Transportation Council
WHITE PAPER
Smart Card Alliance

A SMART CARD ALLIANCE TRANSPORTATION COUNCIL WHITE PAPER

Reference Enterprise Architecture for Transit Open Payment System

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About the Smart Card Alliance

The Smart Card Alliance is a not-for-profit, multi-industry association working to stimulate the understanding, adoption, use and widespread application of smart card technology. Through specific projects such as education programs, market research, advocacy, industry relations and open forums, the Alliance keeps its members connected to industry leaders and innovative thought. The Alliance is the single industry voice for smart cards, leading industry discussion on the impact and value of smart cards in the U.S. and Latin America. For more information, please visit http://www.smartcardalliance.org.

Table of Contents

1 Scope

This Smart Card Alliance Transportation Council white paper describes a framework for a reference enterprise architecture for open payment in the public transportation space. The framework provides a model for implementing a seamless fare payment system that traverses transportation modes, jurisdictions, markets, and technologies.

The Council working group efforts included the following:

- Review of how a reference enterprise architecture for a transit open payment system (TOPS) will deliver economic, program, and development benefits (see Section 2);
- Research of academic and industry architecture frameworks, particularly the Transit Enterprise Architecture and Planning (TEAP) framework that was developed for transit and implemented by several agencies in the U.S. (see Section 3);
- Development of a recommended approach for the TOPS reference architecture including:
  - Description of how the architecture should be modeled (called a metamodel). (See Section 3.5.2.)
  - Description of the scope of the five layers that compose an enterprise architecture: driver, business process, information, application, and technology. (See Section 3.5.1 and Section 4.)
  - Definition of the categories and detailed content contained in each of five layers. This document (Section 4) includes the basic categories and Section 8, Appendix A, includes detailed definitions for several sublayers within each layer. Tables are also included in Appendix A (Section 8.6) with the definitions and relationships between layer content. Version 1 of the white paper only includes a detailed treatment of the driver layer (Section 8.1, Appendix A-1). Additional material is planned for future updates.

As an industry group, the Transportation Council recommends the following:

- Adoption and refinement of the model defined in this white paper based on real world implementations.
- Selection of priority areas to extend and refine the architecture definition focusing on areas which will provide the greatest benefit for cost savings, system interoperability, future-proofing and more.
- Adoption and development of standards in the transportation and related industries that will ensure the longevity of the architecture as it is impacted by emerging forces and technologies.

2 Benefits

Many industries develop and promulgate a reference architecture framework to promote best practices by industry constituents. These include frameworks used many national and local governments (e.g., Australia, United States, Massachusetts), businesses (e.g., banking), and technical organizations (e.g., IBM, Cisco). The Transit Open Payment System (TOPS) Framework aligns transit fare payment stakeholders with standard practices designed to facilitate interoperability, reusability and industry-scale economic benefits. In an article published in Government Technology, the author states[1]:

> "… 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 reference architecture elevates these sentiments to an industry level where the architecture is leveraged not only for a single organization but across markets subject to different rules, regulations and business processes. The reference architecture describes a consistent framework across the diverse environments; it provides the following benefits:

- General framework for how the open payments systems work across vendors, industries, and processes in a technology agnostic environment;
- Showcase of assumptions, patterns, and strategies used to implement the system;
- Reuse and portability of system elements to enable interoperability, best-of-breed selection, application of proven solutions, and future system migration alternatives;
- Identification of critical forces, business processes, organizational roles and responsibilities, and data needs with respect to the system – "soft" areas typically not part of the "technical" system.

The reference model facilitates these benefits by providing developers, integrators, procurers, and users of TOPS with organizing principles ("layers"), high level definitions, and references to proven designs for interoperable system design components. These benefits affect successful outcomes not only for the system implementation, but also for its users and management. Although not a panacea, the framework exposes assumptions related to connections across the system and identifies gaps not only in the technology but in business processes. The reference model also specifies recommended processes for developing, integrating and managing transit fare payment systems throughout their lifecycles in alignment with industry forces to sustain high-quality, cost-effective service levels. These benefits directly impact the initial deployment schedule and costs, as well as longer-term costs to upgrade, change or add functionality to the system.

[1] "Enterprise Architecture Demystified," David Aden, Government Technology, Sep 24, 2008, http://www.govtech.com/gt/articles/418008

3 Reference Architecture Framework

3.1 Importance of a Reference Architecture Framework

A reference enterprise architecture is a template to implement an enterprise architecture. An enterprise architecture framework provides information on the best practices for creating and using the architecture description. An enterprise architecture, as used by many industries, provides a blueprint of how business strategies, processes, and decisions are supported by technology investments. However, developing an enterprise architecture is a long and labor-intensive effort and only standardizes one organization's systems.

A reference enterprise architecture is a general model of a type of business, solution sets, systems, and drivers. Most complex organizations start from experienced, well-formed models that describe an organization's typical business, data, applications and technologies that must work together within a market (such as would be used by transit for an open payment system reference architecture). To that end, a reference enterprise architecture provides a model from which to develop system information, service and technology standards that are consistent across an industry and that can be reused by multiple operating and managing organizations, vendors and integrators across the domain.

This section consists of defining and describing the enterprise architecture framework.

3.2 Enterprise Architecture Framework Definition and Scope

An enterprise architecture (EA) is a blueprint and description of how an organization uses technologies, services, and data to meet business needs, policies and goals. The EA structure provides business (non-technical) and information technology (technical) managers with visibility into the dependencies among their people, processes, technologies and performance. The EA provides visibility into the end-to-end business processes and policies that drive the application and technology solution. The EA provides clear descriptions of key performance indicators, data definitions, and business process flows. It also enables senior managers to plan their technology investment decisions to better meet corporate business needs and processes. More significantly, the EA describes the service (interface) specifications needed to facilitate interoperability with internal and external systems so that implementing organizations (such as public agencies) and vendors won't need to recreate these artifacts for each deployment.

The current methods used to plan for and document an enterprise architecture goes beyond just managing a list of the current technology platforms, assets, and applications. Policies, business processes, organizational structures, data outcomes and measures are impacted when deploying or changing systems. Other internal and external system applications and technology platforms are also affected.

Due to its broad nature, the EA takes time and coordination to develop from scratch. Many large, complex organizations rely on reference architectures; these are "modeled" architectures, reproduced and optimized from years of experience, and generalized to provide a template that includes a taxonomy of processes and data, typical performance measures, range of policies and procedures that drive business processes, specifications for applications, application programming interfaces, and technology configurations. Industries develop these reference architectures so that vendors can build products to meet their industry needs.

The transportation industry's payments ecosystem is evolving into one that converges payment across multiple modes and industries and moves to an open payments model. In order to accomplish this, the industry needs a reference architecture that can accommodate all of the ecosystem players, both public and private. A reference architecture provides a template wherein all the stakeholders can tailor their products and services to be interoperable and provide mobility and a seamless transfer across transportation modes.

A reference architecture for a TOPS will help the industry adopt new and emerging technologies, driven by business processes and standardized information, services and technology.

3.3 Enterprise Architecture Framework

An enterprise architecture consists of information applied to four layers of any business:

- Business process
- Information (and data)
- Application (and services)
- Technology

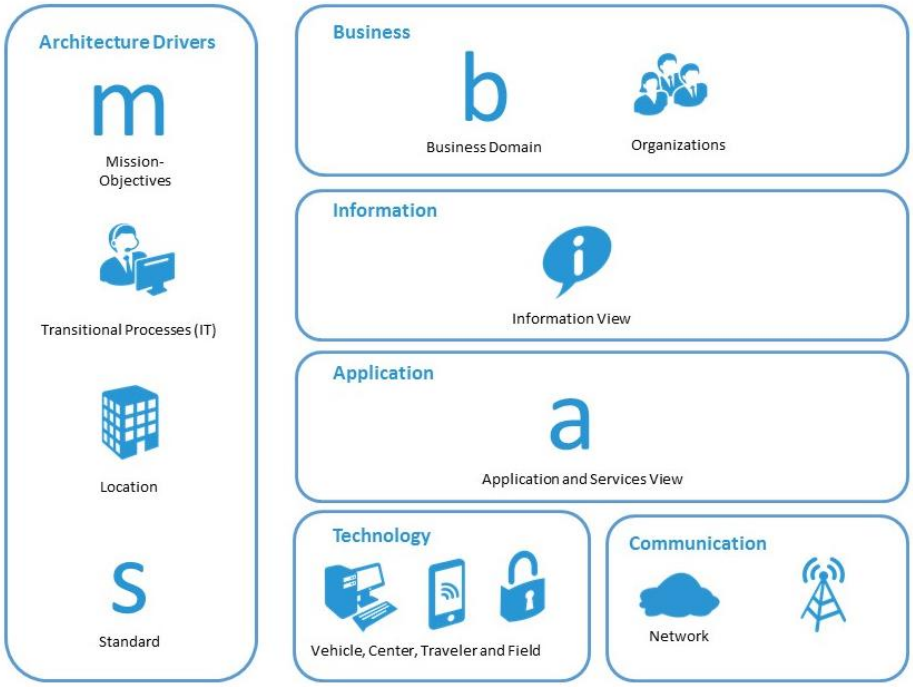

Figure 1: Enterprise Architecture Framework for Transportation Services

External and internal forces drive the business. Examples of these “drivers” may include the following:

- Business strategy (vision, mission, goal/objectives)
- Rules and standards (internal and industry)
- Government regulations
- Customer expectations
- Policies and procedures

For example, fare policies have a significant impact on customer and agency business processes, fare tables and products, software and technology that are deployed in the field and back office, performance metrics, and reporting requirements. For transit open payment systems, financial payment products, security and other forces are also critical to driving the architecture.

The EA helps organizations plan and implement new business processes, IT infrastructure, and applications faster and more efficiently. This is accomplished because the EA allows the staff to ask "what if" questions

related to business processes, stakeholders, information, applications and technologies without lengthy and resource-laden investigations. The EA benefits organizations by:

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

3.4 Enterprise Architecture Planning Process

An EA planning (EAP) process is associated with developing and maintaining an EA. The process documents the following:

1) How all the pieces of a system fit together ("as-is"),
2) What the future system model will be ("to be"), and
3) What the gap is between the "as is" and "to be" models and what the most efficient route is to get from the current system to the vision of the future.

The EAP process is used to help organizations migrate and evolve their business strategies and align their technology procurements. In the context of a reference architecture, the EAP process provides a roadmap for migrating to new and emerging business strategies, business processes, applications, and technology configurations.

Systems engineering processes use a similar approach; however, the systems engineering methodology is solely focused on the slice of the system, and not necessarily the impact across the enterprise. For example, a systems engineering approach may not view the procurement of an inspection application in the context of an agency's mobile device policy, while the EAP process would.

3.5 Components of a Reference Architecture Framework

The components of a reference architecture are the same as an enterprise architecture. This section describes the layers and examples of the types of information that are contained in each layer.

3.5.1 Enterprise Architecture Layers

As mentioned earlier, the EA includes architecture drivers/forces and describes four layers of the business:

- Business process
- Information (and data)
- Application (and services)
- Technology

3.5.1.1 Architecture Drivers/Forces

The driver layer consists of internal and external forces that impact the business and business strategies. Drivers include forces from key stakeholders such as customers, external organizations, other industries (for example, the financial payments industry), government policies and regulations, as well as industry standards and practices. These policies, expectations, rules, and specifications impact how organizations set up their resources, implement processes, make decisions, deploy applications, and renew technologies.

Forces interact in a "feedback cycle" relationship. For the transportation industry, consumer and stakeholder service expectations shape payment solutions (e.g., consumer expectations, government entities, legislation and funding sources). Public agencies (and private transportation organizations) act to create policies,

service delivery organizations, and management processes to meet consumer expectations, often borrowing from other industries for reusable components and services. The need for efficiency drives use of technology tools to automate payment solutions, including use of standard reusable, repeatable components as building blocks. Once automated or improved systems and processes are realized, normal cost and technology constraints modify what is possible and what government or consumers expect. For example, an organization's technology investments evolve when a driver or force changes, such as when a smart card, credit card, or mobile phone are commonly used by consumers and create the expectation of usability for the transportation service.

3.5.1.2 Business Architecture

The business architecture describes the organization of the business including details on business processes, work flows, and organizational roles and responsibilities. It describes the "who, what, where, why, when, how, and how often" related to business process services, operations and planning. From the perspective of the transit operator, the business layer describes what the task flow is and how the work is accomplished from end to end. For example, managing bus stops spans several transit business processes, each of which are supported by different organizational units, as shown in Figure 2.

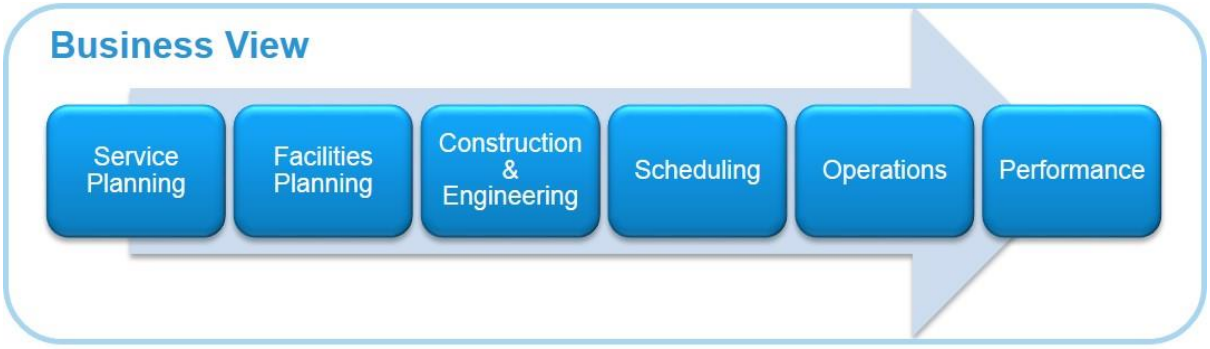

Figure 2: EA Business View – Bus Stop Management Example

The business architecture helps project developers understand the business, identify stakeholders, find dependencies, and generally expedite the information-gathering tasks needed to develop requirements.

3.5.1.3 Data or Information Architecture

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 and information on data integration needed by the organization. The data architecture answers the questions of who, what, where, why, when, how and how often the data is managed. A data architecture can help a transit service provider minimize project delays due to missing or misunderstood data, such as when fare policy updates are delayed because accurate bus stop data is not available. The transit open payment system is a data-driven system. For that reason, enterprise data is a critical element of deploying successful and ongoing deployments. Following the bus stop example, the data view provides visibility on who collects, validates, owns, edits and uses data sets to data managers as shown in Figure 3.

3.5.1.4 Application (Services) Architecture

The application architecture, which contains application programming interfaces (API) or services, describes the organization's technology services and applications, such as web services, account management, customer information, asset management, and financial systems. The application architecture contains information about application flows and information delivery among subsystems, application versions, and

restrictions on use. It helps identify functional integration opportunities and problems, system dependencies, gaps in functional coverage and the status of systems. The application architecture helps to ensure that the development and enhancement of applications align with the business strategies of the organization. This layer includes enterprise and local APIs, message layers, orchestration and dialogue patterns. The application view provides visibility into how many applications are used by a business area, or how many business areas use a particular service or application. For example, the application view would provide visibility into the number of downstream processes, applications and data stores that consume bus stop data from the General Transit Feed Specification (GTFS). The impact of any change to the interface may then be tracked and analyzed by the downstream user.

3.5.1.5 Technology Architecture

In a TOPS, the technology architecture consists of hardware – servers, modems, routers, communications networks, workstations, mobile devices, payment readers and other physical devices – and their system software. For transit operators that also support technology on rolling stock, the technology view also includes all vehicles and on-board subsystems. Many commercial vendors publish reference architectures using their technology and/or applications. Examples include server configurations for highly available systems, or networks for on-board systems. These reference architectures are typically associated with the technology layer only (for example, high availability data center, network security, cloud computing, and virtual machine architectures). These architectures change as vendor offerings change and do not need to be covered in detail in the TOPS reference architecture. For example, systems that use equipment installed in the field may soon migrate to customer handheld payment technologies or sensors that detect customer held payment instruments. Emerging models using passive detection sensors are not yet well described. Yet, these emerging technologies are critical to include in the reference architecture to ensure that the migration path to the next generation processes are covered by the architecture.

Figure 3: EA Information View – Bus Stop Example

3.5.2 A Metamodel for the Transit Open Payment System

The TOPS reference architecture is a framework for the business, information, application, technology and system drivers for an open payment system and its connections to internal and external organizations, such as the financial payment industry. System models include descriptions of language, relationships and processes that form the model, or a "metamodel." A metamodel is similar to a data model, although instead of entities, the boxes depict classes of elements, and the lines between boxes show the relationships and dependencies between elements within a layer and between layers.

For the TOPS reference architecture, the metamodel organizes the content. Content may be hierarchical; for example, an organization has directorates which in turn include departments. The model may relate tuples (like a database); for example, an application may be part of an application family (e.g., human resource, financial management, and general ledger belong to a single vendor solution).

The information in the model is a starting point for agencies, account managers, aggregators, vendors, device manufacturers, and system integrators to tailor their services and systems for faster and more consistent planning, design and deployment, particularly as more stakeholders and players enter the market.

4 Description of a Public Transport Metamodel

There are several ways to describe a metamodel. The Transportation Research Board Transit Enterprise Architecture and Process (TRB TEAP) provides a high level metamodel (see Figure 4) and templates to represent each object in the model. The templates allow developers to insert a canonical ontology that describes each view of the architecture, in this case driver, business, information, applications, and technology. Each template is a spreadsheet that contains attributes that describe important characteristics of the object as well as the connection between the object and a related object (for example, a business process that is performed by one or more departments).

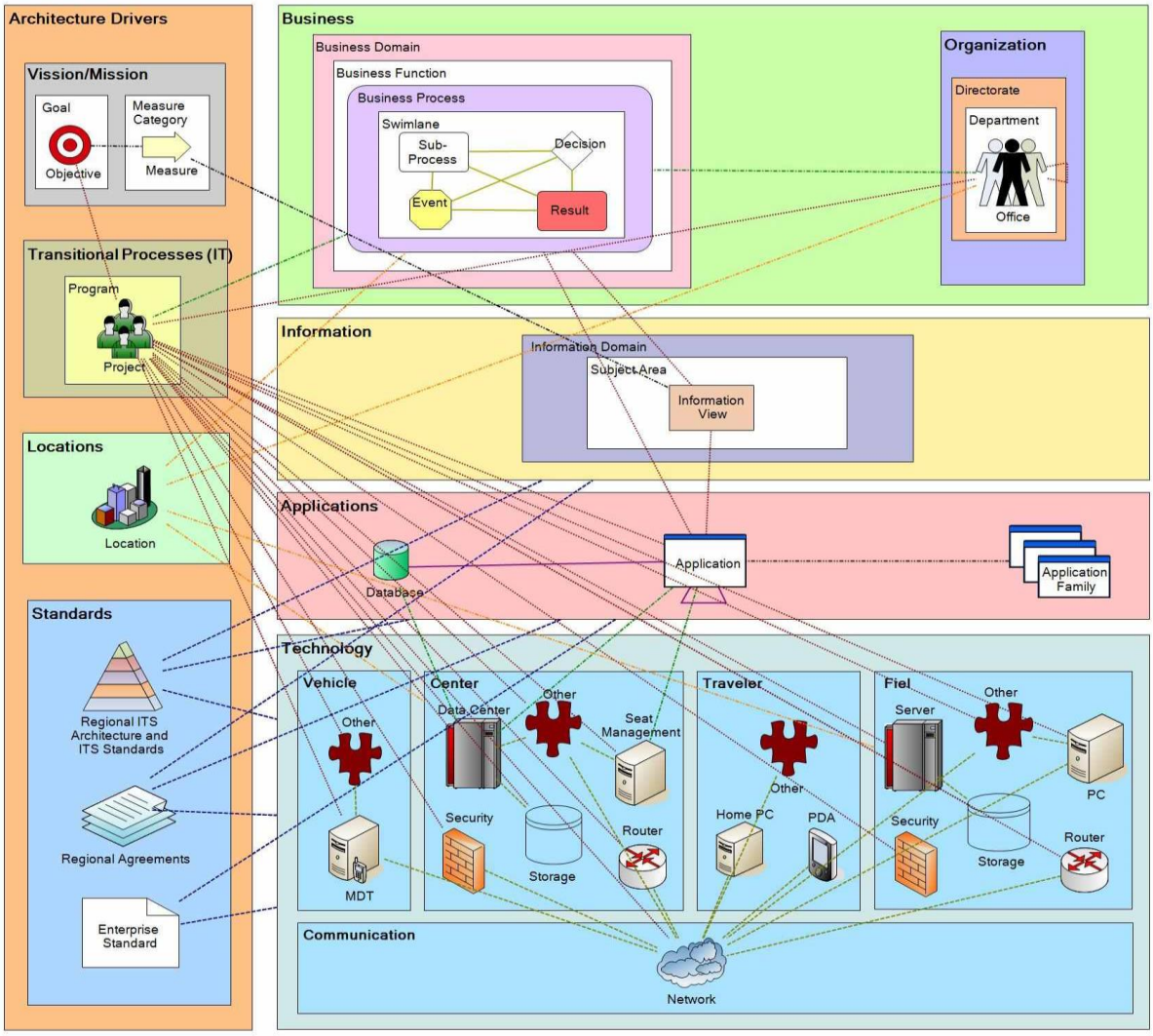

Figure 4: The *TRB TEAP* Reference Architecture Metamodel (An Example of a Metamodel)

In order to show the relationship between the business process and organization, the template that describes the business process will include roles and responsibilities of each department with respect to the activities of the process. This information can be inserted directly into the business plan and systems engineering concept of operations documents.

The TOPS, as discussed by the Smart Card Alliance Transportation Council working group, identified a different set of categories from the TRP TEAP model. The definition of these categories are still a work in progress. The content for each layer is attached in the white paper appendices. The metadata categories are described in the sections that follow.

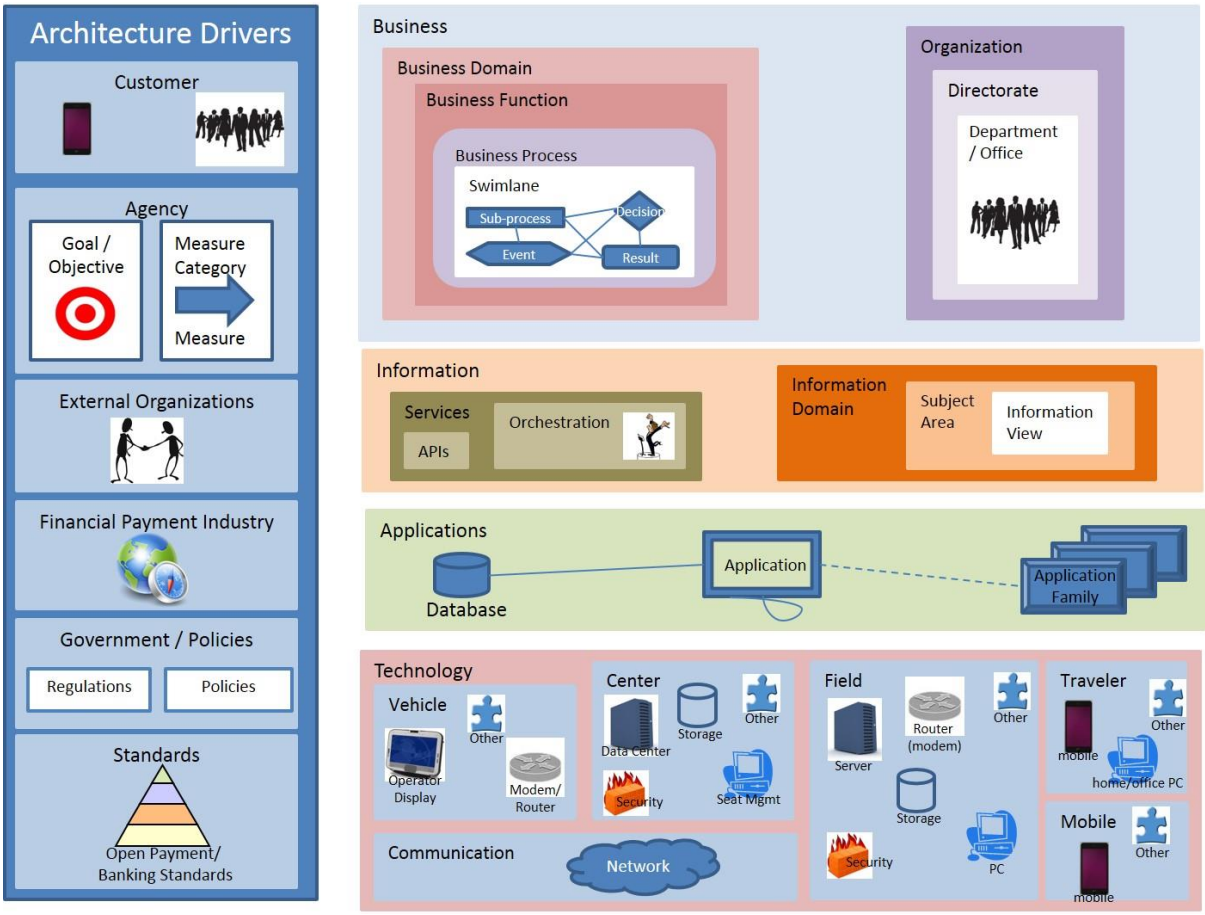

Figure 5: Smart Card Alliance Transportation Council Transit Open Payment System Reference Architecture Metamodel

4.1 Architecture Driver Layer Definitions

Architecture drivers are internal and external forces that impact the business and services provided by an organization. In transit open payments, several types of drivers impact agencies. The high level drivers, as shown in Section 4.1, Appendix A-1: Architecture Driver Layer, Figure 6, are the following:

Customer: The customer driver supports customer needs, rights and market forces related to the transit open payment system.

Agency: The agency driver supports agency needs, policies, business rules, and financial constraints to meet its goals and objectives.

External Organization: The external organization driver supports agency partners' needs, rules and agreements.

Financial Payment Industry: The financial payment industry driver supports the financial payment industry's needs and rules.

Government/Policies: The government and policy driver supports government (federal, state, regional, and local) rules, regulations and policies.

Standards: The standards driver supports industry-promulgated standards, specifications and best practices.

4.2 Business Layer Category Definitions

The business layer models the organization and organizational units and business processes. The business processes and roles and responsibilities of the people who perform the processes drive what information is needed, how the applications should work, and what the performance needs are for the procured technologies. The categories for modelling the business processes and organization are described below. Details are discussed in Section 4.2, Appendix A-2: Business Process Layer (DRAFT).

Business Domain: A business domain is a group of functions, roles and actors grouped together to provide services (processes).

Business Function: A business function is a high level description of activities and services performed by the organization's personnel to meet corporate objectives and business processes.

Business Process: A business process is a general description of activities performed by one or more actors and is grouped by function.

Swimlane: A swimlane is a detailed description of a specific activity that is part of a process. The swimlane is a named activity that is typically associated with a work, information or control flow diagram. The swimlane may be one in a series of activities that compose a process. The swimlane is a container that represents a role that carries out sub-processes. Swimlanes may represent departments or other stakeholders that have responsibilities within business processes. The swimlane contains the elements of a flow chart, including:

Event: An event is a discrete occurrence that results in the execution of a business process or sub-process.

Sub-process: A sub-process is a fine-grained unit of work that is carried out by the organization. Sub-processes are connected to sequence flows to show the steps in which a business process is carried out.

Decision: A decision is a point in a business workflow in which a stakeholder needs to make a choice between two or more courses of action. A decision will usually lead to different sub-processes or results depending on the choice that is made.

Result: A result is the discrete state that comes about after a business process or sub-process has been completed.

Organization: An organization represents the structure of the corporate personnel.

Directorate: A directorate is the highest level 'people' concept and represents an executive management group within the organization.

Department: A department is the second level 'people' concept and represents a group that oversees many business functions within the organization. Each department reports to a directorate.

Office: An office is the third level 'people' concept and represents a group that oversees certain functions or processes within the department to which it belongs.

4.3 Information Layer Category Definitions

The information layer consists of the data categories and sets needed to support the business processes and architectural drivers such as performance measures. The information layer categories are defined below and the details are presented in Section 8.3, Appendix A-3: Information Layer (DRAFT).

Information Domain: The information domain categorizes corporate information into functional areas.

Subject Area: The subject area groups enterprise information into similar business areas.

Information View: An information view identifies information related to a general data concept (or data set) category.

Services: A service is a set of remote calls to access data through exposed entity models, schemas, or procedures.

Orchestration: Orchestration is the arrangement, coordination and management of implementing services to access data through APIs.

Application Programming Interface (API): An API is a routine, protocol or schema that models and specifies (using data structures or object classes) information for exchange. "The API expresses a software component in terms of its operations, inputs, outputs, and underlying types."[2]

4.4 Application Layer Category Definitions

The application layer in an enterprise architecture includes the names of each application. The reference architecture models archetypes or typical applications and application families. Application families are groups of applications related due to a similar vendor. Definitions for the model categories are shown below. Details of the application categories are presented in Section 8.4, Appendix A-4: Application Layer (DRAFT).

Application Family: An application family is a software product line that is interoperable. For example, a commercial vendor may have several modules that include enterprise resource, human resource, inventory, financial and other management applications.

Application: An application is a tool to permit a user to perform a group of coordinated functions, tasks, or activities.[3]

Database: A database is an organized collection of data stored in an application where a user may interact (e.g., create, edit, view, delete, query) with the data sometimes through standards (e.g., SQL).

4.5 Technology Layer Category Definitions

The technology layer definitions conform to the National Intelligent Transportation Systems (ITS) architecture classes. The definitions are taken from the ITS architecture.[4] Similar to the application layer model elements,

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[2] Wikipedia, "Application programming interface," extracted Aug. 31, 2015.

[3] Wikipedia, "application software," extracted 22 July 2015

[4] http://www.iteris.com/itsarch/html/archlayers/transportationlayer.htm

these are typically identified as archetypes. The definitions of these archetypes are included below with the details presented in Section 8.5, Appendix A-5: Technology Layer (DRAFT).

Center: Centers provide management, administration, and support functions for the transportation system. The centers communicate with other centers to enable coordination between modes and across jurisdictions within a region. The centers also communicate with field and vehicle classes to gather information and provide information and control that are coordinated by the centers.

Field: Entities in the field class provide the direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit. They support direct surveillance, information provision, and control plan execution in the surface transportation system. All field subsystems interface to one or more of the center subsystems that govern overall operation of the field subsystems. The field subsystems also generally include direct user interfaces to drivers and transit users and short-range interfaces to the vehicle subsystems to support operations.

The types of field artifacts include:

- Mobile data terminal
- Data center
- Security appliance
- Storage
- Router
- Seat management
- Personal Data Assistant
- Home personal computer
- Server
- Network
- Other

Vehicle: Vehicles are entities that are all vehicle-based and share many general driver information, vehicle navigation, and advanced safety systems functions. The vehicle subsystems communicate with the field subsystems and center subsystems for provision of information to the driver.

Traveler: Traveler entities include the equipment that is typically owned and operated by the traveler. While this equipment is often general purpose in nature and used for a variety of tasks, it is specifically used for gaining access to traveler information within the scope of the ITS architecture. These subsystems interface to the information provider (one of the center subsystems, most commonly the information service provider subsystem) to access the traveler information. A range of service options and levels of equipment sophistication are considered and supported. Specific equipment included in this class include personal computers, smart phones, tablets, and any other communications-capable consumer products that can be used to supply information to the traveler.

Communication: The communications class includes all of the communications equipment (e.g., wireline and wireless transmitters and receivers) and the information management and transport capabilities necessary to transfer information among entities in the transportation layer. The application data content and the transportation application requirements are generally transparent to the communications layer. The communication layer's view of ITS is that of many distributed users, some of them mobile, which require communication services.

Additionally, in this reference model, mobile devices are classified as an entity or artifact in the layer due to their growing importance and flexibility in providing functional convergence regardless of location in the vehicle, field or center. Classes of mobile devices include nomadic devices with different form factors such as hardened laptops, pads and mobile phones or personal devices.

5 Industry Next Steps

The TOPS reference architecture is a launching point for different stakeholder groups to benefit from the framework. The greatest benefit from an architecture and framework is to reduce ambiguity in defining the terms, components, interactions, connections and more. However, the architecture is also a starting point for developing standards and reusable components to accelerate deployment, reduce complexity, decrease costs and create a better fit for the organizations that use the system. The Smart Card Alliance Transportation Council working group has identified the following next steps for moving the architecture forward.

Identify high priority areas that require further refinement. Define a cross-layer solution to extend the understanding about how to deploy a design element. The design element may include components from multiple layers such as processes, organization roles/responsibilities, data, and drivers (e.g., performance metrics). For example, fare policy—distance, zone, flat fares—will drive customer processes (e.g., tap on entrance, tap on exit, or tap on entrance and exit), performance metrics, transaction processing applications, and the equipment deployed at entrances/exits to service. These designs reduce the overall cost so that system integrators have reusable components across multiple deployments and bank card issuers need only implement a standard approach to implement multiple customers. Section 3.5.1 includes an example of a business process and the data and its transformation associated with each process. These types of detailed treatments help to identify not only the technology, but also how the technology supports the business processes.

Form or join standard development groups to identify and develop open standards. As an abstract entity, a framework provides a conceptual view of the whole system. It might provide design patterns and migration paths for understanding how the layers and components are put together, but it only extends the model and design so far. Interoperability comes from using the model to specify process, data and technology standards among the architectural components. Areas that may be of high priority include:

- Technical standards
  - Customer account information exchange
  - Fare/fee tables and product catalogs
- Data and process standards
  - Common performance measures and data gathering techniques about payment/product usage (that can be used for comparison across transit agencies, regions, and modes)
  - Customer discount and promotional agent policies across service operators

6 Publication Acknowledgements

This white paper was developed by the Smart Card Alliance Transportation Council to support developers, integrators, procurers, and users of open payment systems for transit and transportation services with a framework for specifying, developing, integrating and managing the lifecycle and evolution of these systems.

Publication of this document by the Smart Card Alliance does not imply the endorsement of any of the member organizations of the Alliance.

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Trademark Notice

About the Smart Card Alliance Transportation Council

The Transportation Council is one of several Smart Card Alliance Technology and Industry Councils, focused groups within the overall structure of the Alliance. These councils have been created to foster increased industry collaboration within a specified industry or market segment and produce tangible results, speeding smart card adoption and industry growth.

The Transportation Council is focused on promoting the adoption of interoperable contactless smart card payment systems for transit and other transportation services. The Council is engaged in projects that support applications of smart card use. The overall goal of the Transportation Council is to help accelerate the deployment of standards-based smart card payment programs within the transportation industry.

The Transportation Council includes participants from across the smart card and transportation industry and is managed by a steering committee that includes a broad spectrum of industry leaders.

Transportation Council participation is open to any Smart Card Alliance member who wishes to contribute to the Council projects. Additional information about the Transportation Council can be found at http://www.smartcardalliance.org/about_alliance/councils_tc.cfm.

7 References

[TEAP] Okunieff, Paula, et al, “TCRP Report 84, e-Transit: Electronic business strategies for public transportation Volume 9. Transit Enterprise Architecture and Planning Framework”. Transportation Research Board, Transit Cooperative Research Program, Washington, DC, 2001. PP. 139.

8 Appendix A: TOPS Reference Architecture Layer Definitions

8.1 Appendix A-1: Architecture Driver Layer

The reference architecture driver layer was developed and reviewed using an industry review process. The driver categories and forces descriptions are shown in Figure 6 and the list of descriptions are detailed in Table 1.

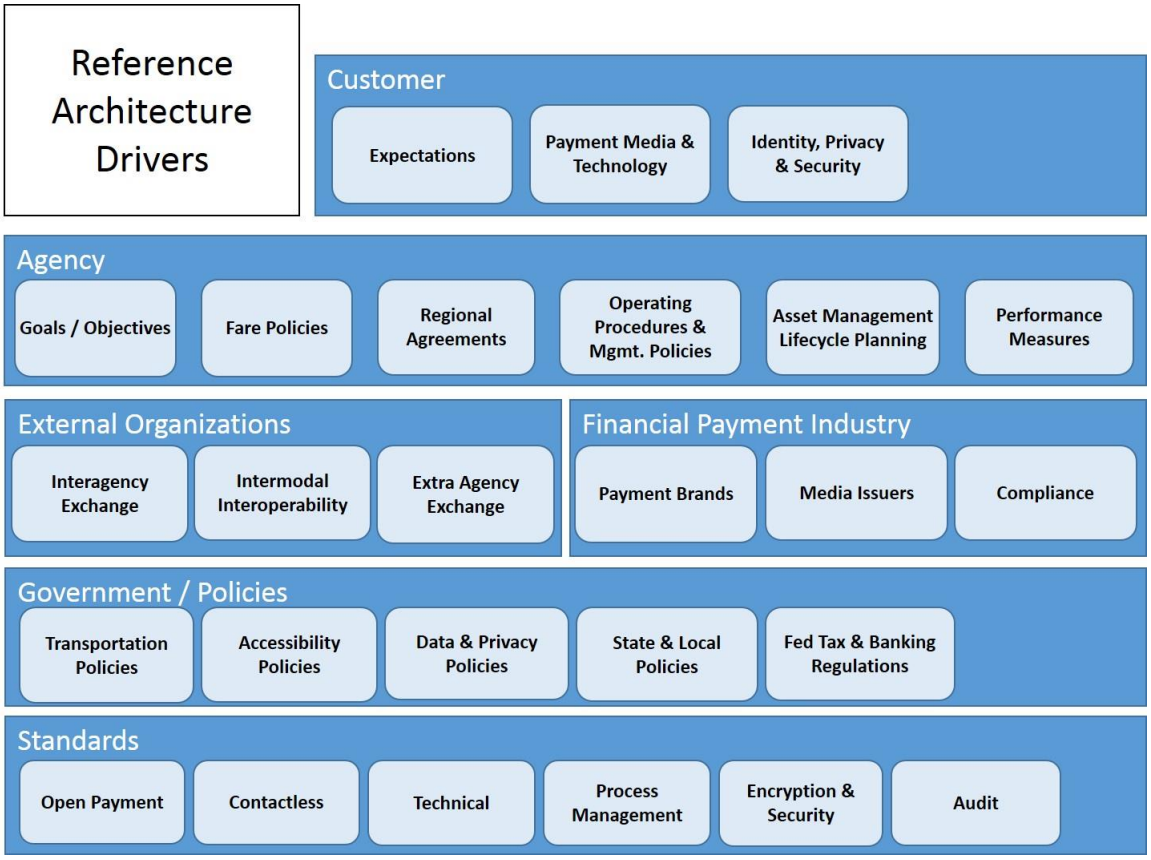


Figure 6: TOPS Reference Architecture Driver and Forces Model

Table 1. TOPS Reference Architecture Driver/Force Layer Descriptions

Driver Domain	Force Name	Force Description
Customer	Expectations	Payment service expectations represent consumer transportation payment service expectations, such as: convenience, privacy, safety, seamlessness across travel modes, reliability, and low risk. Service expectations originate with the "habits" and expectations formed by prior payment solutions, but also evolve with technology and social change. Government legislation, new payment technologies, and new transit services can influence consumer transit payment expectations

Driver Domain	Force Name	Force Description
		(e.g., Internet use, mobile payments, private shared rides). Expectations are usually quantified as preferences via surveys and consumer analysis.
Customer	Payment Media and Technology	Payment media and technology represent the generally accepted payment methods for general social commerce (e.g., goods/services exchange) specific to transit fare payments. Common payment media include paper cash and coin, paper checks, electronic checks or ACH payments, credit/debit cards, mobile payments, web-based payment services (e.g., PayPal), and transit proprietary card types (e.g., paper tickets, magnetic stripe cards, contactless cards). Some payment forms may carry a legal or contractually binding requirement for acceptance. Acceptable transit payment methods are influenced by government regulations (e.g., Title IV) and banking forces which may limit the ability to refuse some payment forms. Transit agencies often establish a method to exchange general payment media for a transit-specific payment media, such as a "ticket." Open payments initiatives may seek to eliminate this step by accepting general consumer payment media directly for service at the time of use. The force includes both what the media is and how a consumer may acquire and/or register the payment media.
Customer	Identity, Privacy and Security	Payment identity, privacy and security expectations represent consumer protections necessary for fare payment solutions risk management. Consumers demand risk prevention and detection when payment methods include personally identifiable information, financial account information, or reoccurring service patterns unique to an individual in order to prevent misuse by unauthorized parties. The protection expectations may also include physical evidence of travel patterns (e.g., video) and represent a significant force for the design of transit fare payment solutions.
Agency	Goals and Objectives	Agency goals and objectives establish transit agency priority guidelines that inform asset allocation and service design decisions for fare payment in context with other competing interests. Fare payment specific design decisions that are influenced by agency goals include: service areas covered, reliability targets, security needs, usage or growth expectations, congestion impacts, patron service level needs or satisfaction targets, labor agreement and worker satisfaction requirements, accessibility needs, cost targets, diversity requirements for contracts, and preferred local service providers. The goals are important inputs to fare collection system design as integration of fare payment data with other systems is a key factor for measurement or implementation of goal achievement.
Agency	Fare Policies	Fare policies document ride tariffs, pass prices, discounts, transfer rules and other "ticket price" related transit system access financial decisions. Typically fare policies are set by the service provider and authorized by their governing body (e.g., elected Board of Directors).

Driver Domain	Force Name	Force Description
		Board approval, federal funding requirements, and state and local laws may impact these policies. The complexity of rules required to calculate the appropriate fare based on patron information, location, time and other factors is an important influence on transit system design. Policies are often implemented as business rules in a rules-based engine of some form.
Agency	Regional Agreements	Regional agreements document the goals and methods by which transit agency governing bodies agree to work together in a specific written form, usually based on the guidance of an over-arching authority, such as a state legislature. The agreements describe the specific requirements, terms and conditions by which interoperability among agencies can be achieved, including compensation for services and other agreements. For example, each of the agency participants in the nine-county region served by the Metropolitan Transportation Commission (MTC) Clipper program sign a memorandum of understanding (MOU) and operating agreement which specifies cost and revenue sharing terms. Agencies also execute transfer agreements in a bilateral form. In essence, regional agreements are contracts that specify how the agencies will operate and exchange revenue for transit in their area, including fare payment collection responsibilities. These agreements usually influence fare payment systems by specifying participation and cost sharing requirements.
Agency	Operating Procedures and Management Policies	Operating procedures and management policies document key business processes necessary to perform fare payment collection work. Procedure and policy documents help to specify the work required to deliver standard services by which fare collection systems are deployed, managed, maintained, operated, and changed. Procedures and policies typically specify either automated or manual steps necessary to perform work, but also may include risk management and asset refresh practices meant to prevent problems. These are often developed during the fare payment system design phase in the form of a design document, by customer service, technology or financial management function.
Agency	Asset Management Lifecycle Planning	Physical technology asset health requirements are managed and tracked specific to the underlying physical assets of a transit fare payment system. For example, transit access control equipment, such as a fare gates, may require compliance with safety, accessibility, operating performance, and other public needs. The compliance requirements may be specified by interpretation of governing law or by the underlying management model for the assets necessary to sustain policy compliant performance. These may also include data privacy and security requirements for protecting/encrypting account information.

Driver Domain	Force Name	Force Description
External Organizations	Interagency Exchange	Interagency exchange are agreement mechanisms by which data, services, revenue and account data (patron and agency) can be shared in context of the delivery of an integrated multi-transit agency provider service. Examples can include: 1) peer-to-peer account information exchange agreements, which specify tariff and revenue sharing terms and conditions between two parties; 2) regional shared service agreements, which define a shared services model for fare payment among multiple operators; and 3) multi-party standard agreements which specify terms for an "open service" which establishes formats for data exchange, liability and service responsibilities in context of a shared open market, exchange or cooperative joint venture (with standard terms of commerce for the participating transit provider community). (Account to Account).
External Organizations	Intermodal Interoperability	To enable intermodal interoperability, collective organizations are formed to facilitate an effective response to consumer demands for seamless travel experiences by defining information sharing mechanisms, security requirements and other standards designed to facilitate seamless travel. Intermodal interoperability focused forces tend to work through cooperative organizations that encourage both local and regional standard setting to allow multi-mode travel using a single or integrated fare payment mechanism. At the simplest form, organizations may post data in a common format or use shared patron identification models.
External Organizations	Extra Agency Exchange	An "extra agency" is a third party that consumes data from the enterprise to aggregate or combine the data with other data (e.g., from another enterprise or added value) to support customers or provide added value services to customers. These services could include multimodal trip planners, discount brokers, reservation services, or coupons/discounts/frequent user services. The exchange is characterized as a business-to-business exchange and requires an agreement between the enterprise and third party.
Financial Payment Industry	Payment Brands	Traditionally, payment brands are companies that set transaction terms for merchants, card-issuing banks, and acquiring banks. These “payment brands” have developed the global systems that manage the mechanics of electronic transactions. These brands are now developing new technologies that work in the digital space to help keep mobile payments secure and advance electronic payments globally.
Financial Payment Industry	Media Issuers	Media issuers include banks, merchants and mobile providers. Retail banking is the provision of services by a bank to individual consumers, rather than to companies, corporations or other banks. Services offered typically include savings and checking accounts, mortgages, personal loans, debit cards, and credit cards. The term is generally used to distinguish these banking services from investment banking, commercial banking or wholesale banking. Additionally,

Driver Domain	Force Name	Force Description
		credit unions are an alternative to traditional banks. A credit union is a member-owned financial cooperative, controlled by its members. It is typically operated for the purpose of promoting savings, providing credit at competitive rates, and providing other financial services, many times similar to products that a retail bank offers like checking accounts and loans, to its members. A merchant is a business which offers products or services for sale. They may also offer private label credit cards which can only be used in their establishments or discount or loyalty programs to their customers. A mobile provider is a carrier whose services are used to securely store payment media offered by one or more of the payment networks or a self-branded media.
Financial Payment Industry	Compliance	Compliance includes adherence to rules and protocols issued and adopted by certifying organizations. With respect to the open payments space, compliance may require audit and certification processes from several specifications/associations including: payment card industry, International Financial Reporting Standards (IFRS), and SEC audit firms. The Payment Card Industry Data Security Standard (PCI DSS) is the security standard issued by the Payment Card Industry Security Standards Council (PCI SSC). PCI DSS is the global data security standard that any business of any size must adhere to in order to accept payment cards, and to store, process, and/or transmit cardholder data. The standard provides an actionable framework for developing a robust payment card data security process – which includes prevention, detection and appropriate reaction to security incidents. International Financial Reporting Standards (IFRS) are designed as a common global “language” for business dealings so that company accounts are understandable and comparable across international boundaries.
Government / Policies	Transportation Policies	Transportation industry policies and procedures respond to Federal, state or local government policies and regulations that drive implementation rules and funding allocations. For example, Title VI of the Civil Rights Act requires transit agencies to "provide meaningful language access to persons who are limited English proficient".
Government / Policies	Accessibility Policies	Accessibility policies and procedures respond to the provisions of the Americans with Disability Act (ADA).
Government / Policies	Data and Privacy Policies	Data and privacy policies and procedures respond to Federal policies and regulations governing consumer privacy (e.g., the Health Insurance Portability and Accountability Act [HIPAA]) and other data security provisions. It also includes compliance with Department of Homeland Security rules for personal privacy.

Driver Domain	Force Name	Force Description
Government / Policies	State and Local Policies	State and local regulation or policies can require adaptations that differ from industry standards. Examples may include labor, technology, or consumer related requirements (e.g., wages, work rules, consumer information privacy protections, prohibited materials, vehicle emission requirements, technology origin requirements, acceptance of local script/benefit programs).
Government / Policies	Federal Tax and Banking Regulations	There are many Federal tax and banking regulations that drive open payment including, fraud and anti-money laundering (AML) rules. Money laundering is the process of making illegally-gained proceeds (i.e., "dirty money") appear legal (i.e., "clean"). It typically takes a number of steps to “clean” the money and add it into the legitimate financial system. There have been eight major AML pieces of legislation that have been passed since the initial Bank Secrecy Act of 1970. They include the Money Laundering Control Act (1986); Anti-Drug Abuse Act of 1988; Annunzio-Wylie Anti-Money Laundering Act (1992); Money Laundering Suppression Act (1994); Money Laundering and Financial Crimes Strategy Act (1998); Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act of 2001 (USA PATRIOT Act); and, most recently, the Intelligence Reform and Terrorism Prevention Act of 2004.
Standards	Open Payment	Open payment standards and protocols support and facilitate interoperation of payment equipment and end-to-end payment processes. Standards tend to come in sets of dialogs and protocol stacks. These typically are promulgated by industry associations and consortia like EMVCo. EMVCo is a consortium which manages the evolving EMV® payment specifications and related testing processes (e.g., EMVCo Level 1 and Level 2 testing). This includes, but is not limited to, card and terminal evaluation, security evaluation, and management of interoperability issues. EMV stands for Europay, MasterCard, and Visa, the three companies which originally created the technical standard for smart payment cards which store data on an embedded chip rather than on a magnetic stripe. EMVCo has six member organizations—American Express, Discover, JCB, MasterCard, UnionPay, and Visa—and is supported by dozens of banks, merchants, processors, vendors and other industry stakeholders who participate as EMVCo Associates.
Standards	Contactless	Contactless standards and protocols are used for contactless cards, devices and readers. Different payment networks provide certification kits for testing the various components related to contactless technologies. Standards for smart cards are based on ISO/IEC 7810 (physical characteristics, size, resistance to environmental factors), ISO/IEC 7816 (ID cards with an embedded chip, power, clock and serial data), and ISO/IEC 14443 contactless integrated circuit cards. EMVCo is developing standards and testing processes for contactless EMV cards. The NFC Forum is promulgating contactless protocols and

Driver Domain	Force Name	Force Description
		standards for wearable and mobile form factors including NFC Level 1 and 2 RF Interoperability Test Service. Additionally, each payment network promulgates their own contactless validation testing/compliance rules, such as Visa Contactless Payment Specification (VCPS); MasterCard Terminal Integration Process (M-TIP) Formal Approval - Contact and Contactless Validation.
Standards	Technical	Technical standards not related to contactless media include banking standards, transit standards, industry specifications (like E-ZPass), among others. In banking, the most prominent standard is ISO/IEC 8583 Financial transaction card originated messages -- Interchange message specification. Transit standards include the General Transit Field Specification (GTFS) that includes schedule, stop and fare zone information. Other industry standards are promulgated from time to time.
Standards	Process Management	Open fare payment services require repeatable business processes to function consistently. By defining process management standards as an industry, the most effective management practices can be identified and aligned for effective/efficient service operations. Process standards may be used to measure performance, document job roles, define measures and objectives, audit compliance against performance or risk management standards, compare one service to another, and perform many other useful roles. Standards are generally built by documenting industry-accepted management principles. Common areas of alignment include: process models (e.g., describe work and information flows, management controls and communications interfaces to other entities); governance models (e.g., describe how decisions are reached and what the structure of decision-making or oversight bodies is); organization models (e.g., define structure, roles, contractual agreements, staff levels, job descriptions), and business performance measures/standards (e.g., define performance expectations for benchmarking). Each functional area may have a set of process standards. For example, the IT Service Management ITIL[5] V3 framework is a common standard for IT management, and the ISACA COBIT standard is a commonly used IT risk management and IT controls auditing framework. Each of these models establishes standards for how systems may be managed and controlled to produce predictable results.
Standards	Encryption and Security	Financial payment systems require secure information management and protection from information loss/corruption. Encryption and IT security frameworks are among their most critical areas of alignment, to allow secure interoperability with components of the open fare

[5] ITIL was formerly an acronym for Information Technology Infrastructure Library. Information on ITIL may be found at www.itil-officialsite.com/.

Driver Domain	Force Name	Force Description
		payment networks. Among the most important standards are the Payment Card Industry Data Security Standard (PCI DSS) and the Triple Data Encryption Standard (3DES). Standards for business continuity are often also addressed within the topic of data and information protection.
Standards	Audit	Financial payment institutions are subject to oversight by government standards for financial accounting. Service providers that are public companies must also conform to regulatory requirements to avoid financial conflicts of interest, improper handling of funds and other risks. The reoccurring financial, system and security audits that have become standard parts of governance processes are key tools to manage risk. Certified audit firms use key audit standards, against which they can produce attestation reports to monitor control over key systems. Financial audits follow accounting standards such as IFRS and GAAP. IT system controls are often audited against the SSAE 16 SOC 2 standard. Standards for IT security assessments, such as penetration testing using automated tools (”pen test”), are also possible areas for industry alignment for cost effectiveness.

8.2 Appendix A-2: Business Process Layer (DRAFT)

The business process layer contains the processes that need to be reviewed and implemented in an enterprise that deploys a transit open payment system. Many of these processes may already be implemented in an organization prior to the system integration.

These categories and their descriptions will be refined and included in the next version of this white paper.

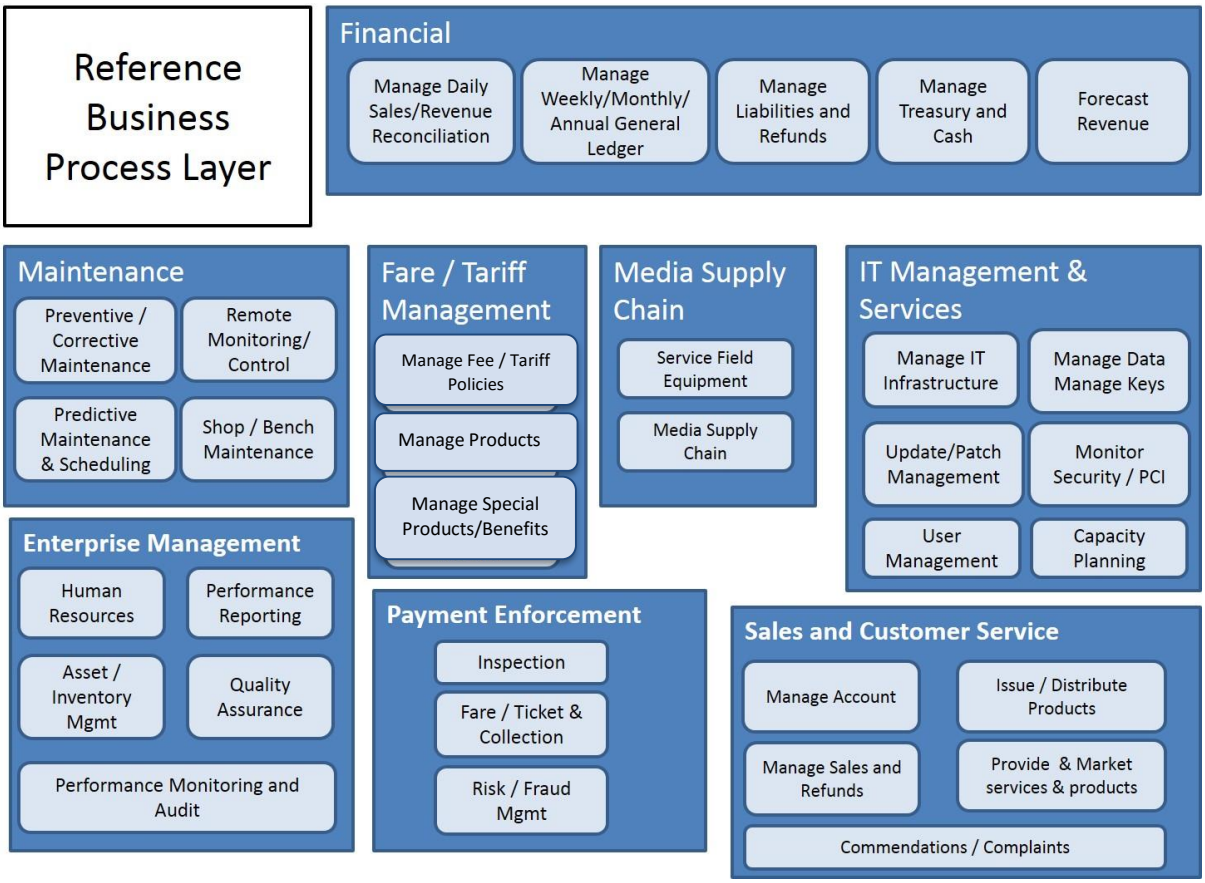
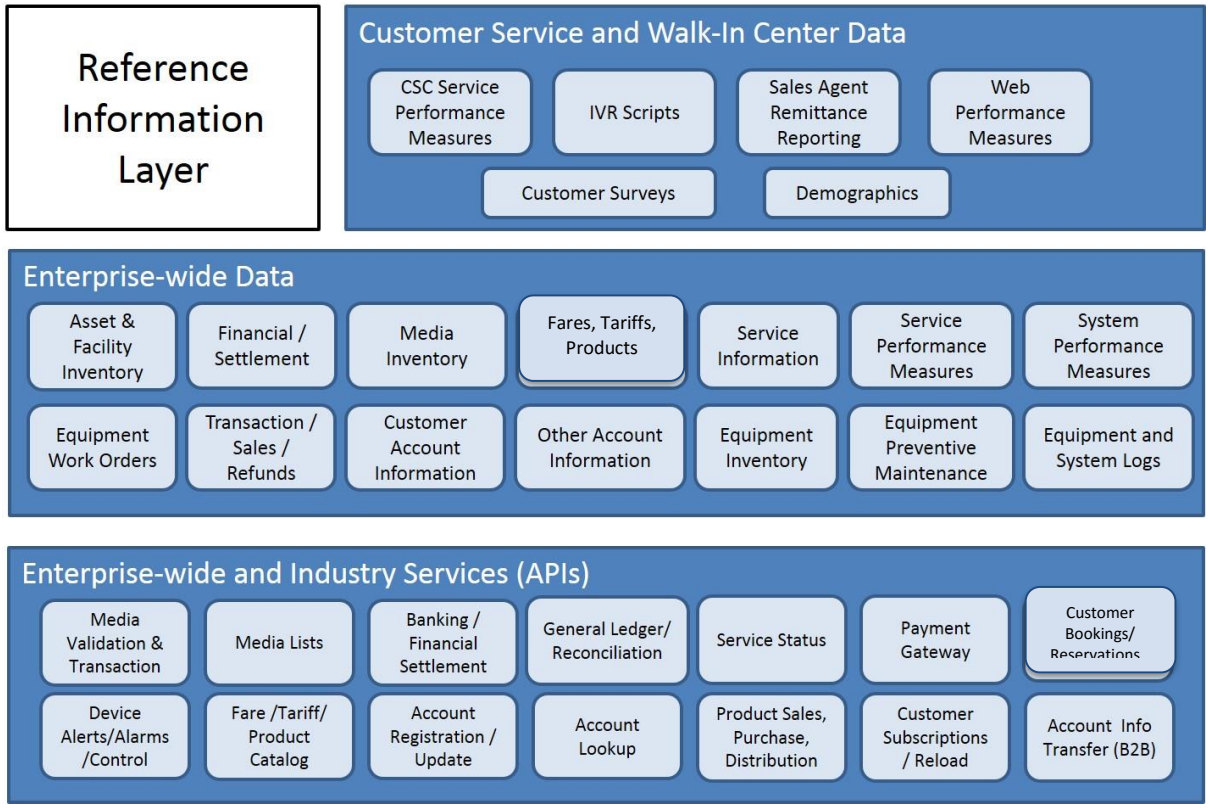


Figure 7: Business Process Layer Model (Draft Version)

8.3 Appendix A-3: Information Layer (DRAFT)

The information layer includes data sets that are created, used or managed by the TOPS. The enterprise metamodel identifies data sets and services (application programming interfaces or APIs) are part of the TOPS reference architecture. In the draft information layer, data sets are distinguished from the services that create, exchange or provide the information.

These categories and their descriptions will be refined and included in the next version of this white paper.



*CSC refers to the customer service center.

Figure 8: Information Layer (Draft Version)

8.4 Appendix A-4: Application Layer (DRAFT)

The application layer includes a solution's actual application software. This template model includes the types of applications that are deployed as part of the TOPS or are used by or interface with open payment processes.

These categories and their descriptions will be refined and included in the next version of this white paper.

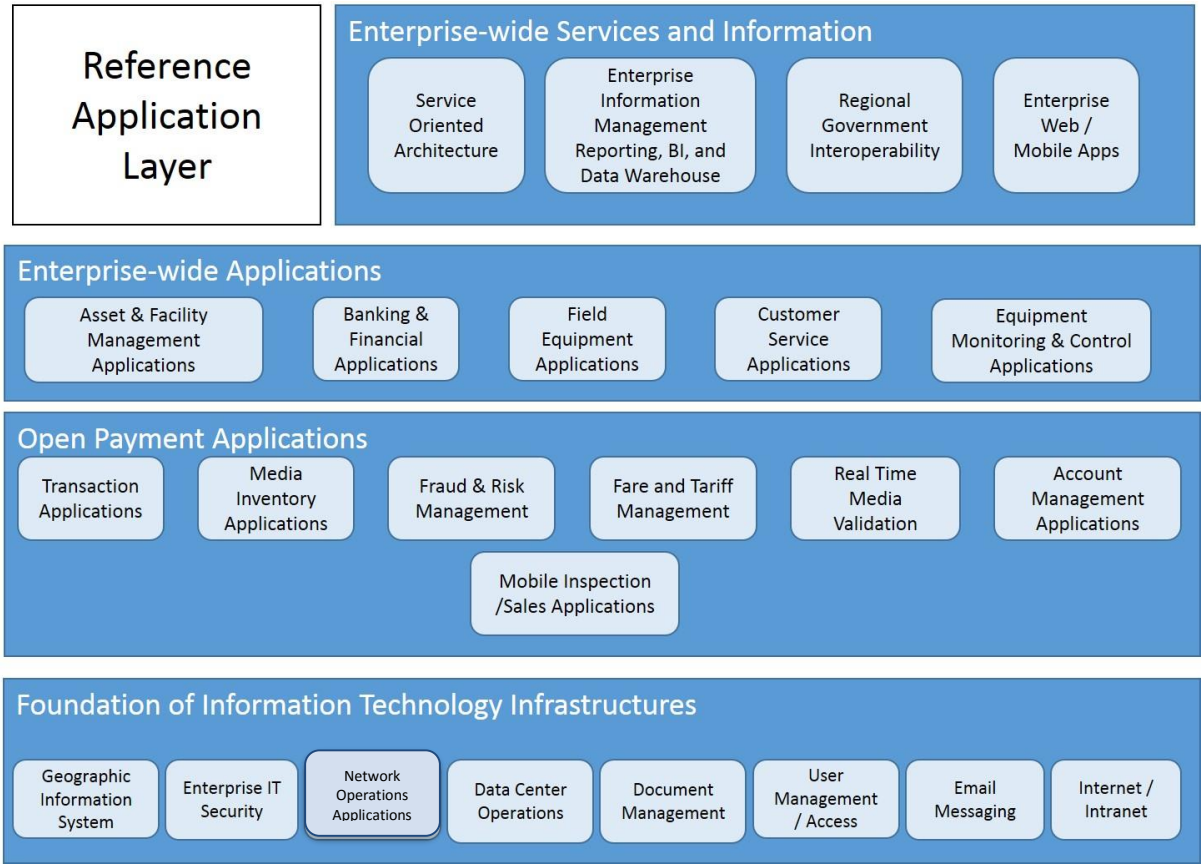


Figure 9: Application (Template) Layer (Draft Version)

8.5 Appendix A-5: Technology Layer (DRAFT)

The technology layer includes the actual equipment that is deployed in a specific TOPS. The template model shown in Figure 10 illustrates the equipment types that are typical in a transit open payment system. Market forces, customer expectations and customer adoption drive shorter technology lifecycles for traveller, mobile, communications and field equipment. To that end, this layer, when used to model deployed technologies, will change in a shorter time horizon.

These categories and their descriptions will be refined and included in the next version of this white paper.

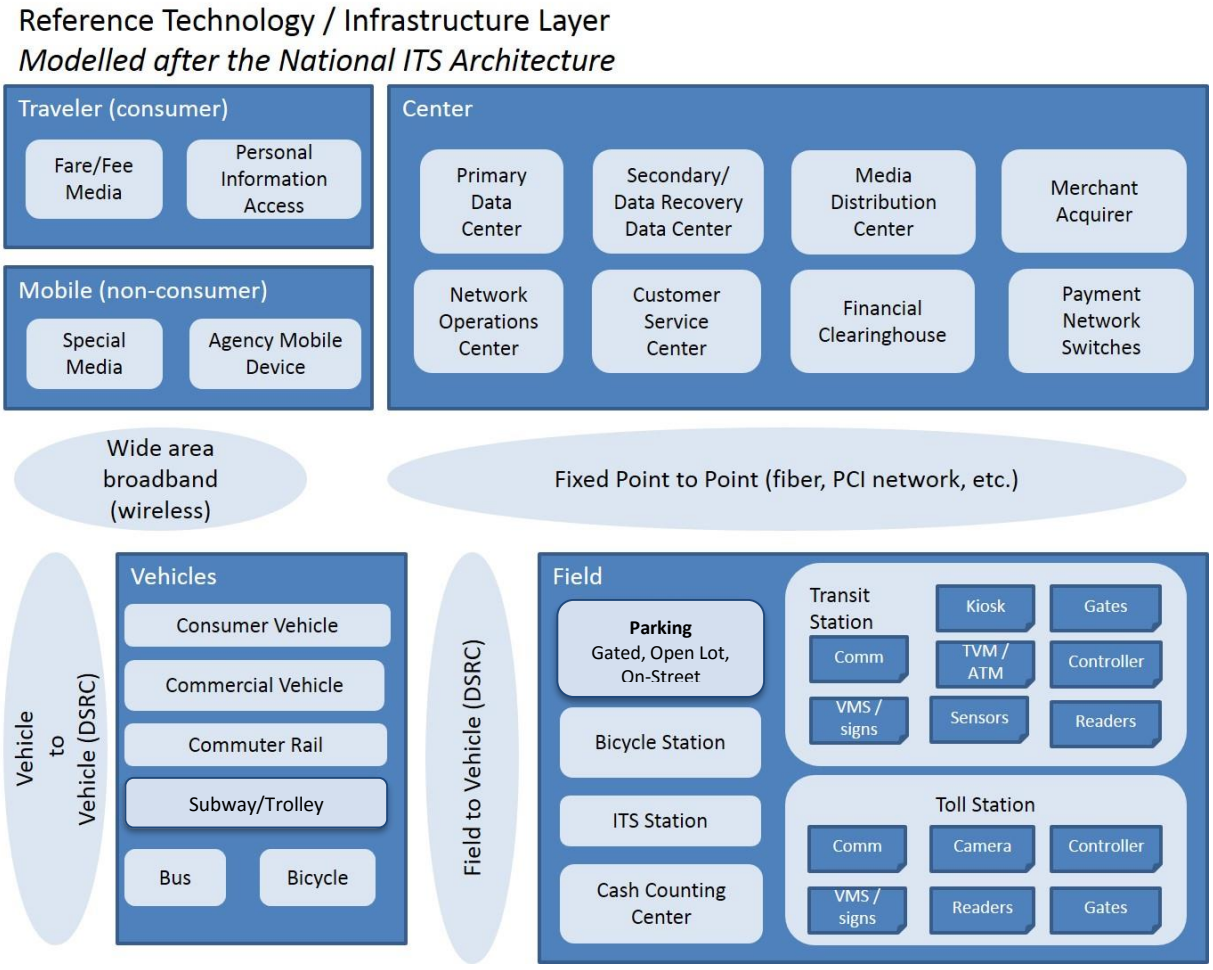


Figure 10: Technology (Template) Layer (Draft Version)

8.6 Appendix A-6: Layer Content Definitions, Relationships and Acronyms

The following tables provide descriptions of the different drivers, forces and layers and their relationships

Table 2. Drivers

Driver Domain	Driver Description
Customer	Supports customer needs, rights and market forces related to the system
Agency	Supports agency needs, policies, business rules, and financial constraints to meet its goals and objectives
External Organizations	Supports agency partners' needs, rules and agreements
Financial Payment Industry	Supports financial payment industry's needs and rules
Government / Policies	Supports government (federal, state, regional and local) rules, regulations and policies
Standards	Supports industry promulgated standards, specifications and best practices

Table 3. Forces

Driver Domain	Force Name	Force Description
Customer	Expectations	Payment service expectations represent consumer transportation payment service expectations, such as: convenience, privacy, safety, seamlessness across travel modes, reliability, and low risk. Service expectations originate with the "habits" and expectations formed by prior payment solutions, but also evolve with technology and social change. Government legislation, new payment technologies, and new transit services can influence consumer transit payment expectations (e.g., Internet use, mobile payments, private shared rides). Expectations are usually quantified as preferences via surveys and consumer analysis.
Customer	Payment Media and Technology	Payment media and technology represent the generally accepted payment methods for general social commerce (e.g., goods/services exchange) specific to transit fare payments. Common payment media include paper cash and coin, paper checks, electronic checks or ACH payments, credit/debit cards, mobile payments, web-based payment services (e.g., PayPal), and transit proprietary card types (e.g., paper tickets, magnetic stripe cards, contactless cards). Some payment forms may carry a legal or contractually binding requirement for acceptance. Acceptable transit payment methods are influenced by government regulations (e.g., Title IV) and banking forces which may limit the ability to refuse some payment forms. Transit agencies often establish a method to exchange general payment media for a transit-specific payment media, such as a "ticket." Open payments initiatives may seek to eliminate this step by accepting general consumer payment media directly for service at the time of use. The force includes both

Driver Domain	Force Name	Force Description
		what the media is and how a consumer may acquire and/or register the payment media.
Customer	Identity, Privacy and Security	Payment identity, privacy and security expectations represent consumer protections necessary for fare payment solutions risk management. Consumers demand risk prevention and detection when payment methods include personally identifiable information, financial account information, or reoccurring service patterns unique to an individual in order to prevent misuse by unauthorized parties. The protection expectations may also include physical evidence of travel patterns (e.g., video) and represent a significant force for the design of transit fare payment solutions.
Agency	Goals and Objectives	Agency goals and objectives establish transit agency priority guidelines that inform asset allocation and service design decisions for fare payment in context with other competing interests. Fare payment specific design decisions that are influenced by agency goals include: service areas covered, reliability targets, security needs, usage or growth expectations, congestion impacts, patron service level needs or satisfaction targets, labor agreement and worker satisfaction requirements, accessibility needs, cost targets, diversity requirements for contracts, and preferred local service providers. The goals are important inputs to fare collection system design as integration of fare payment data with other systems is a key factor for measurement or implementation of goal achievement.
Agency	Fare Policies	Fare policies document ride tariffs, pass prices, discounts, transfer rules and other "ticket price" related transit system access financial decisions. Typically fare policies are set by the service provider and authorized by their governing body (e.g., elected Board of Directors). Board approval, federal funding requirements, and state and local laws may impact these policies. The complexity of rules required to calculate the appropriate fare based on patron information, location, time and other factors is an important influence on transit system design. Policies are often implemented as business rules in a rules-based engine of some form.
Agency	Regional Agreements	Regional agreements document the goals and methods by which transit agency governing bodies agree to work together in a specific written form, usually based on the guidance of an over-arching authority, such as a state legislature. The agreements describe the specific requirements, terms and conditions by which interoperability among agencies can be achieved, including compensation for services and other agreements. For example, each of the agency participants in the nine-county region served by the MTC Clipper program sign a memorandum of understanding (MOU) and operating agreement which specifies cost and revenue sharing terms. Agencies also

Driver Domain	Force Name	Force Description
		execute transfer agreements in a bilateral form. In essence, regional agreements are contracts that specify how the agencies will operate and exchange revenue for transit in their area, including fare payment collection responsibilities. These agreements usually influence fare payment systems by specifying participation and cost sharing requirements.
Agency	Operating Procedures and Management Policies	Operating procedures and management policies document key business processes necessary to perform fare payment collection work. Procedure and policy documents help to specify the work required to deliver standard services by which fare collection systems are deployed, managed, maintained, operated, and changed. Procedures and policies typically specify either automated or manual steps necessary to perform work, but also may include risk management and asset refresh practices meant to prevent problems. These are often developed during the fare payment system design phase in the form of a design document, by customer service, technology or financial management function.
Agency	Asset Management Lifecycle Planning	Physical technology asset health requirements are managed and tracked specific to the underlying physical assets of a transit fare payment system. For example, transit access control equipment, such as a fare gates, may require compliance with safety, accessibility, operating performance, and other public needs. The compliance requirements may be specified by interpretation of governing law or by the underlying management model for the assets necessary to sustain policy compliant performance. These may also include data privacy and security requirements for protecting/encrypting account information.
External Organizations	Interagency Exchange	Interagency exchange are agreement mechanisms by which data, services, revenue and account data (patron and agency) can be shared in context of the delivery of an integrated multi-transit agency provider service. Examples can include: 1) peer-to-peer account information exchange agreements, which specify tariff and revenue sharing terms and conditions between two parties; 2) regional shared service agreements, which define a shared services model for fare payment among multiple operators; and 3) multi-party standard agreements which specify terms for an "open service" which establishes formats for data exchange, liability and service responsibilities in context of a shared open market, exchange or cooperative joint venture (with standard terms of commerce for the participating transit provider community). These data exchanges are typically between accounts, also called an account-to-account information exchange.

Driver Domain	Force Name	Force Description
External Organizations	Intermodal Interoperability	To enable intermodal interoperability, collective organizations are formed to facilitate an effective response to consumer demands for seamless travel experiences by defining information sharing mechanisms, security requirements and other standards designed to facilitate seamless travel. Intermodal interoperability focused forces tend to work through cooperative organizations that encourage both local and regional standard setting to allow multi-mode travel using a single or integrated fare payment mechanism. At the simplest form, organizations may post data in a common format or use shared patron identification models.
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Financial Payment Industry	Payment Brands	Traditionally, payment brands are companies that set transaction terms for merchants, card-issuing banks, and acquiring banks. These “payment brands” have developed the global systems that manage the mechanics of electronic transactions. These brands are now developing new technologies that work in the digital space to help keep mobile payments secure and advance electronic payments globally.
Financial Payment Industry	Media Issuers	Media issuers include banks, merchants and mobile providers. Retail banking is the provision of services by a bank to individual consumers, rather than to companies, corporations or other banks. Services offered typically include savings and checking accounts, mortgages, personal loans, debit cards, and credit cards. The term is generally used to distinguish these banking services from investment banking, commercial banking or wholesale banking. Additionally, credit unions are an alternative to traditional banks. A credit union is a member-owned financial cooperative, controlled by its members. It is typically operated for the purpose of promoting savings, providing credit at competitive rates, and providing other financial services, many times similar to products that a retail bank offers like checking accounts and loans, to its members. A merchant is a business which offers products or services for sale. They may also offer private label credit cards which can only be used in their establishments or discount or loyalty programs to their customers. A mobile provider is a carrier whose services are used to securely store payment media offered by one or more of the payment networks or a self-branded media.

Driver Domain	Force Name	Force Description
Financial Payment Industry	Compliance	Compliance includes adherence to rules and protocols issued and adopted by certifying organizations. With respect to the open payments space, compliance may require audit and certification processes from several specifications/associations including: payment card industry, International Financial Reporting Standards (IFRS), and SEC audit firms. The Payment Card Industry Data Security Standard (PCI DSS) is the security standard issued by the Payment Card Industry Security Standards Council (PCI SSC). PCI DSS is the global data security standard that any business of any size must adhere to in order to accept payment cards, and to store, process, and/or transmit cardholder data. The standard provides an actionable framework for developing a robust payment card data security process – which includes prevention, detection and appropriate reaction to security incidents. International Financial Reporting Standards (IFRS) are designed as a common global “language” for business dealings so that company accounts are understandable and comparable across international boundaries.
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Government / Policies	Accessibility Policies	Accessibility policies and procedures respond to the provisions of the Americans with Disability Act (ADA).
Government / Policies	Data and Privacy Policies	Data and privacy policies and procedures respond to Federal policies and regulations governing consumer privacy (e.g., the Health Insurance Portability and Accountability Act [HIPAA]) and other data security provisions. It also includes compliance with Dept. of Homeland Security rules for personal privacy.
Government / Policies	State and Local Policies	State and local regulation or policies can require adaptations that differ from industry standards. Examples may include labor, technology, or consumer related requirements (e.g., wages, work rules, consumer information privacy protections, prohibited materials, vehicle emission requirements, technology origin requirements, acceptance of local script/benefit programs).

Driver Domain	Force Name	Force Description
Government / Policies	Federal Tax and Banking Regulations	There are many Federal tax and banking regulations that drive open payment including, fraud and anti-money laundering (AML) rules. Money laundering is the process of making illegally-gained proceeds (i.e., "dirty money") appear legal (i.e., "clean"). It typically takes a number of steps to “clean” the money and add it into the legitimate financial system. There have been eight major AML pieces of legislation that have been passed since the initial Bank Secrecy Act of 1970. They include the Money Laundering Control Act (1986); Anti-Drug Abuse Act of 1988; Annunzio-Wylie Anti-Money Laundering Act (1992); Money Laundering Suppression Act (1994); Money Laundering and Financial Crimes Strategy Act (1998); Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism Act of 2001 (USA PATRIOT Act); and, most recently, the Intelligence Reform and Terrorism Prevention Act of 2004.
Standards	Open Payment	Open payment standards and protocols support and facilitate interoperation of payment equipment and end-to-end payment processes. Standards tend to come in sets of dialogs and protocol stacks. These typically are promulgated by industry associations and consortia like EMVCo. EMVCo is a consortium which manages the evolving EMV® payment specifications and related testing processes (e.g., EMVCo Level 1 and Level 2 testing). This includes, but is not limited to, card and terminal evaluation, security evaluation, and management of interoperability issues. EMV stands for Europay, MasterCard, and Visa, the three companies which originally created the technical standard for smart payment cards which store data on an embedded chip rather than on a magnetic stripe. EMVCo has six member organizations—American Express, Discover, JCB, MasterCard, UnionPay, and Visa—and is supported by dozens of banks, merchants, processors, vendors and other industry stakeholders who participate as EMVCo Associates.
Standards	Contactless	Contactless standards and protocols are used for contactless cards, devices and readers. Different payment networks provide certification kits for testing the various components related to contactless technologies. Standards for smart cards are based on ISO/IEC 7810 (physical characteristics, size, resistance to environmental factors), ISO/IEC 7816 (ID cards with an embedded chip, power, clock and serial data), and ISO/IEC 14443 contactless integrated circuit cards. EMVCo is developing standards and testing processes for contactless EMV cards. The NFC Forum is promulgating contactless protocols and standards for wearable and mobile form factors. Additionally, each payment network promulgates their own contactless validation testing/compliance rules, such as Visa Contactless Payment Specification (VCPS); MasterCard Terminal Integration Process (M-TIP) Formal Approval - Contact and Contactless Validation; NFC Level 1 RF Interoperability Test Service.

Driver Domain	Force Name	Force Description
Standards	Technical	Technical standards not related to contactless media include banking standards, transit standards, industry specifications (like E-ZPass), among others. In banking, the most prominent standard is ISO/IEC 8583 Financial transaction card originated messages -- Interchange message specification. Transit standards include the General Transit Field Specification (GTFS) that includes schedule, stop and fare zone information. Other industry standards are promulgated from time to time.
Standards	Process Management	Open fare payment services require repeatable business processes to function consistently. By defining process management standards as an industry, the most effective management practices can be identified and aligned for effective/efficient service operations. Process standards may be used to measure performance, document job roles, define measures and objectives, audit compliance against performance or risk management standards, compare one service to another, and perform many other useful roles. Standards are generally built by documenting industry-accepted management principles. Common areas of alignment include: process models (e.g., describe work and information flows, management controls and communications interfaces to other entities); governance models (e.g., describe how decisions are reached and what the structure of decision-making or oversight bodies is); organization models (e.g., define structure, roles, contractual agreements, staff levels, job descriptions), and business performance measures/standards (e.g., define performance expectations for benchmarking). Each functional area may have a set of process standards. For example, the IT Service Management ITIL V3 framework is a common standard for IT management, and the ISACA Control Objectives for Information and Related Technology (COBIT) standard[6] is a commonly used IT risk management and IT controls auditing framework. Each of these models establishes standards for how systems may be managed and controlled to produce predictable results.
Standards	Encryption and Security	Financial payment systems require secure information management and protection from information loss/corruption. Encryption and IT security frameworks are among their most critical areas of alignment, to allow secure interoperability with components of the open fare payment networks. Among the most important standards are the Payment Card Industry Data Security Standard (PCI DSS) and the Triple Data Encryption Standard (3DES). Standards for business continuity are often also addressed within the topic of data and information protection.

[6] Information on the COBIT IT management and governance may be found at www.isaca.org/cobit/pages/default.aspx.

Driver Domain	Force Name	Force Description
Standards	Audit	Financial payment institutions are subject to oversight by government standards for financial accounting. Service providers that are public companies must also conform to regulatory requirements to avoid financial conflicts of interest, improper handling of funds and other risks. The reoccurring financial, system and security audits that have become standard parts of governance processes are key tools to manage risk. Certified audit firms use key audit standards, against which they can produce attestation reports to monitor control over key systems. Financial audits follow accounting standards such as International Financial Reporting Standard and General Accepted Accounting Principles. IT system controls are often audited against the Statement on Standards for Attestation Engagements (SSAE) 16 Service Organization Controls (SOC) 2 standard. Standards for IT security assessments, such as penetration testing using automated tools (”pen test”), are also possible areas for industry alignment for cost effectiveness.

Table 4. Subforces

Forces	Subforces by Force
Expectations	Social expectations (e.g., convenience, accessible, interoperable, fair, fun, language); technology expectations (e.g., accurate, reliable, secure, private)
Payment Media and Technology	Open/general (government currency); bank/registered (e.g., check, credit, mobile, credit card/debit card); transit proprietary/registered (e.g., ticket, contactless card)
Identity, Privacy and Security	Financial loss prevention; identity/patterns/privacy protections
Goals / Objectives	Geographic service delivery areas, community service goals, revenue goals, cost goals, market penetration goals, capacity needs, congestion management, land use/development
Fare Policies	Categories of fare policies: tariff, transfer, youth/senior/disabled discount, revenue sharing Fare/tariff rules: flat, distance, zone Fare products: single use, multiple “ticket,” time-based pass, service-based pass
Regional Agreements	Operating agreement, cost sharing agreement, procurement, price schedules, MOUs, brand management, data and privacy management/access, shared systems
Operating Procedures and Management Policies	Patron service terms, labor work rules, mobile acceptance, fraud management, device inventory management

Forces	Subforces by Force
Asset Management Lifecycle Planning	Requirements and metrics for asset management, remote monitoring, payment/vending devices, software, software interfaces (API), user interfaces (accessibility), physical specifications (e.g., ADA) [part of the MAP21 State of Good Repair program]
Performance Metrics	Examples of performance metrics include: Transit: ridership, cycles per minute for faregates/turnstiles, transaction times (by mode from reader to authorization and approval) Parking: occupancy rate by location, average time at space by time of day, enforcement by location Tolling: Number of transactions per minute, travel time by segment, trip distribution/dynamic pricing
Interagency Exchange	Peer-to-peer (examples), regional shared service, travel data "open exchange"
Intermodal Interoperability	Travel information, seamless mobility
Extra Agency Exchange	Trip plan/book, offers, rewards, retail ecommerce sites (include non-transit products)
Payment Brands	To be defined
Media Issuers	To be defined
Compliance	To be defined
Transportation Policies	To be defined
Accessibility Policies	Statement that adopts a course of principles or actions to comply with government rules (e.g., American with Disabilities Act of 1990, Civil Rights Act Title VI) with respect to reasonable accommodations for access to facilitates, services and other activities available through the organization. Includes facilities, equipment (faregates, signs, height of interactive point-of-entry/point-of-sale equipment), web page access, audio/visual aids
Data and Privacy Policies	"A **privacy policy** is a statement or a legal document (in privacy law) that discloses some or all of the ways a party gathers, uses, discloses, and manages a customer or client's data. It fulfills a legal requirement to protect a customer or client's privacy. Personal information can be anything that can be used to identify an individual, not limited to but including name, address, date of birth, marital status, contact information, ID issue and expiry date, financial records, credit information, medical history, where one travels, and intentions to acquire goods and services. In the case of a business it is often a statement that declares a party's policy on how it collects, stores, and releases personal information it collects. It informs the client what specific information is collected, and whether it is kept confidential, shared with partners, or sold to other firms or enterprises." [extracted from Wikipedia.org Aug. 3, 2015]

Forces	Subforces by Force
State and Local Policies	To be defined
Federal Tax and Banking Regulations	To be defined
Open Payment	To be defined
Contactless	To be defined
Technical	To be defined
Process Management	Governance/decisions; organization models; process and work/information flow models; performance measurement/benchmarks
Encryption and Security	Network security; encryption key security (e.g., encryption algorithms such as Advanced Encryption Standard (AES)); physical security; business continuity
Audit	Financial audits; technology audits; security audits; customer satisfaction/service quality audits; business continuity and software recovery audits

Table 5. Business Domain

Business Layer	Business Description
Business Domain	A business domain is a group of functions, roles and actors grouped together to provide services (processes).
Business Function	A function is a high level description of activities and services performed by the organization's personnel to meet corporate objectives and business processes.
Business Process	A process is a general description of activities performed by one or more actors and is grouped by function.
Swimlane	A swimlane is a detailed description of a specific activity that is part of a process. The swimlane is a named activity that is typically associated with a work, information or control flow diagram. The swimlane may be one in a series of activities that compose a process. The swimlane is a container that represents a role that carries out sub-processes. Swimlanes may represent departments or other stakeholders that have responsibilities within business processes. The Swimlane contains the elements of a flow chart. **Event:** An event is a discrete occurrence that results in the execution of a business process or sub-process. **Sub-process**: A sub-process is a fine-grained unit of work that is carried out by the organization. Sub-processes are connected to sequence flows to show the steps in which a business process is carried out. **Decision**: A decision is a point in a business workflow in which a stakeholder needs to make a choice between two or more courses of action. A decision will usually lead to different sub-processes or results depending on the choice that is made. **Result**: A result is the discrete state that comes about after a business process or sub-process has been completed.

Business Layer	Business Description
Organization	An organization represents the structure of the corporate personnel.
Directorate	A directorate is the highest level 'people' concept and represents an executive management group within the organization.
Department	A department is the second level 'people' concept and represents a group that oversees many business functions within the organization. Each department reports to a directorate.
Office	An office is the third level 'people' concept and oversees a certain functions or processes within the department to which it belongs.

Table 6. Information

Information Layer	Information Layer Description
Information Domain	The information domain categorizes corporate information into functional areas.
Subject Area	The subject area groups enterprise information into similar business areas.
Information View	An information view identifies information related to a general data concept (or data set) category.
Services	Services are a set of remote calls to access data through exposed entity models, schemas, or procedures.
Orchestration	Orchestration is the arrangement, coordination and management of implementing services to access data through APIs.
Application Programming Interface (API)	An API is a routine, protocol or schema that models and specifies (using data structures or object classes) information for exchange. "The API expresses a software component in terms of its operations, inputs, outputs, and underlying types." [Wikipedia, "Application programming interface", extracted August 31, 2015]

Table 7. Application

Application Layer	Application Category Description
Application Family	An application family is a software product line that is interoperable. For example, a vendor may have several modules that include enterprise resource, human resource, inventory, financial and other management applications.
Application	An application is a tool to permit a user to perform a group of coordinated functions, tasks, or activities [Wikipedia: application software, extracted July 22, 2015]
Database	A database is an organized collection of data stored in an application where a user may interact (create, edit, view, delete, query) with the data sometimes through standards (e.g., SQL).

Table 8. Technology

Technology Layer	Technology Category Definitions
Center	Centers provide management, administration, and support functions for the transportation system. The centers each communicate with other centers to enable coordination between modes and across jurisdictions within a region. The centers also communicate with field and vehicle classes to gather information and provide information and control that are coordinated by the centers.
Field	Entities in this class provide the direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit. They support direct surveillance, information provision, and control plan execution in the surface transportation system. All field subsystems interface to one or more of the center subsystems that govern overall operation of the field subsystems. The field subsystems also generally include direct user interfaces to drivers and transit users and short-range interfaces to the vehicle subsystems to support operations.
Vehicle	Entities are all vehicle-based and share many general driver information, vehicle navigation, and advanced safety systems functions. The vehicle subsystems communicate with the field subsystems and center subsystems for provision of information to the driver.
Traveler	Entities include the equipment that is typically owned and operated by the traveler. Though this equipment is often general purpose in nature and used for a variety of tasks, this equipment is specifically used for gaining access to traveler information within the scope of the ITS architecture. These subsystems interface to the information provider (one of the center subsystems, most commonly the information service provider subsystem) to access the traveler information. A range of service options and levels of equipment sophistication are considered and supported. Specific equipment included in this class include personal computers, smart phones, tablets, and any other communications-capable consumer products that can be used to supply information to the traveler.
Communications	The communications class includes all of the communications equipment (e.g., wireline and wireless transmitters and receivers) and the information management and transport capabilities necessary to transfer information among entities in the transportation layer. The application data content and the transportation application requirements are generally transparent to the communications layer. The communication layer's view of ITS is that of many distributed users, some of them mobile, which require communication services.
Mobile	Entities include devices used within the enterprise for business functions such as inspection, sales, and inventory management

Table 9. Acronyms

Acronym	Descriptions
3DES	Triple Data Encryption Algorithm
APC	Automate Passenger Counting [System]
API	Application Programming Interface
AVA	Automated Voice Annunciation [System]
AVL	Automated Vehicle Location [System]
COBIT	Control Objectives for Information and Related Technology
EA	Enterprise Architecture
EMV	Europay, MasterCard, and Visa (standard for open payments with smart cards)
GAAP	Generally Accepted Accounting Principles (for accounting)
GIS	Geographic Information System
GTFS	General Transit Feed Specification (formerly known as the Google Transit Feed Specification)
IFRS	International Financial Reporting Standards
ISO/IEC	International Standards Organization / International Electrical Commission
IT/ITS	Information Technology / Intelligent Transportation System
ITIL	Information Technology Infrastructure Library
NFC	Near Field Communications
PCI DSS	Payment Card Industry Data Security Standard
PIR	Post Implementation Review
SCA	Smart Card Alliance
SE	System Engineering
SOC	Service Organization Controls
SSAE	Statement on Standards for Attestation Engagements
TEAP	Transit Enterprise Architecture and Planning [Process]
TOPS	Transit Open Payment System
TRB	Transportation Research Board

9 Appendix B: Public Transport Reference Architecture Examples

9.1 Appendix B-1: Transit Enterprise Architecture and Planning (TEAP) Framework

The Transit Enterprise Architecture and Planning (TEAP) Framework provides transit agencies with a blueprint to successfully implement IT/ITS systems that meet their business needs by combining several disciplines. A Transportation Research Bureau project (part of the U. S. National Academy of Sciences) developed 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/ITS investments and maximize their value to the organization. The text included in this section describes the project, results and framework developed in coordination with U.S. transit experts. More details may be found at http://tcrp-teap.pbworks.com/.

The following is an excerpt from *TCRP Report 84 Volume 9, Transit Enterprise Planning Framework*, Appendix A: Guidance for Transit Managers (pp 40-48)

Guidance for Transit Managers

What does the Framework Do?

The Framework and tools 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 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.

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. The key elements of the Framework are:

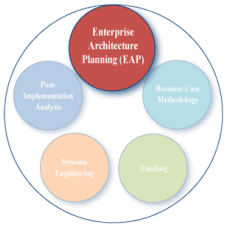
- Enterprise Architecture Planning (EAP) and Enterprise Architecture (EA) development process (developing the blueprints);
- Business Case Methodology (how well does this project fit into your stated priorities; what are the risks, benefits and costs, and estimated return on investment (ROI));
- Funding (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.

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

Figure 1: TEAP Framework Elements

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 your business strategy by associating critical business processes, organizational costs, and service performance with supporting data, applications and technologies. EA models provide insight into cost savings and productivity because they link the revenues and costs to all aspects of a business process. Cuts in staffing may impact an IT system's effectiveness. 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.

More detailed information on EAP/EA, including various IT industry approaches to EAP processes and EA artifacts is included in "Enterprise Architecture (EA)/Enterprise Architecture Planning (EAP)."[7] Some transit examples, tools and resources are provided in "Additional Resources Related to EA / EAP."[8] Guidance for transit managers related to EA/EAP is included in "EA/EAP Checklist for Managers."[9]

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[10]:

- 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

[7] http://tcrp-teap.pbworks.com/Enterprise-Architecture

[8] http://tcrp-teap.pbworks.com/w/page/19763337/Additional%C2%A0Resources%C2%A0Related%C2%A0to%C2%A0EA-EAP

[9] http://tcrp-teap.pbworks.com/w/page/19763368/Managers%20Roles%20and%20Checklists

[10] Description from http://en.wikipedia.org/wiki/Business_case [November 20, 2008]

- Projects with inter-dependencies are undertaken in the optimum sequence."

More detailed information on business case methodologies used for justifying IT/ITS investments, including various approaches to developing a business case, is included in "Business Case Methodology (BCM)."[11] 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 discussion.

Some transit examples, tools and resources related to developing a BCM are provided in "Additional Resources Related to Business Case."[12] Guidance for transit managers related to BCM is included in "Business Case Methodology Checklist for Managers."[13]

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.

More detailed information on IT/ITS funding is included in "IT/ITS Project Funding."[14] Some transit examples, tools and resources are provided in "Additional Resources on Transit IT/ITS Implementation Funding."[15] Guidance for transit managers related to IT/ITS funding is included in "IT/ITS Funding Checklist for Managers."[16]

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[11] http://tcrp-teap.pbworks.com/w/page/19763339/Business%20Case%20Methodology

[12] http://tcrp-teap.pbworks.com/w/page/19763336/Additional%C2%A0Resources%C2%A0Related%C2%A0to%C2%A0Business%C2%A0Case

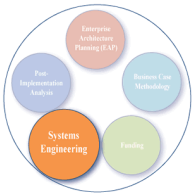
[13] http://tcrp-teap.pbworks.com/w/page/19763368/Managers%20Roles%20and%20Checklists

[14] http://tcrp-teap.pbworks.com/w/page/19763399/Transit%20IT%20ITS%20Implementation%20Funding

[15] http://tcrp-teap.pbworks.com/w/page/19763335/Additional%20Resources%20on%20Transit%20IT%20ITS%20Implementation%20Funding

[16] http://tcrp-teap.pbworks.com/w/page/19763368/Managers%20Roles%20and%20Checklists

System 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.

More detail on the major steps that comprise the systems engineering process can be found in the "Systems Engineering" section.[17] Some examples, tools and resources are provided in "Locating Additional Resources on Systems Engineering."[18] Guidance for transit managers related to SE is included in "Systems Engineering Checklist for Managers."[19]

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."[20] 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

[17] http://tcrp-teap.pbworks.com/w/page/19763393/Systems%20Engineering

[18] http://tcrp-teap.pbworks.com/w/page/19763367/Locating%20Additional%20Resources%20on%20Systems%20Engineering

[19] http://tcrp-teap.pbworks.com/w/page/19763368/Managers%20Roles%20and%20Checklists

[20] 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

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.

More information about how to conduct a PIR and recommended practices are included in the detailed discussion of "Post-Implementation Analysis."[21] Various examples of documents and processes are included in the "Additional Resources on Post-Implementation Analysis" section.[22] In addition, guidance for transit managers related to the topic is included in the "Post-Implementation Analysis Checklist for Managers" section.[23]

How Do the TEAP Frameworks 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 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 decision makers advance a project effectively through funding "decision gates."

[21] http://tcrp-teap.pbworks.com/w/page/19763371/Post%20Implementation%20Analysis

[22] http://tcrp-teap.pbworks.com/w/page/19763334/Additional%20Resources%20on%20Post-Implementation%20Analysis

[23] http://tcrp-teap.pbworks.com/w/page/19763368/Managers%20Roles%20and%20Checklists

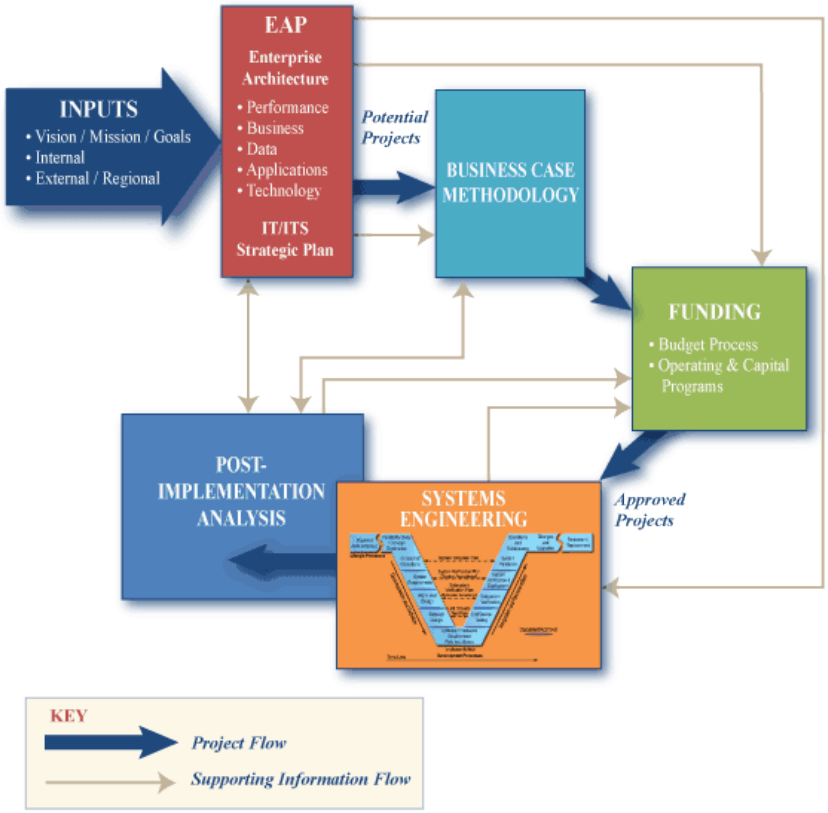


Figure 2: How Framework Elements Relate

Growing need for TEAP Framework Knowledge and 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.