will be discussed below. Before covering the results of the interviews, this section will consider how recent transit publications have discussed the use of Systems Engineering in transit ITS project development.

6.1 Literature Review

The report *Advanced Public Transportation Systems: State of the Art Update 2006 (66)* covers a wide range of topics in transit ITS, including systems engineering. The report highlights the FTA Policy on Systems Engineering (described above) and references the general systems engineering documentation previously discussed. Some of the key points made by the report are:

- The disciplined use of a systems engineering approach is a critical success factor for projects involving integration.
- The systems engineering component to FTA's Policy on the National ITS Architecture is extremely important when developing ITS projects.
- Use a systems engineering approach in developing and integrating applications, and for the definition of stakeholders and their requirements.

In addition the report considers lessons learned from a variety of deployments and identifies the following relative to systems engineering:

- Avoid the tendency to quickly buy systems. Instead, initiate all steps of a systems engineering approach. Do not skip steps such as the definition of key stakeholders, functional requirements definition, alternatives analysis, detailed

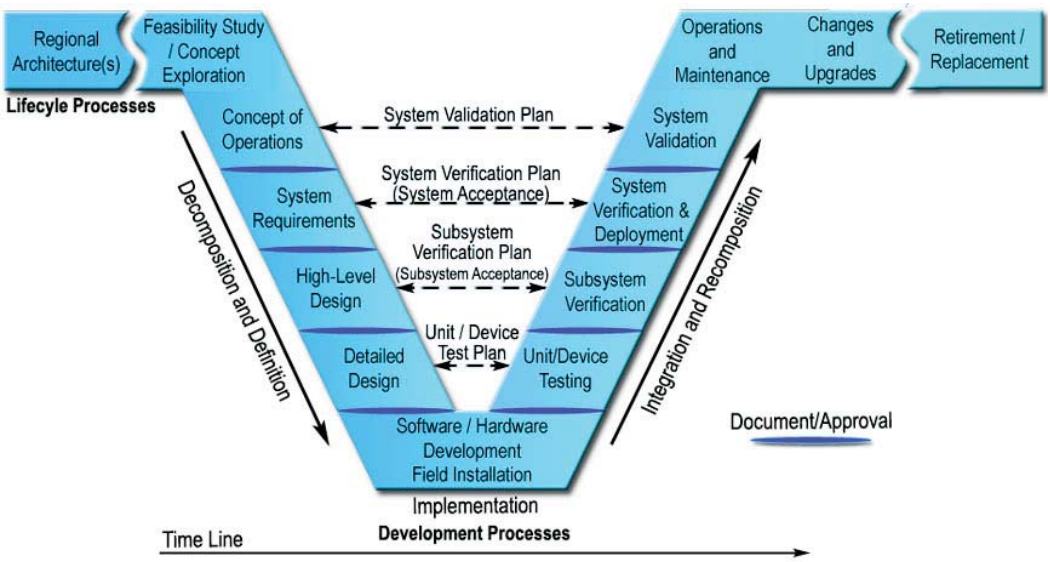


Figure 23. Systems Engineering VEE Model. (Source: U.S. Department of Transportation.)

requirements definition, development of a thorough testing and acceptance criteria plan and development of an Operations and Maintenance Plan.
- Budget the time and resources needed for systems engineering.

The report, *AVL Systems for Bus Transit: Update, TCRP Synthesis 73 (67),* "documents the state of the practice of computer-aided dispatch/automatic vehicle location (CAD/AVL) systems in fixed-route and demand-responsive services (referred to in this synthesis simply as bus AVL systems), as well as changes in agency practices related to the use of AVL systems." The report is based on extensive interviews with transit agencies and includes many lessons learned, including the following related to systems engineering:

- Plan for delays in schedule; ensure the technology matches your current and future agency needs. Do not let the current technology limit your agency vision; use a good systems engineering approach to develop a concept of operations plan.

In addition, the report includes an appendix that discusses the systems engineering process that agencies have used successfully to deploy technology such as bus AVL systems.

Probably the most relevant previous review of the subject of Systems Engineering (and its relation to Enterprise Architecture Planning) is *TCRP Report 84-e-Transit: Electronic Business Strategies for Public Transportation-Volume 5 Concept for an e-Transit Reference Enterprise Architecture (68).* This report, published in 2004, describes "the need for and uses of a reference enterprise architecture; the process for its development based on using systems engineering concepts and practices; the basic concepts behind systems engineering and enterprise architecture; and the transit-specific task associated with creating an e-transit reference enterprise architecture." The report provides a tutorial on the systems engineering process (which predates the FHWA/FTA documents referenced earlier) and describes how to use the systems engineering process in the development of an enterprise architecture framework. Figure 24, taken from the document, provides an illustration of how using enterprise architecture, along with the systems engineering process can be used to transform the operations of a transit agency.

Lastly, a recent report dealing with technology and transit is another volume in the same TCRP series, *TCRP Report 84-e-Transit: Electronic Business Strategies for Public Transportation-Volume 8 Improving Public Transportation Technology Implementations and Anticipating Emerging Technologies (69).* This volume presents the results of a study of technology in transit. The study was performed to address the following two topics: "(1) to identify the steps that must be taken—by both individual transit agencies and the transit industry—to improve technology implementations; and (2) to promote consideration of emerging technologies by identifying several

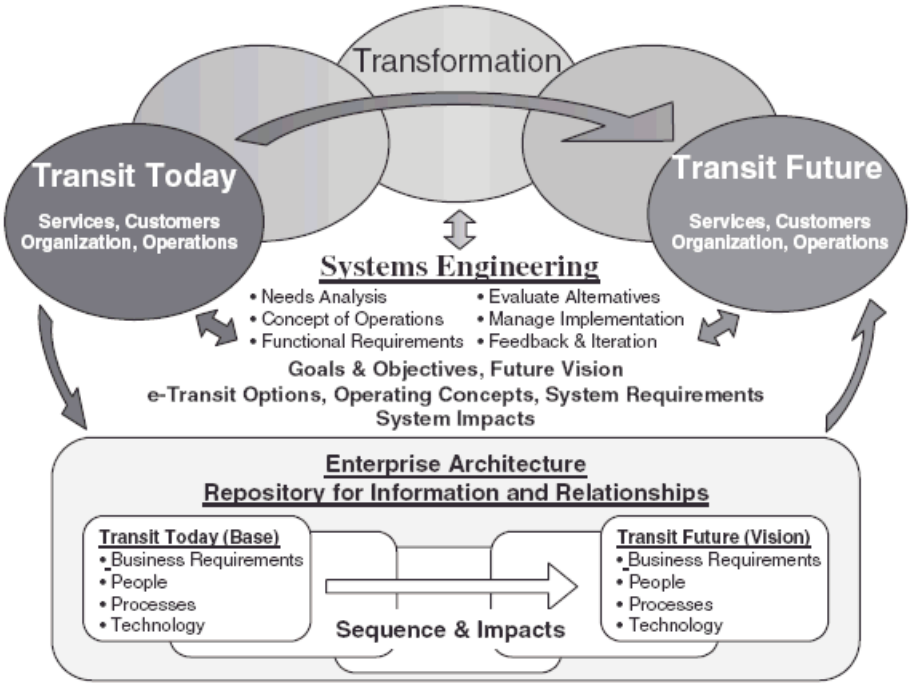


Figure 24. A reference transit framework using systems engineering and enterprise architecture. (Source: TRB.)

developing technologies that have great potential for the transit industry."

One of the key conclusions of the study is that improving transit technology implementation in public transportation requires the incorporation of the critical strategies of enterprise architecture planning (EAP), systems engineering (SE) and change management (which is actually a part of the overall systems engineering process but which the study authors broke out separately because of their view of its importance). The study reviewed the level of systems engineering knowledge and usage within transit agencies (primarily from interviews and literature review performed prior to 2006) and finds a very uneven level of knowledge and usage. Some larger agencies have embraced the process in their technology projects, but many others have little experience with or knowledge of the process.

An overall summary of the previous literature on systems engineering in transit is that using a systems engineering process is one of the critical factors in successfully implementing technology- (or integration-) based projects; however, only select agencies have incorporated the SE process into their development processes, with the majority of transit agencies either turning over responsibility for the process to their contractors or not using the process at all.

6.2 Interview Findings

In order to determine where transit agencies stand on understanding and use of Systems Engineering for ITS project development, a portion of each transit agency interview was devoted to the use of Systems Engineering. For several of the agencies that had recent experience with the systems engineering process, an additional set of interview questions was posed to assess whether the agencies had seen benefits from their use of the Systems Engineering process. The discussion below highlights the key findings from the interviews.

6.2.1 Use of the Systems Engineering Process by Transit Agencies

Almost all of the agencies interviewed indicated they used some type of development process or did some aspects of the Systems Engineering process. Only two answered "no" or "not really" to the basic question, *Do you use a Systems Engineering Process for project/system development?* A closer examination of the interview responses shows that about half of the agencies could be described as having a development process, and of these only a couple are really using the Systems Engineering process. Why the discrepancy? There are several key reasons:

- **Low level of knowledge of the systems engineering process among agency personnel.** In several cases, the agency response was that we do whatever parts of the process the contractor provides. It seems in some cases the agencies are content to rely solely on whatever level of expertise the contractor provides. In one or two of the agencies they specifically hire a contractor to be their system engineer, providing the SE expertise that they lack.
- **Existing project management or system development processes.** Several of the agencies that could be considered more advanced (based on the number and scope of their ITS deployments) have a definite process orientation, but in most cases this orientation is strong on project management (or in one case business management) but not strong in the technical development process that SE represents. Because of the project management focus, these agencies have a structured view of tracking the project's progress against cost and schedule. They may also have detailed consideration of such cross-cutting activities as risk management. However, what these processes lack is the technical development process, with its Concept of Operations (focusing on the stakeholder needs and the operational scenarios of the systems), formal requirements definition, design tradeoffs and verification against requirements. They each cover parts of these activities (most often the requirements definition) but not all of them.
- **Transit Agencies have in general not been required to use the Systems Engineering process.** Although FTA Policy (on Architecture and Standards) requires a systems engineering analysis for each project using federal funds, the requirements do not cover the full range of the SE process, and can be met by cherry picking info from a far less systematic development process. Two of the agencies interviewed were required to closely follow the USDOT systems engineering process. They were developing systems under the Mobility Services for All Americans (MSAA) Initiative. This effort, which in Phase I developed the concept of operations and functional requirements for the system, caused each agency to become knowledgeable of the USDOT SE process and to utilize it in the project development. As will be discussed below under benefits of the SE process, both agencies felt it was a worthwhile exercise and plan on using the Systems Engineering process for future efforts.

6.2.2 Benefits of Using the Process

Have the agencies that have used the Systems Engineering process derived benefits from the effort they put into the process? The answer is a resounding yes. Some of the benefits they identified were:

- Using the process helped the agency and the other stakeholders go through each step rather than jumping to the end.

- The SE process helps the agency keep the project on schedule and budget. It allows the agency to have better visibility into the contractor's progress through the outputs.
- Using the process saves the agency a lot of trouble at the backend of the project because the surprises are minimized.
- The Concept of Operations made the agency and the rest of the stakeholders more aware of how the parts of the system will integrate and work together.

6.3 Recommendations

Based on the observed level of usage of the Systems Engineering process, the following are recommendations for applying the process to the development of Enterprise Architecture Frameworks.

- **Agencies should acquire a basic working knowledge of the Systems Engineering process as it would apply to their projects.** Agency personnel are key participants in the project implementation process and must have an understanding of the process if they are to successfully deploy technology-based systems. This knowledge is available through training, either in workshop or on-line settings, and agencies should put plans in place to obtain the necessary skills.
- **Any agency pursuing development of an Enterprise Architecture framework should use the Systems Engineering process to plan and perform the development.** As mentioned in the TCRP reference above (and as discussed in the results of this current TCRP effort), the two disciplines (SE and enterprise architecture) are inextricably linked and when pursuing enterprise architecture development it is critical to perform the development using a Systems Engineering process.

7 Findings on Post-Implementation Analysis in Transit

Objective of Post-Implementation Analysis Synthesis

The purpose of this synthesis is to document the state of the practice in the transit industry with respect to post-implementation analysis of IT/ITS deployments and to provide high-level guidance on how to approach post-implementation analysis. The synthesis will briefly address the difference between post-implementation analysis and project closeout activities. In addition, potential linkages between the post-implementation analysis and other project stages in the Enterprise Architecture and Planning Framework will be highlighted.

7.1 Approach/Methodology

To develop this synthesis, a review of the literature on Post-Implementation Analysis and Post Implementation Review (PIR) was completed. The literature review encompassed post-implementation analyses in transit ITS as well as other fields. To supplement the literature review, 14 transit agencies and two state DOTs were surveyed regarding their post-implementation efforts. Because post-implementation analysis is called different things in different organizations and methodologies, additional prompts and follow-up questions were needed to clarify what was being discussed.

7.2 What is Post-Implementation Analysis?

Post-implementation analysis or Post Implementation Review (PIR), as it is commonly called in the field of Information Technology (IT), is conducted after a project has been completed. "The purpose of the PIR is to evaluate how successfully the project objectives have been met and how effective the project management practices were in keeping the project on track." *(70)*

PIR is not the testing and verification activities that are typically performed in a project acceptance or closeout phase. As an example, a system may have to be accepted from a vendor if it performs according to the requirements. It passes the test plan and the systems engineering verification process. The system verification step can include both "factory testing" and "on-site testing" that occur during the initial implementation or deployment phase. The system, however, may not perform the way the users want, because either the business changed or it was specified ambiguously and/or incorrectly. The PIR occurs after the IT/ITS system has been incorporated into the business.

PIR corresponds more closely to the Validation phase of the systems engineering process. In the *Systems Engineering Guidebook for ITS (65),* the difference between verification and validation is explained as follows:

> Verification is the process which makes sure that what was built matches the requirements. Was the system built the way the requirements and design specified? Was the system built "right"? Both the verification and validation processes are important and necessary. However, it is the validation which views the system from the system's owner and stakeholder perspective. The verification of the system is viewed from the development team's perspective. Systems engineering's goal is to unify these views.
>
> . . . System Validation by system owners and stakeholders compares against needs, goals, and expectations (this evaluation of validity directs the path to system upgrades and enhancements).

The USDOT's Research and Innovative Technology Administration's (RITA) web site provides guidance on how to complete comprehensive, independent evaluations of ITS projects. The ITS Evaluation Resource Guide at that site *(71)* expands and elaborates on recommended evaluation procedures outlined in the SAFETEA-LU Reporting and Evaluation Guidelines. If the funding is available for one of these more elaborate

evaluations, the PIR results would feed into the evaluation. It should be noted that a PIR can be very elaborate, but they also can be completed in relatively simple forms. Generally, the PIRs are designed to improve the performance of the system or the project management procedures at the particular organization that has implemented the system, rather than provide comprehensive knowledge to the broader industry.

Further detail about post-implementation analyses or PIRs is included in subsequent sections of this chapter.

7.3 PIR Benefits: Why is Post-Implementation Analysis Valuable?

Post-implementation analysis is valuable for many reasons. The most commonly cited benefit of the PIR process is that it provides managers with critical information on how to modify and improve a recently implemented system to better meet the needs of the users and the staff responsible for maintaining the system. The PIR process helps identify system flaws, requirements that need to be changed, ways to improve performance and other potential future enhancements.

The Information Systems Board *(72)* of Washington State believes that PIR process is valuable because "[w]hat gets measured gets managed. Determining performance measures and outcomes at the beginning of a project helps assure that the project stays true to the initial purpose and priorities. Defining the desired outcomes or acceptance criteria at the beginning of the project also clarifies the project's scope. Using performance measures ascertains whether the project did indeed succeed, and provides a starting point for developing future lessons learned."

Other benefits of post-implementation analysis include:

- Identification of "lessons learned" about the technology
- Identification of "lessons learned" about the project management process
- Documentation of "what went well" for:
  - awards and team building
  - developing and incorporating best practices into project management guidelines
  - sharing with other transit business areas and organizations in the industry
- Improved understanding of the client's business needs
- Improved effectiveness of the IT organization by incorporating PIR lessons and, with time, enhancing its credibility
- Increased knowledge on how to quantify benefits of ITS projects
- Better investment decisions on future projects from using the PIR information
- Ability to provide project sponsors and funding organizations with evidence of costs and benefits
- Provide stakeholders with measures of success to help validate their decisions and support if the project went well
- Finally, information from ITS project evaluations can also help the industry with subsequent projects by helping understand the impacts of the technology on transit services and users, transit organizations and their staff.

7.4 Post-Implementation Review Process Overview

Various organizations and vendors have slightly different PIR processes, but the core process consists of the following four steps: Planning, Preparing, Conducting and Reporting/Following up. Generally, a cross-functional team consisting of key stakeholders, users and technical experts plans and conducts the PIR, unless the capability and resources are available for having an independent auditor or evaluator. In that case, the auditor or evaluator works with the team and ensures the data collection and analysis integrity. For very small projects, the PIR may consist of the business manager or IT manager surveying users and the technical staff and then reporting results.

The FAA web site includes a moderate-sized list of what a post-implementation review covers *(73):*

- "Perspective and insight of participants and users, customers, and stakeholders;
- Original investment expectations including performance, investment and operating costs, schedules, benefits, and technical capability;
- Actual investment results (e.g., operational performance; customer, user, and stakeholder satisfaction; investment and operating costs; technical capability; impact on mission and program measures; unanticipated benefits);
- Cost and schedule deviations, such as additional "hidden" costs related to investments that have been made to enable the primary investment;
- Environmental changes that affected the investment (e.g., political, operational, economic, or technical conditions);
- Original business case assumptions that justified the investment program;
- Expected next steps for the investment program;
- Conclusions and learned lessons; and
- Recommendations to senior management."

7.4.1 Planning the PIR

Planning begins during final investment analysis in conjunction with overall planning for implementation and lifecycle management of an investment program. Planning for the PIR is incorporated into the project plan and funding package. Goals, objectives and anticipated benefits that are detailed in the Business Case and ROI need to be considered

in conjunction with the PIR Plan. How will the objectives and benefits realization be measured and analyzed? Is it feasible? Can it be determined if the risks were adequately defined and mitigated? Are resources allocated to complete the detailed planning, data collection and analysis steps of the PIR?

7.4.2 Preparing for the PIR

This step generally corresponds to the systems engineering process's Validation strategy activity. It further defines the PIR Plan and prepares the survey forms, templates, analysis approaches and other resources that will be needed. It defines in more detail how the PIR or validation will take place and what resources will be needed. For example, if a before-and-after study design will be used, the "before" data will need to be collected prior to deployment of the system.

7.4.3 Conducting the PIR

Most post-implementation interviews, surveys, "lessons learned" sessions and other data collection activities are conducted after the IT/ITS system has completed system verification and acceptance testing. Data collection may have to begin earlier to collect "pre-" or "before" data.

7.4.4 Reporting/Follow-up

Data is analyzed, a gap analysis is performed, results are documented and they are reported to the project team, stakeholders, transit managers and individuals and organizations requesting the evaluation results. Ideally, appropriate benefits and lessons learned are reported to RITA for incorporation into the RITA web site databases.

Transit management and project managers should follow-up on the recommendations and implement changes. Action plans should be developed and implemented.

If the results from multiple PIRs from different programs are reviewed together, the review may identify ways to improve an agency's IT/ITS "investment planning and management control processes, enable more accurate estimates of investment costs and benefits, and ultimately result in better investment decisions. Results from successive reviews on singular investment programs enable managers to determine if actions to improve performance and benefits are working." *(74)*

7.5 Transit Survey Findings

The transit agencies that were surveyed had varying levels of understanding of post-implementation analysis or PIR. In addition, post-implementation analysis was called different things in the various agencies, so additional prompts and follow-up questions were needed to clarify what was being discussed.

Does your agency have a post-implementation analysis or evaluation phase for IT/ITS projects?

With the exception of a few of the transit agencies that were surveyed, most of the respondents described relatively little consistent post-implementation analysis activity. In a few cases, PIR was confused with system acceptance or project closeout activities. The majority of the agencies surveyed did not have a formal post-implementation analysis process. Of those that did, it was only sometimes or informally followed by a subset of those respondents. One respondent said their reports had varying levels of formality, but they usually included lessons learned, performance goals and comparisons against initial model forecasts.

Terms used to describe post-implementation analysis activities or processes included Post Project Assessment, Benefits Realization Step, evaluation, Feedback, earned value management analysis and validation. When the transit agency's post-implementation analysis had some form of proscribed procedures, it was generally because the organization's central IT staff had a System Development Life Cycle (SDLC) methodology that included a post-project-closeout analysis step.

An interesting, related comment from MARTA was that they have hired staff to be an in-house, independent verification group that analyzes a new system prior to system acceptance (they complete the system engineering verification process step). This group and process have "paid off in dividends."

What is the time frame for measuring/evaluating the results of the IT/ITS project?

The time frame for completing post-implementation analyses varied, but most were completed within one year of system acceptance.

The Utah Transit Authority (UTA) has an interesting approach that includes two phases. First, it obtains feedback on the system from the customer within 30 days of system acceptance. UTA is striving for ISO (International Organization for Standardization) consistency, so this feedback is part of a regularly followed process. UTA strives to monitor, measure and report on whether the project met the agreed upon quality, schedule and budget expectations defined in the scope, while acknowledging that all categories are subject to change requests that can modify expectations to the scope.

UTA has another regular post-implementation practice, although there is no form for it. An IT supervisor or the project manager always checks back on the new system, generally after it's running for three to six months (maximum one year) to see if anything else could have been done differently. They look for

lessons learned or needed system adjustments, as well as using it as an opportunity to keep up with changing business needs.

The King County Metro Transit Signal Priority (TSP) team completes its Before and After data collection efforts immediately surrounding a new installation to have as similar as possible "before" and "after" operating conditions (usually two weeks before and two weeks after).

Who or what is the driver for having a post-implementation analysis?

A variety of reasons were given for doing post-implementation analyses. Some agencies cited policy or practice for doing post-implementation analyses. Another said ISO standards and procedures, as well as it being critical for providing good customer service. Other answers included the following:

- Federal requirements
- "Usually we think it is the right thing to do."
- Grant requirements
- When a project manager pushes for it
- When it is a problematic project or one with lots of conflicts
- When someone promised cost savings and now we have to find them
- We had to justify why it cost so much
- Want the lessons learned to improve practices and procedures
- Want to know how to improve the system in the enhancement phase and if it is needed

How are the results used?

The most common answer was that the lessons learned were valued for improving future projects. The results were also used to guide the next set of enhancements for the new project or to identify new business requirements.

The Utah Transit Authority used the PIR process for several purposes. Documenting PIR results from all of the IT/ITS projects "allows you to go back and see what you did and learn from errors." From an IT perspective, "one of the best values is the alignment of the requirements and the deliverables (was it that the client changed their mind or that resources changed?). Feedback helps you clearly know what the clients think. It's time consuming, but good. It just takes lots of time."

The TSP team at King County Metro uses the evaluation results in a number of different ways. They use the feedback for adjusting and fine-tuning the TSP system, for TSP staff training and education and for determining whether or not to shut down a location with poor performance. In addition, the analyses have helped them contribute to the industry's knowledge about TSP in talks, papers and during the development of the TCIP standards. Finally, they use the evaluation data to help determine where to put the next TSP installation, where to do improvements, to estimate how much time each vehicle spends on every block of the street and to provide the data to others in the organization who want it. One of the biggest benefits is that it helped build tools, such as the TSP Interactive Model (cost-benefit model), for creating more effective installations.

Does your agency apply the post-implementation analysis process to all or some of its IT/ITS projects?

Three of the agencies said they did some post-implementation analysis regularly after an IT/ITS project has passed systems acceptance. Most said they would try to do more in the future.

What are the biggest issues in completing the analyses?

For those agencies that completed post-implementation analyses, time, money, gathering data, and motivation were issues in completing the work. For some, after the project was over, they felt pressure to either work on enhancements or move onto a new project. Another said that it is a struggle to obtain data for a good ROI analysis; they use the cost/benefit analysis portion of the ROI more as a planning tool for deciding between implementation options.

7.5.1 King County Metro (KCM)

King County Metro has extensive, detailed documentation and requirements for how project managers will run their IT/ITS projects, interact with the King County Project Review Board and document their activities. The process is proscribed from the funding request phase through project close-out, plus a Benefits Realization Report that is due a year after project close-out.

The Project Close-out Report is due within a month of the final monthly monitoring status report. It is supposed to include:

> Documentation of the project description, results, variance and a summary explanation of what the project accomplished—highlighting relevant project scope, schedule, and budget information from the close-out documentation. Also includes benefits measurements, lessons learned, records retention, and deliverables turnover. *(44)*

Forms and templates are provided to help complete the report. Table 7 lists some of the project areas that are to be considered when developing lessons learned. The project teams are also encouraged to describe project practices that worked well and could be utilized by other projects throughout the county to improve their performance.

The Benefits Realization Report is a relatively new requirement that aims to identify the benefits and value of the project after it has been operating for up to a year. In addition, it

Table 7. Lessons Learned.

Lessons Learned-Project Areas to Consider		
Project Planning	**Quality Management**	**Implementation**
Budget Management	Communications	Support
Scope Management	Team Management	Work Effort Estimating
Schedule Management	Project Close-out	Transition to Production
Issues Management	Requirements	Testing
Risk Management	Design	Other
Change Management	Development	

should provide a comparison of the benefits received to the value projected by the Business Case. The lessons learned and other data from the project closeout activities are part of the inputs to the Benefits Realization Report. The key questions addressed by the report are:

- Did the project provide quantifiable value to the county or to the public?
- Did the project provide non-quantifiable benefits to the county or to the public?
- Did the project provide benefits comparable to those projected by the Business Case?

7.5.2 Other Transit Discussion of Post-Implementation Analysis

Transit agencies in the United States are not the only ones finding it difficult to complete PIRs on ITS projects. In 2004, Transport Canada published an article titled, *Evaluation of the Intelligent Transportation Systems (ITS) Deployment and Integration Program, (75)* which examined 12 Canadian ITS projects. The report indicated that "some recipients provided minimal information in their project evaluations." In the recommendations section, the report states that "In the future, Transport Canada should improve the measurement and reporting of results achieved by the ITS projects that it funds. . . . Transport Canada should work with ITS funding recipients to incorporate appropriate and cost-effective performance measurements and reporting methodologies to be able to evaluate the results of ITS projects."

In the ITS field of AVL, a 2008 Transit Cooperative Research Program report titled *Synthesis 73, AVL Systems for Bus Transit: Update (76)* mentioned challenges with obtaining good post-implementation data. "In many AVL system implementations, the implementing agency did not systematically evaluate aspects of benefits that might have been quantifiable as they did not see a need to undertake the additional evaluation." The report further states, "Determining costs is complicated, since some could be attributed to other systems such as the Radio system, fare boxes, APC, WAN upgrades, new staff that work on more than one system."

The AVL Synthesis 73 report does list a number of lessons learned from the post-implementation follow-up, such as "staff resistance to accepting data as valid if it contradicts conventional understandings, . . . staff resistance to adopting needed changes in operational procedures, . . . a number of integration challenges, . . . the importance of securing participation from throughout the agency organization, carefully selecting the systems integrator, applying strong project management for the implementation, and understanding the substantial ongoing effort needed for system management once it is operational."

A paper from 1998, titled, *ITS Benefits: Review of Evaluation Methods and Reported Benefits, (77)* provides background information pertaining to ITS evaluations. It summarizes the reported benefits of a number of ITS systems that have been deployed and the evaluation methods used to quantify the ITS benefits. The report also presents several evaluation frameworks that have been used to evaluate and quantify ITS benefits.

The US Department of Transportation provides information and tools that can help transit agencies with building a business case and designing the analyses for the PIR on its RITA website *(78).* For example, under the "ITS Resources" tab, information can be found in the benefits, lessons learned and cost databases that is helpful in planning a PIR. The evaluation support portion of the website *(79)* provides guidance on how to complete comprehensive, independent evaluations of ITS projects and provides links to a variety of sample evaluation strategies.

Similarly, the IDAS *(80)* website may help with the design and analysis of some benefits of some ITS projects. "The ITS

Deployment Analysis System (IDAS) is software developed by the Federal Highway Administration that can be used in planning for Intelligent Transportation System (ITS) deployments. State, regional and local planners can use IDAS to estimate the benefits and costs of ITS investments—which are either alternatives to or enhancements of traditional highway and transit infrastructure."

7.6 Non-transit Approaches to Post-Implementation Analysis

Other industries and countries have recognized the value of conducting Post-Implementation Analyses and Reviews. Procedures and templates are available from a number of commercial vendors and consultants. In addition, various states and government organizations have instructions and tools available via the Internet. Despite all the available guidance and templates, many organizations struggle with finding the knowledge, time, and resources to complete a PIR on a new system. In addition, some of the barriers and issues cited in the next section conspire against the successful completions of PIRs.

A study conducted in Australia on "The Politics of Post-Implementation Reviews" *(81, Pages 307–319)* indicated that "few organizations undertake any substantive form of ex post evaluation." It is one of several studies that state that systematic use of formal evaluation is relatively rare after a system has been accepted.

Several of the more accessible web sites that provide guidance and templates on PIR are briefly discussed below.

The Washington State Department of Information Services, Information Services Board, provides guidance and templates under the topic, "Project Management Framework, Closure-Post Implementation Review," at the website: http://isb.wa.gov/tools/pmframework/projectclosure/postimplementation.aspx

The Federal Aviation Administration also has easy to follow and understand guidance on PIRs on the web. The initial menu is located at: http://fast.faa.gov/post_implementation/index.htm

One of the initial menu items, PIR Standard Process Guidance, is expanded in Figure 25 to show how the website has nested the guidance and templates. As an example, the following guidance is included under the item #1.5, Can We Tailor the Review?

> Post-implementation reviews are *always* tailored to the size, complexity, and importance of an investment program or set of programs. Activities and costs are scaled appropriately, and may range from periodic surveys or focus-group meetings with users of small, low-cost investment products to multiple site visits by a dedicated cross-functional team of users and stakeholders for large, complex, high-cost investment programs. In all cases, actual operational data from users must be gathered and assessed against performance targets. . . .

As another example, the following guidance is included under the item #1.9, When do we Conduct Post Implementation Reviews?

> We conduct post-implementation reviews 6 to 18 months after deployment at an operational site once initial problems are worked out and users are generally familiar with the new capability. Timing is crucial and dependent on the status of the investment program. A review conducted too soon may fail to capture full benefits, while a review conducted too late may lose institutional knowledge about the investment and recommendations may come too late to influence follow-on installations . . .

Sample survey forms for the Project Manager, Sponsor, Stakeholders, and Team are available at:

> http://www.its.monash.edu/staff/projects/project-management/templates.html. These samples provide additional ideas for questions to include in a PIR process.

Discussion of auditing guidelines for Post Implementation Review from the Information Systems Audit and Control Association (ISACA) can be found at the ISACA's website. This discussion and website is geared more toward auditors or someone having to work with auditors that will look at an organization's PIR process. It can be found at:

> http://www.isaca.org/Template.cfm?Section=home&Template=/ContentManagement/ContentDisplay.cfm&ContentID=18682

7.7 Issues and Barriers Related to Post-Implementation Analysis

A number of issues that pose challenges to the successful completion of post-implementation analyses were cited both in the general literature and by the transit agency survey respondents. The issues include the following:

- Lack of knowledge on how to complete a post-implementation analysis
- Lack of time and resources to complete the PIR
- "Getting people to understand and care about it"
- Failure to collect "before" data so that a comparison of performance can be made "pre-" and "post-" implementation
- Prior post-implementation analysis efforts, which tried to "place blame" for aspects of the project that didn't go well, discouraged staff from planning and participating in subsequent efforts
- The difficulty of collecting accurate financial and operating data
- Common statistics related to transit may be gathered and defined in different ways, both internal to an organization and between transit organizations

Figure 25. FAA guidance on PIR. (Source: FAA.)

- Collection and analysis of quantitative data for the purpose of rigorous evaluation is often very expensive. A Canadian study on its *Intelligent Transportation Systems (ITS) Deployment and Integration Program* found that in some instances, "Quantitative data collection and analysis would require additional funding beyond that which was provided for the actual ITS deployments." *(82)*
- Managers who don't want a discoverable record of system issues and failures
- Major disincentives to further post-implementation analyses, and the future specification of budget-related benefits, are created when organizations promptly cut all dollar and staff savings from a work group that successfully implemented efficiencies through ITS improvements. Most staff that implement new systems hope to see some of the resources that were saved put to use in improving or expanding services in their business area.

7.8 Recommended Practices for Post-Implementation Analysis

The FAA website, which provides distilled, straightforward guidance on how to conduct Post Implementation Reviews, *(83)* includes the following tips for a successful PIR:

- "Build the review into program planning from the start during final investment analysis;
- Conduct the review against expectations in the original business case and program baseline;
- Don't scrimp on resources or effort! This is the last best chance for taking corrective action when a program is not performing as intended;
- Get close with the users; they live it every day and know best where we can improve;
- Report both the good and the bad; there are always opportunities for doing things better;
- Ensure issues are handled effectively and that we have a plan for closure;
- Identify next steps clearly; and
- Follow recommendations and actions to completion."

Other recommendations for improving the success of post-implementation analysis efforts are:

- TriMet felt it was important to have easy to understand procedures and templates for the PIR that require all the key steps to be completed but provide some flexibility and the ability to scale the effort proportionally.

- At the beginning of the project, and again after project closeout, establish expectations and abate fears about the PIR process. It is very common for a project to meet requirements and pass the project verification phase, while still having issues during the project validation or PIR phase. This usually occurs because user needs can change over time and requirements may not have been initially specified optimally.
- Involve and obtain input from the customers, the project team and other stakeholders.
- Use a neutral facilitator during the lessons learned session and avoid placing blame.
- Be clear on the project success measures *prior* to implementation.
- Use available resources, such as the ITS benefits and lessons on the USDOT's Research and Innovative Technology Administration web site, to help develop the project specific list of benefits to assess in the PIR.
- Choose benefits and performance measures to assess for which elements data can reasonably be collected.
- Remember to collect "before" data at the appropriate time, rather than remembering the task at the end of the project. The time period for collecting the "before" data may vary by data set.
- Establish a data collection and analysis methodology for the project's PIR that addresses what data will be collected, how it will be collected, what resources are needed to collect it, when it will be collected and how it will be analyzed or compared.
- Selecting an assessment horizon depends on the ITS system being implemented, how stable the initial implementation was, available resources and the conditions of the operating environment. Some of the assessment should be conducted after the new system and procedures have had ample time to be integrated into the business. Staff learning curves and other project issues may dictate that a number of the benefits be assessed a little later, after the system has "settled down."
- UTA felt it was important to link the PIR activity to an ongoing culture of continuous improvement and the regular rechecking of customer needs and expectations.
- Incorporate the lessons learned and best practices into the organization's procedures. Share the newly gained knowledge that is valuable and constructive.

7.8.1 Checklist for Managers

This Checklist for Managers Section will be used to stimulate discussion among transit staff participating in Task 4 to refine best practices for the Framework. The final Checklist for Managers is intended to assist transit managers in enabling their staff and transit organization to effectively acquire, assess and enhance IT/ITS systems and related business practices.

This portion of the Checklist will focus on management activities that ensure the benefits of completing post-implementation analyses are realized. A number of the steps also improve the value and success of other phases of an IT/ITS implementation.

7.8.2 Transit Manager's Roles

Transit has become more and more dependent on the successful operation of its automated systems. Managers need both system performance and critical information from those IT/ITS systems for effective decision making and for the efficient provision of transit service. Transit business area managers need to play a key role in ensuring the success of these systems. In general, IT/ITS projects cannot be successfully implemented with only the attention of the IT manager.

Manager's Checklist Items

Key roles of the transit management team are to:

- ☐ Ensure a common vision, communicate goals and priorities, be champions of integration, provide oversight and support staff. The transit General Manager and the head of Information Technology have particular responsibility for ensuring that an integrated, agency-wide approach is taken for developing data and information systems solutions. *(84)*
- ☐ Ensure that IT/ITS systems support the operational needs of the agency. The goals of the organization should be one of the drivers of the IT/ITS project's goals, objectives and requirements.
- ☐ Ensure that a realistic evaluation plan, Post-Implementation Review Plan or Project Validation Plan (depending on the terminology used by the agency) is developed before the systems development is started, so appropriate "before" data can be collected.
- ☐ Ensure that complete financial analyses, such as ROI with cost, benefit, and Total Cost of Ownership considerations are completed during the development of the Business Case. These analyses can be used to assess if the completed project met or exceeded the original expectations.
- ☐ Provide motivation, oversight, and the resources necessary to collect the data.
- ☐ Ensure that the project verification steps, which verify that requirements are met, are completed before system acceptance and project closeout.
- ☐ After project closeout, ensure that the PIR data collection plan is underway, so the post-implementation analyses can be completed.
- ☐ Request and review the post-implementation analysis report.
- ☐ Follow-up to make sure appropriate system and process improvement recommendations are implemented.

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APPENDIX C

Validation Report

TABLE OF CONTENTS

Overview: Validation Report

Background

The *Transit Enterprise Architecture and Planning Framework* project seeks to provide transit agencies with a roadmap, based on a Transit Enterprise Architecture and Planning (TEAP) Framework, to successfully implement Information Technology (IT) and ITS technologies that meet their business needs. The draft guidance on the Framework topics was incorporated into a wiki site.

The *Transit Enterprise Architecture and Planning* (TEAP) *Framework* wiki was developed to facilitate access to information about the Framework elements, and their tools, references, examples, and relationships to other Framework elements. Since the various elements of the Framework are related and inter-linked to maximize their benefits, the hyper-linked structure of wiki is well suited for finding information quickly, helping understand relationships among elements, and moving between topics efficiently.

The wiki is designed for transit industry managers and staff that are involved in planning, funding, implementing or assessing IT/ITS projects. A subsection of the wiki is designed specifically for transit managers. Project managers and staff will also find useful information in the section for transit managers.

This Task 8 research validation effort focused on obtaining stakeholder feedback on multiple facets of the Framework and EA/EAP guidance and tool concept.

Objectives

The primary research goal for this research validation task was to obtain customer feedback on the TEAP Framework and guidance (Task 4 deliverable) and EA/EAP Guidebook and tool suite (Task 7 deliverable). In addition, the following Validation Workshop objectives were developed:

- Introduce the draft TCRP project content and the new draft presentation format
- Obtain feedback on the "wiki approach" for presenting the information
- Obtain feedback on the content and recommendations on other materials to add
- Obtain feedback on how the wiki content might be managed and how content might be "quality-controlled" (i.e., what sections should be open to anyone to add/edit?)

Methodology

The validation research methodology activities included the following:

- Two facilitation guides, one general and one focused on EA/EAP, were designed to trigger valuable discussion and insights about the selected topics. The general facilitation guide is included in Appendix A and the EA/EAP focused guide is included in Appendix B.
- Transit agencies were selected and invited to participate in the teleconference workshops. Some participants were from transit agencies that currently have a very basic IT/ITS planning methodology and some participants were from agencies that are more experienced with formal planning processes and systems engineering practices. Some people who were interviewed in prior tasks were invited to participate in these teleconferences. In addition, personnel who were new to the project and the framework were also invited and included in the Workshops. Appendix C contains tables that list the transit agencies that were invited to participate in the workshops and the individuals who participated in the workshops.
- Three workshops were designed and conducted. The workshops were conducted as teleconferences using the www.gotomeeting.com meeting tools, which allowed the Facilitator to guide the participants through the wiki.
- Two 75-minute workshops, conducted on June 16th and June 22nd, 2009, followed the general facilitation guide. A 90-minute workshop, which focused on EA/EAP was conducted on June 24th, 2009. In addition, several transit agencies that were invited were later contacted for feedback, after they called and apologized for not being able to attend the workshops.
- Project team members debriefed on the workshops and developed key findings for improving the wiki, guidance and tool suite. The findings are incorporated into this Validation Report.

Validation Task Findings

Feedback from the webinars is included in the sections below. The feedback falls into several categories:

- Navigability and layout
- Content of topics and pages
- Access and control
- Other feedback

Each section cites general statements and specific comments made by webinar participants. Although the general sentiment was positive, the comments varied by the level of technical expertise of the speaker. So when relevant, the feedback indicates the background of the commenter.

In the invitation to participate, invitees were asked to spend some time reviewing the site prior to the workshop. In half the cases, participants complied with the request. Some of the differences in the feedback can be ascribed to the familiarity of the participant with the site.

Feedback on Navigating through the Wiki

Several Workshop discussion questions elicited feedback on the presentation of the material. With respect to navigation, open ended questions were asked of the webinar participants to solicit their initial experience with the various buttons and pages that were available for revealing the site's organization and links to different areas of the wiki's content. Following the questions, the Workshop facilitators showed the participants the links, training sections, and pages that help traverse the wiki. The responses to these questions were mixed. Several participants thought the web site was laid out in a well organized manner, others thought they needed more direction to get to topics of their interest.

- "The wiki is very intuitive to use, well laid out, clean. I like the Navigator, had no trouble finding stuff." (from a wiki user and CIO)
- Put the "How to navigate the wiki into the Navigator" [Note: We can't do this unless we make a special folder for navigating through wiki]
- A new user asked, "Where do I start if I have a project and I want to find information on it?"
- "The structure for organizing the material is good."
- "I really like that it is searchable."
- An interviewee said, "It would be great if there was a graphic that was consistent throughout the site that showed where you were in the grand scheme of the wiki. Maybe use the circle diagram and have the subarea in color or marked differently."
- **Side Bar:** Several reviewers mentioned that they prefer the side bar on the left because the right hand side is generally considered the area for advertising.

Page-Specific Feedback

Feedback was sought about each of the major sections of the wiki, and targeted a diverse range of pages. Discussion focused particularly on the Front Page, the Guidance for Transit Managers, Overview, Business Case Methodology, EA/EAP Guidebook, and FAQ section that contains the Glossary/Acronyms. The feedback as if they did not have a guide to explain the purpose or content of the page. Then the parts of each section were described and additional feedback was solicited.

Front Page

The Front Page elicited the strongest reaction from most Workshop participants. As one respondent said, "The Front Page needs to establish credibility for the site." The page is too wordy, and it needs to engage transit professionals more effectively. Participants made these comments:

- The Front Page needs to establish credibility for the site.
- The Front Page needs to invite people into the wiki
- It needs to make a good first impression and tell the reader, "Why should I be interested in this and what the main topics are." The first page does say what the key topics are, but parts of the page are too wordy.
- Bring them in with leading questions. Use short questions to hook them . . . Would you build a house without plans? . . . Are you tired of failed IT projects? . . . or Here is a method to manage . . .
- Maybe say there are "Top ten transit" issues for transit executives
- Consider splitting the page into two pages or splitting the bottom of the Front Page into two boxes, where one focuses on the benefits of the wiki to the reader and the other highlights the content areas
- Words by themselves don't attract transit managers, add more pictures
- It can't start too technical
- Many participants agreed they would click the Overview link on the Front Page first.

Overview Page and Sub-pages

Several questions were asked about the placement, content and presentation of the Overview and sub pages. The diagram showing the TEAP Framework (Figure 2) was highlighted to show how the different Enterprise Architecture and IT/ITS Planning and Management elements inter-related. The name of the Framework (e.g., TEAP) is still confusing to the majority of reviewers and there were some suggestions to change the name of the Framework to also emphasize the system management processes (BCM, Systems Engineering, post-implementation analysis) rather than exclusively on the enterprise architecture processes.

The comments that emerged from these sets of questions included:

- The group agreed on the placement of the Executive Summary.
- The level of detail and content seemed appropriate in the Executive Summary
- One participant wanted to know "Why are those the five concepts in the TEAP?" because the name TEAP, Transit Enterprise Architecture and Planning, could lead a person to believe that the project was only on transit EAP. They didn't understand why BCM and systems engineering, etc., were included, given the project name. (Note: maybe

the project should be named TEA-IP Framework for Transit Enterprise Architecture and IT/ITS Planning Framework.)
- One individual wanted to make sure that the wiki says that doing IT/ITS projects in an isolated or stove-piped manner doesn't work for Transit any more.
- Regarding Figure 2: Transit Enterprise Architecture and Planning Framework,
  - Make items in the diagram clickable.
  - Provide definitions of the items in diagram.
  - Provide explanation of the solid and dotted lines.
  - Make sure reader doesn't think this is the EAP diagram for transit, it's a bigger Framework, with funding, BCM, SE, etc. added.
  - Looks at projects in the context of architecture
- One comment was made about IT Governance, that the community of EAP practitioners often viewed it as a three-legged stool (Project Management Office, Capital Planning and Investment, and EAP). The overview section has a discussion of IT Governance based on a model from the IT Governance Institute, which is not inconsistent with that viewpoint, but it uses somewhat different vocabulary at the higher levels.
- Use of more graphics and pictures would be good.

Guidance for Transit Managers

The content of *Guidance for Transit Managers* received very positive feedback. Several senior transit managers who attended the workshops or were interviewed gave the section high marks for clarity, organization and brevity.

- Level of detail looks about right
- "Checklist approach works for me"
- "It's very powerful to relate investments to goals."

Approach to Business Case Methodology Pages

The pages associated with the Business Case Methodology were shown as a template for the five Framework elements. Workshop respondents liked the content, structure of the material, and resources. In particular, they liked the worksheets and papers that were stored on the site. One participant indicated that the pages should further address:

- "[W]ho should participate in BCM" to build a project team, develop trust among the team members, visualize what the project is about, create "organizational learning", bring in diverse perspectives that will execute projects (not just the financial perspective). Make sure it addresses project management—who is in charge? Who is responsible? (if it's not already described in the wiki).

System Engineering

The System Engineering section was only briefly shown. It elicited very positive feedback; one person said, "I like how activities are written out. It gives managers a step by step process to follow." We received an email from a transit professional (who was invited, but unable to attend) who said he had already used the Systems Engineering section of the wiki to help him write a Concept of Operations.

EA/EAP

An entire 75 minute workshop was devoted to review the Enterprise Architecture and Enterprise Architecture Guidebook and Tools section of the wiki. The workshop respondents were very positive about the EA/EAP section, impressed with the details, examples, scope of topics, while simultaneously disappointed that it did not include more (prescriptive) guidance, examples, and detailed models. The comments included:

- I want this section to say how to do the AS-IS
- "I don't want to have to create my own EA for my agency from scratch, when other agencies are working on theirs as well. Examples or a general template would be really helpful."
- "It's very good to see how other agencies do things."
- "Would like to see some future or "to-be" enterprise architectures to help people see where they want to go."
- Need to get business managers to the discussion table on this topic.
- EA and these disciplines are "complex and difficult work". The wiki helps point us to resources. However, it cannot do the work. People need to know that it is difficult to start; agencies are missing long range business planning. They won't realize they need this until they fail and "then realize they need a process . . . don't get tied up in how to [help people] adopt [use of] this until they need it."
- Someone asked, "Where should Data Standardization information be located?"
- Expand the information in the yellow highlighted areas
- Who should be the authority on EA/EAP guidance? "A group of legitimate thought leaders need to go through a process to build a model and guidance that works across transit. Then they need to agree to abide by it. Filling in the boxes is not as key as deciding what the boxes are."
- Schedule an open meeting of the community to refine the EA model. "People from the major transit agencies should get together to hammer out the hard questions" related to developing a transit EA model.
  - "Need to determine the goal or purpose of a Transit EA. For the Federal Government, it was to eliminate overlap, which may not be the primary goal of transit."

  - "Tracking how things relate to each other in transit is currently done ad hoc."
- "The Transit EA can be developed in slices."

About the Project/Survey Results

Feedback from a follow-up interview indicated that it was not easy to find the survey results.

Also, in the Survey Methodology section, it was suggested that the table be clear about the topic areas. They did not want to reader to think that the presence or absence of a check mark reflected on how well an agency did in that topic area.

Glossary

The glossary was cited as an important help-aid to the site. Specific comments included:

- It was suggested that the Glossary link be put by the Site Map link.
- Remove the extra lines in the Glossary [this was done soon after the comment was made]
- Add a paragraph at the top of the page explaining how to add to the Glossary.

Access and Control of Wiki Site

A wiki allows any authorized user to add and modify any page in the wiki. Each webinar included a question on whether the wiki should be open to editing by anyone or should be restricted to experts only. The consensus during the three webinars was to control access to the wiki, particularly to control who was allowed to add or modify the wiki material. They suggested that individuals be allowed to comment on a page in the comment section, but restrict editing functions to only authorized "experts" in order to ensure the credibility of the site.

Access to Modifying Content

A question was asked in all the workshops about who should be given access to modify or add to the wiki content. Specifically, the project researchers wanted to know if the site could be self-managing. The unified agreement was that it needed to be managed by one or more persons with experience and expert credentials. Respondent's comments included:

- "Control Management is necessary"
- [Only] approved individuals should be allowed to add comments in the comment field of appropriate pages
- "Could be open to spam if it's not controlled"
- Need someone to closely manage the site if anyone can change the pages and control it closely for 6 months to see how usage occurs.
- Don't know if it will become overwhelming with people adding more information
- "I like the *Add a Comment*. Then have the comments edited by an administrator"
- Overall the group agreed items submitted should be moderated in all areas of the site.

Site Credibility

The access and control questions led to questions about how to ensure site credibility. Some respondents recommended that the sponsoring agency should brand the homepage. Others suggested that the site would speak for itself and that the site managers should not be listed.

Site Committee

The respondents of the workshops suggested that a group of people need to manage the wiki. One person proposed a group of three people.

Other Feedback

Other feedback was collected that was related to next steps. The comments covered topics such as publicizing the wiki, improving the site, completing the site, etc. The specific feedback is grouped in the sections below.

How should we get this to the right people?

Many respondents brainstormed about how to publicize the existence of the wiki. The comments included:

- ITSC Newsletter.
- Create a buzz about the TEAP with the managers/top level
- One respondent said her IT staff would not go to the EA/EAP section on their own, unless she directed them, because it's out of their area of expertise. But it's of great value to her as the IT Director.

Need to Clean-Up Some Typos

Specific typos and misspellings were identified. These will be cleaned up before the commencement of the Phase II project. Specific typos include:

- On Checklist page, EA/EAP, last bullet under section starting with "Foster the mindset . . ."; change "addresses" to "addressed"

- On BCM pages see header #4—fix caps
- In Acronym list TCO, not TCP
- (we need to see if wiki provides a spell-check tool)

Is this a viable alternative to finding material in a report?

A key question for the Researchers was on the "tool" approach. The collaborative, web-based tool was the approach used to present the information. We wanted to understand whether it was a good, effective and successful approach for presenting the Framework material.

Most respondents said they would use the Wiki more than they would the official Report. In answer to whether a report would be an alternative approach, one person said he would use the Wiki for day-to-day usage, and only use the Report when he needed to make a formal reference to it. The general reactions to the wiki included:

- They like using the wiki because of the search ability and that it's not intimidating.
- Having the material easily locatable across the pages and in a "questions" format made the material less daunting and more accessible
- Beneficial in a different way than a paper document would be
- The wiki allows interaction and discussion among peers.
- Liked the wiki because it is more interactive. A reader can go back and find references more easily, which is worthwhile.

Maturity Levels

One respondent indicated that the material presents the information without discussing the different IT "maturity levels" throughout the industry. This respondent recommended that the wiki should acknowledge that different transit agencies are at different maturity levels. Specifically, "it would be nice if [the content] provided tailored guidance for different maturity levels."

Where it is appropriate, indicate what is a "must have" versus a "nice to have."

Address Updating/Upgrading IT/ITS Systems

One respondent thought it would be nice if the wiki addressed issues associated with how best to upgrade or update existing IT/ITS systems. They indicated that not everyone would have the budget for new systems.

Wiki Upgrades

Feedback on how the wiki will change over time was also gathered. One respondent wanted to ensure that users could identify new content and the importance of the modified or added content.

Use and/or Recommend Wiki?

Finally, workshop respondents were asked if they would recommend the wiki to colleagues and co-workers. The unanimous recommendation was YES!

"Yes, . . . because the vendors tend to drive things for the smaller agencies. This puts information, issues and concerns in front of key people . . . so they can make better decisions and provide better guidance."

"Yes, much of is better than what we tried to develop in-house to help with projects and training. It would be great to think about this with respect to training and how to link from these general wiki pages to our agency specific procedures. We may also have a project, depending on timing, which might use this to build a business case. We would like to be considered for Phase II."

"I've already been using the wiki and the information. It's wonderful, I liked its flexibility and how quick it was to find information." He would direct his different transit stakeholders to different parts of this site (e.g., his high level administrators, operations staff, and his IT Staff). It has information for all, from "high to low level."

Summary of the Validation Research and Recommendations for Improvements

As shown in the prior section titled, **"Use and/or Recommend Wiki?"** reviewers liked and would recommend the site. In fact, some are already using it.

Recommendations for Improvements

There were very good comments provided for improvements and changes to the web site. Some of them are highlighted below as Project Team priorities:

- Change the *TEAP Framework* name to differentiate Enterprise Architecture from the IT/ITS System Management planning elements.
  - Change from TEAP to TEA-IP Framework
- Fix the Front Page to engage the Transit Professionals and make it easier to read
- Add directed questions so Transit Staff looking for specific information can find it more easily.
- Add the Glossary to the Side Bar
- Separate the collaborative pages in the Enterprise Architecture Guidebook from the guidance pages

- Complete the yellow highlighted sections of the Enterprise Architecture Guidebook
- Add more resources to the EA Guidebook (note: this was the intention of the Phase II Work Plan)
- The Project Team would like to look for ways to strengthen the connections or linkages between the sections so the value of an integrated approach is very clear.
- Several transit agencies said they would be very happy to contribute more examples and tools to the wiki site. This would be an easy way for the Project Team to improve the content, if we followed-up with the agencies.

Recommendations for the Wiki Operations and Maintenance

There were some recommendations on how to move forward on engaging the transit community in the collaborative web site. These included:

- Give "read only" access to individuals (so they can comment on a page, but not modify it) for at least the first six months.
- Engage a group of transit professionals who are expert in one or more areas of the EA and IT/ITS system management methods.

Appendices to Appendix C

Appendix A: General Facilitation Guide

Facilitation Guide: TCRP Research Validation

Facilitator Guidelines

- Use an obvious, easy to track cursor symbol
- Tell the participants where you are going next on the page
- Don't move too quickly between locations
- First answer most questions, such as, "Where is the info on xxx?" with one of our own, such as, "Where would you look for it? Or what would you call it?"
- **Note:** <*page*> signifies what page of the wiki is under discussion.

Facilitator's Agenda

- (Optional) Have the early attendees fill out the following poll:
  - How much time did you have to review the wiki before this workshop?
    - None
    - Less than 30 minutes
    - 30 minutes to an hour
    - More than an hour
- <***OBECTIVES PAGE***>
  Welcome everyone (start with the wiki page on the objectives of the workshop) and Introduce:
  - The Project Team (Nancy, Polly, Edward, Susan, Bruce)
  - The initial need in the industry that lead to the project
  - The project—TCRP TEAP Framework Project
  - The Workshop Objectives (indicate that they should be on the screen)
    Objectives:
    - Introduce the draft TCRP project content and the new draft presentation format
    - Obtain feedback on the "wiki approach" for presenting the information
    - Obtain feedback on the content and recommendations on other materials to add
    - Obtain feedback on how the wiki content might be managed and content be "quality-controlled" (What sections are open to anyone to add/edit?)
  - **Workshop Protocol**
    - ask us to slow down if needed
    - ask questions
- <***FRONT PAGE***>
  - Can you quickly tell from the home page what the wiki is about and who should use it?
  - Who do you think it is for? Who do you think might be interested in it?
  - What do you think a new viewer would think the site is about?
  - There are several ways to navigate through the wiki, which approach would you use?
  - What is clear? What is confusing?
- **Objective: Explore some aspects of the site**
  - Did you locate and use the *Side Bar?* Any suggestions on improving its value?
  - Is a Site Map important to you? Did you find the Site Map? Where would you go looking for it?
  - **Go to <*SITE MAP*>** Any feedback for us on the Site Map?
  - **Look at <*NAVIGATOR*> Box** Did anyone explore this wiki option? Was it useful? Explain Purpose.
  - Did anyone go to *How to Navigate and Use this Wiki?* Where would you look for that information?
  - **Go to <*HOW TO NAVIGATE AND USE THIS WIKI?*>** Any comments on the material or anything to add?

Note: If they haven't spent much time on the site before the workshop, maybe here we could quickly review for them how they can get to the content via the site map, the side bar or the front page and do a quick demo, including how to get back to the home page each time.

Return to <***FRONT PAGE***>

Discussion Objective: Obtain feedback on the content and what else to add

Will first talk about the managers section

Go to <***GUIDANCE FOR TRANSIT MANAGERS***> Explain for whom this section was developed and give a quick tour

- How can the value of this section be improved? How can it best be used? (How to encourage managers to read it? Would the project team give portions to the involved managers?)
- Should the order of the materials be changed to encourage further reading?
- How well does the checklist approach to providing the information work?

Go to <***BUSINESS CASE METHODOLOGY***> Done by 10:45am

- Point out the three main areas

Go to <**WHAT, WHY, AND BENEFITS OF A BUSINESS CASE**>

- Scroll through sections providing an overview to the content

Go to <**BCM BEST PRACTICES**>

- Scroll through sections providing an overview to the content

Go to <**ADDITIONAL RESOURCES RELATED TO BUSINESS CASE**>

- Scroll through sections providing an overview to the content
- Does anyone have a favorite site or resource on the topic that should be added?

Return to <**BCM BEST PRACTICES**>

- Solicit feedback on what is there and what to add/change
  - What else would you want to know about developing a Business Case?
  - What do you wish the management team would do with respect to a Business Case or Business Case Methodology in your organization?
  - What key messages related to the Business Case or BCM should be included?

Go to the <***SYSTEMS ENGINEERING PAGE***>

- Point out and give a quick tour through the three major subsections

Go to <***UNDERSTANDING THE WHAT, WHY, AND BENEFITS OF SYSTEMS ENGINEERING***>

- Does the Vee-diagram and explanations help? Anything to add?

Go to <***UNDERSTANDING SE BEST PRACTICES AND RELATIONSHIPS WITH OTHER TEAP FRAMEWORK ELEMENTS***>

- What important best practices messages should be included here?

Go to <***LOCATING ADDITIONAL RESOURCES ON SYSTEMS ENGINEERING***>

- In addition to the two guidebooks mentioned on the page, are there any other favorite web sites, references or resources that you like or use on systems engineering?

Go to <***TEAP FRAMEWORK OVERVIEW AND PURPOSE***>

Provide quick tour through the three sections and stop on final page, <***HOW TEAP FRAMEWORK ELEMENTS RELATE***>

- Is the figure helpful? Do you have questions about any aspects of it?

Return to <***FRONT PAGE***>

- What do you think should be in the FAQ or Frequently Asked Questions section?

Go to <***FAQ PAGE***>

- Give a quick tour
- Any feedback? What else should be added?
- Do other sections if time allows
  - EAP
  - Post-implementation Analysis
  - Funding

Quickly go through other parts of site that are listed below, if time allows

Go to <***IMPLEMENTATION FUNDING***> Give quick tour through the four pages

- Understanding Transit IT/ITS Implementation Funding
- Understanding Transit IT/ITS Implementation Funding Best Practices
- Locating Additional Resources on Transit IT ITS Implementation Funding

Go to <***ENTERPRISE ARCHITECTURE***> Give a high speed intro thru 4 pages

- Understanding the What, Why, and Benefits of a EA/EAP
- Learning about EA/EAP Best Practices (EA Guidebook)
- Locating Additional Resources Related to EA/EAP

Go to <***POST IMPLEMENTATION ANALYSIS***> Give a quick tour through the 4 pages

- Understanding the What, Why, and Benefits of Post-implementation Analysis
- Learning about Post-implementation Analysis Best Practices
- Locating Additional Resources on Post-Implementation Analysis

Transit Involvement with Wiki

Discussion Objective: Obtain feedback on how the wiki content might be managed and content be "quality-controlled" (What sections are open to anyone to add/edit?)

- If this becomes an open site, where should the general public be allowed to make changes to the content?
- How should the content be "quality controlled"?

Value and Use of Wiki

- The big question: Is this a viable alternative to finding the material in a report? Trade-offs?
- If this site were available on the web, would you go back to it, and if so, what would you look for?
- Would you be inclined to contribute to the site?
- Would you recommend it? If so, under what circumstances and to what kind of people?

Terminate Workshop

- Thank them for their assistance.
- Identify ways they can further provide feedback (email, call, comment on site) Survey?

Appendix B: EA/EAP Focused Facilitation Guide

Facilitation Guide for Enterprise Architecture TCRP Research Validation

Note: <page> signifies what page of the wiki is under discussion.

<EAP/EA Webinar Objectives>

Welcome everyone (start with the wiki page on the objectives of the EAP Workshop) and Introduce:

- The Project Team
- The initial need in the industry that led to the project
- The project—TCRP TEAP Framework Project
- The Workshop Objectives
- **Objectives**
  - Introduce the Enterprise Architecture Guidebook content and presentation format
  - Obtain feedback on organization of materials
  - Walk through pages and obtain feedback on usefulness and improvements
- Workshop Protocol
  - ask us to slow down if needed
  - ask questions whenever you have one

Go to *<Front Page>*

- There are several ways to navigate through the wiki and get to the EA/EAP pages.
- Show 4 ways to get to the EA/EAP pages
- 1—navigation bar
- 2—cover
- 3—side bar
- 4—site map

Go to *<Enterprise Architecture>*

- Point out format similar to the other topics
  - Understanding the What, Why, and Benefits of a EA/EAP
  - Learning about EA/EAP Best Practices (EA Guidebook)
  - Locating Additional Resources Related to EA/EAP

General Questions About *<Enterprise Architecture>*

- Can you tell from this page what this section is about and who should use it?
- Who do you think it is for?
- Who do you think might be interested in it?
- What questions have you or your colleagues wanted answered about EA/EAP? What answer or help would you like to find in this portion of the wiki about EA or EAP?
- How should the benefits be organized or categorized to best attract the reader and help them see the value of an EA?

Learning EA Questions About *<Enterprise Architecture>*
Show Guidebook and Guidebook Navigation pages

- I've shown you one of many ways to organize the information and materials on EA and EAP. What changes to the organization or the section headings would help you find the material you need more easily?
- Again, what information would you be looking for on EA or EAP in this website?
- What questions about EA and EAP would you want answered here?
- If you wanted to learn about EA/EAP or recommend a site for a colleague to learn about EA/EAP
  - Would you recommend this wiki? Which sections might you suggest?

  - In what ways is it useful for learning about EA/EAP?
  - In what ways could it be improved?
- If you wanted to do a EA/EAP
  - Would you use this site?
  - In what ways is this site useful?
  - In what ways could it be improved? What should be added?

Walk through problem <*Enterprise Architecture*>

Ask for a question and walk through resources to see if we can answer the question.

Field Survey <*Enterprise Architecture*>

Phase II mandate to work with transit agency to work with site.

Appendix C: Validation Workshop Invitees and Attendees

Table 1 lists the transit agencies invited to participate in the validation workshops. The first column indicates the agencies that were newly introduced to the project with the workshop invitation (they had not been interviewed during the project task to explore the State of the Practice). For some of the agencies, more than one individual in the organization was invited. Invitations were made by a phone call and by email.

Participants in the June 16, 22, and 24 Validation Workshops are listed in Tables 2 through 4. In addition, a number of other agencies contacted the project team members to provide feedback on the wiki, because they were unable to attend the workshops.

Table 1. List of transit agencies invited to the validation workshops.

N=New	**Agency**
N	Ann Arbor Transportation Authority (AATA; Ann Arbor, Michigan)
	Bay Area Rapid Transit District (BART; San Francisco, California)
N	Capital Metro in Austin
N	Central Ohio Transit Authority (Columbus, Ohio)
N	CDTA -Albany
	Clark County Public Transportation Benefit Area Authority (C-Tran)
N	Dallas Area Rapid Transit (Dallas, Texas)
N	Denver RTD
	Hampton Roads Transit (Norfolk, Virginia)
	King County Metro (Seattle, Washington) Mike, WW, John
N	Long Beach
N	Long Island Railroad (LIRR)
N	Los Angeles County Metropolitan Transit Authority
	LYNX (Central Florida Regional Transportation Authority)
	MARTA – Metropolitan Atlanta Rapid Transit Authority
N	Metropolitan Transit Authority of Harris County (Houston, Texas)
	Miami-Dade Transit (MDT)
N	New York City Metropolitan Transit Authority (New York City)
N	NFTA
N	NJ Transit
N	PACE
	Paducah
N	Phoenix
	Rhode Island Public Transportation Authority (RIPTA)
	Riverbend
	TriMet (Portland, OR)
	Utah Transit Authority (Salt Lake City, Utah)
	SEPTA
	Washington Area Metropolitan Transit Authority (WMATA; Wash, D.C.)
	Wichita Falls Transit System
	Iowa State Department of Transportation (IA)
	Kansas State Department of Transportation
	New York State Department of Transportation (NYSDOT)

Table 2. Webinar participants in the June 16, 2009 workshop.

First Name	Last Name	Organization
Bob	McMahan	C-TRAN
Bruce	Eisenhart	ConSysTec
Sarah	Kaufman	New York City Transit
Dennis	McHugh	City of Wichita, KS
Thomas	Guggisberg	Capital District Transportation Authority
Doug	Jamison	LYNX
Shelley	Johnson	Sharp and Company

Table 3. Webinar participants in the June 22, 2009 workshop.

First Name	Last Name	Organization
Peter	Anderson	City of Fort Worth
David	Sullivan	Hampton Roads Transit
Edward	Thomas	Aegir Systems, Inc.
Shirley	Hsiao	Long Beach Transit
Robin	Stevens	Robin Stevens Consulting
Katherine	Keller	Central Ohio Transit Authority
Bruce	Eisenhart	ConSysTec

Table 4. Webinar participants in the June 24, 2009 workshop.

First Name	Last Name	Organization
Jamey	Harvey	WMATA
Katherine	Keller	Central Ohio Transit Authority
Shirley	Hsiao	Long Beach Transit
Lawrence	Harman	GeoGraphics Laboratory, BSC
Shelley	Johnson	Sharp and Company
Nancy	Neuerburg	N-Squared Associates

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HMCRP	Hazardous Materials Cooperative Research Program
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
PHMSA	Pipeline and Hazardous Materials Safety Administration
RITA	Research and Innovative Technology Administration
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation