Module 2: Transit Management Standards, Part 1 of 2

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Module Description

This module is the first of the two course modules on transit management using standards. This module provides the background for understanding transit management functions and the standards that facilitate the implementation of systems and technologies that support those transit management functions by:

1) Briefly explaining the transit management functions and systems within the context of National ITS Architecture;

2) Describing the basic taxonomy that will help define where standards should be considered within the functions;

3) Discussing the functions of transit management systems to conceptualize technology implementation at an agency so that participants understand where the standards can be used; and

4) Introducing systems engineering process (SEP) and its use in planning, procuring, and deploying transit management systems.

Also explained in this module is how to best adapt the state-of-the-practice, such as systems engineering, for those functions within transit management where standards do not exist. Knowledge of transit management functions and systems within the National ITS Architecture framework will provide participants with the context necessary to consider those standards that will facilitate data exchange among various technologies within or external to a transit agency.

1. Introduction/Purpose

Transit management covers technologies and systems that facilitate and automate operations, planning, management, maintenance, safety, security, and data management functions of public transit systems. Transit management systems, which include hardware and software, are typically located on-board vehicles, at control centers/dispatch or garage locations, and at transit stations or stops. Communications technologies provide the basis for receiving and transmitting the data and information generated by these systems. In some cases, information generated by several transit management systems provides the basis for generating customer-facing traveler information.

On-board transit management systems include several technologies that provide vehicle location information to dispatch, count boarding and alighting passengers, provide surveillance of the interior and exterior of the vehicle, provide the driver and passengers with security, monitor the "health" of vehicle components (e.g., engine, transmission, propulsion), monitor vehicle performance (e.g., G-force monitoring), provide collision warnings, lane control and precision docking information, and facilitate signal priority (which is discussed in Modules 8 and 9). Transit management systems at a central location like dispatch or garage facilities include technologies that schedule and dispatch vehicles and vehicle operators, manage yard facilities, manage maintenance and fueling activities, manage and analyze data, and provide reporting capabilities. (Please note that Fare Collection standards are covered in Module 10.)

The relationships among central Transit Management and other transit ITS technologies are shown in Figure 1. Figure 2 shows an example of the relationships on-board a transit vehicle.

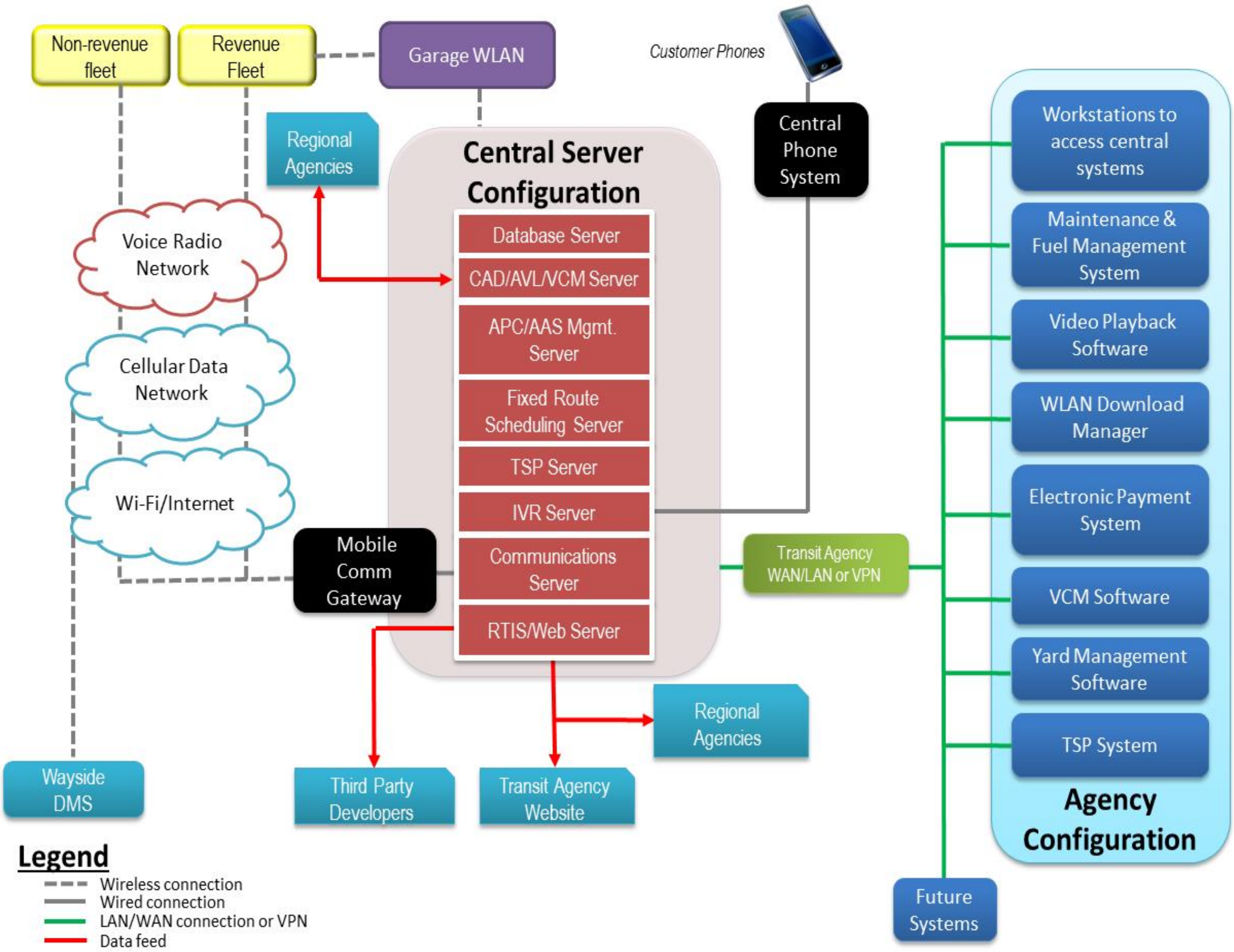

Figure 1. Example of Central System Technology Relationships (courtesy TranSystems Corporation)

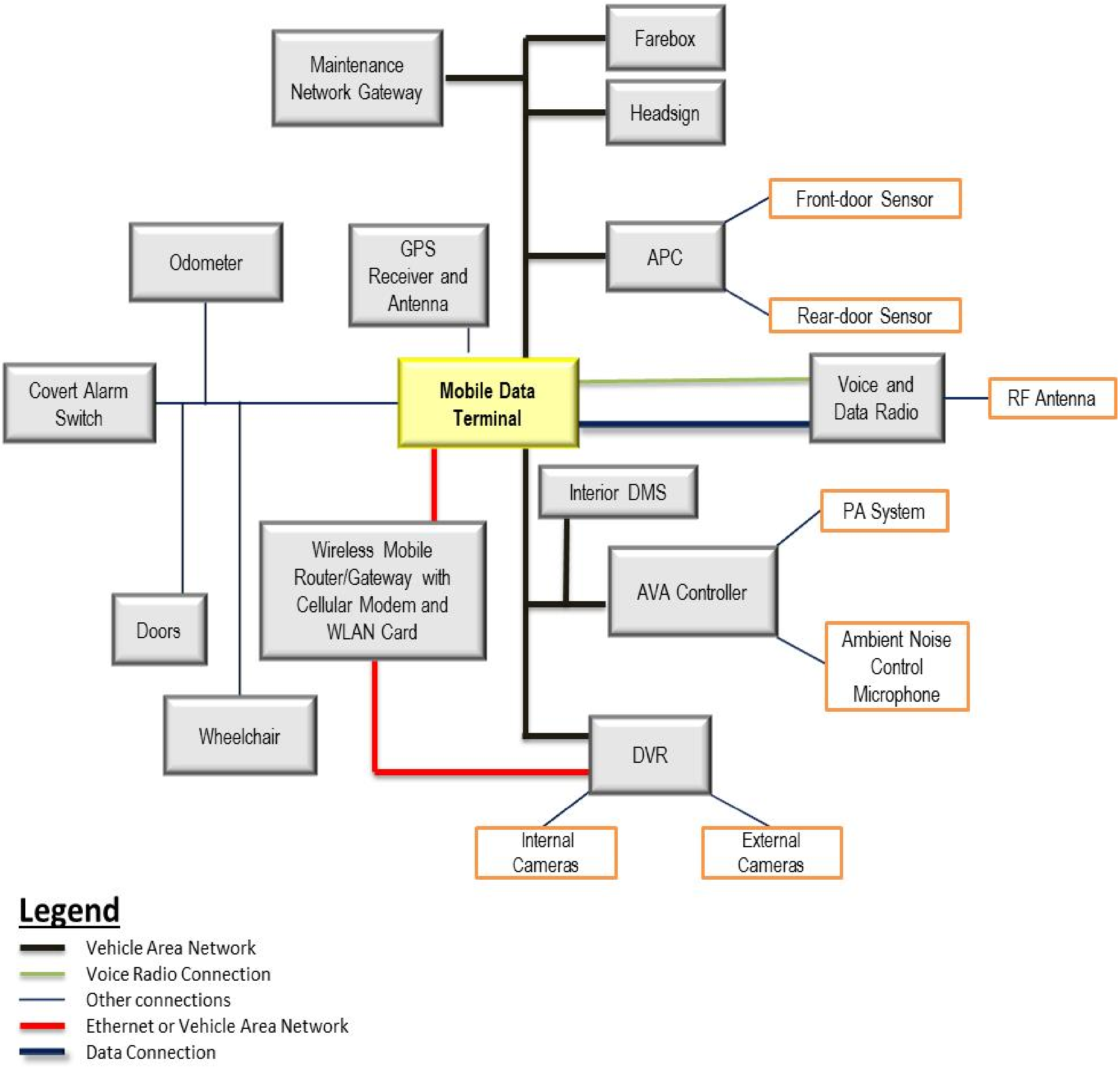

Figure 2. Example of On-Board Technology Relationships (courtesy TranSystems Corporation)

2. Samples/Examples

As described in Module 1, System Engineering (SE) is a structured process for arriving at a final design of a system. The final design is selected from a number of alternatives that accomplish the same objectives and considers the total life-cycle of the project. It includes not only the technical merits of potential solutions, but also the costs and relative value of alternatives.

As shown in Figure 3, one key to SE is the use of a repeatable process or set of processes. As your organization employs SE practices more and more, you should sit down with your colleagues at the conclusion of each project and determine what worked well and what should be done differently the next time. Start to document the processes you used during the project life cycle and modify them based on your lessons learned. You'll want to pay extra attention to any project reviews you held to measure their quality. After you've developed a good set of processes that have been used on several projects, obtain agreement from your organization to establish processes for your organization. This will require buy-in from senior management, who should establish a policy that will support the processes and guidelines for their use.

Be sure to look at existing processes that are already defined in your organization. You may find that the Information Technology group has already implemented a good set of processes, many of which can be applied to ITS projects. The processes that are used for traditional capital development projects may also be helpful. For example, many agencies already have good, established project management processes such as risk management, establishment of integrated project teams, and value engineering processes; any of which may be equally applicable to ITS projects. When processes apply to many types of projects, it makes sense to define a single organizational process that can be applied to technology projects and other types of projects.

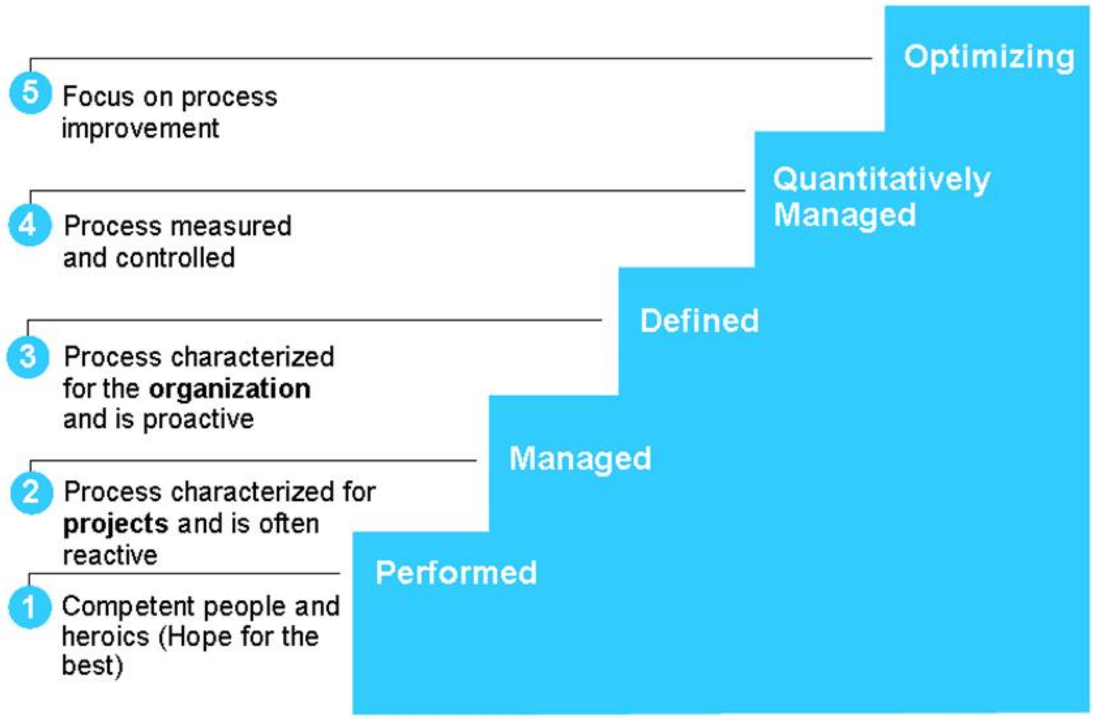

Figure 3. Systems Engineering is a Repeatable Process

Since it was first developed in the 1980s, the SE Vee model has been refined and applied in many different industries. Figure 4 is a reminder of the Vee model at a very high level. Figure 5 provides the details of the Vee as described in Module 1.

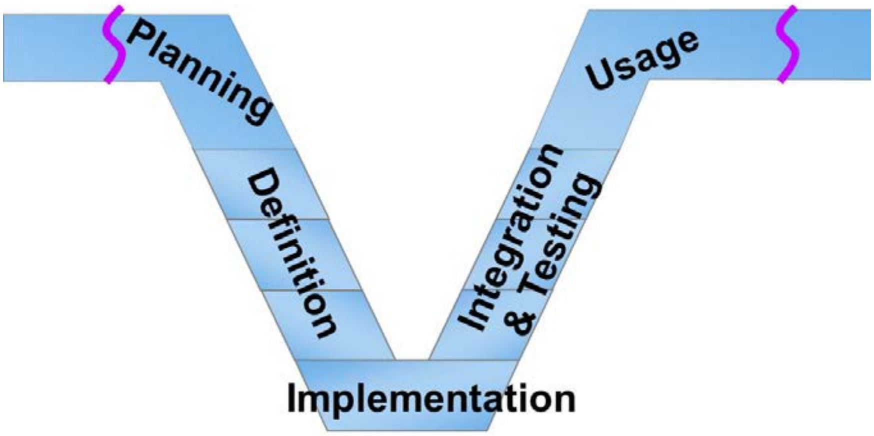

Figure 4. High-level SE Vee Model

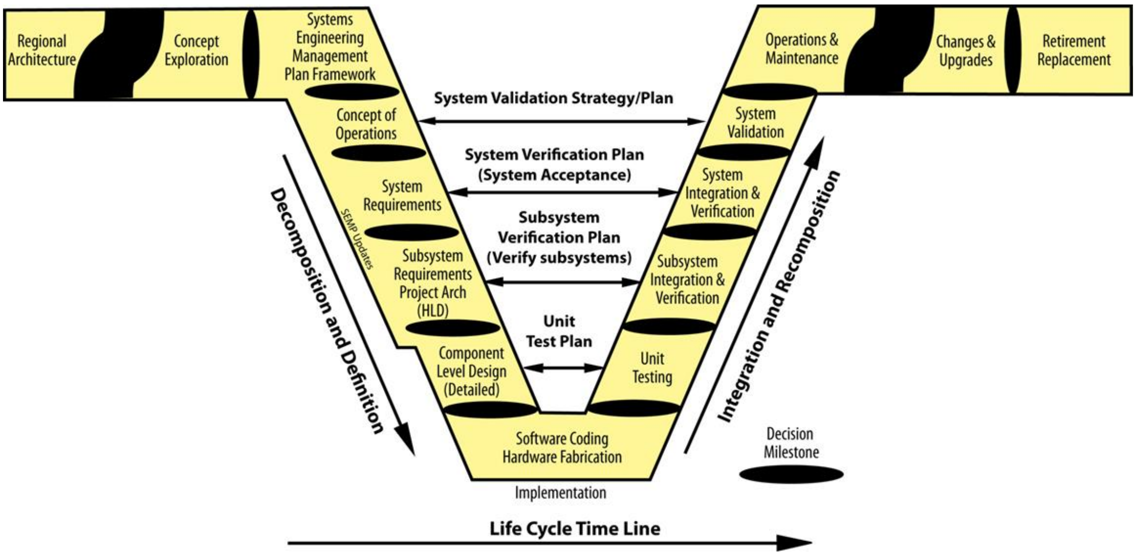

Figure 5. Detailed Vee Diagram

3. Reference to Other Standards

N/A. References will be made in Module 5: Transit Management, Part 2.

4. Case Studies

4.1. Chattanooga Area Regional Transportation Authority (CARTA)

Chattanooga Area Regional Transportation Authority (CARTA) followed the Vee approach, but tailored the approach as indicated on Figure 6 to better suit the scale of their organization and the incremental approach used to develop the overall technology program through a sequence of individual project deployments.

For example, the subsystem and system verification steps were combined in an overall acceptance testing process based on the modest scope of each individual deployment project. There were also opportunities to involve key CARTA end users throughout the project development and implementation process to validate that the system would meet their needs. The concept of operations was incrementally updated when needed to reflect the specific effects of individual projects as they were deployed.

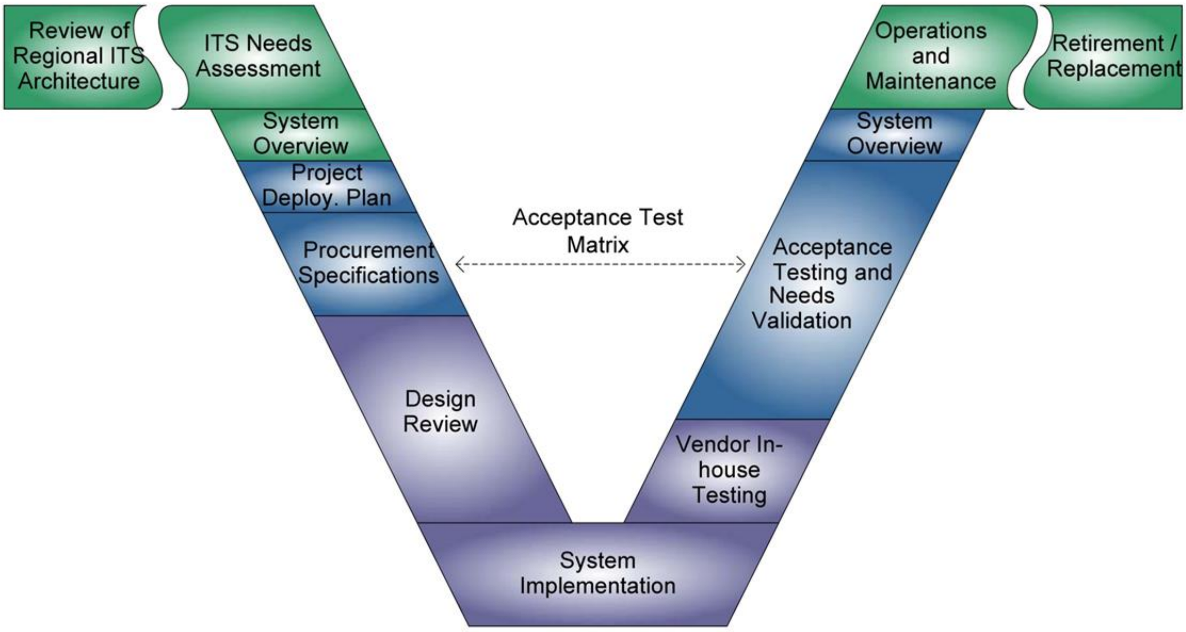

Figure 6. Systems Engineering Process Used by CARTA

In Figure 6, green shading indicates activities that were conducted for their entire technology program and blue shading indicates activities that were conducted for each project. Purple shading indicates activities performed primarily by project implementation contractors in a collaborative approach involving CARTA review and feedback.

CARTA began its process with a review of the existing Regional ITS Architecture. This included a review of CARTA operations/organization/infrastructure to help identify needs that could be addressed through the deployment of proven technologies and related these needs to the User Services and Market Packages in the ITS Architecture. These efforts helped CARTA explore and define an overall technology program vision – a system concept overview for how existing and additional technologies could be best integrated to address the agency's needs and situation over the course of developing the overall technology program. This system overview document defined the ongoing and near-term procurement packages and provided general descriptions of medium- and long-term plans for procurement packages. It also served as both a concept of operations for CARTA technology and a planning document.

As individual project procurements were being initiated, CARTA developed a project deployment plan. These plans defined the scope of the individual projects and helped CARTA prepare to successfully transition each project into revenue service once the deployment was completed. It addressed aspects such as organizational impacts, operations and maintenance, monitoring and evaluation, and outreach. The project requirements were documented in the procurement package for the project, including an acceptance matrix that served as the basis for the design review and acceptance testing.

The selected project implementation contractor completed a collaborative design documentation and review process with CARTA, prior to developing and deploying the system hardware, software, and integration. The project implementation contractor was responsible for in-house testing prior to the start of formal acceptance testing, which was witnessed by CARTA for each subsystem and the overall system. The testing followed procedures that were collaboratively planned in advance with the vendor so as to formally verify all acceptance matrix requirements.

CARTA's keys to success are as follows:

- *Documenting the long-term vision for technology.* CARTA developed documents that described its long-term vision for technology, and these documents helped keep them on track in its deployments. They also helped ensure that long lead-time activities were completed in time to support its future plans.
- *Avoiding the temptation to do too much too fast.* CARTA sequenced its deployments so that systems were deployed sequentially, avoiding deployment of dependent systems at the same time. For example, one reason the CARTA data warehouse was its first technology deployment was that so many other systems would need to integrate with it. Deploying it first meant that it could be operating stably before these other integrations occurred.
- *Being willing to accept schedule delays when needed to help manage deployment risks.* When changes to CARTA's deployment schedule were needed, CARTA was willing to accept delays in order to control risks. For example, when the bus arrival time prediction system was deployed early to take advantage of an outside funding opportunity, CARTA delayed other deployment activities so as not to overburden its limited IT resources.

- *Using a data warehouse.* The presence of a data warehouse at CARTA simplified other deployments in two ways. First, the data warehouse provided reporting tools, which eliminated the need for sophisticated reporting tools in other CARTA applications. Second, applications could be integrated with the data warehouse, reducing the total number of interfaces that were required.

- *Testing systems thoroughly before introducing them to operations.* CARTA displayed a strong commitment to thoroughly testing all systems before accepting them as complete and introducing them to operations. CARTA found and corrected many problems during final testing. If these problems had occurred in an operational system, they could have caused operational problems that could have reduced the confidence of the public and CARTA management in the technology plans.

4.2. LYNX, Orlando FL

LYNX used the Vee systems engineering model to develop and implement their Model Orlando Regionally Efficient Travel Management Coordination Center (MORETMCC) program. Generally, their approach was to address the following:

- Problem: What are you trying to solve?
- Concept: How do you think you will solve the problem? Who are the stakeholders?
- Needs: What do the stakeholders need the solution to do?
- Requirements: How must the solution perform to meet the needs?
- Design: Incorporate the problem statement, concept, needs, and requirements.

LYNX used every step of the Vee model, as shown in Figure 7, to establish a replicable and scalable model of a TMCC that provides one-stop, unified customer-based travel information and trip planning services, and supports coordinated human services transportation operations. They followed the intent of the SEP: Focusing on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem.

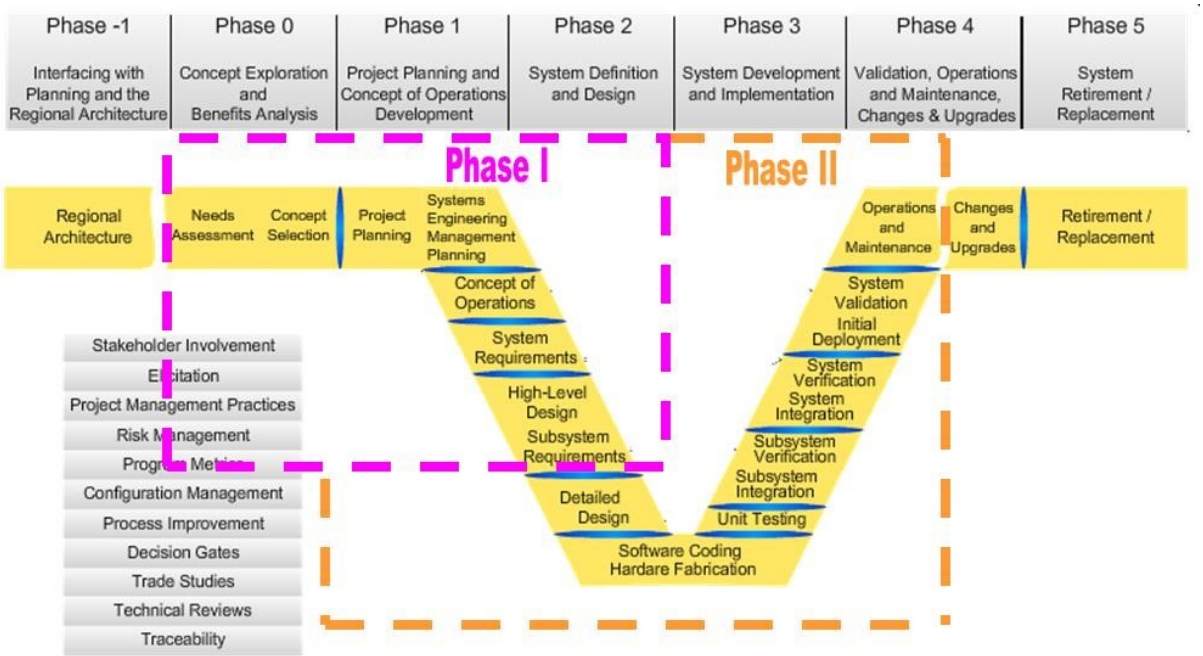

Figure 7. LYNX MORETMCC Use of the Vee Model

4.3. Efficient Deployment of Advanced Public Transportation Systems (EDAPTS)

The Efficient Deployment of Advanced Public Transportation Systems (EDAPTS) project has helped transit agencies across California and other states develop new viewpoints on how ITS systems can help fill unmet needs and resolve nagging problems over the past 15 years. They developed a methodology, guidelines and tools to make the procurement of ITS easier, less costly, more effective and more efficient for smaller agencies. They adapted the Vee model as shown in Figure 8.

EDAPTS identified unique small transit operational and customer service problem areas where ITS might help, developed conceptual solutions, and tested those solutions in a real world environment. Their detailed solutions used the FHWA National ITS Architecture Guidelines and the National Transit Coordinated Interface Protocol's (TCIP) as integral elements of the design. The conceptual designs incorporated novel, cost saving approaches such as transmission of digital data by time sharing the current analog voice radio link, using a single text paging service to simultaneously update bus arrival data at all bus stop Dynamic Messaging Sign's (DMS), and using solar power for the signs to allow installation anywhere

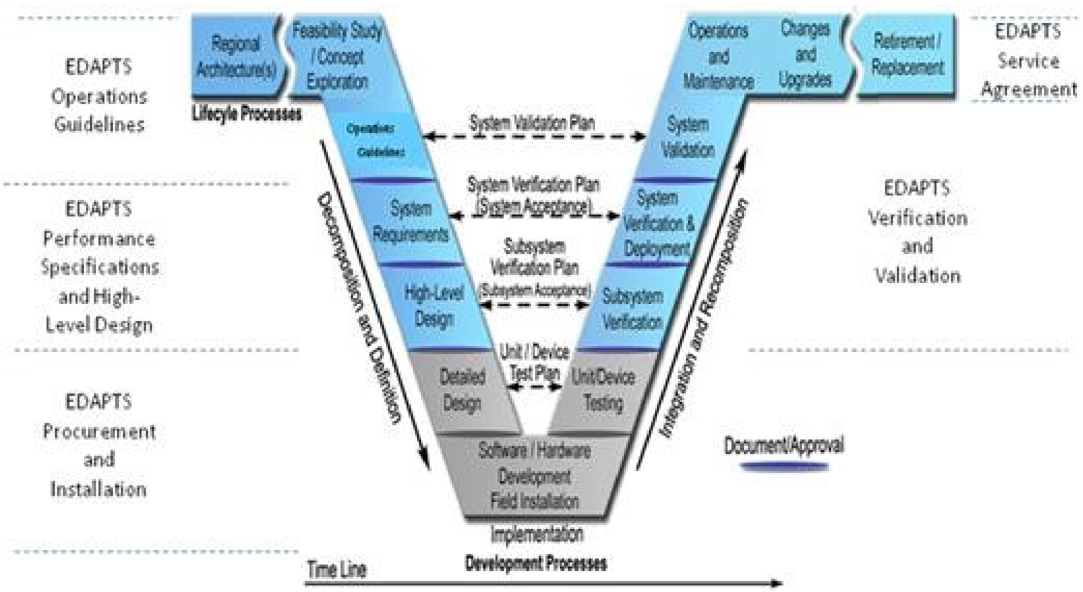

Figure 8. EDAPTS Adaptation of the Vee Model

5. Glossary

Term	Definition
Communications Layer	One of three layers (along with the transportation and institutional layers) defined by the National ITS Architecture. The communications layer 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.
Equipment Package	The building blocks of the subsystems of the physical architecture subsystems. Equipment packages group similar processes of a particular subsystem together into an implementable package. The grouping also takes into account the user services and the need to accommodate various levels of functionality.

Term	Definition
Institutional Layer	An integral component of the National ITS Architecture that represents the existing and emerging institutional constraints and arrangements that are the context for all ITS deployments. The transportation layer and communications layer together provide the technical framework within which interoperable systems may be implemented. The institutional layer introduces the policies, funding incentives, working arrangements, and jurisdictional structure that support the technical layers of the architecture. This institutional layer provides the basis for understanding who the stakeholders will be and the roles these implementers could take in implementing architecture-based ITS systems.
Logical Architecture	The part of the National ITS Architecture that defines what has to be done to support the ITS user services. It defines the processes that perform ITS functions and the information or data flows that are shared between these processes.
Physical Architecture	The part of the National ITS Architecture that provides agencies with a physical representation (though not a detailed design) of the important ITS interfaces and major system components. It provides a high-level structure around the processes and data flows defined in the logical architecture. The principal elements in the physical architecture are the subsystems and architecture flows that connect these subsystems and terminators into an overall structure.
Service Package	The service packages, formerly known as market packages, provide an accessible, service-oriented perspective to the National ITS Architecture. They are tailored to fit, separately or in combination, real world transportation problems and needs. Service packages collect together one or more equipment packages that must work together to deliver a given ITS service and the architecture flows that connect them and other important external systems. In other words, they identify the pieces of the physical architecture that are required to implement a particular ITS service. Service packages are implemented through projects (or groups of projects, aka programs) and in transportation planning, are directly related to ITS strategies used to meet regional goals and objectives.

Term	Definition
Systems Engineering	An interdisciplinary approach and means to enable the realization of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem. Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs
Transportation Layer	One of three layers (along with the communications layer and the institutional layer) defined by the physical architecture. The transportation layer shows the relationships among the transportation related elements. It is composed of subsystems for travelers, vehicles, transportation management centers, and field devices, as well as external system interfaces (terminators) at the boundaries.
User Service	User services document what ITS should do from the user's perspective. A broad range of users are considered, including the traveling public as well as many different types of system operators.

6. References

- National ITS Architecture 7.0: http://www.iteris.com/itsarch/
- ITS ePrimer Module 7: Public Transportation: http://www.pcb.its.dot.gov/eprimer/module7.aspx
- Systems Engineering for Intelligent Transportation Systems: http://ops.fhwa.dot.gov/publications/seitsguide/section3.htm
- Carol L. Schweigerand Santosh Mishra, “Utilizing Archived ITS Data: Opportunities for Public Transport,” Proceedings of the 19th ITS World Congress, Vienna, Austria, 22/26 October 2012, Paper Number AM-00078
- Haas, E. Perry, and J. Rephlo, *A Case Study on Applying the Systems Engineering Approach: Best Practices and Lessons Learned from the Chattanooga SmartBus Project*, prepared for United States Department of Transportation, Intelligent Transportation Systems Joint Program Office and Federal Transit Administration, submitted by Science Applications

International Corporation, November 2009, Contract No.: DTFH61-02-C-00061 Task No.: 61027, http://ntl.bts.gov/lib/32000/32600/32672/61027_se.pdf

- NTI course, Systems Engineering for Technology Projects
- ITS PCB T3 Webinars on ITS Transit Standards, http://www.pcb.its.dot.gov/t3_archives.aspx, which includes 14 archived webinars about Transit Management
- EDAPTS: http://www.dot.ca.gov/research/operations/edapts/
- Doug Jamison and Bill Hearndon, "MORETMCC: Building ITS Capabilities, One Step at a Time," National Rural ITS Conference, Coeur d'Alene, ID, August 31, 2011, http://www.nritsconference.org/downloads/Presentations11/SessionHST_Jamison.pdf

7. Study Questions

1. What is the purpose of ITS standards?
   a) To keep up with technology
   b) Interoperability, compatibility and interchangeability
   c) To document data exchange among ITS systems
   d) All of the above

2. Which of these are not public transportation service packages?
   a) Transit Vehicle Tracking
   b) Multimodal Connection Protection
   c) Multimodal Coordination
   d) Traffic Metering

3. Which one of these technologies is included in the Fleet Operations and Management category?
   a) On-board automated voice announcements
   b) Scheduling software
   c) Data management and reporting
   d) All of the above

4. Which of these technologies are in the Safety and Security category?
   a) G-force monitoring
   b) Data management
   c) Geographic information systems

   d) Traveler information

5. Computer-aided dispatch (CAD) is dependent upon which one of these technologies?
   a) Voice and data communications technologies
   b) Automatic vehicle location (AVL) system
   c) Route and vehicle schedule data
   d) All of these

6. Within the Maintenance category, is Fuel Management dependent on another technology?
   a) Yes
   b) No

7. Does EDAPTS assume Commercial-off-the-Shelf (COTS) using a simplified SEP?
   a) Yes
   b) No

8. Which one of these standards is used for CAD/AVL systems?
   a) GTFS
   b) SAE J1939
   c) TransXChange
   d) All of the above