1 Introduction

This document is intended to serve as a guide to assist transportation professionals in the preparation, development, and use of a Concept of Operations in a regional, statewide, or multi-state transportation management integration project. This chapter introduces the reader to the topic and describes the methods used to develop the guidance document and how the document may be used by its intended audience.

1.1 CHAPTER OVERVIEW

This chapter introduces the reader to the purpose of the guidance document and provides information to help the reader effectively use the document. Its basic objectives are:

- To define the challenges and state-of-the-practice in the development and use of a Concept of Operations for a regional integration initiative.
- To provide a brief background on key topics that serve as a foundation for the document.
- To provide information to help readers effectively use the document.

The chapter consists of the following sections:

- Importance of Concept of Operations for Regional Integration Initiatives

  This section explains why a Concept of Operations is necessary to support projects that endeavor to integrate transportation operations elements in a regional setting.

- The Challenge

  This section highlights the differences between “single-system” and regional integration projects and the challenges posed by those differences.

- General Description of the Guidance Document

  This section describes the objective of the guidance document and identifies its intended audience.

- How Document Was Developed

  This section describes the philosophy and methodology used to develop the guidance document.

- Contents of the Guide

  This section provides an overview of each chapter in the guidance document.

- How To Use This Document

  The document was developed to be of use to transportation professionals with a wide range of backgrounds and roles. This section is intended to help a reader determine how to use the document to meet his/her specific needs.

- Chapter Summary

  This section briefly summarizes the main points of the chapter.

- Literature Supporting this Chapter

  This section provides references for the literature used to support this chapter.

1.2 IMPORTANCE OF A CONCEPT OF OPERATIONS FOR A REGIONAL INTEGRATION INITIATIVE

When planning, designing, deploying, and operating regional integration initiatives, defining a shared set of expectations is of critical importance. The Concept of Operations supports the development and documentation of these expectations to serve as the essential foundation for a regional integration initiative. The Concept of Operations can provide structured, comprehensive guidance by:

- Identifying, and serving as a tool to engage the diverse array of stakeholders who will be impacted by the proposed regional integration.

- Identifying the users of the proposed system so that a description of user needs can be developed.

- Developing goals and objectives based on identified user needs and an agreed upon vision for the regional initiative.

- Revealing institutional barriers to collaboration and suggesting ways to surmount the obstacles.

- Describing the current infrastructure and institutional framework.

- Providing a comprehensive view of how the proposed system will function under expected conditions (scenarios).

- Describing current operations within the region and describing how this will be affected by the proposed regional project.

- Differentiating between those functions and services that would provide greater benefit if approached at the regional level and those that should continue to be performed at the local level.

- Identifying the resources necessary to build, operate, and maintain the new system or service created by the project.

- Detailing the number and types of agreements needed to implement the proposed project.

- Defining the roles and responsibilities of the various agencies that will build, operate, and maintain the proposed system.

1.3 THE CHALLENGE

The development of a Concept of Operations for a regional integration initiative differs from that of “single-system” project (i.e., a project that is under the purview of a single transportation agency, and involves only a single transportation management system) in several important respects. These challenges are identified below, along with a brief description of the strategies employed by the guidance document to address these challenges.

Diversity and Complexity

Developing a project involving regional integration presents unique challenges because, as compared with a stand-alone or localized system, in a regional system there is:

- Greater difficulty in identifying and bringing together stakeholders, who represent diverse and sometimes competing interests.

- A more complex process for forging essential agreements.

- A greater need for communication, while communication is usually more difficult to establish and maintain

- A greater need for the coordination of management and control (interoperability) of the system, which is made more difficult by inter-jurisdictional institutional barriers.

- Greater technical complexity in the proposed integration, making it difficult to present and therefore "sell" to stakeholders and the public.

- Greater difficulty in securing funding for the building, operation and maintenance of the proposed system

The use of Systems Engineering is essential to effectively address these obstacles and to successfully implement a regional initiative. In order to guide the systems engineering process, a Concept of Operations must encompass a description of the multiple needs of users in the proposed regional system. This guide for preparing such a Concept of Operations addresses the complexity of this undertaking with an approach that is comprehensive without being overly prescriptive, thus allowing the flexibility to apply the assessment to varying regional, statewide, or multi-state requirements.

Incorporating Current Best Practices

In addressing these challenges, this guide identifies specific examples from previously developed Concept of Operations and related documents from regional integration initiatives that demonstrate sound practice.

1.4 GENERAL DESCRIPTION OF THE GUIDANCE DOCUMENT

Objective

The objective of this guidance document is to support transportation professionals as they seek to develop and use a Concept of Operations to guide regional integration initiatives. In particular, the document will clearly differentiate between a Concept of Operations for a single-system project and that of a regional, statewide, or multi-state transportation management system or service.

Intended Audience

The guide is intended for individuals involved in, or responsible for, a wide range of transportation operations activities: Management, Planning, Design, Operation, and Maintenance. This will include but will not be limited to officials of Departments of Transportation, planning commissions, emergency service organizations, etc. This guidance document will be useful to a broad scope of people - ranging from technical personnel to individuals with less technical knowledge:

- Managers will find the guide useful in that it elucidates the need to identify the wide range of user expectations implicit in a regional initiative and the need to define roles and responsibilities of other transportation professionals who will interact with the proposed system.

- Planners can use the guide to be apprised of the factors that need to be considered in addressing regional transportation needs, such as resource identification, ongoing operations and maintenance support, cooperative agreements, and the usefulness of a Concept of Operations for future planning activities.

- Designers and builders involved in regional integration efforts can learn from the guide how a Concept of Operations can support the identification of high-level functional requirements and inform other phases of the systems engineering process.

1.5 HOW DOCUMENT WAS DEVELOPED

This guidance document was built upon the existing guide, *Developing and Using the Concept of Operations in Transportation Management Systems*. It is expected that this *regional* guide will serve as a companion document to the existing one. Please note that much of the structure of the current document is identical to the previous guide; however, the content describes methods and elements unique to the development of a guide for regional integration projects. In differentiating the regional guide, we focused on integration issues with respect to elaborating the elements of a Concept of Operations, such as: describing a complex regional system (or "system of systems"), identifying and defining user and operational needs across jurisdictions, forging agreements among a diverse array of stakeholders, addressing institutional barriers to cross-jurisdictional funding, developing realistic scenarios that anticipate complex communications and implementation issues.

The overall development philosophy for the guide emphasized the benefit of the synergy of a Concept of Operations for a regional integration initiative (the whole is more than the sum of its parts) and the need for flexibility in developing a regional document. Flexibility is an important attribute of any Concept of Operations, but the intricacies of an integrated system place a greater demand on a document's ability to define relationships

Like the previous guidance document, this guide is based on industry standards such as *IEEE 1362-1998 Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document* and *Guide for the Preparation of Operational Concept Documents. (ANSI/AIAA G-043-1992)*. This guide also benefited from the best of current regional transportation management-related documents, many of which provide excellent, high-level introductions. The writing team also conducted interviews with individuals involved with regional transportation management and Concept of Operations development and use. Using the input from standards, pertinent literature, and interviews, this guide uses case studies/real examples to elucidate current best practices.

1.6 CONTENTS OF THE GUIDE

A description of each of the subsequent chapters in the guidance document is presented below:

Chapter 2 Overview

Systems Engineering Overview

Systems Engineering is a widely accepted methodology for developing dynamic, large-scale system, particularly those involving both technical and human components. The Concept of Operations "starts" the Systems Engineering process and is the foundation for the activities that follow. Therefore, understanding the systems engineering process is essential for proper development and use of a Concept of Operations for any application. This is especially true at the regional level, where a high-level analysis of multi-user expectations is essential to support complex high-level requirements development. This chapter provides a very brief overview of the systems engineering process (For a more detailed overview see the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook*). It is for readers with a moderate amount of Systems Engineering experience who need a quick review. Those already familiar with Systems Engineering can skip over this chapter. It is suggested that those not familiar with Systems Engineering consult the more in-depth reference listed at the end of this chapter (Gonzalez, Paul J. Building Quality Intelligent Transportation Systems Through Systems Engineering. Report No FHWA-OP-02-046. April 2002).

Chapter 3 Overview

Concept of Operations in the Regional Context

As introduced in Chapter 2, the Concept of Operations initiates and sets the foundation for the systems engineering process. It guides each step of the process and serves to validate the system when it becomes fully operational. This is true regardless of the scope or complexity of the project. However, developing and using a Concept of Operations for a project involving regional integration presents special challenges. This chapter discusses the context of a regional initiative and the implications this has for development of a Concept of Operations. Its objectives are:

- To describe the context wherein regional projects emerge.
- To discuss the importance of a Concept of Operations for a regional integration initiative
- To describe the difficulties involved in developing and using a Concept of Operations for a regional initiative.

Chapter 4 Overview

Concept of Operations Defined for the Regional Initiative

This chapter defines a Concept of Operations and provides a description of the elements that compose a Concept of Operations, using examples from regional integration initiatives. It references Chapter 3 of the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook*, which provides an in-depth description of each element of the Concept of Operations.

Chapter 5 Overview

Developing a Concept of Operations for a Regional Initiative

The previous chapter noted that, while the structure/components of a Concept of Operations is the same for all initiatives (i.e. single system or regional integration), the content of a Concept of Operations for a regional integration initiative encompasses more complex interactions and inter-relationships due to the very nature of these integration initiatives. The necessity to produce a comprehensive document that addresses this degree of complexity has significant implications for the strategy utilized to develop the Concept of Operations. This chapter identifies development issues that are critical to the creation of a Concept of Operations for a regional initiative, and addresses these issues with advice based on interviews with transportation professionals and with best practices from regional examples.

Chapter 6 Overview

How to Use a Concept of Operations in Regional Integration Initiatives

A Concept of Operations is a living document that is intended to be modified and used throughout the life-cycle of a system. This chapter illustrates how the Concept of Operations can be used to effectively support key activities in the systems engineering life cycle of a regional integration initiative. It references pertinent source material and draws upon the perspective of regional experts. Its objectives are:

- To describe how a regional Concept of Operations can be used in the development of high-level functional requirements.
- To describe how a regional Concept of Operations can be used to support cooperative agreements.
- To describe how a Concept of Operations can be used to support planning.

Chapter 7 Overview

Case Study

While the previous chapters in this Guidance Document address individual elements and issues related to Concepts of Operations for regional integration initiatives, this final chapter demonstrates and highlights the guidance principles using a single case study. This chapter presents a comprehensive case study - a Concept of Operations developed by the Delaware Valley ITS Technical Task Force - to guide regional integration in the Philadelphia metropolitan area. This regional initiative is referred to as the Regional Integrated Multi-Modal Information Sharing (RIMIS) system. The referenced documents along with noteworthy material from participants' interviews are used to illustrate salient points. This chapter's objectives:

- To illustrate how the elements of the Concept of Operations were developed to address the needs of the RIMIS system.
- To document lessons learned during the RIMIS Concept of Operations development process.
- To document lessons learned during the use of the Concept of Operations in the RIMIS development process.

1.7 HOW TO USE THIS DOCUMENT

This guide is intended to complement and be used in conjunction with the previously published guide, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook.* This guide complements the other document by identifying and addressing the unique challenges posed by *regional* integration, discussed briefly above and amplified and elucidated throughout the remaining chapters by using regional examples of best practices.

The person who is embarking upon a regional integration initiative, but who may not have recent experience with developing a Concept of Operations, should consult the companion document to either acquaint, or re-acquaint, themselves with basic principles before consulting this guide.

Those who are already familiar with Concept of Operations development for single-system projects but need a refresher in systems engineering, should begin with Chapter 2 of this document; others with a strong systems engineering background can begin with Chapter 3. Those who are already familiar with Concept of Operations development for regional initiatives, but need a refresher or a more current resource, can begin with Chapter 4. Individuals experienced with developing and using Concept of Operations in regional integration projects can use this guide as a reference by using the Chapter headings and overviews to locate pertinent information.

1.8 CHAPTER SUMMARY

This chapter introduced the reader to the purpose of the guidance document and provided information to help the reader effectively use the document. It provided a brief background on key topics that serve as a foundation for the document:

- The importance of a Concept of Operations for regional integration initiatives.
- The important differences between single-system and regional integration projects and the challenges posed by those differences
- The objective of the guidance document and identification of its intended audience
- The philosophy and methodology used to develop the guidance document
- An overview of each chapter in the guide
- Options for using the guide for varying classes of users

1.9 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER:

- IEEE 1362-1998 Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document. New York: IEEE, 1998

- Guide for the Preparation of Operational Concept Documents. (ANSI/AIAA G-043-1992). American National Standards Institute, 1992

- Developing and Using a Concept of Operations in Transportation Management Systems; FHWA, Spring 2005
http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=38&new=0

2 Systems Engineering Overview

Systems Engineering is a widely accepted methodology for developing dynamic, large-scale projects, particularly those involving both technical and human components. The Concept of Operations "starts" the Systems Engineering process and is the foundation for the activities that follow. Therefore, understanding the systems engineering process is essential for proper development and use of a Concept of Operations for any application. This is especially true at the regional level, where a high-level analysis of multi-user expectations is essential to support complex high-level requirements development. This chapter provides a very brief overview of the systems engineering process (For a more detailed overview see the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook*). It is for readers with a moderate amount of Systems Engineering experience who need a quick review. Those already familiar with systems engineering can skip over this chapter. It is suggested that those who are not familiar with Systems Engineering consult the more in-depth reference listed at the end of this chapter (Gonzalez, Paul J. *Building Quality Intelligent Transportation Systems Through Systems Engineering.* Report No FHWA-OP-02-046. April 2002). Additionally, FHWA has recently published Version 2.0 of the *Systems Engineering Guidebook for ITS,* which has been "restructured, extensively edited and revised, and new content has been added". This chapter will be followed by a discussion of the importance of the development and use of a Concept of Operations in applying the systems engineering process to regional integration projects in Chapter 3.

2.1 CHAPTER OVERVIEW

The material in this short chapter is an abbreviation of the description of the Systems Engineering process in the companion document (*Developing and Using a Concept of Operations in Transportation Management Systems*) and is identical to Section 2.1.2 of that document, entitled "The Systems Engineering Life Cycle and the Systems Engineering "Vee" ". Its objective is to provide summary information concerning systems engineering.

2.1.1 Relationship to Previous Chapter - This chapter transitions from the general introduction of a Concept of Operations for Regional Integration Projects in Chapter 1 to provide a brief introduction to systems engineering. This chapter is designed as a quick refresher for readers with a moderate amount of systems engineering experience to provide a foundation for the detailed guidance provided in later chapters. It also enables readers to determine the need to review the companion document or other listed references for more background information.

2.1.2 Chapter Sections:

- What Is Systems Engineering?
- Chapter Summary
- Specific Literature Supporting This Chapter

2.2 WHAT IS SYSTEMS ENGINEERING?

Systems engineering was developed to address contemporary, large-scale, engineering projects involving large information technology components. Systems engineering facilitates the development, maintenance, refinement, and retirement, of dynamic, large-scale systems consisting of both technical components and human components. Systems engineering is an appropriate process for large-scale, technically sophisticated transportation projects. It is particularly important for a regional initiative where a structured process is essential to manage the large number of diverse operational elements and the often vast array of interconnects to satisfy a variety of users. The phases of the process are depicted in the widely used "Vee" graphic and briefly described below.

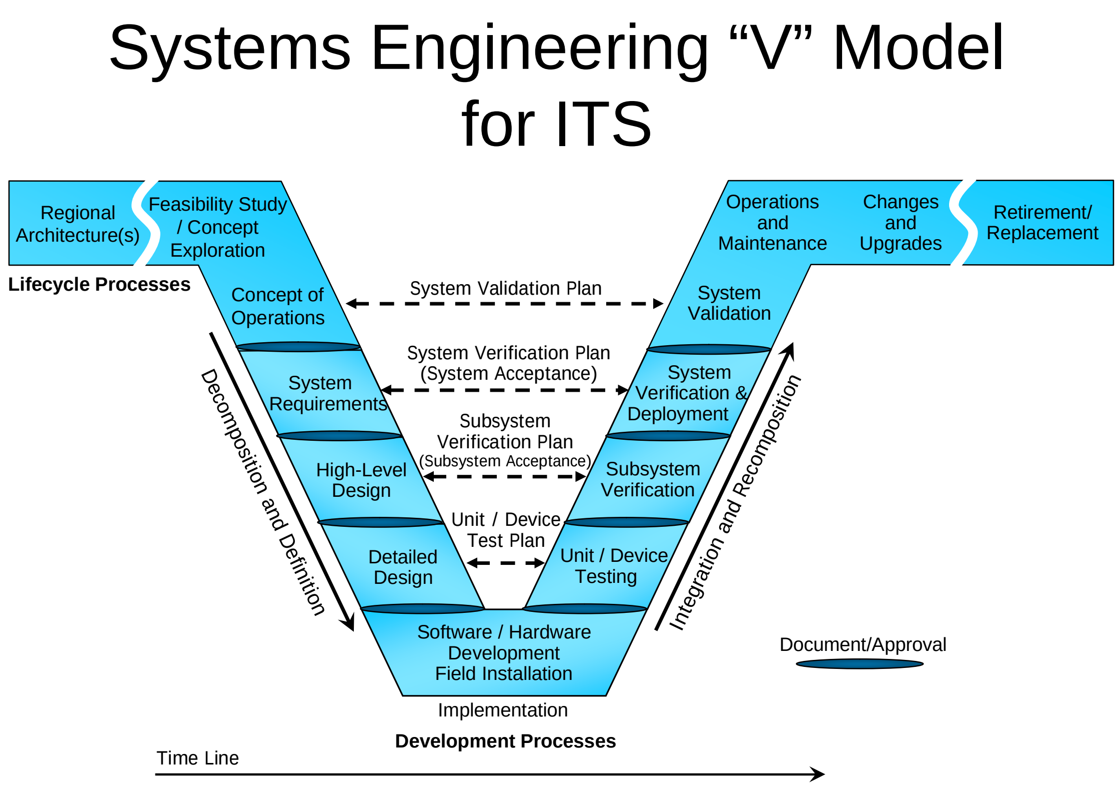

Figure 2.1 - The Systems Engineering "Vee" -- This updated model includes the range of activities that occur prior to the Concept of Operations and following System Validation on the "shoulders" of the vee. Within the vee itself, this model depicts the steps of the systems engineering process for the three methods:

Decomposition and Definition (left line of vee): Concept of Operations, System Requirements, High Level Design, and Detailed Design

Implementation (bottom of vee): Software/Hardware Development and Field Installation

Integration and Recomposition (right line of vee): Unit/Device Testing, Subsystem Verification, System Verification and Deployment, and System Validation

Though the entire process is inherently iterative, the first and last step in this model includes the use of a Concept of Operations.

- Concept of Operations – The Concept of Operations is the first step in the systems engineering "Vee" – while integral throughout the entire process; its most critical, and directly related, roles will be in the direct assistance to the generation of System Requirements, and in System Validation once it has entered an Operations and Maintenance phase.

- System Requirements – The second step in the systems engineering "Vee" is the development of the overall System Requirements. The purpose of the requirements is to clearly define what the system will do.

- High Level Design – The third step is driven by the System Requirements. This step begins the process of organizing system functions into higher-level units. This is commonly referred to as system architecture.

- Detailed Design – This step involves the detailed design of all elements of the system. It is important to note that this is driven by all previous activities. At this stage, the process moves from a functional perspective of what the system will do, to a definition of how it will accomplish the functions.

- Software/Hardware Development and Field Installation – With detailed input from the previous step, the actual build process begins here; software code is written, parts fabricated, and the system integrated.

- Unit/Device Testing – At this stage, each subcomponent, or unit, which will exist within the greater system, is tested individually; they are verified by comparing with the Detailed Design completed two steps earlier.

- Subsystem Verification – After each subcomponent has been assembled, integration begins and appropriate configuration for each subcomponent must be performed. This step takes the components past the unit testing and begins to configure them for appropriate system operation. This configuration is tested by examining the High-level Design developed several steps earlier.

- System Verification and Deployment – This testing step involves ensuring that all aspects perform as intended, and the system may be "accepted" for operation. It traces back to System Requirements for comparison.

- System Validation – In this last step, the system operates to fulfill its mission in the real world. Note that validation is in relation to the Concept of Operations.

It is important to mention that these steps are not terminal—an organization does not finish one step, and begin directly on the next step. The systems engineering process is only effective if viewed as iterative throughout each step of the process and also iterative in the long run. This dynamic process should take place over a period of years, not months or weeks.

Please consult the references listed below in Section 2.4 for more information about systems engineering.

2.3 CHAPTER SUMMARY

This chapter briefly summarized the phases of the systems engineering process, emphasizing the importance of the Concept of Operations to all phases of the process.

2.4 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

- Developing and Using a Concept of Operations in Transportation Management Systems; FHWA, Spring 2005
  http://tmcpfs.ops.fhwa.dot.gov/cfprojects/new_detail.cfm?id=38&new=0

- Gonzalez, Paul J. Building Quality Intelligent Transportation Systems Through Systems Engineering. Report No FHWA-OP-02-046. April 2002
  http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13620.html

- Systems Engineering Guidebook for ITS, Version 2; FHWA, 2007
  http://www.fhwa.dot.gov/cadiv/segb/whatsnew/listings/2007/january/guide.htm

- National Highway Institute Training. The National Highway Institute offers a wide-ranging selection of courses that relate directly to transportation operations. Their series on ITS includes the following courses directly addressing systems engineering (for additional information, please see the NHI web site, http://www.nhi.fhwa.dot.gov):
  - 137024A Introduction to Systems Engineering for Advanced Transportation
  - 137026A Managing High Technology Projects in Transportation

3 Concept of Operations in the Regional Context

As stated in Chapter 2, the Concept of Operations initiates and sets the foundation for the systems engineering process. It guides each step of the process and serves to validate the system when it becomes fully operational. This is true regardless of the scope or complexity of the effort. However, developing and using a Concept of Operations for a project involving regional integration presents special challenges. This chapter discusses the context of a regional initiative and the implications this has for development of a Concept of Operations.

3.1 CHAPTER OVERVIEW

3.1.1 The purpose of this chapter is to discuss the necessity of developing a Concept of Operations for projects that involve regional integration and to address the challenges posed by the demands inherent in such a project. Its objectives are:

- To describe the context wherein regional projects emerge.
- To discuss the importance of a Concept of Operations for projects that involve regional integration
- To describe the difficulties involved in developing and using a Concept of Operations for projects that involve regional integration

3.1.1.1 Relationship to Previous Chapter – Chapter 2 provided an overview of the Systems Engineering process. This chapter delves in detail into the Concept of Operations phase of the systems engineering process. It discusses the necessity and challenge of developing a thorough Concept of Operations to launch the Systems Engineering process for projects that involve regional integration.

3.1.2 Chapter Sections:

- The Regional Context
  - Planning Activities and Regional Projects
- The Importance of a Concept of Operations for a Regional Integration Project
  - Support for High-Level Functional Requirements
- Challenges Posed by a Regional Integration Initiative
- Chapter Summary

- Specific Literature Supporting This Chapter

3.2 The Regional Context

The need for a project that involves regional integration does not materialize magically, out-of-the-blue. A number of dynamic planning processes exist on a regional level that identify the transportation needs of the community. Planning is integral to the effective evolution of a transportation network. Thus, as with the need to construct new highways or add capacity, the need to create the infrastructure and policies/procedures to facilitate regional integration is established through planning processes.

3.2.1 Planning Activities and Regional Projects

The ITS Architecture has served as the foundation of many regional planning activities. "The National ITS Architecture provides a common framework for planning, defining, and integrating intelligent transportation systems." FHWA requires regions to develop a Regional ITS Architecture if the agencies intend to use the Highway Trust Fund to finance ITS projects. The Regional ITS Architecture is based on the National ITS Architecture but tailored to address the local situation. "It is a plan for the deployment of electronic technology throughout a region with a focus on integration of systems within the region. The architecture identifies stakeholders, systems or 'elements' they operate and the information to be exchanged between stakeholder elements. The architecture also provides selected standards for information exchange." (Mark Thomas. “Regional ITS Architecture for Northern Eastern Illinois, Project Summary.” Spring 2003). Detailed information about ITS Architecture is available at http://www.iteris.com/itsarch.

While the ITS Architecture serves as a framework that a region may use to guide deployment of ITS improvements (most often, these improvements involve enhancement of system operations), it has become clear that regions must establish strong working relationships to sustain collaboration and coordination of operations. This allows regional partners to plan for improved relationships and procedures, resource arrangements, and physical enhancements necessary for a higher level of operations. Regional transportation operations collaboration and coordination is described in a December 2002 FHWA Primer, *Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security*. A planning tool growing out of this process is the Regional Concept for Transportation Operations (RCTO). RCTO development involves the identification of the relationships, procedures, resource arrangements, and physical improvements needed to achieve and sustain the region’s operations objectives. A RCTO may simply define how regional partners work together, or it may also identify physical improvement needs by identifying one or more projects. It outlines 3 – 5 year transportation operations objectives for a region. In our interview with the principal author of the above referenced primer, he described this tool as an important link between planning and operations. It fosters high-level institutional relationships, helps identify regional needs, and engenders high-level explanations of how to address the needs.

With input from regional stakeholders, such as Metropolitan Planning Organizations (MPOs), state Departments of Transportation (DOTs), Emergency response agencies, and local governments, the RCTO establishes plans for regional operations. To make these plans a reality, they must be implemented. Any number of specific projects may be identified by this process; each of these projects should be developed using Systems Engineering, the first phase of which should be the development of a thorough Concept of Operations. The projects are planned and developed in consultation with the Regional ITS Architecture. The diagram in Figure 3.1 depicts the relationship between the ITS Architecture, RCTO, and Concepts of Operations for specific regional projects.

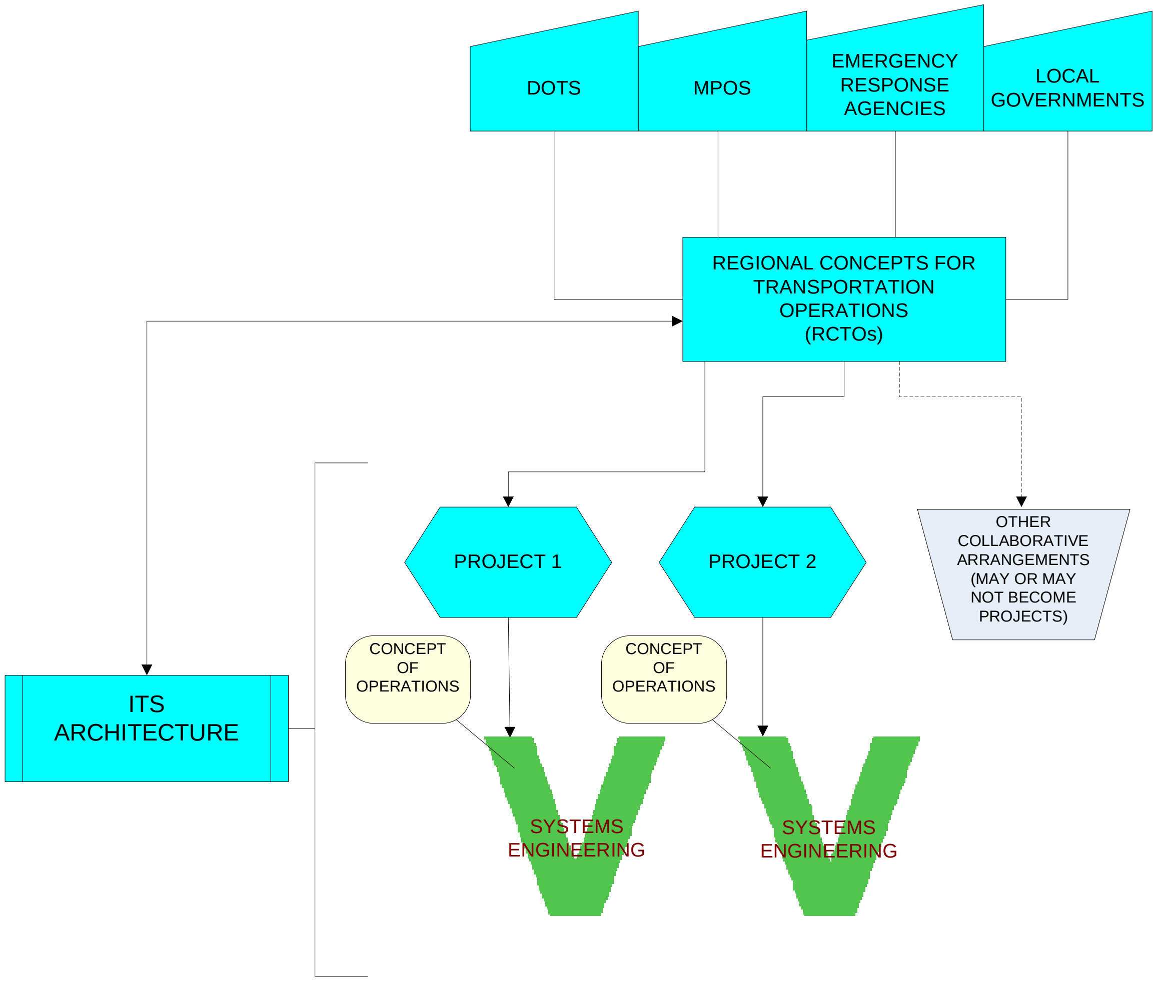

Figure 3.1 - Concept of Operations, ITS Architecture, and RCTO

This diagram shows how RCTOs, with input from regional stakeholders and ITS Architecture, can develop plans for regional operations leading to individual projects, each of which can be implemented using Systems Engineering guided by a Concept of Operations.

It is important to differentiate here between transportation documents with similar sounding names: Operational Concept, Regional Concept for Transportation Operations (RCTO), and Concept of Operations.

- In support of the Regional ITS Architecture described above, the **Operational Concept** describes the roles and responsibilities of regional stakeholders at a high-level. This is a generic description in the sense that it does not relate to a specific project or initiative within the region.

- A **Regional Concept for Transportation Operations (RCTO)** discusses the stakeholders' goals for regional operations and how to achieve those goals. This may or may not include ITS. The RCTO doesn't get down to the technical details of any particular system; although it may identify one or more needed regional projects.

- A **Concept of Operations** is associated with a single project/initiative that covers, not only roles and responsibilities on the project, but the overall environment in which the system(s) of the project will operate. It starts and guides development of a specific initiative.

The Maricopa Association of Governments Regional Concept for Transportation Operations is a good example of this "planning to project" progression (Maricopa is a County in Arizona, which includes the Phoenix Metropolitan region.) It is described in Figure 3.2 below:

Regional Example

Maricopa Association of Governments

Regional Concept of Transportation Operations

The MAG RCTO was the outcome of the ITS Strategic Plan Update for implementing ITS Architecture in the region. In shaping a regional vision, the Maricopa Association of Governments (MAG) Intelligent Transportation Systems (ITS) Committee considered several perspectives, including city, county, regional, state and federal, as well as transit and emergency services agencies. They began with the then current status of transportation operations and existing cooperative agreements in order to differentiate between regional and local functions. This generative approach enabled them to determine which functions "would provide greater benefit if approached at the regional level". They demonstrated needs, identified challenges, established goals (3 and 5 Year), and developed performance measures related to those goals. Eleven initiatives and their associated functions (action steps) were established in order to implement the goals. In our interview with the MAG ITS and Transportation Safety Program Manager, he stated: "These functions were the first steps in implementing specific programs, such as integrated signal optimization." The initiatives and functions are depicted in the graphic below:

Initiatives

Eleven **initiatives** are recommended as a framework of actions for the region to follow in pursuit of the stated vision of providing a safe, reliable, efficient and seamless surface transportation system. Through these initiatives, the goals established for the ten categories of regional operations can be achieved. Associated with each initiative are the **functions**, or action steps, to be carried out in executing the initiative. These functions are at the core of implementing the Regional Concept of Transportation Operations recommendations.

INITIATIVES		FUNCTIONS
REGIONAL TRAFFIC SIGNAL OPTIMIZATION PROGRAM	**Improved traffic signal timing within cities and across jurisdictional boundaries will result from better regional traffic engineering collaboration.**	▪ **Optimize agency traffic signal system operations.** ▪ **Optimize traffic signal operations of cross-border traffic signals and regional arterials.** ▪ **Develop regional pre-set traffic signal timing structure and criteria for traffic signal timing plan changes during incidents.**
ARTERIAL AND FREEWAY INCIDENT MANAGEMENT	**Improved incident management can be achieved with better collaboration of the fire and public safety personnel with the transportation departments.**	**Freeways** ▪ **Improve agency-specific incident management practices and guidelines to reduce incident clearance times.** ▪ **Schedule incident debriefing sessions after large incidents with representatives of public safety, fire departments, and applicable local transportation agencies.**

INITIATIVES		FUNCTIONS
ARTERIAL AND FREEWAY INCIDENT MANAGEMENT (CONTINUED)		▪ Improve the pre-qualified list of towing and recovery vehicles. ▪ Facilitate agreements between agencies to extract computer-aided-dispatch (CAD) information for travel information services and ADOT TOC. ▪ Facilitate improvement of practices for on-scene coordination and communication. ▪ Facilitate improvement of practices for placement of emergency vehicles at incident scenes. Arterials ▪ Implement and maintain a multi-jurisdictional Arterial Incident Management Program, based on results of feasibility study and pilot project. ▪ Facilitate agreements between agencies to extract CAD information for local traffic management centers.
SHARED MAINTENANCE RESOURCES	Improved system performance and significant cost savings to the region will result from sharing resources (staff and equipment).	▪ Improve preventive maintenance and prompt repair of locally owned ITS field devices and central systems. ▪ Improve preventive maintenance and prompt repair of regionally significant ITS field devices and central systems. ▪ Maintain regional communications infrastructure. ▪ Develop cost sharing agreements between agencies.
FREEWAY-ARTERIAL OPERATIONS	An emphasis and focus on improving the operations of the arterials and freeways at traffic interchanges can be beneficial in optimizing the operation of the freeways and arterials.	▪ Plan, deploy, operate and maintain a freeway-arterial corridor operations pilot project.
EMERGENCY VEHICLE SIGNAL PREEMPTION	Preemption on a regional basis will be more effective and safer with a common set of standards for its implementation.	▪ Develop regionally accepted standard for emergency vehicle signal preemption.
TRANSIT SIGNAL PRIORITY	The implementation of transit signal priority on a corridor will demonstrate the effectiveness of this concept for regional transit mobility.	▪ Plan, deploy, operate, maintain and evaluate a Transit Signal Priority pilot project.

INITIATIVES		FUNCTIONS
CENTER-TO-CENTER COMMUNICATIONS	Better communications between agencies.	▪ Establish center-to-center communications between agencies.
ARCHIVED DATA	Collecting and storing data from implemented transportation systems will be an excellent resource for the region in planning operational enhancements.	▪ Develop and implement a regional data archiving system.
LOCAL TMC AND ADOT TMC OPERATORS	The effectiveness of TMC operators will be improved with better coordination and communication between themselves.	▪ Develop and maintain a comprehensive personnel and logistics resource list. ▪ Develop practices for after-hours monitoring of local TMC systems and devices. ▪ Improve inter-agency communication between TMCs during incidents.
TRAVEL INFORMATION	Improved travel information in the MAG region will benefit the regional mobility.	▪ Make available work zone and incident information to HCRS and/or 511. ▪ Integrate transit information with travel information services (e.g., provide AVL data to 511). ▪ Develop practices for collecting information from arterial detectors. ▪ Post travel information/messages on freeway and arterial VMS. ▪ Market travel information services.
PERFORMANCE MEASUREMENT	The effectiveness of all the initiatives can be measured through a performance measurement program.	▪ Develop performance measurement program.

The MAG RCTO also contained an implementation strategy and Transportation Operations Guidelines, a tool to assist agencies in implementing the identified functions.

RCTO development involves the identification of the relationships, procedures, resource arrangements, and physical improvements needed to achieve and sustain the region's operations objectives. This may include identification of one or more specific projects. A Concept of Operations and the systems engineering process can then be used to develop the specific regional integration projects (called initiatives in this example).

Figure 3.2 - Maricopa Association of Governments Regional Concept of Transportation Operations

This figure describes how the MAG region performed regional transportation planning, resulting in a Regional Concept of Transportation Operations (RCTO), to be implemented with a shorter time horizon than Regional ITS Architecture. A table contains a list of identified initiatives with their associated functions. These functions can guide the creation of specific regional projects, for which a Concept of Operations can be developed.

3.3 THE IMPORTANCE OF A CONCEPT OF OPERATIONS FOR A REGIONAL INTEGRATION PROJECT

For the kinds of integration initiatives that might be considered necessary for a regional implementation (e.g., managing traffic for special events, enhancing response during emergencies, transit fare collection, signal system coordination), a shared set of expectations, defined by a Concept of Operations, is critical for building-in and maintaining system performance and reliability.

The systems engineering process becomes more difficult to perform when a project involves the integration of regional components. Given the challenges posed by such an undertaking, a thorough Concept of Operations is essential to provide structured, comprehensive guidance by:

- Identifying, and serving as a tool to engage the diverse array of stakeholders who will be impacted by the proposed regional integration.

- Identifying the users of the proposed system so that a description of user needs can be developed.

- Developing goals and objectives based on identified user needs and an agreed upon vision for the regional initiative.

- Revealing institutional barriers to collaboration and suggesting ways to surmount such obstacles.

- Describing the current infrastructure and institutional framework.

  "The description of the existing system provides an agreed context for system development. All of the participants need to understand the elements of all systems to be managed. As additional participants are added they will need this context for what they are building upon. The existing system description can probably be assembled, in large part, from existing planning documents and from the legacy systems description of the regional ITS architecture." (FHWA White Paper: Regional Concepts of Operations for Transportation System Management and Operations, Discussion Draft 2.1, February 6, 2003)

- Providing a comprehensive view of how the proposed system should function under expected conditions (scenarios).

- Describing the current operations within the region and describing how those operations will be affected by the proposed regional project.
- Differentiating between those functions and services that would provide greater benefit if approached at the regional level and those that should continue to be performed at the local level.
- Identifying the resources necessary to build, operate, and maintain the new system.
- Detailing the number and types of agreements needed to implement the proposed project.
- Defining the roles and responsibilities of the various agencies that will build, operate, and maintain the proposed system.

3.3.1 SUPPORTING HIGH-LEVEL FUNCTIONAL REQUIREMENTS

The Concept of Operations describes, in laymen's terms, the needs and expectations for a proposed system from the user viewpoint. It describes how the system will work once it’s built. This description should address current operations, needs not satisfied by the current system, the proposed system, context and scope of the proposed system, scenarios showing how the proposed system should operate under expected conditions, and resources required to build, operate, and maintain the new system.

This concept description should be adequate to support the next step in the systems engineering process, the development of high-level functional requirements. Functional Requirements spell out the capabilities of the system in greater detail, with a view toward design and implementation. It asks: "What needs to be done to implement the user-defined system that was described in the Concept of Operations?" It is important to note that the persons who develop the Concept of Operations are often not the same persons who develop the functional requirements. The latter will need to be able to *use* the Concept of Operations to specify requirements for the proposed system.

Providing a clear and complete statement of the needed capabilities of the system can be especially challenging for a project involving regional integration. Among these challenges are: 1) to provide an adequate description of desired capability so that no confusion could arise when developing requirements for interconnectivity among the various ITS elements; 2) to support the development of adequate data sharing capabilities between the cooperating jurisdictions; 3) to support the development of a security system which will prevent unauthorized users from getting access to the system; and 4) to ensure that cooperating jurisdictions have compatible equipment and software so as to make interconnections simple, faster and less costly.

By comprehensively describing the needs and expectations of users in the region, a Concept of Operations aids in the development of user requirements for a regional integration initiative and helps avoid costly changes much later in the development process.

3.4 CHALLENGES POSED BY A REGIONAL INTEGRATION INITIATIVE

Developing a project involving regional integration presents unique challenges because, as compared with a stand-alone TMC or a localized system, in a regional system there is:

- Greater difficulty in identifying and bringing together stakeholders, who represent diverse and sometimes competing interests.

  The Washington Metropolitan region will attempt to integrate existing transportation information and management systems in Virginia, Maryland, and the District of Columbia into a Regional Integrated Transportation Information System (RITIS). Their draft stakeholder description (See Figure 3.3 below) is a good example of the large number and diverse types of agencies that have an interest and stake in regional TMC operations:

Regional Example

Metropolitan Washington Regional ITS Architecture
Draft Stakeholder Description

Metropolitan Washington Regional ITS Architecture — **DRAFT** Stakeholder Description

Stakeholder Description

Stakeholder Name	Stakeholder Description
CapCOM	The Washington Metropolitan region will integrate existing transportation information and management systems in Virginia, Maryland, and the District of Columbia into a Regional Integrated Transportation Information System (RITIS) . CapCOM center will host the RITIS. RITIS collects data of regional interest and fuses these data into regional information that can be used to enhance regional traveler information and transportation management functions performed by member agencies. Member agencies include : FHWA, Metropolitan Washington Council of Governments (COG); Virginia DOT; Maryland State Highway Administration; DC Department of Public Works; Washington Metropolitan Area Transit Agency; Montgomery County Department of Public Works
DDOT	DDOT manages and maintains the majority of the roads, streets, bridges, traffic signals, and related transportation infrastructure within the District of Columbia. DDOT is responsible for the management and response to regional emergencies regarding streets and roadways in the District of Columbia. DDOT operates the DC Integrated Transportation Management System (ITMS).
District of Columbia Public Safety and Emergency Management	DC safety agencies represent the police, fire rescue and other emergency services provided by the DC.
Dulles Greenway	Greenway Center-Private Road Operation in Loudoun county
Event Promoters	These agencies include all the event planners and the major attractions in the Region.
Federal Agencies	Federal Agencies are major employment centers in the region.
General Public	The community or the people as a whole using the transportation system. The general public may be an automobile driver, transit passenger, computer, or cell-phone user obtaining travel information, or any other person interacting with the transportation system in the Region.
I-95 Corridor Coalition	The I-95 Corridor Coalition is an alliance of transportation agencies, toll authorities, and related organizations, including law enforcement, from the State of Maine to the State of Florida, with an affiliate member in Canada. The Coalition provides a forum for key decision and policy makers to address transportation management and operations issues of common interest.
Local Public Safety and Emergency Management	Regional county government operations are included within the Region. Departments typically participating in emergency management operations include county police, fire, EMS, 911, and emergency management agencies.
Local Signal Agencies	The City of Bowie, the City of College Park, Montgomery County, the City of Gaithersburg, the City of Greenbelt, the City of Takoma Park, Prince George's County, the City of Rockville, and Frederick County are local government members of the TPB in Maryland. The City of Alexandria, Arlington County, the City of Fairfax, Fairfax County, the City of Falls Church, Loudoun County, the City of Manassas, and Prince William County are local government members of the TPB in Virginia. These local jurisdictions own and maintain a variety of local roadways and streets, and in some cases provide local transit services.
Local Transit Agencies	Agencies operating public transportation services within the Region.
Maryland Public Safety and Emergency Management	MD safety agencies represent the police, fire rescue and other emergency services provided in MD.

Metropolitan Washington Regional ITS Architecture **DRAFT Stakeholder Description**

Stakeholder Name	*Stakeholder Description*
VDOT NOVA District	The Northern Virginia District (NOVA) of the Virginia Department of Transportation (VDOT) is comprised of VDOT owned and operated facilities located within the jurisdictions of Arlington, Fairfax, Loudoun and Prince William Counties; the Cities of Alexandria, Fairfax, Falls Church, Manassas, Manassas Park; and the Towns of Herndon, Clifton, Dumfries, Middleburg and Leesburg. The NOVA Smart Traffic Center operates the Interstate roadways in Northern Virginia. The NOVA Safety Service Patrol provides field incident management and motorist assistance on the Interstate roadways. The NOVA Smart Traffic Signal System operates traffic signals throughout Fairfax, Loudoun and Prince Williams Counties. Many jurisdictions located within the boundaries of the VDOT Northern Virginia (NOVA) District are responsible for operating and maintaining the secondary roadways and for providing emergency services within their borders. VDOT NOVA is also responsible for clearing state-maintained roads (snow removal), all cities, as well as Arlington County clear their own streets.
Virginia Department of Transportation (VDOT)	VDOT is responsible for building, maintaining, and operating state roads, bridges, and tunnels. VDOT owns and operates most major and local streets and roadways in the counties of Fairfax, Loudoun, and Prince William in the Washington metropolitan area, as well as major highways in Arlington County and the cities and towns in Northern Virginia (See separate entry for Virginia local jurisdictions). VDOT statewide systems include but not limit to statewide video sharing, electronic toll collection, archive data sharing, emergency management, and weather information, etc.
Virginia DMV	The Virginia Department of Motor Vehicles (DMV) is responsible for truck weigh stations and credentialing in the NOVA District.
Virginia Public Safety and Emergency Management	VA safety agencies represent the police, fire rescue and other emergency services.
Virginia Railway Express (VRE)	VRE is a transportation partnership of the Northern Virginia Transportation Commission (NVTC) and the Potomac and Rappahannock Transportation Commission (PRTC). VRE provides commuter rail service from the Northern Virginia suburbs to Alexandria, Crystal City, and downtown Washington, D.C., including Union Station and L'Enfant Plaza Station in Washington. Origin jurisdictions include Stafford County, Prince William County, and Fairfax County and the cities of Fredericksburg, Manassas, and Manassas Park.
Virginia State Police	Safety agencies represent the police, and other emergency services provided by the Virginia
Washington Metropolitan Area Transit Authority (WMATA)	WMATA operates the MetroRail transit system (subway) and much of bus network in the Washington DC metropolitan area and MetroAccess, the ADA paratransit program for the Washington D.C. Metropolitan area. WMATA also manages and maintains (including snow removal): parking facilities associated with rail stations, rail maintenance yards, bus garages and bus maintenance facilities. WMATA right-of-way supports fiber optic infrastructure for WMATA and area venderss as well as radio transmission faculities for WMATA and the region. As a regional compact agency, WMATA plays a leading role coordination transit in the region including regional fare payment system, incident and energency management, special event and local transit providers.

Figure 3.3 - Metropolitan Washington Regional ITS Architecture Draft Stakeholder Description

This figure lists and describes the various stakeholders for the Regional Integrated Transportation Information System (RITIS) for the Washington, D.C. metropolitan region.

- A more complex process for forging essential agreements.

  National Cooperative Highway Research Program, Synthesis 337, Cooperative Agreements for Corridor Management reported on a survey of 22 transportation agencies in its study of cross-jurisdictional agreements. This quote from the summary of this report gives a flavor of the difficulties posed in creating, maintaining, and implementing such agreements:

> "A variety of institutional, political, economic, and interpersonal factors were identified as potentially derailing the agreement process or causing an agreement to be unsuccessful. Institutional factors included bureaucratic resistance to long-term commitments, agency reluctance to assume a leadership or mediation role, and lack of internal cooperation across divisions. Political factors included turnover of elected officials, reluctance to adhere to prior commitments, intergovernmental competition, perceived inequity in the allocation of responsibilities and resources, growth/no-growth politics, or anti-government attitudes. A general lack of trust, personality conflicts, or even controversy over unrelated community issues can destabilize support for the agreement."

- A greater need for communication, while communication is usually more difficult to establish and maintain

  An ITS Transportation Safety Program Manager spoke to this issue when we interviewed him in conjunction with preparing this guide: "Issues are arising now around the establishment of center-to-center communication. Because of liability issues, some jurisdictions do not want to give access to video camera recordings; they are much more willing to share maintenance resources."

- A greater need for the coordination of management and control (interoperability) of the system, which is made more difficult by inter-jurisdictional institutional barriers.

  Figure 3.4 displays an excerpt from a brochure entitled, *When They Can't Talk, Lives are Lost: What Public Officials Need to Know about Interoperability* (February 2003), prepared through the collaboration of numerous Public Safety/Emergency Services stakeholders. This excerpt addresses the issue of barriers to interoperability across jurisdictions.

Regional Example

**When They Can't Talk, Lives are Lost:
What Public Officials Need to Know about Interoperability**

"Imagine a different public safety communications future. A future where emergency responses are coordinated, where information is shared in real time, where precious minutes are not wasted, and where emergencies are handled more effectively and safely."

Judi Wood, Chief Information Officer, Maryland Department of Public Safety and Correctional Services

Why Aren't Public Safety Communications Already Interoperable?

Five key reasons. Incompatible and aging communications equipment, limited and fragmented funding, limited and fragmented planning, a lack of cooperation and coordination, and limited and fragmented radio spectrum.

- Different jurisdictions use different equipment and different radio frequencies that cannot communicate with one another, just as different computer operating systems will not work together or an AM receiver will not accept an FM signal. There are limited uniform standards for technology and equipment.
- There is limited funding to replace or update expensive communications equipment, and different communities and levels of government have their own budget cycles and funding priorities.
- Planning is limited and fragmented. Without adequate planning, time and money can be wasted and end results can be disappointing. Agencies,

jurisdictions, and levels of government compete for scarce dollars, inhibiting the partnership and leadership required to develop interoperability.

- The human factor is a substantial obstacle—agencies are reluctant to give up management and control of their communications systems. Interoperability requires a certain amount of shared management, control, and policies and procedures.

This is a job that requires policy-makers across jurisdictions to work together for the common good—to plan, fund, build, and govern interoperable public safety communications systems.

- There is a limited and fragmented amount of radio spectrum available to public safety.

What Is Radio Spectrum?

It is electronic real estate—the complete range of frequencies and channels that can be used for radio communications. Spectrum is the highway over which voice, data, and image communications travel. Radio spectrum, one of our Nation's most valuable resources, is a finite resource—what exists today is all there ever will be.

Figure 3.4- When They Can't Talk, Lives are Lost: What Public Officials Need to Know about Interoperability

A brochure is displayed which discusses five barriers to interoperability of communications components in Public Safety/Emergency Services operations: Incompatible and aging communications equipment, limited and fragmented funding, limited and fragmented planning, a lack of cooperation and coordination, and limited and fragmented radio spectrum.

- Greater technical complexity in the proposed integration, making it difficult to present and therefore "sell" to stakeholders and the public.

  The *National Cooperative Highway Research Program, Synthesis 337, Cooperative Agreements for Corridor Management* report, alluded to above, queried agencies about difficulties with corridor management agreements. Fifty-four percent "cited a lack of local government understanding of corridor management". Also, 23% cited the need for technical assistance as a problem in implementing specific elements of such agreements.

- Greater difficulty in securing funding for the building, operation and maintenance of the proposed system

  The Kentucky Transportation Center's *Intelligent Transportation Systems Strategic Plan* (Figure 3.5) places significant emphasis on an ITS operations and maintenance plan (O&M) and lists specific challenges:

Regional Example

University of Kentucky

Kentucky Transportation Center

Intelligent Transportation Systems Strategic Plan

8.0 ITS OPERATIONS AND MAINTENANCE

To date, much of the emphasis regarding ITS within the Federal Government and state agencies has been focused on developing and deploying systems. In most cases, very little emphasis has been given to proper operation and maintenance (O&M) of those systems once they are deployed. ITS technologies present some significant O&M challenges to traditional transportation agencies. Some specific challenges are listed here:

- Operating advanced systems requires a high level of integration among existing systems and agencies.
- Deployment of new systems places an additional burden on existing operations and maintenance personnel, who already have responsibilities and may already be overloaded. These personnel must then deal with conflicting priorities.
- When new systems are deployed, it is not always clear who is to have responsibility for operating and maintaining them.
- Operating advanced systems requires new skills and capabilities, which may not exist in a traditional transportation agency. This creates a need to train existing personnel and/or add new personnel.
- Maintaining ITS technologies requires a high degree of technical proficiency, with specialized skills and expertise. Again, this necessitates training of existing personnel and/or hiring new personnel.
- Deployment of non-standard devices and systems can create an operations and maintenance headache, with non-standard interfaces, additional training requirements, and excessive spare parts requirements.

With these challenges in mind, it is important that every new ITS project include full consideration of how the system will be operated and maintained. This would include a clear assignment of responsibility, delineation of training requirements, selection of a maintenance approach (in-house, contract, etc.), and any standardization requirements. These considerations should be brought in at the earliest stages of planning the project, and should continue to be included throughout all stages of the project development.

In addition to including O&M considerations in project planning and development, the Transportation Cabinet should develop an ITS Maintenance Plan. This plan would be developed with heavy stakeholder involvement, and would lay out the Cabinet's strategy for effectively and efficiently maintaining all of its ITS deployments. At least one other state (Oregon) has developed an ITS Maintenance Plan, and several metropolitan areas have developed maintenance models. The work of these agencies could be used as a model or a starting point for the Kentucky plan.

Figure 3.5 - Kentucky Transportation Center's Intelligent Transportation Systems Strategic Plan

Section 8.0 of this document is displayed. It outlines Operations and Maintenance challenges involved in deploying ITS systems.

The use of Systems Engineering is essential to the surmounting of these obstacles and to the successful implementation of a regional initiative.

3.5 CHAPTER SUMMARY

This chapter described the context wherein regional transportation projects emerge and the relationship between planning activities and a Concept of Operations for a regional initiative. It discussed the necessity of developing a Concept of Operations, as part of the systems engineering process, for a regional integration project and addressed the challenges posed by the demands inherent in such a project.

3.6 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

- Mark Thomas, Regional ITS Architecture for Northern Eastern Illinois, Project Summary, Spring 2003

- National ITS Architecture Version 5.1, U.S. Department of Transportation

http://www.iteris.com/itsarch/

- Regional Transportation Operations Collaboration and Coordination: A Primer for Working Together to Improve Transportation Safety, Reliability, and Security, Federal Highway Administration and the U.S. Department of Transportation. Dec 2002

- Maricopa Association of Governments. “Regional Concepts of Final Operations: Final Report.” November 2003

http://www.mag.maricopa.gov/pdf/cms.resource/RCTO-Final_Report79101.pdf

- FHWA White Paper: Regional Concepts of Operations for Transportation System Management and Operations, Discussion Draft 2.1, February 6, 2003

- Metropolitan Washington Regional ITS Architecture Draft Stakeholder Description

http://www.mwcog.org/uploads/committee-documents/t1xYV1k20050406154100.pdf

- Cooperative Agreements for Corridor Management, NCHRP Synthesis Report 337, 2004

http://www.accessmanagement.gov/pdf/nchrp_syn_337.pdf

- When They Can't Talk, Lives are Lost: What Public Officials Need to Know about Interoperability (February 2003), prepared through the collaboration of the following organizations: Association of Public Safety Communications, Officials International, Inc., International Association of Chiefs of Police, International Association of Fire Chiefs, International City/County Management Association, Major Cities Chiefs, Major County Sheriffs’ Association, National Association of

Counties, National Association of State Chief Information Officers, National Association of State Telecommunications Directors, National Conference of State Legislatures, National Criminal Justice Association, National Emergency Management Association, National Governors Association, National League of Cities, National Public Safety Telecommunications Council, National Sheriffs' Association, The Council of State Governments, The United States Conference of Mayors
http://www.dhs.alabama.gov/PDFs/cannot_talk.pdf

- Kentucky Transportation Center, College of Engineering, University of Kentucky. "Intelligent Transportation Systems Strategic Plan." June 2000
http://www.ktc.uky.edu/Reports/KTC_00_05_SPR188_98_1F.pdf

4 Concept of Operations Defined for the Regional Initiative

This chapter provides a description of the elements that compose a Concept of Operations, using examples from regional integration initiatives. It references Chapter 3 of the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems*, which provides an in-depth description of each element of the Concept of Operations.

4.1 CHAPTER OVERVIEW

The purpose of this chapter is to define a Concept of Operations – using examples from regional initiatives. Its objectives are:

- To define a Concept of Operations for a regional integration project.
- To demonstrate the core elements of the Concept of Operations using transportation examples from integrated regional systems.

4.1.1 Relationship to Previous Chapter:

Chapter 3 discussed the *role* of a Concept of Operations in using the systems engineering process to implement a regional initiative. This chapter now *defines* a Concept of Operations for a regional integration project, by using regional examples. It provides more specificity in terms of the Concept of Operations itself.

4.1.2 Chapter Sections

- Concept Of Operations Defined
- Core Elements Of A Concept Of Operations: Regional Examples
- Chapter Summary
- Specific Literature Supporting This Chapter

4.2 CONCEPT OF OPERATIONS DEFINED

A Concept of Operations is a process and a document (or group of documents) that describes the users' vision of the to-be-delivered system, highlighting the current and proposed interfaces, organizational elements, and needed resources. It is: "A mechanism for documenting a system's characteristics and the user's operational needs in a manner that can be verified by the user without requiring any technical knowledge beyond that required to perform normal job functions." (*IEEE 1362-1998 Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document*. New York: IEEE, 1998.) As such, is it serves as a bridge between the users' needs and the developer's technical specifications.

The Concept of Operations definition is the same for a regional integration project as it is for a local TMC development project. "No definition of 'system' states what size a system has to be. In fact, the parts of a system can themselves be systems. When we describe an ITS system, we are generally describing a 'system of systems'. Where you draw the *boundaries* of a system determines what its components are. However, the wider you draw the boundaries, the more complex the interactions of the system's parts become." (Gonzalez, Paul J. *Building Quality Intelligent Transportation Systems Through Systems Engineering*. Report No FHWA-OP-02-046. April 2002)

It is a regional integration project's *size* and *complexity of interactions* that differentiates it from a local initiative and guides the Concept of Operations development and use strategy. There are various kinds of regional initiatives for which a Concept of Operations could be developed: a regional TMC; multiple system integration; enhancement of an existing regional system. The kind and scope of the integration project will determine its level of complexity and therefore influence the Concept of Operations development process. The scope of an integration project could involve multiple TMCs, multiple states, multiple counties, a large metropolitan area, multiple corridors, multiple systems; all with a multitude of ITS component interconnects and information flows. The project might require authorization for inter-jurisdictional interoperability of communications and other equipment, multiple funding sources, and support and "buy in" from a wide variety of stakeholders.

For example, the Indiana Department of Transportation's *TrafficWise* is a statewide ITS project that integrates numerous system capabilities over a wide area, including multiple metropolitan areas: "TrafficWise is the intelligent transportation system for the State of Indiana, whose mission is to make driving easier and safer for motorists in Indiana, especially in highly traveled metropolitan areas. Operated from traffic management centers (TMC) located in Gary and Indianapolis, TrafficWise encompasses the traffic monitoring, incident detection and response, and traveler information functions of INDOT. The TrafficWise system consists of vehicle sensors and cameras to monitor traffic and detect incidents, dynamic message signs and highway advisory radio to alert motorists of current travel conditions, a real-time interactive website to provide pretrip traffic information, and communications infrastructure to link all of these systems to the traffic management centers where system data is collected and disseminated." (Indianapolis Metropolitan Planning Area Regional Intelligent Transportation System Architecture, *Inventory of Existing Documentation*, *Final Appendix A*, Prepared By Edwards and Kelcey for the Indianapolis Metropolitan Planning Organization, June 2005)

Regardless of the size and complexity of the proposed system, the major goals of a Concept of Operations remain the same and are worth repeating. The goals, as outlined in the companion document, *Developing and Using a Concept of Operations in Transportation Management Systems Handbook,* are listed below:

- Stakeholder Identification and Communication. A major goal of a Concept of Operations document is to facilitate discussion, and eventually find middle ground, among the relevant groups associated with system design, development, and operation.

- High-level System Definition. All stakeholders must understand, at a high-level, what the system is being designed to do. This will include the major entities within the system, the flows of information among those entities, the information flow to any entity external to the system, the high-level capabilities of the system, and the main daily operational occurrences for the system.

- Foundation for Lower-level System Description. The Concept of Operations is a starting point for the lower-level description of the system, beginning with a requirements document. Although the Concept of Operations is not a requirements document, a well-formed Concept of Operations will be a source of information that can be decomposed into a first cut of high-level functional requirements.

- Definition of Major User Classes and User Activities. All stakeholders are made aware of the different types of users of the system and activities those users will perform. This allows everyone who uses the document to get an idea of who is performing what task and in what order they are performing those tasks. This information can then be linked to the high-level capabilities of the system for traceability purposes (i.e. who is doing what activity, and which high-level capability is this activity supporting?)

The attainment of these goals is crucial to the guidance of the comprehensive requirements analysis needed to support design of the regional project. However, it is not *necessary* that the guidance be embodied within a single document called "Concept of Operations". It may be contained in separate documents that deal with various aspects of the system. What is important is that the relevant information is readily available and accessible to users, stakeholders, and developers and that it provide a solid foundation for supporting other systems engineering stages. While the statement above is generally true, the *ideal* practice for a regional initiative, because of the volume and complexity of the information required, is that it be contained in a single document, which can be easily referenced and shared among various interested parties so that everyone can be certain that they are on the "same page".

4.3 CORE ELEMENTS OF A CONCEPT OF OPERATIONS: REGIONAL EXAMPLES

This section describes the basic components of a Concept of Operations. In order to illustrate the scalability of the definition, we provide a regional example for each of the core elements. The core elements are based on the ANSI/AIAA G-043-1992 standard as referenced in the companion guide, *Developing and Using the Concept of Operations in Transportation Management Systems*, and are as follows:

4.3.1 Scope

Similar to an executive summary, this subsection will outline the contents of the document, discuss the purpose for implementing the system, highlight major objectives and goals, identify the intended audience, describe the boundaries of the system, and describe an overarching vision for the system.

Kansas DOT developed a Concept of Operations for a statewide Transportation Operations and Management Center (Kansas DOT Bureau of Transportation Planning and PB Farradyne and Olsson Associates: *Transportation Operations and Management Center Concept of Operations*). Sections 1.1-1.7 of that document serve as a good example of the Scope element. It is presented in Figure 4.1 below.

Regional Example

Kansas Statewide Transportation Operations & Management Center Study

Transportation Operations and Management Center

Concept of Operations

1.1 Document Organization

The Kansas Statewide TOMC Concept of Operations document is divided up into several sections that describe and explain the reasoning behind the TOMC concept. The sections in this document are arranged as follows:

Section 1 – Introduction
The introduction section provides an executive summary of the concept of operations, the vision, goals, and objectives of the study.

Section 2 – Referenced Documents, Operations Centers, and Other Systems
Section 2 identifies key related documents to the study and other systems and operation center models that have been referenced during the study.

Section 3 – User Oriented Operational Description
Section 3 describes the users of the system and what operational functions they perform along with how they interact with other users.

Section 4 – Operational Needs
Section 4 details agency and region specific goals and objectives that will drive the requirements for the TOMC. It describes what is necessary for KDOT to complement and improve the existing transportation operations and maintenance through a TOMC.

Kansas Department of Transportation

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1.2 Purpose of the TOMC Concept of Operations

The purpose of the Concept of Operations is to provide an operational, high-level description of how a Statewide TOMC concept could impact transportation operations in Kansas. The concept identifies the functionality of a TOMC, the major users and stakeholders in a TOMC, how a TOMC can impact them, how information will be communicated between them, what the roles of other users are, and how a TOMC impacts those other users.

The very generic purpose of the Concept of Operations is to communicate an idea to multiple stakeholders in the most basic terms so that all have a clear common understanding of what they are trying to achieve. The Concept of Operations defines the business needs of the TOMC. From the Concept of Operations, functional requirements of the TOMC will be developed. The purpose of the functional requirements is to clearly define what the TOMC will do and what capabilities it must have in order to meet the business needs of the users. The Concept of Operations does not define all of the system capabilities, hardware requirements, information flows, or communication requirements. That is part of the detailed design and takes place later in the System Engineering process.

After system implementation, the Concept of Operations can be referred back to as a way of verifying that the system design met the desired functionality expressed by users and stakeholders at the beginning of the System Engineering process.

1.3 Audience for the TOMC Concept of Operations

The audience for this document includes the following stakeholders:

- Kansas Department of Transportation
- Kansas Highway Patrol

Kansas Department of Transportation

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- Kansas National Guard Adjutant General's Office
- Kansas Emergency Management
- Local Emergency Management Offices
- Federal Highway and Motor Carrier Safety Administrations
- Kansas Motor Carrier Association
- Kansas Turnpike Authority
- Kansas City Scout
- Other States
- Major Metropolitan Areas in Kansas
- Local Public Safety Agencies
- Local Public Works Agencies

1.4 TOMC Vision

Statewide ITS Vision: The overall vision for ITS in Kansas is that ITS will be an open, integrated and cost effective system that is safe and efficient to assist movement of people and goods across Kansas through the use of advanced technologies and management strategies.

Kansas Statewide TOMC Vision: With minimal impact on State of Kansas human resources and organizational structure, improve statewide operations capabilities to support interagency communication and cooperation for incident and emergency response and to support the State's mission to provide a statewide transportation system to meet the needs of Kansas.

1.5 TOMC Goals and Objectives

The purpose of a Statewide TOMC is to create an environment within Kansas that will allow for immediate and real-time transportation system operation from both the local level and a statewide level. This environment will allow for faster response to emergencies and weather related incidents and provide better quality and timelier traveler information to the users of the transportation network in Kansas.

More specifically, the Statewide TOMC will meet the following needs:

- Need 1 – Improve Incoming Communication With KDOT
- Need 2 – Improve Traveler Information Collection
- Need 3 – Improve Traveler Information Distribution
- Need 4 – Improve the Effectiveness of KDOT Operations

Kansas Department of Transportation

1.6 TOMC Functions

Stakeholders identified fifteen unique functions that should be supported or managed through the TOMC. The functions support the overall KDOT vision for ITS in general and for a TOMC. The functions also support the TOMC goals. These functions are:

- Function 1 – Operate ITS Field Devices
- Function 2 – Backup Urban TOCs
- Function 3 – Respond to Other Agencies
- Function 4 – Use External Information Service Providers
- Function 5 – Archive Transportation Data
- Function 6 – Track Permitted (OS/OW, HazMat) Trucking
- Function 7 – Share Information with Other States
- Function 8 – Manage Evacuation and Major Route Detour Traffic
- Function 9 – Collect Road Condition Information
- Function 10 – Coordinate between KDOT Districts
- Function 11 – Notify KDOT Personnel
- Function 12 – Provide Flood Warning
- Function 13 – Manage KDOT Emergency Assets
- Function 14 – Provide Travel Times
- Function 15 – Provide KDOT Resource Arrival Timeframes

1.7 TOMC Scope Boundaries

The boundaries of the TOMC are defined by the users and stakeholders who are involved in or affected by its operation. Some of these users will be an integral part of the TOMC operation while others will be external interfaces to the TOMC, which is both a receiver and transmitter of data and information with these external stakeholders.

The internal boundaries of the TOMC include the following agencies:

- Kansas Department of Transportation (KDOT)
- Kansas Highway Patrol (KHP)
- Kansas Emergency Management Agency (KEM) (including the Kansas National Guard)

The external boundaries include:

- Broadcast and Print Media
- Non-Commercial Transportation System Users
- Kansas Motor Carrier Administration
- Commercial Freight Haulers
- Adjacent States
- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- Kansas Cities and Counties
- Local 911 Centers
- Fire and Police Departments, Emergency Services
- Traveler Information Services

Kansas Department of Transportation

Figure 4.1 - Kansas DOT Transportation Operations and Management Center Concept of Operations

This figure shows Sections 1.1 - 1.7 of the Concept of Operations, which outlines the contents of the document, discusses the purpose for implementing the system, , identifies the intended audience, describes an overarching vision for the system, highlights major objectives and goals, and describes the boundaries of the system.

4.3.2 Referenced Documents

In order to develop a Concept of Operations, it is important to review and reference related documents. This section can be used to clarify the sources of information that went into the document as well as pointing the reader to additional information. The kinds of documents used include planning documents, reports, meeting minutes, concepts of operations and requirements documents (especially from the systems being integrated), and studies of operational needs. Resources might include consultation with systems experts and key personnel throughout the region, legal analysts, and elected officials

The example depicted in Figure 4.2 is from the iFlorida Draft Concept of Operations, which served as a Concept of Operations for a number of specific statewide projects related to the deployment of information infrastructure. (Florida Department of Transportation: Surface Transportation Security and Reliability Information System Model Deployment (iFlorida) *Draft Concept of Operations*, July 25, 2003)

Regional Example

Surface Transportation Security and Reliability
Information System Model Deployment

iFlorida

Draft Concept of Operations

2.0 Referenced Documents

Documents have been utilized in the development of the ConOps document include:

- iFlorida Final Work Plan, Version 1.0, PBS&J, June 2003
- Functional Requirements, iFlorida – Statewide and Central Florida Conditions System, FDOT, August 2003.
- Design and Implementation of the Central Florida Data Warehouse (CFDW) – Year 1: The TCSP Funding, UCF, October 2002.
- Design and Implementation of the Central Florida Data Warehouse (CFDW) – Year 1: The TCSP Funding, Approved Revision 6.0, UCF, May 2003.
- iFlorida Field Components Specification, PBS&J, June 2003.
- Scope of Work – Weather Forecasting by Road Segment, Meteorlogix, Version 2.3, FDOT, July 2003.
- Scope of Work – Security Command and Control, Boeing Autometric, FDOT, July 2003.
- iFlorida Conditions System Functional requirements Meeting Summary. PBS&J, July 9, 2003.
- Conditions System ITN Concept Meeting #2 Presentation, PBS&J, July 16, 2003.

In addition, information from several interviews with stakeholders and a site visit to the RTMC was utilized in the development of the ConOps. The information contained in this document has been reviewed and confirmed in a workshop environment with the iFlorida Stakeholders on July 23, 2003.

Figure 4. 2 - iFlorida Draft Concept of Operations

This figure presents Section 2 of the Draft Concept of Operations, which lists the referenced documents and other resources (interviews with transportation professionals and site visit).

4.3.3 User-Oriented Operational Description

This subsection describes the intended system operation from a user's vantage point. It is also important to note how organization/system-specific goals and objectives are accomplished: strategies, tactics, policies, and constraints. Emphasis must be placed on who the users are and what the users do.

Figure 4.3 presents an excerpt from Next Generation 9-1-1 System Preliminary Concept of Operations. The *Next Generation 9-1-1 Initiative* is a US DOT research and development project with a multistate (nationwide) scope.

Regional Example

Next Generation 9-1-1 System

Preliminary Concept of Operations

2 User Oriented Operational Description

2.1 *Operational Overview*

The mission of PSAPs remains the same within an NG9-1-1 system – to receive emergency calls from the public, ascertain the nature, status and location of the emergency, and relay the call to the appropriate public safety dispatch center for response to the emergency. The call-related expectations of the PSAPs also remain the same – "calls" should be delivered to the proper PSAP within the seconds typical at many locations in the U.S. and arrive in formats that can be readily processed.

NG9-1-1 changes the core capabilities of emergency services in three areas – (1) types of calls received; (2) ability to transfer/receive calls from PSAPs outside the local region; and (3) capability to accept additional information designed to facilitate emergency services. These are expansions of current functions, not fundamentally new roles. Presently, most PSAPs can receive wireless and wire line 9-1-1 voice calls and TDD/TTY text calls and can transfer these calls to a limited number of local/regional alternate PSAPs and dispatch centers. However, there are notable differences among PSAPs on the information that can be accepted and processed with a call. For example, as of late 2005, more than 50% of counties in the United States cannot receive the location of a wireless 9-1-1 call in their PSAPs.

These changes in core capabilities will have operational implications. Some changes in operational processes and procedures will be necessary for handling the new types of

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calls and data; for working with other emergency services organizations; and purchasing, maintaining and managing new technology systems. The present local/regional government framework for PSAP and public safety communications operations will likely continue. However, the new technical capabilities (e.g. remote call acceptance and transfer) remove some of the geographic constraints on current PSAP facility location. Conversely, these new technologies require that PSAP and emergency services personnel develop new and extended working relationships with diverse and unfamiliar agencies and organizations.

Although some aspects of PSAP call taking will change, it is unclear what the impact will be on call taker[8] workload. The growth of the wireless phone market in the mid 1990s led to an increase in 9-1-1 call volume. This was primarily due to the phenomena of multiple calls for some types of emergencies. For example, it is not unusual for a PSAP to receive 50 or more calls for a single motor vehicle crash. Although NG9-1-1 will permit many more ways to call 9-1-1, this will not necessarily result in more calls per emergency in the United States beyond what would already occur due to virtual ubiquity of landline and wireless phones. In this context, NG9-1-1 may foster a replacement of some calls from one communication medium to another medium.

The current financing paradigm for the 9-1-1 system operations will likely prove inadequate in the future. Surcharges, fees and taxes on telephone equipment and services fund a significant portion of the capital and operating costs for today's 9-1-1 system. Traditional landline telephone services are being replaced by wireless and VoIP services.[9] Consequently, the corresponding revenue stream for the 9-1-1 system is expected to decline. Moreover, there is reason to believe that telephony will eventually be a "free" application available to Internet users along with email, instant messaging, and other communications applications.[10] This would further undermine the telephone-dependency for 9-1-1 funding.

While new revenue sources will be needed in the future, the good news is that costs for 9-1-1 equipment and operations should drop due to the lower costs for IP-based equipment and infrastructure. The Federal Communications Commission's (FCC) Seventh Network Reliability and Interoperability Council (NRIC VII)[11] concluded that "[w]e believe there are significant cost savings to be achieved in mortality, morbidity,

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[8] "Telecommunicator" and "communications officer" are other terms for these PSAP professionals.

[9] ACA International reports that 6 percent of U.S. households have replaced landline telephone service with wireless service (http://www.acainternational.org/?cid=6488). According to FCC, household telephone subscribership has declined by 3.1% from March 2003 to March 2005 (http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-258942A2.pdf).

[10] September 2005, *The Economist* , http://www.economist.com/displaystory.cfm?story_id=4400704

[11] NRIC VII, a designated federal advisory committee, has been specifically asked to address the "future dependence of emergency communications networks on IP networks, and in particular, whether IP technologies should be used to get information to and from the PSAPs as communications networks continue to evolve."

and operations from this new internetwork and the new services it will enable, but a significant initial investment is required."[12]

2.2 Primary System Users and Operational Processes

The quintessential operational processes for 9-1-1 will continue within the NG9-1-1 system. The general public, PSAP call takers, public safety dispatchers, and first responders will remain as the primary users of the 9-1-1 system. However, NG9-1-1 will accept a broader range of public users. The person requesting help will no longer be limited to a telephone or TTY/TDD and may use multiple communications media in a single "call." Third party service providers, such as telematics, medical alert, central alarm monitoring, N-1-1 services, and relay services, will now have direct access into the 9-1-1 system. Ultimately, "the users of the network will be any and all organizations that improve the safety of the public by being able to exchange information in emergencies."[13] This will include the police, fire, and EMS first responders but also secondary responders such as public works agencies, towing companies, and HAZMAT remediation teams.

The table 2-1 lists the key operational capabilities of the NG9-1-1 system compared to the current system for the primary users and the implications for new procedures.

Table 2-1. Key Operational Capabilities of the NG9-1-1 System

User	Current Capabilities	Key Changes	New Process and Procedural Issues
General Public	• Call local 9-1-1 directly via telephone, cell phone, TTY/TDD, possibly VoIP • Call PSAP indirectly (not using the 9-1-1 system) via 3rd party emergency or relay service via a broader range of communication options • Deliver location and callback number, with various restrictions	• More viable options for communicating directly with PSAPs • More capabilities for delivering data beyond location and callback. • Direct support of 3rd party originated 9-1-1 calls • More options for receiving up-to-date information, warnings and/or instructions on large-scale events. • Greater ability to get through to someone who can help in disaster or other mass calling situations	• Understanding/knowing if device/service is E9-1-1 capable. • Understanding/knowing qualitative differences in E9-1-1 capabilities (e.g., E9-1-1 via residential wire line provides more reliable location than cell phone from inside building) • Universal access code/symbol for emergency access from all (or most) devices. "9-1-1" is not the telephone access code used by most countries. • New ways to obtain, represent and convey location • New ways to route a call given location • New ways to obtain information related to the location, call, caller • Security-related factors (certification; authentication), threats (e.g., denial of service attacks), and potentially differing impacts on citizen access depending on access service. • Privacy issues.
PSAP Call takers	• Receive local E9-1-1 calls from telephone, cell phone, TDD/TTY, possibly VoIP users • Voice, TTY/TDD text and location data are the only accessible information sources from callers. • Transfer 9-1-1 call to/from a limited number of local PSAPs • Handoff a 9-1-1 call to a limited number of local public safety dispatch entities	• Increased number of viable methods for receiving E9-1-1 calls (= more accessible to the public) • More data available in addition to location. • Capability for transferring calls to/from any emergency service entity, independent of geographic location.	• Receiving, switching, logging, etc. voice, video and text media streams • Displaying, acting on and forwarding new kinds of data • Training, policies and procedural issues for "long distance" 9-1-1 activities. • Confidentiality issues. • Network security issues
3rd Party Service Providers	• Receive voice, text, data, images and video via full range of communication options • Relay emergency service request to PSAP via 10-digit administrative lines, not as "native" 9-1-1 calls.	• Expect s more appropriate remote transfer capabilities as PSAP-PSAP (e.g. call delivery through the emergency services internetwork). • Ability to originate 9-1-1 calls on behalf of client, with routing based on location of client • Ability to supply additional data related to location, call, client • Ability to have automatic conference with CSR, Call taker and client	• Certification, authentication, and other requirements for access to Public Safety Network(s).
Public Safety Dispatchers	• Dispatchers can receive call, ALI/ANI data, and supplemental text provided by PSAP call taker. • Depending on CAD/RMS capabilities, can access and integrate additional data relevant to particular emergency. • Key information relayed to responders verbally. Depending on mobile capabilities, some data can be transferred to responders.	• Additional data or links to relevant data resources will be included with all "calls."	• Information triage issues – overload issue. • More devices to create "abandoned" calls. • Training, policies and procedural issues.
First Responders	• Typically receive voice instructions from dispatcher via radio • Increasing, MDTs in vehicles can receive and access additional data beyond the 9-1-1 call information	• Additional data or links to relevant data resources may be included via MDTs and other wireless devices. • Improved "mobility" = improved response times (acknowledgement to transport) • Improved access to up-to-date information on events. • Multimedia stream access (e.g. surveillance video)	• Information triage issues – overload issue. • Confidentiality issues. • Network security restrictions • Training, policies and procedural issues • Privacy issues (transport/3rd party access)
Secondary Responders	• Typically, government and private secondary responders (e.g., public works, transportation, towing and recovery) are notified by public safety dispatchers via telephone • Electronic notification and sharing of some incident data is operational in a few locations	• Additional data or links to relevant data resources may be included in electronic notifications. • More integration into public safety incident networks • Improved "mobility" = improved response times (acknowledgement to transport) • Improved access to up-to-date information on events.	• Information triage issues – overload issue. • Confidentiality issues ("need to know" issues) • Network security issues • Training, policies and procedural issues • Privacy issues (transport/3rd party access

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Figure 4. 3 - Next Generation 9-1-1 System Preliminary Concept of Operations

This figure is an excerpt from Section 2 User Oriented Operational Description of the Preliminary Concept of Operations, which describes an overview of operational changes proposed for the new system and discusses the implications for the various users.

4.3.4 Operational Needs

This subsection addresses the question of what is required by the region that the existing systems and services do not provide. This implies a description of the process for identifying these requirements and for establishing their relationship to the current operational environment.

The Concept of Operations and Action Plan, prepared by the Western Transportation Institute for Modoc County Transportation Commission (California), addresses Operational Needs for a rural, multi-county project that will include the implementation of trip-planning technology and the creation of a Mobility Management Center (MMC) "that would provide a 'one stop shop' for transportation information within the given region". This is shown in Figure 4.4.

Please note that a scenario style was employed here to illustrate a shortcoming of the *current* system. Later we will discuss the use of scenarios as a Core Element that describes the operation of the *proposed* system under expected conditions.

Regional Example

Western Transportation Institute
College of Engineering
Montana State University – Bozeman

Rural California Transportation
Coordination and Technology Plan

Concept of Operations and Action Plan

2. CURRENT SITUATION AND NEED FOR CHANGE

This section focuses on the current transportation situation in Inyo, Lassen, Modoc, Mono and Plumas counties, and the reasons to modify how the services are currently being provided.

2.1. Current Situation

As identified in the Tri-County Non-Emergency Medical Transportation (NEMT) study [1], the region identified in Figure 1 faces barriers that are common in rural areas. Great distances, low population densities, and limited funding lead to transit systems with limited coverage areas, shorter service hours and fewer days of operation. To receive specialized health care, people in these counties have to travel to Chico, Redding, Sacramento, or Truckee, California; Klamath Falls, Oregon; or Reno, Nevada.

To travel to these destinations, people with limited access to a car may use the public transportation systems, a Medi-Cal van, senior transportation programs, volunteer drivers, agency vehicles, gas vouchers, veteran services vans, for hire cars, private intercity shuttles, or taxis [1]. Depending upon an individual's origin and destination, transfers between one or more providers may be necessary to complete a particular trip.

Currently, there is no single source of information for the various transportation options within the five-county region. To get a general idea of how the current system works, suppose David, a college-educated, computer-literate potential rider, needed to use web-based information to schedule a trip from Alturas in Modoc County to Lone Pine in Inyo County. To determine how to make this trip, he could start with the Sage Stage web site [2]. The web site gives information about the current schedules and a map showing the routes and stops. The information from the website is shown in Figure 2, Figure 3, and Figure 4.

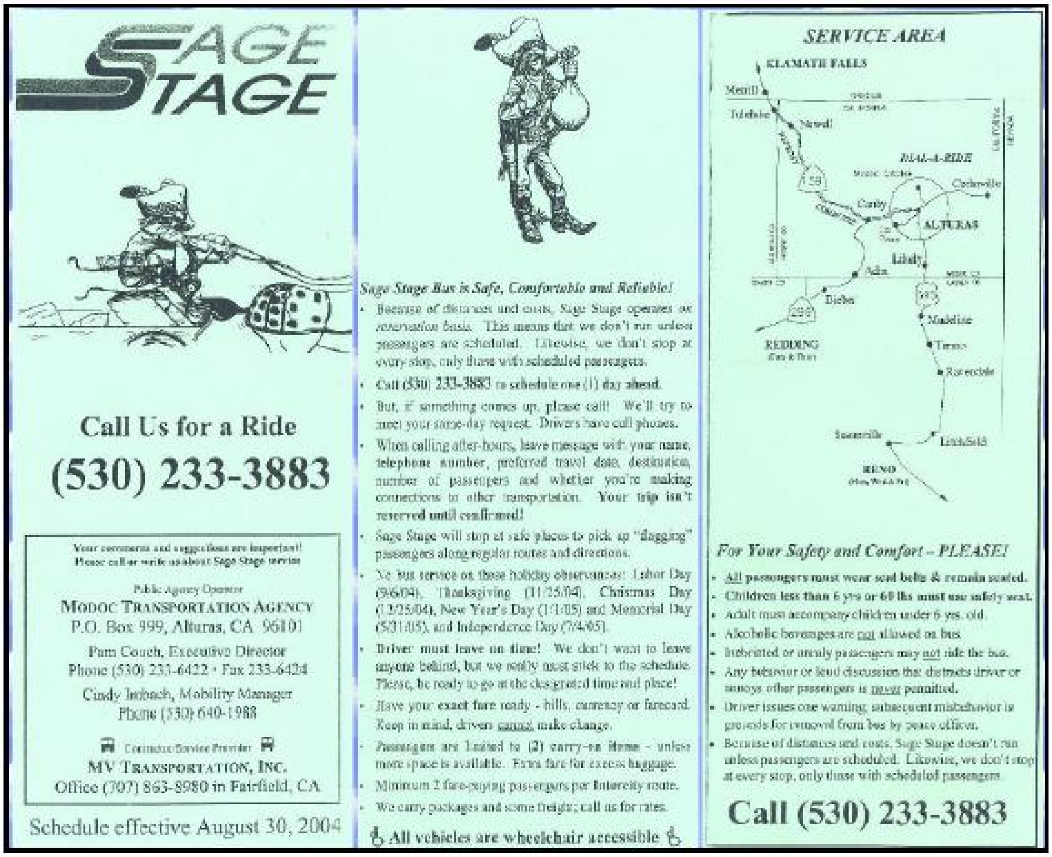

Figure 2 - Sage Stage Website Page 1

As David browses the web page, he notices the map that shows that service is available to Reno on Mondays, Wednesdays and Fridays. As David scrolls down to the second page on the website, Figure 3, he sees the schedule for the service from Alturas to Reno.

REGULAR AND *DISCOUNT FARES**

Per Passenger per One-Way Trip at Boarding

DIAL-A-RIDE		*Dis*	GEN
0.0 – 2.0 miles	within City of Alturas	$1	$2
2.1 – 5.0 miles	to Modoc Estates	$2	$4
5.1 – 10.0 miles	to Cal Pines	$3	$6

FIXED ROUTES ALTURAS - RENO	Alturas	Likely	Madeline	Termo	Susanville	Reno
Alturas		$6	$10	$12	$16	$24
Likely	$3		$6	$8	$14	$22
Madeline	$5	$3		$6	$10	$18
Termo	$6	$4	$5		$10	$18
Susanville	$8	$7	$5	$5		$20
Reno	$12	$11	$9	$9	$10	

ALTURAS-REDDING	Alturas	Canby	Adin	Bieber	Burney	Redding
Alturas		$6	$8	$10	$14	$18
Canby	$3		$8	$8	$12	$18
Adin	$4	$4		$6	$10	$16
Bieber	$5	$4	$3		$8	$14
Burney	$7	$6	$5	$4		$10
Redding	$9	$9	$8	$7	$5	

ALTURAS-TULELAKE / KLAMATH FALLS	Alturas	Canby	Newell	Tulelake	Merrill	K. Falls
Alturas		$6	$12	$12	$12	$14
Canby	$3		$10	$10	$12	$14
Newell	$6	$5		$4	$6	$8
Tulelake	$6	$5	$2		$4	$8
Merrill	$6	$6	$3	$2		$8
Klamath Falls	$7	$7	$4	$4	$4	

** Seniors [1], Disabled [2] or Youth [3] pay Discount Fares*

[1] Seniors are persons 60 years or older with Medicare or ID card.

[2] Disabled discount only for persons who meet ADA definitions with valid Sage Stage (or other transit agency) card – picture ID.

[3] Youth are children (3-12 yrs) or students with school ID (13-18 yrs)

ALTURAS DIAL-A-RIDE

EVERY WEEKDAY

Shared transportation within 10 miles of Alturas, operating Monday - Friday. First pick up 8 AM and last drop off 5 PM. Priority for trips to appointments.

Routes and travel times vary by demand and travel conditions. Allow extra time, as scheduled pick up or drop off may be ± 15 minutes. Subscription service is available for routine transportation (to/from work or school). First-come, first-served! Call (530) 233-3883 **to schedule at least one (1) business day ahead.**

Cancel without penalty (fare): one hour before scheduled time for separate trip; one day before subscription trip.

ALTURAS – TULELAKE

MONDAY – WEDNESDAY - FRIDAY

BY ADVANCE RESERVATION ONLY

Stop (Location)		Morning	Evening
Alturas	(Black Bear)	**5:30 AM**	**3:30 PM**
Canby	(Sharer Chevron)	5:50 AM	3:50 PM
Newell	(Homestead Market)	-	4:45 PM
Tulelake	(Jack's Market)	6:45 AM	4:50 PM
Newell	(Homestead Market)	7:00 AM	-
Canby	(Sharer Chevron)	7:40 AM	5:40 PM
Alturas	(Black Bear)	**8:00 AM**	**6:00 PM**

ALTURAS – SUSANVILLE - RENO

MONDAY - WEDNESDAY - FRIDAY

Time	Bus Stop	Location
5:45 AM	Special Pick Up as Arranged *	
6:00 AM	**Alturas**	**Black Bear**
6:20 AM	Likely	General Store
6:40 AM	Madeline	Old Chevron
8:00 AM	**Susanville**	**Apple Peddler**
9:30-10:00 AM	**Reno**	**Connections**
10:00 AM-1:00 PM Lunch/Excursion Trips with Reno		
1:00 - 1:20 PM	**Reno**	**Connections**
1:30 PM	**Reno/Tahoe Airport**	**Door "D"**
3:00 PM	**Susanville**	**Apple Peddler**
4:20 PM	Madeline	Old Chevron
4:40 PM	Likely	General Store
5:00 PM	**Alturas**	**Black Bear**
5:15 PM	Special Drop Off as Arranged *	

Transportation Connections - Susanville, CA & Reno, NV

① Lassen Rural Bus — Susanville routes — (530) 252-7433

② RTC Citifare Bus — 23 local routes — (775) 348-7433

③ CREST Bus (Reno-Carson-Bishop) — (800) 922-1930

④ Amtrak — (775) 329-8638 or (800) 872-7245

⑤ Greyhound — (775) 322-2970 or (800) 231-2222

⑥ Reno/Tahoe Airport — Administration (775) 328-6400

Figure 3 - Sage Stage Website Page 2

David sees the schedule for service between Alturas and Reno, notes the times of service, and the cost ($24). David sees the "Transportation Connections" that show the CREST Bus service to Bishop, but is still unsure of how to get from Reno to Lone Pine. David could call the 800 number to get further information, or look on the Internet for further information.

ALTURAS - REDDING
TUESDAY - THURSDAY

Time	Bus Stop	Location
6:45 AM	Special Pick Up as Arranged *	
7:00 AM	**Alturas**	**Black Bear**
7:20 AM	Canby	Clinic/Chevron
7:40 AM	Adin	Adin Supply
7:55 AM	Bieber	Kathy's Corner
8:20 AM	Fall River Mills	H&C Cookhouse
8:40 AM	Burney	McDonalds
10:00-10:30 AM	**Redding**	**Connections**
10:30 AM-1:30 PM Lunch/Excursion Trips w/in Redding		
1:30-1:50 PM	**Redding**	**As Needed**
2:00 PM	**Transit Center**	**California Street**
3:10 PM	Burney	McDonalds
3:30 PM	Fall River Mills	H&C Cookhouse
3:55 PM	Bieber	Kathy's Corner
4:10 PM	Adin	Adin Supply
4:40 PM	Canby	Clinic/Chevron
5:00 PM	**Alturas**	**Black Bear**
5:15 PM	Special Drop Off as Arranged *	

Transportation Connections in Redding, CA

① RABA (Redding Area Bus Authority)	(530) 241-2877
② Amtrak feeder bus	(800) 872-7245 or amtrak.com
③ Greyhound	(530) 241-2070 or (800) 231-2222
④ ABC Cab Co	(530) 233-5909
⑤ ABC Taxi	(530) 244-5909
⑥ Redding Yellow Cab	(530) 222-1234

SPECIAL PICK UP / DROP OFF FARES

Before / After Intercity Trip   Alturas DAR zone & fares

EXCURSION FARES

Shuttle service <5 miles during layover in terminus city

$6 / regular passenger $3 / discount passenger

ALTURAS – KLAMATH FALLS
WEDNESDAY

Time	Bus Stop	Location
7:45 AM	Special Pick Up as Arranged *	
8:00 AM	**Alturas**	**Black Bear**
8:20 AM	Canby	Clinic/Chevron
9:10 AM	Newell	Market
9:20 AM	Tulelake	Jock's Market
9:50-10:00 AM	**Klamath Falls**	**Connections**
10:00 AM-1:30 PM Lunch/Excursion Trips w/in K. Falls		
1:30-1:50 PM	**Klamath Falls**	**As Needed**
2:00 PM	**Transit Center**	**Near K-Mart**
2:30 PM	Tulelake	Jock's Market
2:40 PM	Newell	Market
3:25 PM	Canby	Clinic/Chevron
3:45 PM	**Alturas**	**Black Bear**
4:00 PM	Special Drop Off as Arranged *	

Transportation Connections in Klamath Falls, OR

① Basin Transit local bus routes	(541) 883-2877
② Shuttle to Medford or Lakeview, OR	(541) 883-2609
③ Amtrak	(541) 884-2822 or (800) 872-7245
④ Greyhound	(541) 882-4616 or (800) 231-2222
⑤ Klamath Falls Airport	Admin. (541) 883-5372

CANBY CONNECTIONS
WEDNESDAY

Time		Bus Stop / Location
8:00 AM	(Via K Falls Bus)	Alturas
8:20 AM		Canby (Clinic)
10:40 AM		Alturas (Black Bear)
11:00 AM	(Round Trip 1)	Canby / Clinic
11:20 AM		Alturas (Black Bear)
12:40 PM		Alturas (Black Bear)
1:00 PM	(Round Trip 2)	Canby / Clinic
1:20 PM		Alturas (Black Bear)
3:25 PM	(Via K Falls Bus)	Canby / Clinic
3:45 PM		Alturas

Figure 4: Sage State Website Page 3

Since David's destination is in Inyo County, David next searches to find out about bus services in Inyo County. David finds the Inyo Mono website [3] shown in Figure 5.

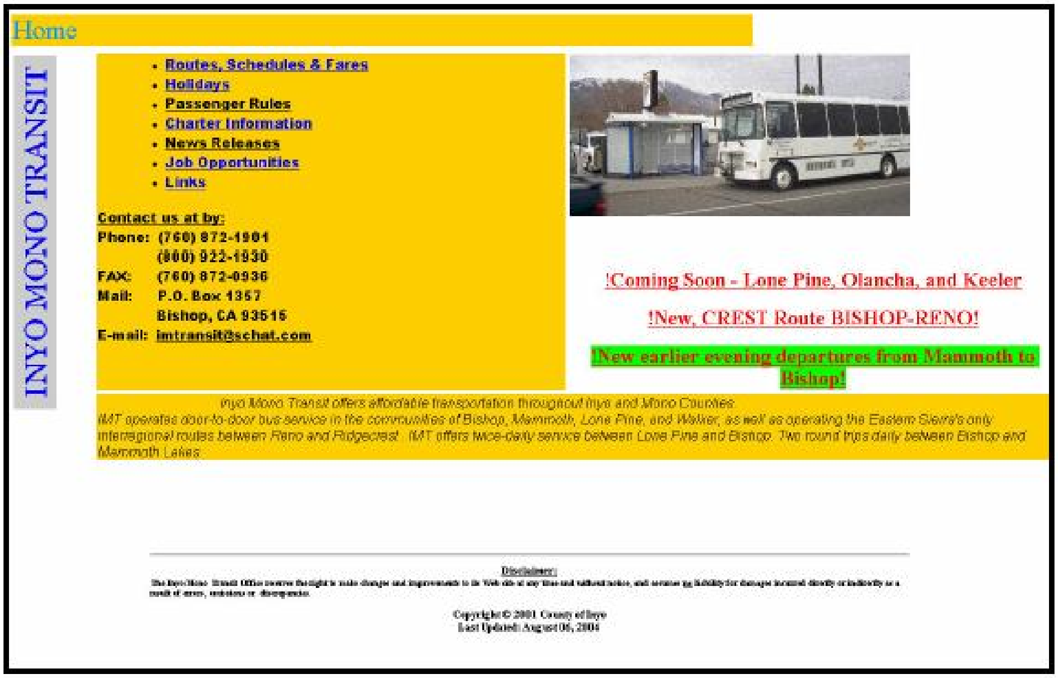

Figure 5: Inyo Mono Transit Homepage

David sees the link highlighting the new route from Reno to Bishop and clicks on that link. The link takes him to the schedule and fare information, shown in Figure 6 and Figure 7.

INYO MONO TRANSIT

FARES

Traveling NORTH
Between Bishop and Reno

From:	Adults	Discount
Bishop	$ 28.00	$ 23.00
Tom's Place	$ 25.00	$ 20.50
Crowley Lake	$ 24.50	$ 20.00
Mammoth	$ 23.00	$ 18.50
June Lake	$ 21.00	$ 16.50
Lee Vining	$ 20.00	$ 15.50
Bridgeport	$ 17.00	$ 13.00
Walker	$ 13.00	$ 10.00
Coleville	$ 12.50	$ 9.50
Topaz	$ 11.50	$ 9.00
Carson	$ 8.00	$ 6.00

Traveling SOUTH
Between Mammoth and Ridgecrest

From:	Adults	Discount
Mammoth	$ 21.00	$ 17.50
Crowley	$ 18.50	$ 15.50
Tom's Place	$ 18.00	$ 15.00
Bishop	$ 15.50	$ 13.00
Big Pine	$ 14.00	$ 11.50
Aberdeen	$ 13.00	$ 10.50
Independence	$ 11.00	$ 9.00
Lone Pine	$ 9.50	$ 7.50
Olancha	$ 7.00	$ 5.50
Coso Junction	$ 5.00	$ 4.00

Additional fare information available from the driver or by calling Monday through Friday 8:00 a.m. to 5:00 p.m. Reservations are strongly recommended.
To confirm your ride please call (760) 872-1901 the prior business day.

Prices and times are subject to change - Please call to Confirm.

Figure 6: Reno-Bishop Fares

Traveling NORTH
Between Bishop and Reno
Tuesdays-Thursday-Friday

Location	A.M. Departure Times	P.M. Return Times
Bishop 201 S. Warren terminal	7:00 am	5:30 pm
Tom's Place ** Storefront	7:30 am	5:00 pm
Crowley Lake ** Crowley Storefront	7:35 am	4:55 pm
Mammoth McDonalds	7:50 am	4:40 pm
June Lake** Fire House	8:15 am	4:15 pm
Lee Vining Caltrans Yard	8:25 am	4:05 pm
Mono City**	8:35 am	3:55 pm
Bridgeport Bridgeport General Store	8:55 am	3:35 pm
Walker Walker Sporting Goods	9:35 am	2:55 pm
Coleville ** Across from Post Office	9:45 am	2:45 pm
Topaz ** Trailer Park Entry	10:00 am	2:30 pm
Gardnerville **	10:35 am	2:15 pm
Carson City - Nugget Robinson St. & Hwy 395	10:45 am	1:45 pm
Reno Airport	11:45 am	11:45 am

** By request stops only

Traveling SOUTH
Between Mammoth and Ridgecrest
Monday-Wednesday-Friday

Location	A.M. Departure Times	P.M. Return Times
Mammoth Mc Donald's	8:05 am	4:50 pm
Crowley Crowley lake Store	8:20 am	4:35 pm
Tom's Place	8:25 am	4:30 pm
Bishop 201 S. Warren terminal	9:15 am	3:50 pm
Big Pine Texaco Bench	9:30 am	3:35 pm
Aberdeen** Storefront	9:45 am	3:20 pm
Independence Mair's Market	10:00 am	3:05 pm
Lone Pine Statham Hall	10:25 am	2:50 pm
Olancha** Ranch house restaurant	11:45 am	2:30 pm
Coso Junction** Rest stop	11:05 am	2:10 pm
Pearsonville** Texaco Parking Lot	11:20 am	1:55 pm
Ridgecrest City Hall 100 W. California Ave.	11:45 pm	1:30 pm

** By request stops only

Figure 7: Reno-Bishop Schedule

David reviews the information and sees that he would have a layover in Reno from about 10:00 am until 11:45 am. David sees that he would depart Reno at 11:45 am and arrive in Bishop at 5:30 pm.

David then goes back to the Inyo Mono Transit homepage to figure out how to get from Bishop to Lone Pine. After David sees the link for "Route Maps, Schedules and Fares" Figure 8, he clicks on the "Lone Pine to Bishop" link and sees the specific route and fare information (Figure 9).

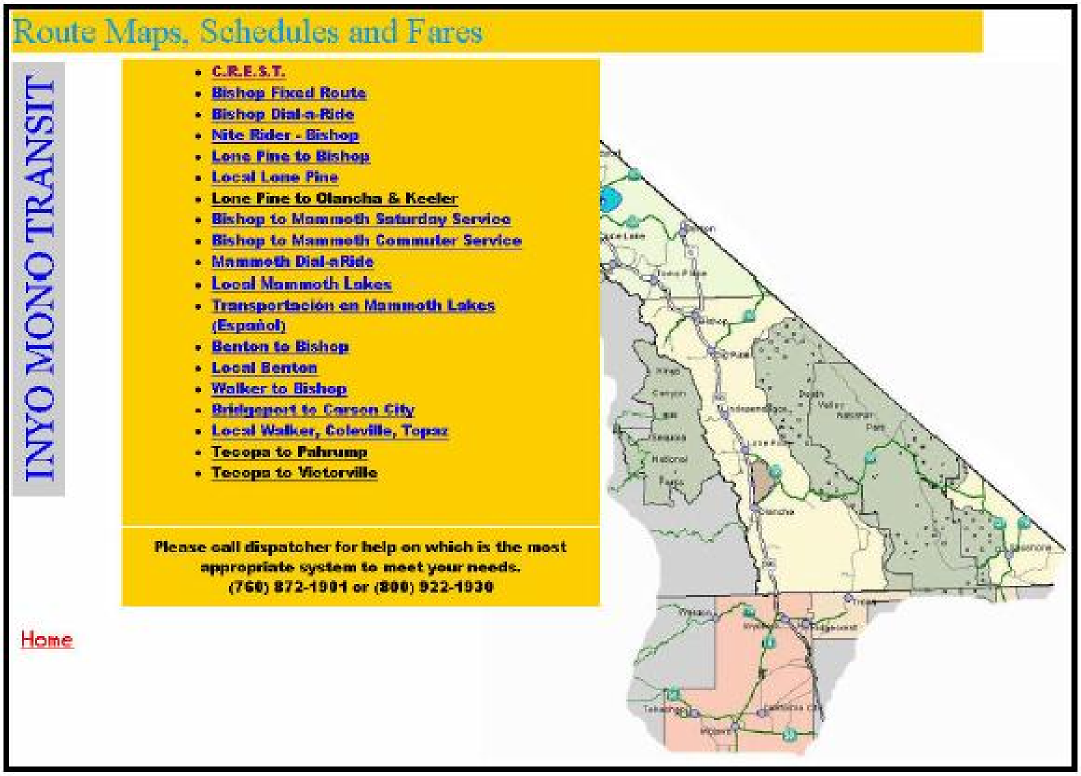

Figure 8: Inyo Mono Transit Route Map and Schedules

Lone Pine to Bishop

INYO MONO TRANSIT

INYO MONO TRANSIT
LONE PINE TO BISHOP

Monday thru Friday
Two Round Trips Daily

	MORNINGS		AFTERNOON	
	Arrive	Depart	Arrive	Depart
Lone Pine - Statham Hall		6:30 am		12:30 pm
Independence - Austin's Mkt.	6:45	6:45	12:47	12:47
Aberdeen - Store**	7:00	7:00	1:03	1:03
Big Pine - Carrol's Mkt	7:20	7:20	1:22	1:22
Bishop - Kmart	7:40		1:45	
Bishop - Kmart		12:00 (noon)		5:30 pm
Big Pine - Texaco	12:15	12:15	5:45	5:45
Aberdeen - Store**	12:30	12:30	6:05	6:05
Independence - Mairs Mkt.	12:45	12:45	6:20	6:20
Lone Pine - Statham Hall	1:00		6:40	

** Must call day prior to request bus.

FIRST SATURDAY OF EVERY MONTH

Departs		Departs	
Lone Pine – Statham Hall	8:30 am	Bishop - Kmart	3:00 pm
ndependence – Austin's Mkt.	8:45	Big Pine - Texaco	3:15
Big Pine – Carroll's Mkt	9:15	Independence - Mair Mkt.	3:45
Bishop – Kmart	9:30	Lone Pine - Statham Hall	4:00

Figure 9: Bishop to Lone Pine Schedule

David sees that he can leave Bishop at 5:30 pm and arrive in Lone Pine at 6:40 pm. David's trip itinerary is shown in Table 1:

Table 1: Alturas-Lone Pine Trip Itinerary

Action	Time	Service	Cost
Depart Alturas	6:00 am		
Arrive Reno	10:00 am	Sage Stage	$ 24.00
Depart Reno	11:45 am		
Arrive Bishop	5:30 pm	CREST	$ 28.00
Depart Bishop	5:30 pm		
Arrive Lone Pine	6:40 pm	Inyo Mono Transit	$ 4.00
Totals	12 hours 40 min.	3 providers	$ 56.00

For David, who has proficient computer skills and a decent understanding of bus schedules, it could take at least 30 minutes to put together this itinerary using the current system. A person who is unfamiliar with the Internet would likely take longer and may not be able to identify the trip at all. Of course, another option would be to call the various providers directly. When calling the providers, the individual would hope that the providers know of the possible transfers, and the other providers' services, so they could suggest possible routings to complete the trip.

The above scenario shows how difficult it currently is for an individual to plan a trip from one town to another. In addition, it is difficult for a single transportation operator to have detailed information about all the various transportation options within the region. This scenario shows how important it is to have a one stop shop, or a single source for transportation options within the region.

The scenario also shows how current information is critical to the concept of trip planning. As schedules change, new brochures must be produced, and webpages must be updated. Dispatchers must be educated of changes, and the new information must be shared with current and potential riders.

With the current system, a change with one transportation provider may have an impact on clients of other transportation providers. The current system makes it harder to maintain current information, and share any changes to schedules, routes, etc., with the public or other providers. With the current system, individual transit providers are responsible for maintaining their web sites, ensuring that all information about the transit system is current.

Further, individuals at the transit systems are typically available to answer questions during normal office hours (8:00AM – 5:00PM). Therefore, if someone wanted to plan a trip during the evening or weekends, they may have limited access to the information they need to plan the trip.

All of the issues concerning trip planning and transportation information noted in this section highlight the need for changes to the current system, which are discussed in detail in the next section.

2.2. Need for Change

The transit systems in Inyo, Modoc, Mono and Plumas counties have a website. Lassen County is currently developing a web site. The web sites' objective is to provide information and schedules about the individual service. They are somewhat limited in scope in that they usually provide information only about their own service. Information regarding possible connections with other transit services is typically not provided. These individual web sites may not have the most current information, and may not be constantly operational (on-line), and hence their effectiveness as individual information dissemination centers is limited. Potential travelers can, however, also get information about transit in their county through paper schedules or by calling the transit provider. There are limitations to these approaches, which have already been discussed.

Currently, if a customer needs to travel in the eastern Sierra corridor using public transportation, the customer is responsible for planning the trip. If the service is available through a single provider, the trip planning is fairly simple. The customer accesses the web site or paper schedule; reserves a seat with the transit agency, if required, then makes the trip.

However, as the earlier scenario showed, if the desired trip requires changing providers, the methodology is more complicated. The customer first identifies the counties he or she has to pass through. Then he/she contacts the individual county transit services including their origin, intermediate points and destination. The customer may need to explain the purpose of the trip to all service providers to obtain information about the routes, timings, restrictions, and transfers. Once the customer gathers all the information, the customer identifies the transit services he or she needs to use to reach the destination. The timings get calculated and if the customer comes up with a feasible trip plan, then the individual agencies are called and reservations are made if necessary. This process could be vastly improved (simplified) by implementing a single source of transportation information and a trip planning tool.

In addition to the usual lack of a single source of transportation information, rural transit operates differently than urban or suburban transit due to the characteristics of a rural environment. Rural transit systems' vehicles are often smaller. Demand responsive service or deviated routes are common. Often, rural service includes routes to urban centers, and frequency can be in terms of days as opposed to minutes in the urban environment. In addition, many urban transit providers have implemented various technologies to improve the efficiency of their operations, and increase the use of technology by their customers. Some of these technologies include:

- Automatic Vehicle Location (AVL) and Mobil Data Communications (MDC)
- Next Bus Signs
- Trip Planning Tools

However, there are limited deployments of such systems in rural environments. Technology can be used to improve the effectiveness and efficiency of individual transportation providers, and to enhance transportation coordination.

The benefits of coordinated transportation have been document in various sources, including the recent publication of *TCRP Report 91: Economic Benefits of Coordinating Human Service Transportation and Transit Services* [4]. In fact, the Ohio Department of Transportation noted that coordinating transportation services is "the best way to stretch scarce resources and improve mobility for everyone." Coordination efforts can be enhanced through the use of technology. As shown in Table 2, there are a host of technologies that can be utilized to enhance not only coordination, but the operations of individual public transportation providers.

Table 2: Transportation Provider's Needs vs. Technologies

NEEDS	APPLICATIONS: Accounting Software	Automatic Passenger Counters	Automatic Vehicle Location Systems (AVL)	Communications	Customized Spreadsheets and Databases	Demand-Responsive Transit Software - Automated	Demand-Responsive Transit Software – Computer Assisted	Electronic Payment Systems	Geographic Information Systems (GIS)	Internet website	Maintenance Software	Silent Alarm System	Mobil Data Communications / Terminal	Palmtop Electronic Manifest Device	Personnel Management Software
More Accurate, Easier Reporting and Record Keeping	X				X									X	X
More Efficient Service Coordination		X	X	X	X	X	X		X				X		
Safer, More Accurate Cash Handling					X								X	X	
Improved Operations, Staff Performance, and Productivity			X		X	X	X		X				X	X	
More Effective Maintenance Tracking					X						X		X		
Clearer Communication			X	X									X	X	
More Effective Dispatching			X	X	X	X	X				X			X	
Faster, More Efficient Trip Request Processing						X	X		X	X					
Improved Scheduling Productivity			X		X	X	X		X				X		
Improved Service Quality			X		X	X	X		X				X		
Greater Safety			X		X	X	X						X		
More Accessible, More Useful Customer Information			X		X	X	X		X	X					

Source: Technology In Rural Transit: Linking People With Their Community [5]

In short, the following factors point to the need for changing the way transportation information and services are provided in rural California:

- Currently there is no trip planning capability; the burden of obtaining information, planning the trip, and making necessary reservations or arrangements between the service providers rests on the shoulders of the customer.
- The dispatcher for an individual service provider has limited information about other service providers in the region.
- Each transit website in the region describes their service in a different way. This complicates a customer's attempt to understand service in multiple regions. Furthermore, some of the transportation services are eligibility oriented, and other services such as door to door paratransit systems need 24 hour advance reservations.
- Coordination between transit services is limited to informal communication via telephone between service providers.
- If information were more easily available, people may be encouraged to try public transportation services.
- Coordination is a proven tool to increase the effectiveness and efficiency of transportation (transit) providers.

This section (Section 2) highlighted how the current system operates, and the need for changes to the current system. The next section describes the proposed changes to the system.

Figure 4. 4 - Western Transportation Institute Concept of Operations and Action Plan

This figure shows Section 2, which describes the current situation regarding information availability for trip planning in a rural region and identifies the need for change that will be addressed by the proposed system.

4.3.5 System Overview

The Concept of Operations should provide a high-level description of the interrelationships of key system components, their scope and interfaces. The section describes all aspects of the integrated system at once. This information is often most effectively conveyed via a diagram.

In Figure 4.5 the Concept of Operations for the VII Michigan Test Bed Program provides the system overview in Section B of that document.

Regional Example

VII Michigan Test Bed Program

Concept of Operations

B. What – What are the Known Elements and the High-level Capabilities of the Michigan VII Test Bed Program?

Test beds are anticipated to consist of four different subsystems– on board equipment, roadside equipment, network management and data processing. Test facilities are anticipated at the OEM Facilities, supplier and other test bed participant facilities, and MDOT and other local road agencies, on roads and parking lots and in laboratories, research facilities, and control centers. **Figure 2** outlines conceptual linkages between the various test bed elements, and does not prescribe a design for attributes that will be particular to each separate Test Bed. As such, it is meant to be a guide to use for the planning, design, implementation, operation and maintenance of test bed elements and interfaces. It should be noted that the test bed architecture is using the Internet as a means to transmit data from the roadside device to the test bed participants. Each participant will be responsible for securing their data packets.

Vehicle Equipment Subsystem

The Vehicle Equipment Element within the Test Bed will consist of privately-owned vehicle fleets that will collect data for use in testing the feasibility to collect and communicate data to / from the infrastructure. Vehicle fleet equipment will be the full responsibility of each individual test bed participant or participant team. In addition, it is envisioned that, for the duration of the VII Michigan Test Bed Program, each Test Bed will utilize a dedicated fleets of vehicles, owned by those organizations participating in the Test Bed activities. This arrangement will provide less problematic access to vehicle data due to privacy agreements made with employees rather than the general public.

Data from vehicles will be:

- Collected for use by both the private-sector and the public-sector stakeholders

Michigan Department of Transportation 4

- Archived for the purpose of allowing stakeholders to research and develop the means to fuse, package and disseminate information to other users (e.g., Independent Service Providers, telematics, etc.) and infrastructure (e.g., CCTV cameras, Dynamic Message Signs, etc.) in support of their agency or organization's goals and objectives.

The VII test bed fleet will transmit data packets using Internet Protocol (IP), to each respective test bed participant or participant team's VII server. Data required by MDOT, including the data format, will be set forth in a requirements document that will be shared with the private-sector stakeholders for their use in designing a Test Bed.

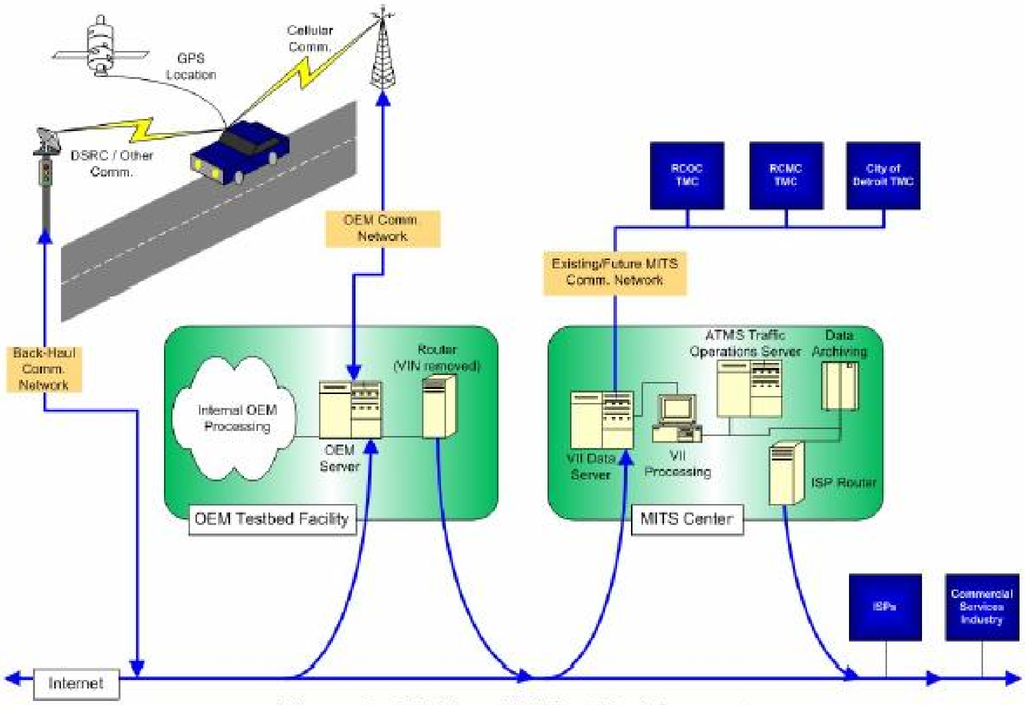

Figure 2 – Michigan VII Test Bed Concept

Roadside Equipment Subsystem

The Roadside Equipment Element within the Test Bed may include a variety of system components that will depend on the design developed for each particular Test Bed. For Test Beds that will utilize a non-cellular communications medium, the roadside equipment will be located within the public-sector right-of-way and is anticipated to receive data from Test Bed vehicles. Data will either be processed or forwarded along the Internet to OEM Test Bed facilities, depending on the nature of the test activities. Subsequently data will be transmitted to MDOT once the data is anonymized (the Vehicle Identification Number (VIN) or other identifiers, are removed from the data packet).

Network Management Subsystem

The fundamental building blocks of the VII concept are coordinated deployments of communication technologies in all vehicles by the automotive industry and along all major U.S. roadways by the transportation public-sector. Short-haul vehicle-to-roadside communications are anticipated to occur via high-speed licensed (e.g., Dedicated Short Range Communications) or unlicensed (e.g., 802.11, WiMAX, etc.) short range wireless communications. Data will then be back-hauled via wired or wireless media that may be leased or agency owned, to an Internet field portal, for transport to the OEM Test Bed servers. Initial test bed deployments will focus on the use of 802.11-based technologies to facilitate vehicle-to-roadside communications.

Private Sector Test Bed Facilities Element

At a minimum, Private Sector Test Bed facilities will collect, store, anonymize and disseminate data from either the Vehicle Fleet or Roadside Equipment Elements to the MDOT/Public-Sector Element and the Vehicle Fleet. The private sector test bed participants will then forward the appropriate anonymized data to the public sector participants via the internet for public sector use and analysis. The raw data may be used by the private sector partners for their own purposes. Existing private sector Test Bed facilities within the VII Michigan Test Bed Program (as of August 2005) include:

- Ford Motor Company (Dearborn)
- DaimlerChrysler (Auburn Hills)
- Nissan Motors North America (Farmington Hills)
- Collision Avoidance Metrics Partnership (CAMP) (Farmington Hills)
- Motorola (Farmington Hills)
- General Motors (Detroit)
- University of Michigan Transportation Research Institute (UMTRI) (Ann Arbor)

MDOT/Public-Sector Element

Each OEM Test Bed Facility will interface via the Internet with a server housed within the Michigan Intelligent Transportation Systems Center (MITSC). The MDOT server will be dedicated to collecting, processing, and distributing anonymized VII data. MDOT will be responsible for disseminating final VII data to other public-sector partners, including:

- Road Commission for Oakland County
- Road Commission of Macomb County
- City of Detroit

In later stages of the Program, data may further be shared with other industry stakeholders for use in traveler information applications, including Information Service Providers (ISPs), commercial services industry, and media outlets. As these later stages approach, issues associated with sharing this data, such as confidentiality and non-disclosure agreements for certain information, will be addressed at the local level based on the decisions made and directions being set forth at the national level.

C. When – What is the Time-Sequence of VII Michigan Test Bed Program Activities that will be Performed?

The VII Michigan Test Bed Program is a multi-phased program which will be implemented over time from 2005 through 2008 to coincide with development efforts in the private sector and Field Operational Test plans in the public sector. Major segments of the region-wide Test Bed (Phase 3) are planned for deployment by the 4th quarter of 2007. This region-wide Test Bed (Phase 3) will be an expansion of the initial, localized Test Beds (Phase 1), that will eventually be expanded in geographic coverage (Phase 2). These expanded Test Beds, along with additional future Test Beds, will ultimately be linked in Phase 3 to evaluate the interoperability of the various locations and technologies. **Figure 3** depicts the high-level phased approach.

Figure 3 depicts the test bed locations in a clouds reference. Future meetings and developments in the VII community – both locally and nationally – will determine the exact locations of various roadside devices, and their coverage ranges. For example, some of the test bed areas described below are intended to provide continuous coverage along an entire corridor or series of corridors. Others are focused at specific intersections.

To accomplish this deployment, the following two things must occur by summer 2008:

1. Deployment of a Test Bed that will utilize a combination of products and technologies to demonstrate the technical feasibility and interoperability of collecting and forwarding VII data thru the use of open-standards and an open-architecture. This "Interoperable Test Bed" could leverage the above-captioned individual Test Beds as well as other Test Beds that have yet to evolve.
2. Continued support within the public and private sectors of the VII program that ensures that the VII program is not limited to either a geographic area or a subset of automobile manufacturers.
3. Successful testing and pre-deployment activities that demonstrate a marked improvement (or demonstrate significant potential improvements) in safety and congestion, while demonstrating the ability of VII to meet the overall goals of the National and Michigan VII programs, as well as those of the suppliers and original equipment manufacturers at an acceptable cost to benefit ratio.
4. The successful deployment of a series of individual Test Beds that prove the technical feasibility to collect and forward data in a fashion that can support VII. The VII Michigan Test Bed Program is well along the way of successfully deploying multiple Test Beds, including the following:

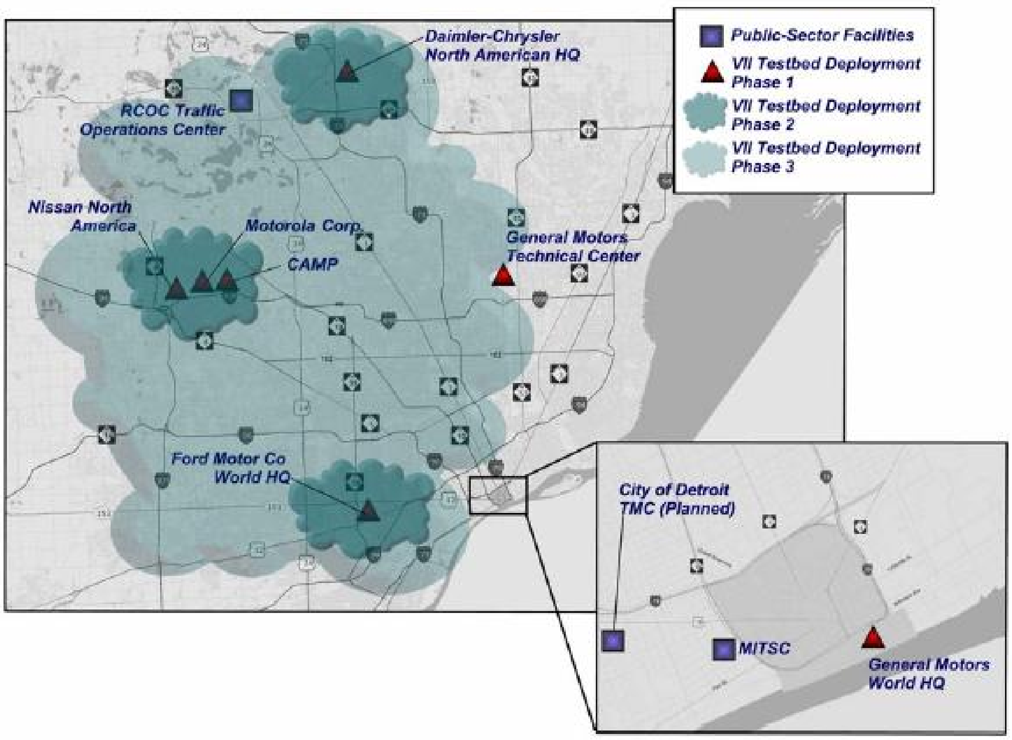

Figure 3 – Phased Test Bed Deployment

VII Michigan Test Bed Program *Concept of Operations*

- Ford Test Bed - Ford Motor Company, MDOT, Wayne County and the City of Dearborn are partnering to develop a test bed near Ford's facilities in Dearborn. The initial deployment will include the installation of a Motorola Canopy short-haul wireless network around three intersections along City roadways aimed at achieving full wireless VII coverage of a triangular configuration formed by three roadways.

- DaimlerChrysler Test Bed – DaimlerChrysler, MDOT and RCOC are partnering to develop a test bed along the roadways surrounding DaimlerChrysler's Auburn Hills headquarters and technical center. The test bed will include deployment of DSRC-surrogate (802.11) radios at signalized intersection locations along public roadways.

- General Motors Test Bed – General Motors is evaluating the use of data collected from its OnStar™ cellular network for use in VII applications. In partnership with MDOT, GM will begin sharing anonymized OnStar™ data via the Internet with MDOT for MDOT use. The GM test bed in Warren includes detection to permit GM to validate the accuracy of probe vehicle data in comparison with data collected from traditional ITS methods.

Figure 4. 5 - VII Michigan Test Bed Program Concept of Operations

This figure shows Section B, which describes known elements and high-level capabilities of the Michigan VII Test Bed system. A diagram of component interrelationships is included

4.3.6 Operational Environment

This section describes the "world" in which the proposed system will operate. This information will support Operations and Maintenance budgeting and funding decisions.

Section 7 of the Kansas DOT Concept of Operations for a statewide Transportation Operations and Management Center breaks down its operational and support environment into five categories: facilities, hardware, software, personnel, and communication needs. See Figure 4.6 below.

Regional Example

Kansas Statewide Transportation Operations & Management Center Study

Transportation Operations and Management Center

Concept of Operations

7 The Operational and Support Environments

This section describes the environment or "world" in which the TOMC will operate. This section includes information about the TOMC's environment in terms of the following categories:

- Facilities
- Hardware
- Software
- Personnel
- Communication Needs

The information in this section is based on stakeholder feedback, past experience of the Project Team, and Project Steering Committee input. This section summarizes the information contained in the Statewide TOMC Implementation Plan. For additional detail, please refer to that document.

7.1 Facilities

One of the reasons that the Virtual TOMC concept was selected was to minimize space impacts and eliminate the need for a dedicated facility or building to house the TOMC. It is envisioned that the TOMC application will be installed on work station computers that will utilize existing office spaces and desks. These work stations will be located in each District, likely at the District headquarters building. The designated operator can utilize their existing office to house the work station or a dedicated desk/office can be used. It will be up to each District to determine what configuration works best. At KDOT headquarters, the work station can be located in a designated office, most likely the responsibility of the Division of Operations. In addition, KDOT may desire to load the application on a portable workstation that could be used in a conference room for demonstration purposes or for events requiring a group of decision makers to gather. Partner agencies such as the Kansas Highway Patrol may wish to locate their workstation at the Salina dispatch center in the dispatch room for easy access. The Kansas Division of Emergency Management may wish to locate their workstation in their main conference room for gathering officials in the event of a statewide emergency.

The computer servers will require space in a KDOT equipment room and will probably be installed in existing server racks without need for additional space. If additional space is required, KDOT should plan on two racks to provide space for the TOMC software server, a communications server, and a video server along with the associated cabling. In addition, if CCTV communications are to be district based, room for a video server should be planned in each district office.

7.2 Hardware

7.2.1 Typical TOMC Hardware Requirements

The primary new hardware required for the TOMC will be central servers designed to support the TOMC software application. The number of servers required will be based on the software requirements for the TOMC, but a typical system might require as many as three servers to support all of the subsystems needed to provide statewide

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operations. Secondary servers to support communication, archiving, and sharing of information with partner agencies and organizations will also be needed. A typical system would require the following minimum server specifications:

One (1) Database Server

- **Dell Power Edge 2850**
- Intel® Xeon™ processor at 3.2GHz/1MB Cache, 800MHz FSB
- 2GB DDR2 400MHz (4X512MB), Single Ranked DIMMs
- 3 36GB Drives attached to embedded PERC4ei, RAID 5
- Dual On-Board NICs
- Windows 2003 Server, Standard Edition with Client Licenses
- 24X IDE CD-RW/DVD ROM Drive for PowerEdge Servers
- Embedded RAID (ROMB) - PERC4ei (Embedded Integrated)
- Riser with PCI-X Support and Embedded Raid (ROMB) Support
- Controller Card SCSI, 39160 Internal/External, U3, Low Voltage Differential
- 3Yr BRONZE Support, Next Business Day Onsite
- Keyboard / Mouse
- Dell E173FP Digital Flat Panel Panel Monitor,17 inch(17in Viewable)
- Rack Chassis w/Versarail, RoundHole-Universal
- Rapid Rails, Square Hole (Replacement for versa)

Two (2) Network / Communications / Video Servers

- **Dell Power Edge 2850**
- Intel® Xeon™ processor at 3.2GHz/1MB Cache, 800MHz FSB
- 2GB DDR2 400MHz (4X512MB), Single Ranked DIMMs
- 3 36GB Drives attached to embedded PERC4ei, RAID 5
- Dual On-Board NICs
- Windows 2003 Server, Standard Edition with 5 Client Licenses
- 24X IDE CD-RW/DVD ROM Drive for PowerEdge Servers
- Embedded RAID (ROMB) - PERC4ei (Embedded Integrated)
- Riser with PCI-X Support and Embedded Raid (ROMB) Support
- 3Yr BRONZE Support, Next Business Day Onsite
- Rack Chassis w/Versarail, RoundHole-Universal
- Rapid Rails, Square Hole (Replacement for versa)

It is KDOT's desire to have the TOMC servers and software reside in a central location, likely KDOT Computer Services in Topeka. For the TOMC software application, space for one server rack will be required in the central location. Communications equipment required will be based on ITS infrastructure in the field as will a video server with specifications based on the simultaneous video usage needed at the District offices. Space for these equipment racks, minimum 1, and the associated cabling, will be needed in headquarters and in the District office if field communications are routed through the District offices.

In order to run a typical COTS application, a PC with the following minimum recommended specifications is required:

Operator Interface (Workstations)

- **Dell Precision Workstation 370 Minitower**

- Intel® Pentium® 4 Processor 3.00GHz, 1MB/800
- Microsoft® Windows® XP Professional, SP2 with Media
- 512MB, 533MHz, DDR2 SDRAM Memory, ECC (2 DIMMS)
- C1 All SATA drives, Non-RAID, 1 or 2 drive total configuration
- 80GB SATA, 7200 RPM Hard Drive with 8MB DataBurst Cache™
- 48X/32X CD-RW/DVD Combo w/ CyberLink PowerDVD
- 64MB PCIe x16 nVidia Quadro NVS 280, Dual DVI/VGA Capable
- Sound Blaster Audigy™ 2 (D), w/Dolby Digital 5.1 & IEEE1394a
- Serial Port Adapter
- Keyboard
- Mouse
- Dell Two Piece Stereo System
- Dell 19 inch UltraSharp™ Flat Panel, adjustable stand, VGA/DVI

These workstations are on the high-performance end and one should be supplied to each District (6), KDOT HQ (1), and partner agencies (2) as the main interface with the TOMC application for a total of 9 initially. Most modern workstations will be satisfactory to run a COTS application.

7.3 Software

7.3.1 TOMC Software Requirements

The TOMC is intended to be a software application that runs on a common server and is accessible through KDOT's existing networks for KDOT users statewide and to KDOT agency and private partners. Users will be provided user names and passwords. Level of access will depend on permissions assigned within the software for each user. KDOT users will have the highest level of access while partner agencies and organizations will have more restricted access. The software must address the 15 TOMC functional requirements as well as certain basic requirements. These basic requirements include:

- Support center to center (C2C) and center to field (C2F) communication
- Scalable, upgradeable, and modular design
- Compliant with NTCIP
- Able to communicate with devices from different vendors
- Able to handle different signal formats (NTSC, PAL etc)
- Share real time information over WAN / LAN
- Support multi-user multi-priority level access
- Backup operations at other centers
- Allow user access from remote terminals

7.3.2 TOMC Software Model

There are several ways to implement TOMC software: purchase a statewide license for "commercial off-the-shelf" or COTS software; acquire "freeware" and utilize a programmer to customize it for KDOT's use; utilize a programmer to develop new software; or, modify existing KDOT software such as KanRoad. The key to selection of software will be functionality relative to the 15 TOMC functions, costs and timeframe for implementation. It will also be necessary to determine how long-term support for the

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software will be provided. Will KDOT be able to support the software in-house or will vendor support be required?

7.4 Personnel

Staffing hours for the Kansas Statewide TOMC will be highly variable. Factors that influence staffing hours include:

- Complexity or simplicity of TOMC user interface related to the TOMC functionality.
- Types and quantities of integrated ITS field devices available to TOMC users.
- Intensity of active events, incidents and/or emergencies.
- Need for KDOT or other partner participation in a particular event.
- KDOT policies on frequency and timeliness for updates to messages on DMS and HAR and for providing messages and updates to external partners.
- Centralization (Statewide or District) or decentralization (Area, Sub-Area, Maintenance Worker) of TOMC monitoring, control, and input responsibilities.
- Frequency, scope, and duration of system and communication tests and diagnostics.
- Reliable or frequently maintained or repaired communication, ITS field devices, and networks.
- Availability of staff and budget to monitor TOMC functions.
- Availability of key staff after hours or on-call staff to monitor TOMC functions.
- Ability for TOMC users to access the TOMC interface from home or other convenient locations.

The amount of training and the number of people to be trained are influenced by the same factors. KanRoad, for example, is updated by over 300 people throughout KDOT. Not all the staffing hours required or recommended for TOMC should be considered new hours. In some cases, TOMC hours replace, and hopefully streamline, effort already expended by the Districts during events and incidents.

7.4.1 Estimated TOMC Daily Hours

It is estimated that the TOMC will require one to two hours per day during normal operations at the District level and about the same at the headquarters level in Computer Services for routine checks and system/server maintenance. Table 7-1 identifies many of the activities that could be done on a daily basis during normal operations. Although these activities will not require a full-time equivalent position either in KDOT Headquarters or the KDOT District, individuals will need to be assigned duties related to TOMC activity.

Table 7-1: TOMC Daily Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Verify server function and network connectivity ▪ Update TOMC administration controls (user names, password, level of access) ▪ Archive TOMC data ▪ Respond to District or Partner Agency TOMC malfunction notifications and/or support requests ▪ Maintain dedicated ITS communications backbone between KDOT network and field devices	▪ Update KDOT contact information ▪ High-level TOMC system availability check ▪ High-level TOMC field device availability check ▪ High-level communication function check ▪ Verify accuracy of messages on active DMS, HAR ▪ Verify camera views are appropriate ▪ Report problems noted to Computer Services or applicable KDOT staff ▪ Perform traffic management for work zones	▪ High-level system availability check ▪ Check for alerts or other TOMC messages from KDOT ▪ Report problems to KDOT using TOMC contact information

7.4.2 Estimated TOMC Weekly Hours

It is estimated that TOMC will require two to four hours per week during normal operations at KDOT Headquarters by Computer Services personnel for system testing and diagnostics and two hours per week by District staff and partners to conduct training exercises. Table 7-2 identifies the activities that should be done on a weekly basis.

Table 7-2: TOMC Weekly Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Perform full TOMC system diagnostics ▪ Maintain ITS communications backbone	▪ Conduct system training and exercises with HQ and District staff ▪ Perform system testing in conjunction with Computer Services	▪ Conduct system training and exercises with organization staff in conjunction with KDOT

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7.4.3 Estimated Minimum TOMC "As-Needed" Hours

During events and incidents, hours will be more extensive. During events and incidents other demands on KDOT staff also peak. Depending on the duration, extent, and transitional nature of the event, KDOT effort relative to the TOMC will be highly variable. Another factor on TOMC effort will be the nature of KDOT policies regarding TOMC operations. It is estimated that TOMC activity could range from 25% to 30% of a full time person per District during active events. Many events last more than one shift. Long, continuous events may require TOMC operation for more that one day during the event. Staffing would be less per person if TOMC operations were distributed to Areas and Sub-Areas, but probably more in total. For the purposes of this estimate, an average major incident duration will be three hours, an average storm event duration will be 24 hours, a flooding event will be six hours, and a statewide emergency will last 48 hours. Table 7-3 describes as-needed TOMC activities.

Table 7-3: TOMC As-Needed Staff Activities

KDOT Computer Services	HQ and District Construction & Maintenance Operations	KDOT Partner Agencies & Organizations
▪ Perform on-call services to maintain the system during emergencies ▪ Update TOMC integration with field devices, external partners, etc. as needed when new devices are added. ▪ Repair servers, update software, add users, replace equipment as needed.	▪ View and control CCTV ▪ Activate DMS, provide DMS messages ▪ Activate HAR, provide HAR messages ▪ Update HAR and DMS messages ▪ Deactivate HAR and DMS messages ▪ View traffic detector information ▪ Send alerts to media, adjacent states, and KDOT partners ▪ View flood monitors ▪ Notify adjacent District when control of DMS or CCTV is needed per KDOT policy ▪ Utilize TOMC input and output pages as needed to communicate with internal KDOT and external agencies and organizations. ▪ Monitor KDOT field assets and vehicle locations ▪ Maintain and/or repair ITS field devices	▪ Review KDOT alerts ▪ Respond to KDOT alerts as appropriate ▪ Provide information to KDOT when applicable ▪ View and control CCTV ▪ View traffic detector information ▪ Perform statewide coordination for major emergencies ▪ Notify the media of events and disseminate information to the public

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7.4.4 Estimated Full-Time Equivalent (FTE) Requirements

Based on the estimation of duties and hours per day, per week and per special event required for personnel in each KDOT District, KDOT Computer Services, KDOT Headquarters Operations Division, and partner agencies such as the KHP and KDEM, a total FTE requirement has been calculated for each work group. As shown in Table 7-4, the total FTEs required for each work group per year all fall short of the need for at least one FTE. Partial FTEs are all that is estimated to be required to operate the TOMC in any of the work groups. The importance of this number is that there is likely not enough TOMC duties to keep any one person occupied full-time. TOMC duties will fall upon existing personnel and in addition to other assigned duties.

As has been stated by members of the Project Steering Committee and Project Stakeholders, there are very few available FTEs to dedicate to TOMC functions on a full-time basis and that those duties will need to be assigned to existing personnel who already have defined duties. Even though the FTE requirements shown in Table 7-4 are fractional, they are still a significant amount of one person's total duties, especially in Computer Services and each District. Therefore, when the TOMC duties are assigned, they should be assigned to personnel that have the work load capacity to handle the duties effectively.

Table 7-4: Estimated TOMC FTE Requirements

Event	Events/Yr[1]	Duration Per Event (Hours)							
		Computer Services	Total Hours/Yr	HQ Operations	Total Hours/Yr	District Operations	Total Hours/Yr	TOMC Partners	Total Hours/Yr
Daily Activities	260	2	520	1	260	2	520	1	260
Weekly Activities	52	4	208	2	104	2	104	2	104
Snowstorm	6	2	12	2	12	24	144	2	12
Major Incident/Road Closure	5	0	0	3	15	3	15	1	5
Flooding	4	0	0	0	0	6	24	2	8
Statewide Emergency	1	48	48	48	48	48	48	48	48
TOTAL HOURS/YR			**788**		**439**		**855**		**437**
Full-Time Equivalents (at 2080 hours/yr)			**0.4 FTE**		**0.2 FTE**		**0.4 FTE[2]**		**0.2 FTE**

1 - The number of events per year are considered to be statewide for estimating purposes. Even though each District will not experience the number of snowstorms, major incidents, and flooding events shown, these events tend to affect more than one District per occurrence. No adjustment in the total hours per each District has been made.

2 - The 0.4 FTE figure is per District.

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7.4.5 Typical TOMC Staff Positions

The following position descriptions are general in nature but describe what skill sets are necessary for typical positions to be staffed in a TOMC. The FTE requirements noted above do not necessarily refer to just one person, but rather may be a collective of people, each with a particular skill set described below. For the Computer Services FTE, that may include a System Administrator, Communications Technician, and Software/Computer Support. The Headquarters FTE will include skills closely related to that of an Operations Supervisor and System Operator. The District FTE will closely match the System Operator and Operations Center Technician. Partner Agency FTEs will be similar to Operations Supervisor and System Operator.

Operations Supervisor / Shift Supervisor: This position is frequently filled by a person who came up through the ranks and achieved competence through a blend of job-related training and personal experience. The supervisor must have a well-developed judgmental skill that allows him/her to distinguish between situations that can be handled within the resources of the operations center and those that require the participation of one or more partner agencies. This person is responsible for the management of previously developed operating plans, including the magnitude of the response to implement based on the type of incident. Another skill highly prized in a supervisor is the ability to teach others how to be excellent system operators. The operations supervisor manages the daily operations of the TOMC operations staff and performs a number of reporting and administrative duties. The shift supervisor is in charge of the staff operations for their shift.

Systems Administrator: This position is filled by a person will all of the skills described for the software/computer support position plus this position requires a thorough knowledge of the local area network (LAN) or other network structure that is operating within the TOMC. The system administrator is responsible for the maintenance and upgrading of the TOMC network. The system administrator will maintain the systems security by providing the needed system access to various staff or contractors via passwords. Often the system administrator will manage the software/computer support personnel.

System Operator: This is the hands-on position. The system operator must be computer literate and capable of performing many computer-related skills, such as keying in text data and using a mouse. Most ITS systems are actually composites of several different subsystems, so the system operator must be familiar with the operating commands of several different systems. A typical combination could include Highway Advisory Radio (HAR), dynamic message signs (DMS), and ramp metering, as well as a CCTV surveillance system. Each of these subsystems may have a different operator interface, and the system operators must be fully trained on all of the systems.

Software/Computer Support: While it is possible for an operating agency to maintain the real-time system software, this is generally not the case. A contractor generally maintains the real-time system software. There is a need, however, for software and hardware support in the operating agency. This level of computer skill would require proficiency in the data base management programming languages, including Oracle® or

Sybase®. In addition, the programmer must be proficient in GIS and CADD software packages (e.g., ARC/INFO®, ArcView®, AutoCAD®, MapInfo®, and Microstation®) and firmware for traffic signal controllers (e.g., National Electrical Manufacturers Association, 170,270, and 2070) on Mac®, Sun®, and HP® platforms, as well as the software specifically installed in the TOMC to manage traffic operations. The primary task of the software/computer support personnel is to maintain the software necessary to track maintenance operations and support the operations function.

Communications Technician: This position requires an electronics technician who is trained in the operations of a variety of wireline, wireless technologies, and radio communications (AM and FM) systems supporting video, data, and voice transmissions. An evaluation of the capital cost of the equipment in any ITS system will show that the category with the highest investment is communications. It only makes sense to protect this investment by providing a high level of maintenance. This category is not only the largest but also the one that changes most frequently. As communications hardware evolves, it becomes almost a steady state situation where one subsystem or another is always being upgraded and/or replaced.

Operations Center Technician: This is an electronics technician who may be junior to the communications specialists but nevertheless has been trained in the maintenance of digital electronic equipment, particularly microprocessors. This person can identify hardware failure and make repair/replace decisions. The position requires considerable troubleshooting skills as well as the ability to perform all types of testing.

7.5 Communication Needs

The development of communication requirements for future ITS infrastructure in Kansas will be the speculative at best due to the lack of knowledge of future deployments, future communications technologies, cost variability (either up or down), use of state-owned infrastructure versus leased communication lines, and potential cost sharing between multiple agencies. The following presents a representation of the communications infrastructure existing in Kansas and future communication options.

7.5.1 TOMC Communication Requirements

KDOT is currently using T-1 lines to provide network communication between District Offices. As ITS field devices, particularly traffic cameras, are deployed, the demand for Center-to-Center (C2C) communication will increase beyond the current capacity of the T-1 lines. Network communication to IP addressable devices in the field can be accomplished with most ITS equipment that are only exchanging data such as DMS and detection devices. The use of cameras and transporting of video is going to be the key factor in determining communication requirements.

KDOT owns fiber optic cables and conduit across the state as shown in Figure 7-1. These cables can currently, or with additional last mile connections, be used to provide communication between KDOT Headquarters, Districts 1, District 2, and the Kansas City and Wichita urban areas. The fiber can also be used to connect with partner agencies such as KHP and KDEM in the Topeka and Salina areas as well as any ITS elements that are located along roadways with adjacent fiber optic cabling. Fiber is not currently available to connect to District offices in Norton, Garden City, Hutchinson or Chanute.

7.5.2 Communication Options

Center-to-Center Communication

Table 7-5 shows several options are available for increasing bandwidth for C2C communications. These options include leasing additional T-1 lines, installing additional fiber, or digital microwave wireless communications. Leasing costs for T-1 lines can be very expensive over the long run. Installation of fiber provides the largest potential bandwidth but also the highest initial costs. Microwave communications may be a cost effective alternative. However, depending on the frequency band utilized, weather could cause disruptions to microwave transmissions. A thorough frequency analysis will be required to ensure frequency availability and line of sight availability for placement of towers.

TOMC Concept of Operations
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Figure 7-1: Constructed Fiber Optic Routes in Kansas (KDOT Owned)

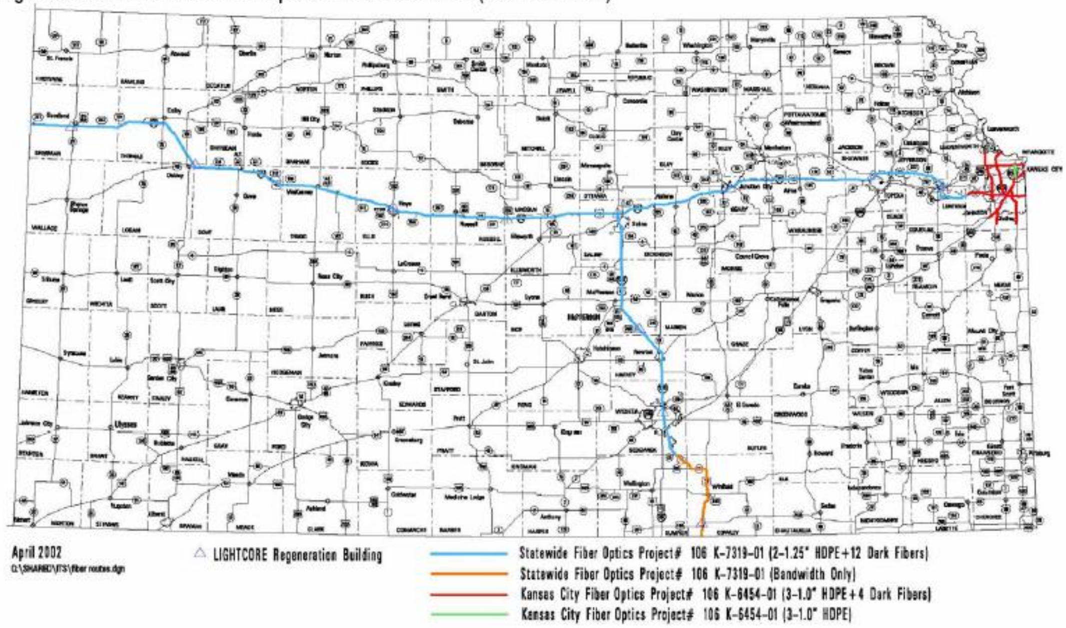

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Table 7-5: C2C Communication Options

Communication Option	Initial Costs	On-Going Costs	Data Capacity	Comments
T-1 Lines	<u>Low</u> Low initial cost if leased.	<u>Moderate</u> Recurring lease costs.	1.54 mbps	Useful for most data applications, but limited usefulness for video.
T-3 Lines	<u>Low</u> Low initial cost if leased.	<u>High</u> Recurring lease costs.	45 mbps	Probably adequate capacity for sharing video between centers.
Fiber	<u>High</u> Costs include conduit, cable and equipment to light the fiber.	<u>Moderate</u>	1,000 mbps	Example is Gig-E Ethernet. Fiber capacity is "unlimited" depending on number of fibers and use of multiplexing.
Digital Microwave	<u>Medium</u> A major factor is cost of towers.	<u>Low</u>	155 mbps	Can be multiples of 155 mbps depending on technology. Most microwave bandwidths require FCC license.

<u>Center-to-Field Communication</u>

In the Kansas City metro area, Center-to-Field (C2F) communication is being accomplished by fiber, especially where traffic cameras are present. In rural areas C2F communication is typically by telephone line (RWIS field devices) or cellular telephones. Cellular could continue to play a significant role for ITS field devices except for traffic cameras. Cellular, though, does have an inherent weakness in that during emergencies cellular tower capacity may be exceeded limiting availability of communication with ITS field devices. Some regions and even some states are developing agreements with local cellular companies for "always-on" cellular connections with ITS field devices. Where these agreements have been implemented reliability of cellular for C2F communication has been increased.

If available from the local telephone companies, Integrated Services Digital Network (ISDN) telephone circuits could be used utilizing MPEG4 video compression equipment to provide low cost video transmission from remote cameras to the TOMC. This would not provide full motion video, but somewhere in the range of 15-20 frames per second. This type of installation would be recommended where easy access to fiber or wireless access points is not available. Costs for leasing an ISDN circuit typically ranges from $50-75 per month per end, not including any long distance charges that could apply. The MPEG4 video compression equipment and ISDN interface equipment will cost approximately $1500-2500, depending on the specific vendor selected.

Figure 4. 6 - Kansas DOT TOMC Concept of Operations

Section 7 of the Kansas DOT Concept of Operations for a statewide Transportation Operations and Management Center breaks down its operational and support environment into five categories: facilities, hardware, software, personnel, and communication needs.

4.3.7 Operational Scenarios

In this section, the proposed system is described under various operating conditions relative to the core users and the stakeholders. This is an important aspect of a Concept of Operations as it demonstrates how the proposed system or service operates under conditions that stakeholders and users expect.

The Concept of Operations (Figure 4.7) for the deployment of an Automated Vehicle Location System in the Lincoln, Nebraska metropolitan area provides five scenarios that describe "how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances". (City of Lincoln StarTran Automated Vehicle Location System Concept Of Operations, prepared by: Mixon/Hill, Inc., November 2005)

Regional Example

City of Lincoln

StarTran Automated Vehicle Location System

Concept Of Operations

5 OPERATIONAL SCENARIOS

The following scenarios describe situations in which the StarTran AVL system could improve operations and safety. Each scenario is a step-by-step description of how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances. The scenarios will tie together the system, the users, and other entities by describing how they interact.

5.1 Scenario 1: Bus Operator Automated Systems

Marcel, a StarTran bus operator, usually begins his work shift with administrative activities. After receiving supervisory direction, he boards the bus and prepares the AVL system. He begins by logging into the system.

The system then prompts Marcel for the route to be followed. He enters the planned route number, and the AVL system retrieves the appropriate route and schedule information from the AVL system server. The bus' AVL system then asks Marcel to verify the appropriate route and schedule information were properly retrieved.

Once he provides verification, the bus' head sign is automatically updated to reflect the appropriate route information. The fare payment schedule is automatically adjusted to reflect the verified route, modified as necessary by the system clock to reflect any applicable time-differential rates.

The system then loads the appropriate bus stop announcements for the chosen route. These prerecorded announcements are consistent regardless whether Marcel or another bus operator is driving the route, and have been verified as ADA compliant. These announcements are then broadcast at the appropriate bus stop throughout the route.

5.2 Scenario 2: Security/Emergency Response

While performing her duties, a bus operator, Susan, notices an individual enter the bus. This individual was profiled on the previous evening's news as a person wanted for questioning related to a recent violent crime. Susan knows she must convey this information to the proper authorities, and do so in a manner that does not expose the other customers or her to potential violence.

Susan continues with her route as if nothing has happened. After leaving this bus stop, she uses the MDT to notify StarTran dispatch of the situation. James, the StarTran dispatcher, confirms receipt of her message, and advises her that the Lincoln Police Department has been notified.

James, who is still on the line with the Lincoln Police Department, accesses the bus' AVL system data. He relays to the Lincoln Police Department the bus' current location, its direction of travel, and the speed at which it is traveling. He then engages and accesses the real-time camera located within the bus. Using the information provided by the bus operator, James identifies the suspect and relays his seat location to the Lincoln Police Department as well.

The Lincoln Police Department notifies the nearest on-duty police officer, who follows the bus to the next stop. James advises Susan to stay parked at the next bus stop. At the next bus stop, the responding police officer enters the bus and apprehends the individual without incident.

While this process is documented for a security incident, the same interactions could occur for a health emergency.

5.3 Scenario 3: Trip Planning and Real Time Status Information

Mary Lewis is a retired schoolteacher. She regularly volunteers at the Lincoln City Libraries, and usually drives her car. However, her car is in need of body repair work, and will be in the shop for approximately a week. Mary's coworker suggests she use StarTran service while her vehicle is being repaired.

Mary accesses the StarTran website from the library's computer. She selects the trip planning function from the website, and enters her starting location (at home) and her ending location (the library), along with the time she needs to be at the library. The StarTran trip planning function provides the bus stop nearest her starting location and the time she must be there to catch the bus. It tells her she must make one transfer, and provides the transfer location and estimated wait time at the transfer station. The trip planner also provides the bus stop nearest her ending location and an estimated arrival time. Mary prints out the trip plan and takes it home with her.

The day arrives when Mary plans to take the bus to volunteer at the library. Unfortunately, inclement weather has entered the region and Mary does not wish to wait for the bus in the snow. Using the information she has saved on the printed page, Mary calls the StarTran route status line. After entering her bus stop and initial route information, the system advises Mary the bus is running 3-5 minutes behind schedule due to inclement weather. Mary uses the extra time to make sure she has her overshoes for the trip to the bus stop.

5.4 Scenario 4: Dispatcher Management of Routes and Schedules

StarTran has recently hired a new bus driver, Gregory. After passing the necessary examinations and completing his introductory training, Gregory has been assigned the #7 Belmont route.

Although he studied the route, Gregory has the normal apprehension associated with starting a new job and being concerned with performance. His dispatcher, Julie, advises him that she will use the AVL system to help ensure he is performing well.

Gregory starts his route at midday, and approximately 20 minutes in, experiences confusion over the planned route. He accesses the bus' AVL system, and using the inlaid route map loaded based on his login, he realizes he made a wrong turn. He quickly corrects his routing and continues with the remainder of the planned route.

Meanwhile, the AVL system has informed Julie that Gregory is off-route. By the time she accesses the system, he has returned to the proper route but is now behind schedule. The AVL system advises Julie he is behind schedule, and appears to be making up a little of the time. Julie contacts Gregory via the MDT and inquires about what happened. Gregory advises her he made a wrong turn, but corrected it and made sure he did not miss a stop. He is now trying to make up time at each stop so as not to impact the remainder of the afternoon's schedule. Julie reminds him the schedule has some cushion built in at the 2:40 p.m. Autumn Wood stop, and if he's diligent between now and then, he'll be back on schedule at that point.

5.5 *Scenario 5: Automated Fleet Management*

Manny, a StarTran Garage Supervisor, is responsible for scheduling maintenance for a percentage of the StarTran fleet. As part of his goals, he plans for as much preventative maintenance as possible, limiting the amount and expense of unanticipated equipment failures. He also knows that unanticipated equipment failures impact operations by requiring equipment rotation and perhaps contracting of additional equipment from Transport Plus.

Manny recognizes that a key to meeting his goal is regularly scheduled preventive maintenance. Realizing that scheduling every oil change to be performed in one day is not a practical method of accomplishing this goal. Using the daily mileage/hours reports automatically provided by the AVL system, Manny is able to plan needed preventive maintenance over the upcoming workweek.

Manny also utilizes the AVL system's real time equipment status alerts to receive notification of equipment functions that are reaching critical thresholds. During his shift, the AVL system sends Manny a pager notification regarding the #19 Salt Valley line bus. The bus' transmission temperature is reaching cautionary levels, indicative of possible impending failure. Manny contacts Louise, the responsible dispatcher, who has also received the same notification from the AVL system.

Manny and Louise determine the risk is low, as the bus is on the day's final run. However, Manny makes arrangements to pull this bus out of service at the day's end, and Louise makes plans to utilize alternate equipment while fleet maintenance personnel evaluate the bus and make any necessary repairs. The AVL system's notification has help avoid a potential transmission failure.

Regardless of the level of planning, unforeseen equipment failures will still occur. Such was the case when Manny received an AVL system pager notification about the #2 Bethany line bus' brake system failure. He quickly determines the failure will not permit a field repair. Almost simultaneously, Manny receives a call from Louise who has received the same notification. Louise advises Manny she has already made arrangements for a replacement bus to pick up the existing passengers and complete the route. While talking, Manny has accessed the bus' AVL system and has determined the bus' exact location and orientation on the roadway. He makes arrangements to have the bus retrieved and returned to the garage for repair. Because of the close coordination and the availability of real time information, the recovery team arrives just as the replacement bus has loaded the passengers. This minimizes the time the bus is disabled in traffic, thus reducing the secondary traffic flow impacts.

Figure 4. 7 - City of Lincoln Automated Vehicle Location System Concept of Operations

Section 5 of the Concept of Operations for the deployment of an Automated Vehicle Location System in the Lincoln, Nebraska metropolitan area provides five scenarios that describe the operation of the proposed system under various user-expected conditions.

4.4 CHAPTER SUMMARY

This chapter explored the definition of a Concept of Operations in the context of a regional integration project. It noted that, while the definition is the same for all systems, the Concept of Operations description for a regional system must encompass more complex interactions and inter-relationships. The Core Elements of a Concept of Operations are illustrated here with regional examples in order to demonstrate scalability.

4.5 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

- *IEEE 1362-1998 Guide for Information Technology—System Definition—Concept of Operations (ConOps) Document*. New York: IEEE, 1998

- Indianapolis Metropolitan Planning Area Regional Intelligent Transportation System Architecture, *Inventory of Existing Documentation, Final Appendix A*, Prepared By Edwards and Kelcey for the Indianapolis Metropolitan Planning Organization, June 2005

- Kansas DOT Bureau of Transportation Planning and PB Farradyne and Olsson Associates: Transportation Operations and Management Center Concept of Operations

http://www.ksdot.org/burtransplan/burovr/pdf/Task%207%20ConOps%20Final%20September%202005.pdf

- Florida Department of Transportation: Surface Transportation Security and Reliability Information System Model Deployment (iFlorida) Draft Concept of Operations, July 25, 2003

http://www.iflorida.net/documents/FinaliFloridaConOps.pdf

- USDOT ITS, Next Generation 9-1-1 System Preliminary Concept of Operations

http://www.its.dot.gov/ng911/next_gen_911_sys.htm

- Deepu, Philip; Sularz ,Brandy; Kack David, Concept of Operations and Action Plan , prepared by Western Transportation Institute College of Engineering Montana State University Bozeman for Modoc County Transportation Commission Alturas, California September, 2004

http://www.coe.montana.edu/wti/wti/pdf/425509_ConOps_Final_Report.pdf

- Michigan Department of Transportation VII Michigan Test Bed Program Concept of Operations REVISED DRAFT – October 10, 2005

- City of Lincoln StarTran Automated Vehicle Location System Concept Of Operations, prepared by: Mixon/Hill, Inc., November 2005

5 Developing a Concept of Operations for a Regional Initiative

The previous chapter noted that, while the structure/components of a Concept of Operations is the same for all systems, the content of a Concept of Operations for a regional system or service encompasses more complex interactions and inter-relationships due to the very nature of these integration initiatives. The necessity to produce a comprehensive document that addresses this degree of complexity has significant implications for the strategy utilized to develop the Concept of Operations. The purpose of this chapter is to identify development issues that are critical to the creation of a Concept of Operations for a regional initiative, and to address these issues with advice based on (1) interviews with transportation professionals, and (2) illustrations of best practices from regional examples.

5.1 CHAPTER OVERVIEW

The purpose of this chapter is to provide guidance to support the development of a Concept of Operations document for a regional integration project. The key objectives of this chapter are:

- To address critical issues related to Concept of Operations development, including stakeholders, institutional barriers, resources, and performance measures
- To provide specific guidance on how to develop core elements.

5.1.1 Relationship to Previous Chapter

Chapter 4 defines the Concept of Operations in the context of a regional integration initiative: it explains the goals and objectives and defines the individual core elements of a Concept of Operations, using regional examples. This chapter provides guidance for *developing* a Concept of Operations for an integrated system, including advice for beginning the process, identification and involvement of stakeholders, and developing each of the individual core elements.

5.1.2 Chapter Sections:

- Initiation of the Process
  - Assembling the Writing Team
  - Required Resources
- Stakeholder Identification and Involvement
  - Institutional Barriers

  - Developing Performance Measures

- Developing the Elements
- Chapter Summary
- Specific Literature Supporting This Chapter

5.2 INITIATION OF THE PROCESS

5.2.1 Assembling the Writing Team

The development of any Concept of Operations is an iterative process, but the first order of business is to assemble a writing team. The writing team is the core group of individuals responsible for working with stakeholders to pull together all of the information required in a Concept of Operations. The method used to recruit the team and the composition of the team should be based on the nature of the identified regional need. It makes sense to include persons who were involved with the needs assessment/planning process *if they are appropriate for the writing team*; if they are not, they may nevertheless be appropriate for the stakeholder list as the development task evolves. The writing team should be composed of those persons who will be immediate users of the system, and who have the time, energy, and *regional* commitment. It is important for a team that is developing a Concept of Operations for a regional initiative to be composed of individuals from a variety of backgrounds, who represent the core of regional stakeholders. Its composition should be a balance of technical and non-technical individuals who reflect:

- The types of organizations involved in the integration (e.g., planning organizations, transportation agencies, emergency services, transit, private partners).
- The jurisdictional/geographic scope.
- The levels of technical expertise needed.
- Identified "champions" for the system who might not fit into the above categories.

The writing team will develop a concept based upon the identified regional need. It will then bring in more stakeholders from the region to refine and solidify the initial concept.

5.2.2 Required Resources

Demand for resources is driven by the scope and complexity of the proposed regional system. This section will address important issues to be considered in identifying and defining those resources.

The scope of a project will greatly affect the staff time and funds that are necessary for completing a Concept of Operations. A regional integration project can expect to require a significant budget and staff involvement. Staff involvement may be mitigated somewhat by the hiring of consultants for the writing task. However, user/stakeholder involvement will still be required for input, monitoring, and management of the process. One advantage of consultants is that they may be seen as "neutral" by stakeholders who fear that a lead organization may be using the process to promote its own narrow interests. In this sense, consultants may help de-politicize the process and may be better able to address institutional barriers. A disadvantage of consultants is that they may lack the regional commitment and perspective of a lead agency or well-assembled writing team. After all, consultants will not likely be major users of the system.

A key resource for Concept of Operations development is existing transportation-related documents, especially those pertinent to a regional/integrated system. There will likely be many of these to choose from given the number of systems, the existence of regional planning, and the previous build-out of projects in the constituent systems. The types of documents used will vary with the system, but examples of the kinds of documents that might be useful are listed below:

- Development and Preparation Guides for Concept of Operations Documents – This would include our companion document Developing and Using a Concept of Operations in Transportation Management Systems Handbook and the Guide for the Preparation of Operational Concept Documents (ANSI/AIAA G-043-1992), as well as documents that describe other phases of the systems engineering process.

- Regional ITS Architecture – This valuable resource provides the general framework for the planning and deployment of ITS for a region.

- Regional Concept for Transportation Operations (RCTO) – This management tool is a product of Regional Transportation Operations Collaboration and Coordination (RTOCC), a process, related to Regional ITS Architecture, which seeks to link planning and operations. A RCTO outlines 3 – 5 year transportation operations objectives for a region.

- Other regional planning documents, such as Early Deployment Plans, Strategic Planning, and Business Planning documents.

- Existing Concepts of Operations and Functional Requirements documents – Concepts of Operations from constituent systems will inform, and eventually be informed by, the more comprehensive regional document.

- Concepts of Operations and Functional Requirements of integration projects, from other regions, that are similar to the project under consideration.

It is important also to document these resources in the Concept of Operations. Figure 5.1 presents an excerpt from Next Generation 9-1-1 System Preliminary Concept of Operations. The *Next Generation 9-1-1 Initiative* is a DOT research and development project with a multistate (nationwide) scope. It is a good example of the kinds of documents needed to develop a Concept of Operations for a regional project.

Regional Example

Next Generation 9-1-1 System

Preliminary Concept of Operations

6 Source References

Primary sources of information used in this document were published and working draft documents from the Federal Communications Commission, National Emergency Number Association, the Internet Engineering Task Force (IETF), and the Alliance for Telecommunications Industry Solutions (ATIS) Emergency Services Interconnection Forum (ESIF).

- *Network Architecture Properties in 2010, Extending E9-1-1 to Satellites, and Generic Architectures to Support Video and Advanced Services;* Network Reliability and Interoperability Council (NRIC) VII Focus Group 1B, Federal Communications Commission (FCC); June, 2005. *Long Term Issues for Emergency/E9-1-1 Services*; (Draft). – These documents are designed to provide a set of specific recommendations regarding future emergency communications network properties, and their capability by 2010 to support the exchange of voice, data, text, photographs and live video through the emergency services internetwork to the PSAP and beyond.

- *Communication Issues for Emergency Communications Beyond E911: Report #1, Properties and Network Architectures That Communications Between PSAPS ad Emergency Services Personnel Must Meet in the Near Future.* NRIC VII Focus Group 1D, FCC. December 2004. – *Communication Issues for Emergency Communications Beyond E911: Final Report - Properties and network architectures for communications between PSAPs and emergency services organizations and personnel*. The purpose of these documents is to describe the properties that network architectures for communications between PSAPs and emergency services personnel must meet.

- *Draft i3 Requirements*. National Emergency Number Association (NENA) VoIP Technical Committee Long Term Definition Working Group. September 2005. This document provides requirements for a NENA-recommended standard for the i3 architecture for end-to-end emergency calling over IP-networks.

- *Requirements for Emergency Context Resolution with Internet Technologies*. Internet Engineering Task Force. October 2005. http://www.ietf.org/internet-drafts/draft-ietf-ecrit-requirements-01.txt - This document enumerates requirements for emergency calls placed by the public using voice-over-IP (VoIP) and general Internet multimedia systems, where Internet protocols are used end-to-end.

- The ATIS-ESIF Emergency Services Network Interfaces Task Force 34 will define a new messaging and interaction protocol between PSAPs and Emergency Services Networks that goes significantly beyond the paradigms that exist to provide those services today. Various summaries and briefing materials are available at the Task Force 34 website at http://www.atis.org/esif/esmi.asp. The Task Force 34 messaging and interaction protocol will be specified as an American National Standard (ANS).

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This outline follows the guidance in the recent Federal Highway Administration (FHWA) pooled fund study, *Developing and Using a Concept of Operations in Transportation Management Systems*,[2] which is based on the ANSI/AIAA standard, *Guide for the Preparation of Operational Concept Documents.*[3] The Concept of Operations is the first step in the systems engineering process promoted by FHWA (see Figure 1-1). The concept of operations describes broad goals, user needs, and the operating environment. It forms the basis for developing system requirements. Note: common usage in systems engineering has the terms "Concept of Operations Document" and "Operational Concept Document" as interchangeable terms.

Figure 5.1- Next Generation 9-1-1 System Preliminary Concept of Operations

This figure is an excerpt from Section 6 Source References of the Preliminary Concept of Operations, which provides a list and brief description of the documents used in developing this Concept of Operations. An additional excerpt in the figure (from Section 1) identifies another source document.

5.3 STAKEHOLDER IDENTIFICATION AND INVOLEMENT

Developing a Concept of Operations for a regional project will require particularly intense stakeholder participation. Engaged stakeholders are critical for both input and support. For a regional integration project especially, stakeholder involvement is crucial in addressing two key areas:

- Institutional Barriers
- Performance Measures

5.3.1 Institutional Barriers

Although integrating systems can present a considerable technical challenge, many transportation professionals that have been involved in such undertakings have stated that the greatest challenge lies in evolving a strategy to deal with institutional barriers.

For any regional integration effort to be successful, the constituent organizations will need to coordinate operations and share information. The details of this sharing and coordination will need to be worked out. This can be a difficult and time-consuming process and, inevitably institutional barriers will need to be confronted. This issue was addressed in a Integrated Transportation Management Systems (ITMS) Conference White Paper (Louis Neudorff, *Institutional Challenges, Barriers and Opportunities: Institutional Integration* White Paper for ITMS Conference, July, 2001):

Regional Expertise

"…these numerous organizations must first agree to share information and to coordinate with one another. Subsequently, they must identify what information will be shared and how it will be utilized; define how the information will be exchanged (e.g., communications and system interfaces); determine the level and extent of their inter-agency coordination (e.g., shared control of field devices), and under what circumstances this coordination is initiated; commit the necessary resources to implement, operate, and maintain the ITMS; and develop the necessary inter-agency agreements (and possibly legislation) documenting the various ITMS agreements, policies, and procedures."

While the Concept of Operations is the starting point of the systems engineering process, and should not be looked at as *THE* place to solve institutional issues, it is clear that this document must identify key issues and begin the process of addressing them if the integration effort has any chance of success. Key institutional barriers and the strategies for surmounting them that generally must be addressed in a Concept of Operations development for a project involving regional integration are discussed below:

Barriers

- One significant barrier identified was "institutional inertia". This refers to the lack of promptness (or willingness) of some senior managers or other transportation professionals to make the transition from a "culture" of construction and maintenance to one of operations.

Regional Expertise

"It is a relatively new way of thinking – this concept of using computers and electronics to improve traffic flow with little steel or concrete, coupled with the need to coordinate your operations with other entities – to which senior management and the institutional framework within many organizations may not have completely adjusted."

- An additional barrier is the tendency of individual agencies to exhibit tunnel vision: to focus exclusively or primarily on their own operational needs.

- In addition to the inter-agency institutional barriers described above, the paper also identified intra-agency barriers.

Regional Expertise

"Different departments within the same agency (e.g., operations, construction, financial) will likely have roles to play within an ITMS; but they may also have overlapping responsibilities, a lack of understanding of the other departments' missions, and conflicting priorities and policies."

Strategies to Address Institutional Issues

- The best way to proactively address these concerns is by involving all classes of users in the development process as early as possible. The early inclusion of stakeholders in the Concept of Operations development process can offer the following benefits for the regional development effort:
    - It cultivates an interest in the project and underscores its importance.
    - It encourages the various participants to identify and focus on common goals, making it more likely that the conceived system will satisfy those goals.
    - It fosters each agencies appreciation of the others perspectives and institutional constraints, thereby enhancing the collaborative effort
    - It helps in the identification of any additional agencies and other stakeholders that should be participating
    - It helps in the identification of resources for Concept of Operations development and to build, operate, and maintain the proposed system.
- It is also very helpful for a lead agency (e.g., MPO, Regional TMC, state DOT) or "champion" to take the lead to organize meetings, promote the project, focus energy, and help maintain momentum.

Summarizing this guidance, please note the experience of a transportation professional who oversaw the development of the Concept of Operations for a regional traffic signal coordination project:

Regional Expertise

"We have had to deal with a host of multi-jurisdictional institutional issues to develop, implement and maintain agreement around the project concept of operations. Having strong regional champions for the project; developing structured ways to get input from all of our participating agencies; taking advantage of new funding opportunities as they have presented themselves; serving as a "neutral" third-party; taking time to build and maintain relationships with and between project stakeholders; and using opportunities to build trust in our competence to assist in traffic signal coordination have all been important to our success to date with this effort."

5.3.2 Performance Measures

As the name implies, performance measures are metrics developed to monitor and evaluate the performance of the system once it is operational. It is important for a Concept of Operations to provide the information necessary for the formulation of high-level performance measures and to describe the process for their development. This high-level definition of system performance measures should be relevant to the goals and objectives promulgated in the Concept of Operations. Performance measures are user-oriented tools for measuring system operations performance (with respect to goals) and reliability. Performance measures are also used to support future planning. Development of performance measures requires a high degree of stakeholder involvement. For the regional integration initiative this is a time-consuming and intensive process.

In the development of statewide multi-modal performance measures, Caltrans sought extensive stakeholder input, as Figure 5.2 shows. (John Wolf, California Department of Transportation (Caltrans), *Performance Measurement and Integrated Transportation Management Systems-A Traffic Operations Perspective* 4TH Integrated Transportation Management Systems (ITMS) Conference White Paper, July 15-18, 2001)

Regional Example

Caltrans Statewide Performance Measures:

Stakeholder Input

Caltrans approached the development of performance measures in a variety of ways to allow for ample stakeholder and decision maker input.

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A technical advisory group (Transportation Assessment Steering Committee or TASC) was established to assist in detailed development of system outcomes, indicators, measures, links to decision-making, data collection and terminology. The group consisted of representatives from regional transportation planning organizations, private interest groups, the Federal government and Caltrans programs and districts.

A Policy Advisory Committee (PAC) was convened to provide overall policy guidance and to review and comment on the framework as it developed. The PAC was comprised of almost fifty people representing various public and private interests in the state.

To obtain additional stakeholder perspectives, a two-day conference to specifically address transportation system performance measures was organized and presented by the University of California. Several hundred attendees from across the State representing agencies as large as the Southern California Association of Governments (SCAG) and the Bay Area Metropolitan Transportation Commission (MTC) to small, rural county governments came to Sacramento for the conference.

Government, academic and private industry representatives were gathered from across the country to discuss the topic with this wide spectrum of California transportation stakeholders. The conference helped establish a common language for developing the measures, identify critical issues and opportunities related to development and implementation of the measures, and receive input from a broad stakeholder community.

To supplement the findings from the conference, a review was also conducted of existing transportation system performance measure frameworks from other states and from California regional transportation planning organizations. The review sought to highlight the variety of approaches taken and to identify areas of consistency in approach so that California might build upon what others had already accomplished.

Public input was received from meetings held in various cities to present findings and to solicit reactions and suggestions. Formal presentations were made to several regional transportation planning organizations and to statewide transportation committees

The development group laid out the following design criteria:

- Indicators must be easy to use/simple to understand
- Indicators must be measurable across all modes
- Indicators must use existing data sources, and conform to existing performance activities (Metropolitan Transportation Commission, Southern California Association of Governments, ITMS[already developed in California] etc.) where and whenever possible

Figure 5.2 - Caltrans Statewide Performance Measures

This figure describes the process of stakeholder involvement in the development of performance measures for a statewide integrated system.

High-level performance measures should relate to specific goals for the proposed regional system. The two graphics in Figure 5.3 below demonstrate how the performance measures developed for the MAG region in Arizona (second graphic) match specific goals for the region (first graphic). (Maricopa Association of Governments, *"Regional Concepts of Final Operations: Final Report."* November 2003)

Regional Example

Maricopa Association of Governments

Regional Concept for Transportation Operations

Goals

Operational goals are prepared as a means of setting a target for the region to aim for over the next three to five year time period. Having these goals in front of all agencies provides some focused direction, leading to achieving the stated vision and mission for the region. The proposed three-year and five-year goals for the MAG Region are summarized in the following table.

OPERATIONAL CATEGORIES	THREE-YEAR GOAL	FIVE-YEAR GOAL
FREEWAY MOBILITY	▪ Limit the percent increase in average travel time to less than the percent increase in traffic volume.	▪ Same as three-year goal.
ARTERIAL MOBILITY	▪ Limit the percent increase in average arterial travel time to less than the percent increase in traffic volume. ▪ Optimize traffic signal coordination within and between cities on major arterials, or where appropriate.	▪ Continue to limit the percent increase in average arterial travel time to less than the percent increase in traffic volume. ▪ Update the traffic signal coordination within cities and between cities every two years or when traffic volumes through the intersection change by more than five percent.
FREEWAY INCIDENT MANAGEMENT	▪ Reduce incident duration by 10 percent.	▪ Reduce incident duration by 20 percent.
FREEWAY-ARTERIAL INTERFACE	▪ Establish integrated freeway-arterial corridor operations on one corridor.	▪ Establish integrated freeway-arterial corridor operations on three corridors.
ARTERIAL INCIDENT MANAGEMENT	▪ Conduct a feasibility and planning study for a multi-jurisdictional arterial incident management program.	▪ Implement a multi-jurisdictional arterial incident management program (based on outcomes of feasibility study).
ARTERIAL OPERATIONS	▪ Establish a regional standard for implementation of emergency vehicle signal preemption (EVSP).	▪ Ensure adoption of the EVSP standard by each of the MAG member agencies, and implement the standard on 100 percent of the traffic signals with EVSP.
TRANSIT MOBILITY	▪ Deploy a transit signal priority pilot project.	▪ Where beneficial, deploy transit signal priority to BRT routes.
COMPUTER SYSTEM RELIABILITY	▪ Operate the system with up time of 95 percent – no more than 450 hours down time per year. Allows for approximately eight hours of system maintenance per week. Maintenance is preferably conducted in off-peak periods. ▪ Minimize system down time to an average of one hour per system failure.	▪ The five-year goals for system reliability are the same as the three-year goals.

Operational Categories	Three-Year Goal	Five-Year Goal
Multi-Agency Coordination	▪ Establish center-to-center communications between 15 agencies in the region. These agencies should include traffic and transportation, enforcement, emergency management, and transit. ▪ Facilitate incident and emergency response and travel information sharing between 15 agencies.	▪ Establish center-to-center communications between 20 agencies in the region. These agencies should include traffic and transportation, enforcement, emergency services, and transit. ▪ Facilitate incident and emergency response and travel information sharing between 20 agencies.
Travel Information Provision	▪ Increase travel information usage (web, 511, television, radio, etc.) by 100 percent, and achieve a 75 percent customer satisfaction rating. On a scale of 1 to 10, a score of 7 or higher is desired. ▪ Expand Phase 1 of the ADOT / MCDOT / City of Scottsdale web-based HCRS pilot project for local closure and restriction information to include 5 additional MAG member agencies (Phase 2). ▪ Incorporate transit status information from AVL data from buses into travel information services. ▪ Develop web-based arterial maps for 100% of instrumented smart corridors.	▪ Increase travel information usage (web, 511, television, radio, etc.) by 200 percent, and achieve a 75 percent customer satisfaction rating. On a scale of 1 to 10, a score of 7 or higher is desired. ▪ Evaluate performance capabilities of Phase 2 web based HCRS pilot project for local closure and restriction information and expand to include additional MAG member agencies. ▪ Obtain travel time information on 50% of instrumented arterial roadways and post this information to Web, 511, and variable message signs.

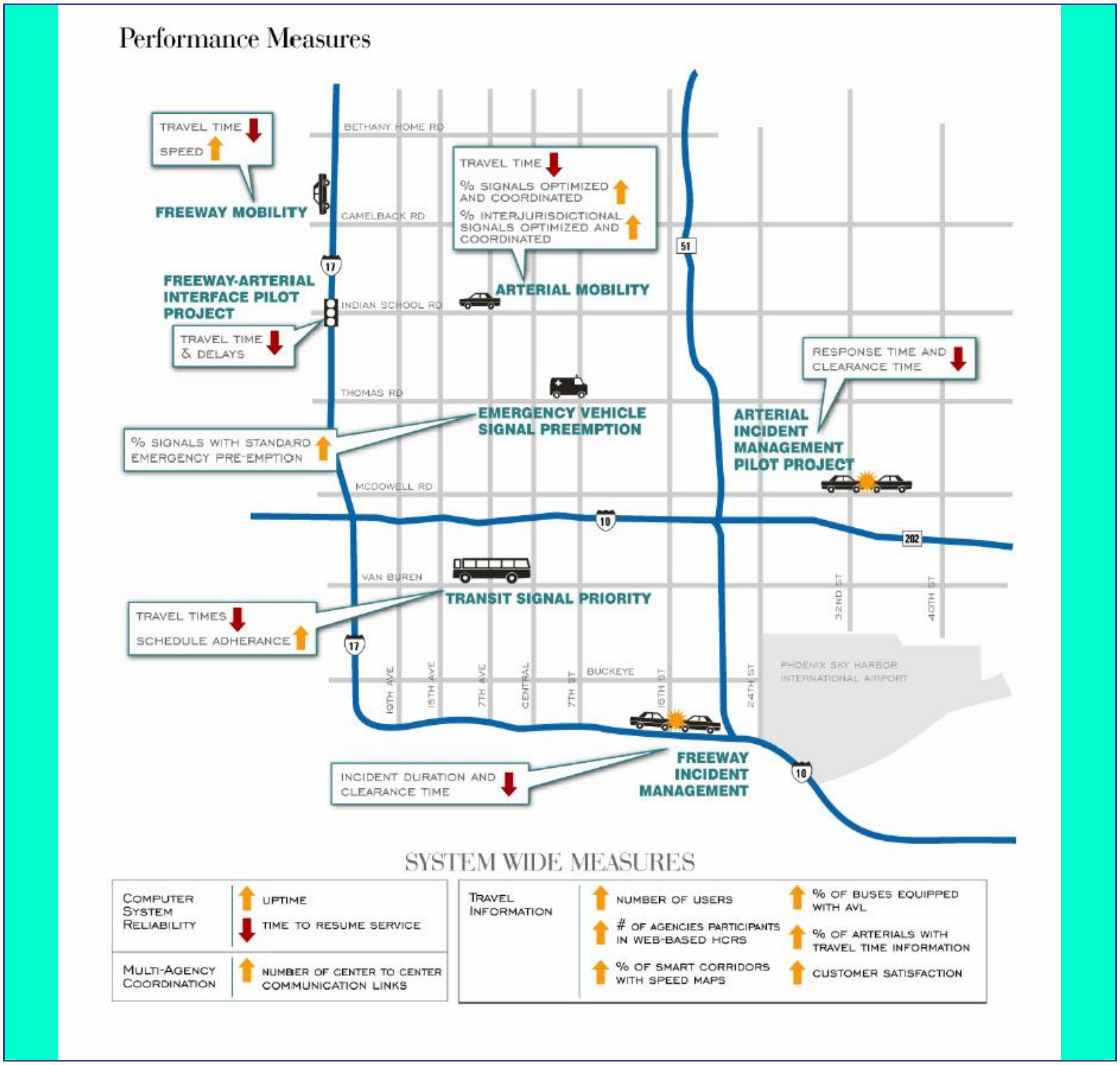


Figure 5.3 - Maricopa Association of Governments Regional Concept for Transportation Operations

These two graphics demonstrate how the performance measures developed for the MAG region in Arizona (second graphic) match specific goals for the region (first graphic).

5.4 DEVELOPING THE ELEMENTS

Scope

Set Boundaries on the Scope of the System

This should be considered tentative at the beginning of the process, but once the relevant Concept of Operations development phases are completed the boundaries' description can be solidified. It must be remembered that, especially with an integration project, the boundaries can be functional, political and institutional as well as spatial and temporal.

There is a great temptation, especially when the collective energy of the regional stakeholders has been fully engaged, to try to establish a "super system", with a multitude of capabilities and interconnects. The practice of "over-scoping" the regional project beyond that which is manageable should be discouraged; every phase of the systems engineering process could be overburdened and the energy and commitment of stakeholders could wane, leading to "stakeholder turnover".

One of the transportation professionals involved in regional integration, whom we interviewed for the development of this guide, had this to say on the subject of scope:

Regional Expertise

"If we had it to do over, we would have identified fewer goals, making everything more manageable and practicable – doable within our time frame. We are not moving along at the pace we expected."

Purpose for Implementation of the proposed System, Major Objectives and Goals, and Vision

Although generally stated, these subsections all require major stakeholder consideration, participation and input, especially given the magnitude of the proposed system. For this reason, we stress the importance of careful identification of users and stakeholders; please see the discussion above on Stakeholder Identification and Involvement.

Referenced Documents

It is important to list the resource documents that support the Concept of Operations development; they serve as the basis for understanding the rationale for the proposed system and they provide interested parties with a guide for finding more information. There are likely to be many documents supporting the regional initiative. Types of reference sources that are typically listed include:

- The Concepts of Operations and Functional Requirements of all constituent systems as well as those impacted by the regional project should be included. This is important for understanding and demonstrating need, identifying stakeholders, and establishing interconnects and information flows.

- Regional Business Planning Documents are useful for stakeholder identification and to support decision-making related to phasing the project.

- Human Resources: Identifying experts in various aspects of systems operations - whether fiscal, human, or technological – as well as local "champions" may be helpful for developers of this or other regional systems.

- Regional Studies of operational needs can be used to support needs-assessment and justification for the proposed system.

- System Development Meeting Minutes can provide useful information for future system integration efforts or for future refinement of the currently proposed system.

- Strategic Plans and Strategic Plan Updates, including Regional ITS Architecture and any Regional Transportation Concept for Transportation Operations (RCTO) should be referenced as a starting point for Concept of Operations development as they provide the context for identifying institutional issues and for defining goals and responsibilities.

User-Oriented Operational Description

Strategies for accomplishing goals and objectives for the proposed operation of a regional system must be described from each user's orientation within the regional context. The system overview must describe the user's roles and responsibilities – including shared responsibilities - and the order in which operations take place. All interactions between systems and subsystems within the scope of the project must be elucidated. There are likely to be more constraints on a cross-jurisdictional system and they must be clearly addressed. All policies and procedures necessary to support regional integration must be described.

As the companion document pointed out, the User Orientated Operational Descriptions are sometimes contained only in the scenarios. For clarity and thoroughness in describing a regional system, it is a better practice to provide this information *both* in this section and in the scenarios.

Operational Needs

This subsection addresses the question of what is required by the region that the current system or set of services does not provide. This implies a description of the process for identifying these requirements and for establishing their relationship to the current operational environment.

It might be beneficial to approach the question as the Maricopa Association Governments did in developing their RCTO:

Regional Expertise

"… it was important to identify what 'functions' local agencies had to consider with the region in mind – such as coordinating traffic signals on cross-jurisdictional corridors – and what 'functions' were indeed regional in nature, such as freeway operations or travel information".

It is important to establish the context and methodology for assessing needs.

The Operational Needs section is the place to make the case for the proposed regional system and it is important to: 1) be sure that the needs statement satisfies all of the user and stakeholder expectations, and 2) align the needs with the proposed remedies. Be sure that the stated need and the proposed modified operations or added capabilities match. This is especially important for a regional initiative because of the number and diversity of people who will be needed to support the system and who will need to "buy" into it. In order to surmount institutional barriers to sensitive issues such as shared control, funding, and enabling agreements, justification for the proposed operations must be clearly stated and well-documented.

System Overview

The System Overview is intended to describe all aspects of the system at once. This includes the system scope, users, system interfaces, system states and modes, system capabilities, system goals and objectives, and system architecture, all at a high-level. The use of diagrams is highly recommended because diagrams concisely communicate a large amount of information for a complex system. This can be a problem when describing large and complex integrated systems, as the diagram can become too cluttered to serve its purpose. In this case, it might be best then to use a series of diagrams that starts with a high-level view of the integrated system and then breaks out geographical/jurisdictional zones or identified functionalities for emphasis or for more detail.

In Figure 5.4, the Concept of Operations for the VII Michigan Test Bed Program provides a series of maps depicting the same system overview, but then using fading (or transparency increase) to deemphasize/emphasize user roles and responsibilities among the public and private sector:

Regional Example

VII Michigan Test Bed Program

Concept of Operations

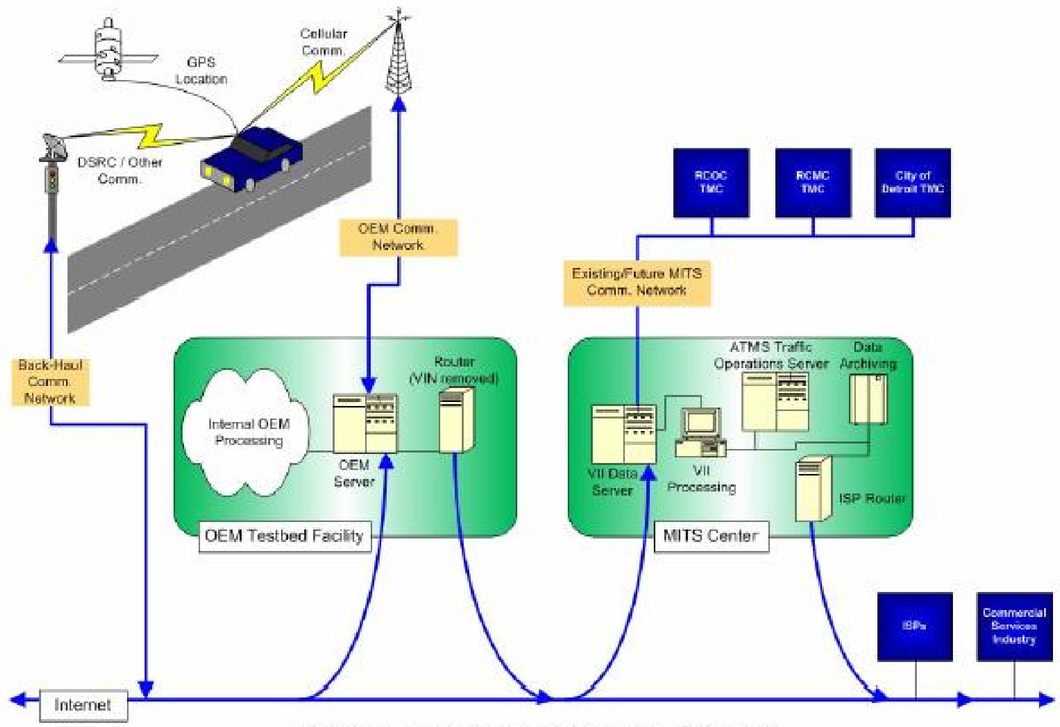


Figure 2 – Michigan VII Test Bed Concept

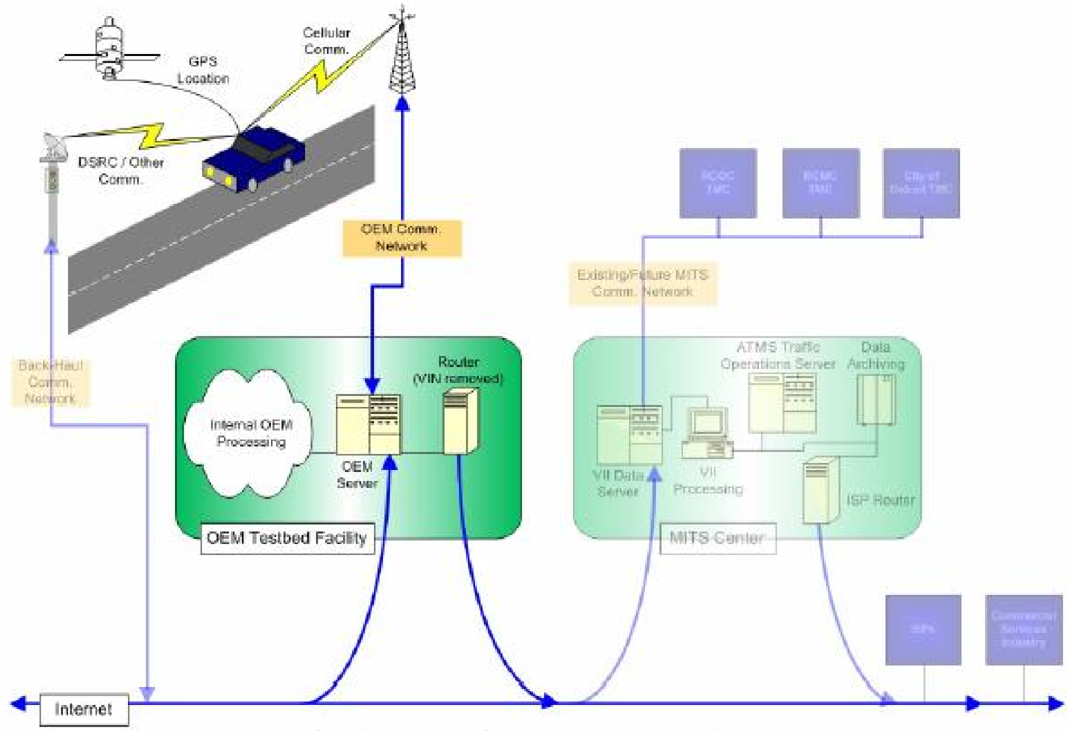


Figure 4: OEM / Private-Sector Roles and Responsibilities

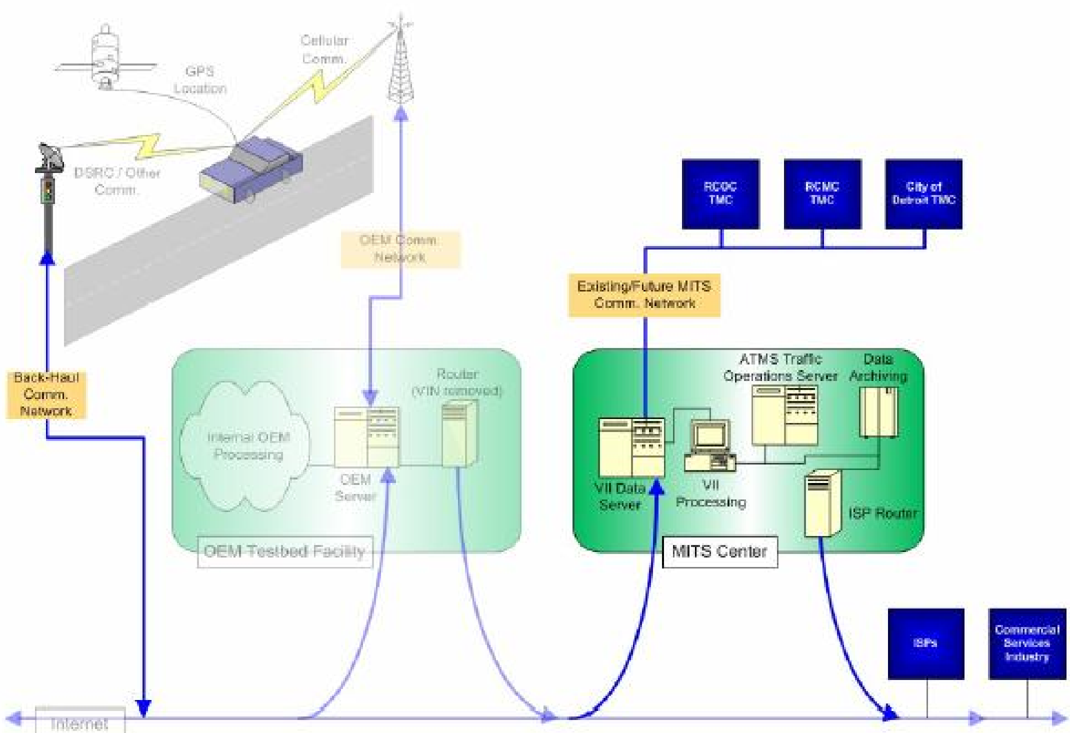


Figure 5: MDOT / Public-Sector Roles and Responsibilities

Figure 5.4 - VII Michigan Test Bed Program Concept of Operations

This figure shows a series of maps depicting the system overview and the roles and responsibilities of public and private sector users.

Operational and Support Environments

The ANSI/AIAA standard describes this section thusly: "This section should describe the required physical operational environment, if known, in terms of facilities, equipment, computing hardware, software, personnel, operational procedures and support necessary to operate the deployed system." Depending on the nature of the regional initiative, it is possible that much of the physical operational environment will be known; much of the infrastructure for the proposed integration, and the procedures and personnel needed to operate and maintain it, may already be in place. Even so, the added functionality and other factors that the regional integration demands will need to be clearly documented.

Figure 5.5 shows Section 6 of the Columbus Metropolitan Freeway Management System Concept of Operations, which details the personnel, operational procedures and support necessary to operate the deployed system (Mid-Ohio Regional Planning Commission, Columbus Metropolitan Freeway Management System *Detailed Project Plan: Concept of Operations* prepared by DMJM+Harris, Inc., March 2001)

Regional Example

Mid-Ohio Regional Planning Commission

Columbus Metropolitan Freeway Management System

Concept of Operations

6.0 Organizational Concept

Concept of Operations 5

The organizational concept addresses agency roles and responsibilities; staffing; hours of operation; and dispute resolution.

Agency Roles and Responsibilities

ODOT will own, operate and maintain the CMFMS. The division of responsibilities between ODOT and the City's Division of Parking and Traffic is shown below in Exhibit 1.

Exhibit 1 – Agency Responsibilities

System	Agency
CMFMS Operations	ODOT / City
CMFMS Maintenance	ODOT
ATIS	ODOT / City
Computer Controlled Signal System	City
Ramp Metering	ODOT / City
Incident Management	ODOT / City Police & Fire / City Traffic (TERT)

The cost of installing, operating, maintaining, upgrading or replacing the equipment located along the arterials and freeways will be the responsibility of the respective operating parties as indicated above, and all expenditures will be at the agency's complete discretion.

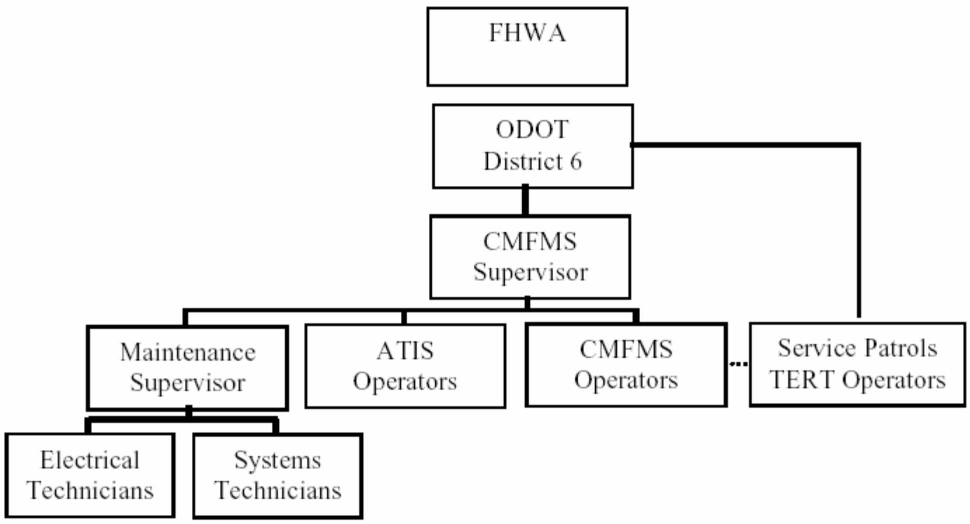
The CMFMS Supervisor, with input from the City, will develop Standard Operating Guidelines that will provide the day-to-day roles, responsibilities, and communications requirements for operations and maintenance staff assigned to the CMFMS. These Standard Operating Guidelines will include but not be limited to the following:

- Identifying personnel from ODOT and the City who have operational access to CMFMS;
- Clearly delineating the roles of personnel working with the CMFMS;
- Clearly stating which agency has exclusive or primary responsibility for certain actions necessary for transportation and emergency operations and management, and where supporting roles are planned (i.e., operation of the other agency's equipment when they are not present);

- Establishing detailed guidelines for personnel to manage or respond to incidents and events as they occur; and
- Clearly delineating the roles, responsibilities, and access of other CORTRAN partners sharing in the operation of the CMFMS.

The organizational structure for the CMFMS is presented Exhibit 2. This structure was developed to foster integration among ODOT / City operations staff while minimizing redundancy in the day-to-day operations of their agencies' functions.

Exhibit 2 – CMFMS Organization Chart



<u>Staffing Plan</u>

A brief description of the roles and responsibilities of key staff positions, to support the organizational concept, is presented below:

> *CMFMS Supervisor* - The CMFMS Supervisor provides "hands-on" management of the day-to-day operations for the CMFMS. Specifically, the CMFMS Supervisor is responsible for managing and scheduling the operations staff; providing training of the operators; assisting operators during periods of high activity or staff shortages; assigning staff authorization to control subsystems; assisting in identifying problems and determining times for preventive / corrective maintenance; and developing procedures dealing with planned and unplanned events. Reports to the ODOT District 6 Office.

CMFMS Operator - CMFMS Operators monitor and control the CMFMS field devices from the CORTRAN facility. Specifically, this position is responsible for operation of CCTVs, DMSs, ramp meters, lane control signals, HAR; and other assignments made by the CMFMS Supervisor. Operators are also responsible for responding to public inquiries regarding traffic condition and notifying appropriate agencies when an incident occurs. Reports to the CMFMS Supervisor.

ATIS Operator - ATIS Operators distribute traveler information through the HAR, website and other means (e.g., 511 system). They evaluate and package data into useful, timely and accurate traveler information. Reports to the CMFMS Supervisor.

Maintenance Supervisor – The Maintenance Supervisor is responsible for maintenance of the CMFMS. This position troubleshoots both control center and field equipment and works directly with the ODOT District 6 Maintenance Department to coordinate the maintenance crews to repair electronic equipment used in traffic control devices, CCTV systems, and the fiber optic communications plant. This position is also responsible for documentation of changes made to any component in the system through maintenance or construction operations. This position reports directly to the CMFMS Supervisor.

Electrical Technician – The Electronic Technician is responsible for troubleshooting and repairing electronic equipment used in traffic control devices, CCTV systems, and the fiber optic communications plant. This position is also responsible for documentation of changes made to any component in the system through maintenance or construction operations. This position reports directly to the Maintenance Supervisor.

Systems Technician – The Systems Technician is responsible for maintaining current and / or consistent computer operating systems on all computer equipment; installing hardware and software upgrades; troubleshooting and repairing equipment malfunctions; maintaining computer communication links with CORTRAN partners; and maintaining database and data files for all CMFMS activity. Reports to the Maintenance Supervisor.

In addition, the CMFMS Operators will coordinate with the local District 6's Service Patrols and TERT Operators within the region.

<u>Hours of Operation</u>

The CMFMS will initially operate Monday – Friday, 6 am to 8 pm as well as during special events (e.g., OSU football games, Red, White & Boom, etc.). This coverage will ultimately expand to 24 hours / day, 7 days / week. The CMFMS will be used remotely by CMFMS Operators to be assigned off-duty responsibilities on a rotational basis.

Columbus Metropolitan Freeway Management System Detailed Project Plan

Dispute Resolution Process

The CMFMS Supervisor will resolve disputes pertaining to CMFMS operation.

Figure 5.5 - Columbus Metropolitan Freeway Management System Concept of Operations

This figure shows Section 6 Organizational Structure, which details the personnel, operational procedures and support necessary to operate the deployed regional system.

The companion document, which focused on single agency or local TMC development, warned against neglecting the *institutional environment*. If this injunction is important for the local TMC Concept of Operations, it is *critical* for the regional document. The cross-jurisdictional nature of the regional institutional environment requires that roles and responsibilities be clearly delineated and that necessary agreements be identified.

Operational Scenarios

Scenarios represent the single most important segment of the Concept of Operations. For a regional integration effort, they provide a great opportunity for demonstrating how the completed system should work for all users in the region, under every foreseeable condition for which the system is designed, including extreme event conditions. The complexities and intricacies of the integration, which have been presented in static form thus far, can now be further described and clarified through dynamic examples of how they will operate in a real world circumstance.

As a start, the writing team could ask all regional stakeholders to provide a synopsis of how and under what conditions they expect to use the system. Writers can then tap their own experience and expertise in using this information to generate a hypothetical scenario. Any scenarios that exist in documents from the constituent systems should also be reviewed (and perhaps eventually updated to reflect the new regional functionality).

It is reasonable to assume that a Concept of Operations for a regional initiative will require a greater number of scenarios than that for a single TMC. The number of scenarios required will depend upon the spatial, temporal, and functional aspects of the project, the political and institutional boundaries, the number and variety of users, and the expected conditions for operation.

The Concept of Operations for the I-95 Corridor Coalition Information Systems Network (Figure 5.6) provides eleven operational scenarios that describe various functions performed under conditions ranging from normal to "stressed" or "extreme". (I-95 Corridor Coalition, *Information Systems Network: Concept of Operations,* September 2005)

Regional Example

I-95 Corridor Coalition

Information Systems Network

Concept of Operations

5 OPERATIONAL SCENARIOS

A scenario is a step-by-step description of how the proposed system should operate and interact with its users and its external interfaces under a given set of circumstances. The following scenarios will allow readers to walk through activities and gain an understanding of how the various parts of the proposed system function and interact. The scenarios will tie together the system, the users, and other entities by describing how they interact.

In scenarios where it is necessary for a [Primary TMC] to consult with a [Secondary TMC], ISN users should reference contact information provided in the ISN.

5.1 Subscribing to the Information Systems Network

A key component of the ISN will be the registry of information subscribers and providers within the network. Subscribing agencies (system stakeholders) will use this registry to discover information on the ISN and to contact those agencies providing the information.

When an [Agency] determines that it wants to get information from a neighboring system the [Agency] submits their credentials to the ISN administrator. The ISN administrative oversight group clears the [Agency] for subscription to the ISN. The ISN administrator registers the [Agency] to the ISN.

5.2 Publishing to the Information Systems Network

As discussed in the previous scenario, a key component of the ISN will be the registry of information subscribers and providers within the network. Information providers will publish information to the locations and in the formats specified in the registry.

When an [Agency] determines that it wants to publish information to the ISN the [Agency] must assure that the [System] providing information to the ISN complies with ISN standards for publication. The [Agency] will submit its credentials to the ISN administrator. ISN administrative oversight group clears the [Agency] for publishing to ISN and the ISN administrator registers the [System] in ISN.

5.3 Operation without Incidents

TMCs monitor traffic conditions through various sources, including: the ISN, CCTV, speed sensors, and other intelligent transportation systems. When TMC operators discover incidents, they assess the situation and provide information to other agencies and the traveling public. If a TMC does not encounter any unusual situations, no information is published to the ISN, DMS, HAR, or 511 systems. Websites show traffic moving at normal speeds.

5.4 Highway Incident

In some situations, an incident that affects the primary TMC may not have an impact on a secondary TMC. In this scenario, a multi-vehicle crash occurs on a major highway. [TMC1] detects slow moving traffic as a result of the crash. [TMC1] operators assess the situation and determine the effects are serious enough to publish information to the ISN, DMS, HAR, and 511.

[TMC2] discovers information about the multi-vehicle crash and its effects on traffic. [TMC2] determines that the event will not affect its region of operations and takes no action. [TMC1] will continuously publish updates about the incident to the ISN, therefore [TMC2] will monitor updates to determine if action should be taken at a later point in time.

When the incident is cleared, [TMC1] publishes the update to the ISN and closes the event. [TMC2] receives the update, since no actions were taken in response to the incident, no actions are taken in response to its cancellation.

5.5 *Exceptional Congestion*

A transit system outage occurs, forcing commuters to use other modes of transportation. A large portion of these travelers will choose to travel in private vehicles. The potential of an increased number of private vehicles on the roadways threatens to significantly impact highway traffic conditions. Realizing the severity of the situation, [TransitMC] publishes information about the outage on their website, the ISN, and notifies the media.

As [TMC3] is monitoring traffic events, operators discover information about the transit outage on the ISN. [TMC3] assesses the situation and determines that the transit outage may significantly increase congestion in its region of operations. [TMC3] publishes information about the outage to DMS, HAR, 511, and other traveler information systems in their area.

Until the outage is resolved, [TransitMC] continuously publishes updates to the ISN. When [TransitMC] recovers from the outage, they publish an update to the ISN and close the event. [TMC3] receives the update, removes messages from traveler information systems, and closes the event.

5.6 *Work Zone*

Pre-planned work or events should be (although are not always) coordinated with neighboring agencies prior to publishing information to the ISN. This scenario is an example of a work zone event that was not coordinated with neighboring agencies prior to publishing the event to the ISN.

[TMC4] has planned a work zone for a segment of highway in their region of operations. [TMC4] works to establish an operating plan to provide alternate routes and traveler information during the period of abnormal operations. [TMC4] does not expect the work zone event to affect operations in the [TMC5] region and therefore does not notify them prior to publishing the event to the ISN.

[TMC5] discovers the upcoming event information on the ISN and determines that the event will affect patterns in its region of operation. [TMC5] consults with [TMC4] to prepare traveler information for alternate routes and publishes the information to DMS and HAR during work zone operations.

[TMC4] publishes any changes in work zone operations to the ISN. [TMC5] updates traveler information systems as needed. When work zone operations are complete, [TMC4] publishes an update and closes work zone messages. [TMC5] receives the update and closes messages they have initiated. Normal operations have resumed.

5.7 *Winter Weather*

A winter weather advisory indicates that a nor'easter is due to pass through the eastern seaboard. Agencies in adjoining jurisdictions will be affected differently, with snowfalls varying drastically in a single jurisdiction and from one jurisdiction to another. If the storm moves quickly, cold rain or snow may fall for six to eight hours. If the warm air stalls against a high pressure wall, the snowfall may last 24 hours or more, as it has done in the past. Roadways, transit transportation services, businesses, and possibly entire cities or states may close as a result of the storm conditions. Agencies are limited to the amount of information available for publishing prior to the onset of the storm. However, they will work together prior to the storm to provide traveler guidance before entering regions with potentially dangerous road conditions.

Multiple agencies will publish information about road and weather conditions to the ISN during the storm. For this scenario, multiple agencies are referred to as "[TMCs]" and a single agency is referred to as "[TMC7]".

The nor'easter sets in, and as expected, snowfall amounts range drastically throughout the eastern seaboard. [TMCs] publish a variety of winter road operation messages to DMS and HAR in their respective region and to the ISN. 511 systems throughout the eastern seaboard get event information from the ISN and formulate and publish broadcast messages to their region of operations. The following are examples of messages that may be published to the ISN:

- Philadelphia: "I-95 – Icy road conditions"
- Philadelphia: "I-476 – 4 feet of snow"
- New York City: "Staten Island – 70 mph winds, blizzard conditions, low visibility"
- Connecticut: "I-95 closed from Greenwich to New Haven, use alternate route"

[TMC7] determines that operations in two [TMCs] may affect traffic patterns in its region of operations. [TMC7] disregards information that does not affect its region of operations and locates contact information for appropriate [TMCs], which may be found in the ISN Contact Database. [TMC7] works with the two [TMCs] individually to prepare traveler information on alternate routes between their regions of operation. [TMC7] publishes information to DMS and HAR regarding winter conditions and alternate routes for travelers entering the neighboring region.

Surrounding [TMCs] continuously publish updates to road weather conditions. As storm conditions subside and winter operations cease, the [TMCs] publish updates and close winter operation messages. 511 systems receive updates and remove messages from traveler information services. [TMC7] receives the updates and removes messages for the respective region.

5.8 HAZMAT Closure

A multi-vehicle crash occurs on a major highway, resulting in an emergency operating mode requiring extensive emergency response operations. An overturned tractor trailer leaking diesel fuel and hydraulic oil has blocked traffic and caused congestion to build up around the incident. Emergency services personnel, at the scene of the crash, discover the hazardous material spills, close the highway, and request HAZMAT response.

[TMC8] detects the incident remotely, surveys the scene, and publishes event information to DMS and HAR in their jurisdiction. Event information is picked up by the 511 system and the ISN. [TMC9] discovers event information on the ISN and determines that operations in [TMC8] region will affect traffic patterns in its region of operations. [TMC9] consults with [TMC8] to prepare traveler information for alternate routes. [TMC9] publishes information to DMS and HAR on [TMC8] closure and alternate routes. Meanwhile, HAZMAT works diligently at the scene of the spill to prevent any material from entering the stormdrain system and any subsequent natural waterways.

[TMC8] continues to monitor the event and publish updates to ISN. [TMC9] evaluates updates to determine if any changes need to be made to traffic patterns. The incident is cleared and HAZMAT assures that the hazardous material spills are fully remedied. [TMC8] publishes an update and closes event. [TMC9] discovers the update, removes closure and alternate route messages.

5.9 Weather Closure

This scenario builds on the "Winter Weather" scenario, moving from an abnormal mode to an emergency mode.

A nor'easter has swept through an agency's region of operations. Snowdrifts have blocked segments of major highways. The major portion of the region monitored by [TMC10] has been officially closed down by order of the Governor. Surrounding regions use information from the ISN to inform travelers of alternate routes prior to reaching a segment of closed highway.

[TMC10] publishes notice of closed roadways on DMS and HAR. Road closures are picked up on 511 systems and the ISN. [TMC11] discovers event information on the ISN and determines that operations in [TMC10] region will affect traffic patterns in its region of operations. [TMC11] consults with [TMC10] to prepare traveler information for alternate routes. [TMC11] publishes event information to DMS and HAR on [TMC10] winter conditions and alternate routes. [TMC10] continuously publishes updates to the ISN and [TMC11] evaluates updates to determine the impact on its region of operations.

After several hours, winter weather conditions subside and maintenance crews clear roadways. As roadways are cleared and reopened, [TMC10] publishes updates and closes winter weather messages. 511 systems and [TMC11] receive updates and remove winter weather messages.

5.10 Hurricane Evacuation

Officials issue a mandatory hurricane evacuation and implement lane reversal plans. Transportation operations are affected across multiple regions and responding agencies. [TMC12] publishes notification of evacuation routes and lane reversals on DMS and HAR. Event information is picked up on 511 systems and the ISN. [TMC13] discovers event information on the ISN and determines that operations in [TMC12] region may affect traffic patterns in its region of operations. [TMC13] consults with [TMC12] to prepare traveler information on alternate routes.

If necessary, [TMC13] may initiate lane reversals on select roadways to support traffic patterns and allow for maximum outbound use. [TMC13] publishes event information to DMS and HAR on [TMC12] hurricane conditions and alternate routes. [TMC12] continuously publishes updates to ISN and [TMC13] monitors updates to determine if changes should be made to traffic operations.

Hurricane conditions clear and maintenance personnel from stakeholder agencies clear debris and begin repairing damaged roadways. As roadways are reopened, [TMC12] publishes updates and closes hurricane evacuation messages. [TMC13] and 511 service receive updates and remove hurricane evacuation messages.

5.11 Terrorist Act

This scenario describes the response to a terrorist act requiring TMCs to function in disaster operating mode with extensive emergency response operations. Terrorists rammed a barge carrying flammable materials into a major bridge causing severe damage and rendering the bridge impassible. Traffic and waterway operations experience considerably degraded operations.

Emergency Services stakeholders and operators close the bridge and highway approaches. [TMC14] publishes notice of the closed bridge on DMS and HAR. Event information is picked up on the ISN and 511 system. USCG Captain discovers event information on the ISN and closes down the waterway. USCG Captain works with neighboring agencies to redirect watercraft to surrounding ports.

[TMC15] discovers event information on ISN and determines that traffic operations in [TMC14] region may affect traffic operations in its region. [TMC15] consults with [TMC14] to prepare traveler information on alternate routes. [TMC15] publishes traveler information to DMS and HAR regarding [TMC14] bridge closure and alternate routes. [TMC14] continuously publishes any changes in events to the ISN. [TMC15] monitors updates for changes or notice that the events have cleared.

The waterway is reopened to watercraft during reconstruction of the bridge. When construction is complete, the bridge is reopened and normal traffic operations resume. [TMC14] publishes an update and closes messages. 511 service and [TMC15] receive the update and remove messages.

Figure 5.6 - I-95 Corridor Coalition, Information Systems Network: Concept of Operations

This figure depicts section 5 of the Concept of Operations which presents eleven operational scenarios that describe various functions performed under conditions ranging from normal to "stressed" or "extreme".

5.5 CHAPTER SUMMARY

This chapter addressed critical issues involved in developing a Concept of Operations for a regional integration initiative. It used advice from regional experts and best practices contained in regional examples to advance strategies for developing the document. This chapter spoke to the formative issues of assembling the writing team and gathering necessary resources. It described how to involve stakeholders in the tasks of confronting institutional barriers and developing performance measures. The chapter also addressed issues involved in developing the core elements.

5.6 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER:

- USDOT ITS, Next Generation 9-1-1 System Preliminary Concept of Operations

http://www.its.dot.gov/ng911/next_gen_911_sys.htm

- Louis Neudorff, Institutional Challenges, Barriers and Opportunities: Institutional Integration White Paper for 4TH Integrated Transportation Management Systems (ITMS) Conference White Paper, July 15-18, 2001

- John Wolf, California Department of Transportation (Caltrans), Performance Measurement and Integrated Transportation Management Systems-A Traffic Operations Perspective 4TH Integrated Transportation Management Systems (ITMS) Conference White Paper, July 15-18, 2001

- Maricopa Association of Governments, "Regional Concepts of Final Operations: Final Report." November 2003

http://www.mag.maricopa.gov/pdf/cms.resource/RCTO-Final_Report79101.pdf

- Michigan Department of Transportation VII Michigan Test Bed Program Concept of Operations REVISED DRAFT – October 10, 2005

- Mid-Ohio Regional Planning Commission, Columbus Metropolitan Freeway Management System Detailed Project Plan: Concept of Operations prepared by DMJM+Harris, Inc., March 2001

http://www.dot.state.oh.us/its/Concept%20of%20Operations.pdf

- I-95 Corridor Coalition, Information Systems Network: Concept of Operations, September 2005

http://144.202.240.28/pman/projectmanagement/Upfiles/reports/full326.pdf

6 How to Use a Concept of Operations in Regional Integration Initiatives

A Concept of Operations is a living document that is intended to be modified and used throughout the life-cycle of a system. This chapter describes how a Concept of Operations can be used to support key systems engineering activities related to regional integration initiatives. The chapter will reference pertinent source material and will draw upon the perspective of regional experts.

6.1 CHAPTER OVERVIEW

This chapter will illustrate how the Concept of Operations can be used to effectively support key activities in the systems engineering life cycle of a regional project. Its objectives are:

- To describe how a regional Concept of Operations can be used in the development of high-level functional requirements.
- To describe how a regional Concept of Operations can be used to support cooperative agreements.
- To describe how a Concept of Operations can be used to support planning.

6.1.1 Relationship to Previous Chapter

This chapter transitions from the Concept of Operations development phase discussed in Chapter 5 to a demonstration of how the developed document can be used to support key systems engineering activities.

6.1.2 Chapter Sections:

- Support for Functional Requirements Development
- Support for Cooperative Agreements
- Support for Planning
- Chapter Summary
- Specific Literature Supporting This Chapter

6.2 SUPPORT FOR FUNCTIONAL REQUIREMENTS DEVELOPMENT

This section addresses the use of a Concept of Operations to support the development of high-level functional requirements for a regional system. Functional requirements describe the capabilities that a system must have in order to accomplish the goals and objectives of the organization(s) for which the system is built. In the systems engineering approach, the Concept of Operations provides a user-oriented description of the proposed system and this description then serves as the basis for development of high-level functional requirements.

The *Bay Area Regional Intelligent Transportation Systems (ITS) Plan* described the role of a Concept of Operations in developing functional requirements in the regional context:

Regional Expertise

"In the regional context, a functional requirement is what a system must do to address a regional need. This could mean provision of a regional service or prompting the performance of stakeholder's regional responsibility. A Regional Concept of Operations facilitates the development of high-level functional requirements by providing the user-defined context for the 'shall' statement: A functional requirement is characterized by naming the system, the stakeholder, and presenting a list of 'shall' statements that constitute the functions to be provided by the system. Note also that the use of 'shall' statements is deliberate as it sets forth a declarative statement about what a system needs to do."

In order to provide the user-defined context for the statements about what a system needs to do, the Concept of Operations must have identified all the regional users and demonstrated how the users will interact with the proposed system. As was previously stated, the developers of functional requirements may not be the same persons who develop the Concept of Operations. If the Concept of Operations for a regional integration project is to effectively inform requirements development, it must provide a clear description of the proposed system and subsystem components and interconnects, describe all users and user operations, and the order of those operations under expected conditions.

For example, is important for a Concept of Operations for a regional integration effort to clearly describe the technological variance and institutional authority factors affecting cross-jurisdictional operations. This need was underscored by *Transit Signal*

Priority (TSP): a Planning and Implementation Handbook in a discussion of Concept of Operations and Functional Requirements development:

Regional Expertise

"It should be noted that the *ConOps* requirements might vary across different jurisdictions because of different traffic control software or controller equipment, or because of local policy. These variations will need to be reflected in the *Requirements document*."

The information contained in the following Concept of Operations elements should support decomposition into systems requirements:

- Referenced Documents can provide information about any existing agreements, regulations, etc. that may impact operations in the proposed system.

- The User-Oriented Operational Description is the most informative component for requirements development as it describes the proposed system and demonstrates how each user will interact with it. The User-Oriented Operational Description was aptly demonstrated by the Regional Integrated Multi-Modal Information Sharing (RIMIS) system for the Delaware Valley Region. According to the concept of operation document produced by the Delaware Valley Planning Commission with regards to RIMIS, this system(RIMIS) will serve as a resource for agencies to help them make decisions, communicate decisions and perform authorized missions to deal with these situations on a timely basis. Thus, an example of a User-Oriented Description is as follows (the tables are courtesy of the Delaware Valley Planning Commission's Concept of Operations document: RIMIS Concept of Operations, 3-11,3-13):

Regional Example

Table 3-4
Potential RIMIS User Organizations

Organization Type or Class	RIMIS User Organization
Transportation Operations and Facilities	Burlington County Bridge Commission
	County/Municpal Traffic Operations Centers
	Delaware DOT
	Delaware River & Bay Authority
	Delaware River Joint Toll Bridge Comm.
	Delaware River Port Authority
	NJ Turnpike Authority
	NJDOT Statewide Traffic Operations Center
	NJDOT Traffic Operations South
	PennDOT Statewide Traffic Operations Center
	PennDOT District 6-0
	Philadelphia Sports Complex
	Philadelphia Streets Department
	Port of Philadelphia Terminals
	South Jersey Transportation Authority
Transporatlon Providers	AMTRAK
	NJTransit Operations South
	Philadelphia International Airport
	PATCO
	SEPTA
Emergency Responders	Delaware State Police
	Municipal Police/Fire Departments
	NJ Office of Emergency Management
	NJ State Police
	PA Emergency Management Agency
	PA State Police
	Philadelphia Fire Department
	Philadelphia Police Department
County 911's	Bucks County, PA 911
	Burlington County, NJ 911
	Camden County, NJ 911
	Chester County, PA 911
	Delaware County, PA 911
	Cloucester County, NJ 911
	Mercer County, NJ 911
	Montgomery County, PA 911
	Philadelphia County, PA 911
TMA's	Bucks County PA TMA
	Chester County PA TMA
	Cross County Connection TMA
	Delaware County TMA
	Greater Mercer TMA
	Greater Valley Forge TMA
	The Partnership TMA
Information Providers	AAA Mid-Atlantic
	I-95 Corridor Coalition
	Center City District
	Philadelphia Conventionand Tourist Bureau
	Metro Network/Westwood One(Smart Routes)
	Traffic.com
	TRANSCOM

Figure 6.1: RIMIS Concept of Operations (Conops) Document

This figure is an excerpt from section 3-11, which shows a list of potential users of the RIMIS.

Table 3-5
User Classes

Operations and Maintenance Management Personnel

- Oversee top-level operations and maintenance activities of state DOTs, state and local transportation operations centers, or transit authorities
- Supervise staff, coordinate resources, and exercise authority to commit resources for the agency
- Responsible for budget development and identification of funding sources and coordination of interagency programs such as maintenance, construction, and special events with state and local jurisdictions.

Control Center/Dispatch Center Manager

- Provide technical responsibility for operations/control/dispatch centers, facility, staff, and daily operations
- Coordinate programs such as system enhancements to upgrade operations/control/dispatch operations

Figure 6.2: RIMIS Concept of Operations (Conops) Document

This figure is an excerpt from section 3-13, which shows the *functions* of the potential users of the RIMIS.

- Manage agency systems (e.g., freeway or transit management, and supporting infrastructure)
- Coordinate with interfacing functions (e.g., maintenance, safety, and administrative).

Operators/Dispatchers

- Monitor internal agency systems and operation status
- Notify staff, supervisors, internal and external departments, and appropriate authorities of emergency response needs
- Dispatch resources and coordinate fleet or field personnel response to traffic and incident issues
- Troubleshoot system operations.

Information Technology Staff

- Implement, repair, and provide maintenance of communications equipment, infrastructure, and databases
- Assess system operations, databases and networks to troubleshoot potential system errors
- Specify, procure, and install telecommunications infrastructure to support agency operation function
- Implement appropriate network security measures consistent with agency policies.

Emergency Management Authorities

- As regional and state entities responsible, ensure the safety and security of employees and the public;
- Evaluate security programs and plans for compliance with state and federal regulations
- Establish protocols for large-scale emergency notification, response, and multi-agency coordination.

Public Safety Operators//Dispatchers

- Provide 911 operators, as well as dispatchers at police, fire, and other emergency responder communications facilities;
- Answer emergency calls and dispatch to the appropriate emergency response agency
- Initiate CAD logs for incidents, including initial call, incident details, dispatch details, and updates.

Emergency Response/Law Enforcement Personnel

- Provide police, fire, ambulance, and other emergency response staff from the states, cities, counties, bridge authorities, transit, and others.

Information Service Providers

- Generate information that will be used within the RIMIS messaging infrastructure
- Disseminate appropriate subset of information to the public

Public Affairs/Community Relations

- Provide management and liaison with the media and general public for dissemination of information and press releases
- Coordinate events and work with other agencies as part of multi-agency efforts
- Respond to media requests regarding incidents, road closures or public safety concerns.

Program Management and Administration Staff

- Serve as program managers and administrators in non-operational roles in overall program management, guidance, contract management, funding, and other key administrative components of the program.

Figure 6.2 (continued): RIMIS Concept of Operations (Conops) Document

This figure is an excerpt from section 3-13, which shows the *functions* of the potential users of the RIMIS, the first portion of this figure is on the previous page

- Scenarios will further clarify the roles and responsibilities of the various users and other stakeholders in operating and maintaining the system under all expected conditions.

6.3 SUPPORT FOR COOPERATIVE AGREEMENTS

Cooperative agreements are essential for implementing regional integration projects because funding actions and shared control of operations and resources, both technical and human, transcends the jurisdictional authority of any single regional entity. This section focuses on the types of agreements often required for regional integration and discusses the role of a Concept of Operations in identifying and enabling such agreements.

6.3.1 Types of Agreements

In its study of cross-jurisdictional agreements, *National Cooperative Highway Research Program, Synthesis 337, Cooperative Agreements for Corridor Management* reported on a survey of 22 transportation agencies. Of the state and provincial agencies surveyed, 59% had entered into some type of agreement to forge cooperation with other agencies or private entities. Of these, 69% used two or more types of agreements and 46% used three or more types. The primary types of agreements were:

Regional Expertise

RESOLUTIONS

"A resolution can be generally defined as the formal expression of an opinion or the will of a governing body on a given policy at a particular point in time. As such, resolutions are not legally binding and are subject to change, particularly if the members of the elected body change. However, a resolution in support of corridor management may serve as an initial step toward a more formal and legally binding cooperative agreement (*1*). Resolutions are often used as a vehicle for adopting a new plan or policy. Some state statutes require all parties to an intergovernmental agreement to pass resolutions in support of the agreement (*2*)."

MEMORANDUMS OF UNDERSTANDING

"A memorandum of understanding (MOU) goes beyond a resolution to document the desire of involved parties to engage in a particular course of action. For corridor management, an MOU is generally used to define roles and responsibilities of participating entities, as well as to establish common direction on a particular course of action. An MOU could serve as an intermediate step toward more extensive cooperation or it may be the only form of declaration in those places where a more formal or binding agreement cannot be attained (*1*)."

INTERGOVERNMENTAL AGREEMENTS

"An intergovernmental agreement may be defined as “a legal pact authorized by state law between two or more units of government, in which the parties contract or agree on the performance of a specific activity through either mutual or delegated provision” (*2*). Because they are tantamount to contracts, intergovernmental agreements work best when responsibilities, financial obligations, and procedures are detailed (*1*). They also are the most binding, from a legal perspective, of the types of intergovernmental cooperation reviewed. Maintenance agreements may take the form of an intergovernmental agreement between governments or it may be a public–private agreement between a government and a private entity. These agreements pertain to roadway maintenance issues, such as paving, signalization, signing, lighting, landscaping, access permitting, and construction activities within the right-of-way of a transportation facility. Increasingly, maintenance agreements involve access management issues, given that driveway permitting by state transportation agencies has traditionally been a maintenance activity. Maintenance agreements with private entities often address restoration of pavement or sidewalk damage caused by a private entity in the course of its activities. An example of this type of agreement is the road repair agreement between the city of Fort Worth (Texas) and gas well drilling operators (*3*)."

PUBLIC–PRIVATE AGREEMENTS

"A public–private agreement is a binding contract between two or more parties, with at least one being a governmental entity and another a private entity. This type of agreement generally applies to the rights and responsibilities of each party in regard to the common boundary between a roadway and adjacent private property. Public–private agreements for corridor management often involve developer mitigation, access conditions, future roadway improvements, and/or multiparty funding arrangements. Some public–private partnerships or agreements are those between a government agency and a utility provider with regard to utility corridors. A development agreement is a common form of a public–private agreement between a landowner and a government agency. Development agreements allow agencies to obtain concessions from landowners, beyond what may be otherwise possible under the normal exercise of regulatory authority (*4*). As such, they are often governed by specific statutory requirements and limitations. The motivation of a landowner for making such concessions is to obtain agency approval and to “freeze” applicable regulations at a given point in time or otherwise reduce the number of new regulations that may be applied during the life of the contemplated project (*4*). For corridor management, developers may seek approval of a particular site plan and access concept, as well as confirmation as to the amount of right-of-way that will be needed, any impact mitigation, and improvements that the government agency plans for the adjacent roadway."

1. Williams, K., *NCHRP Synthesis of Highway Practice 289: Corridor Management*, Transportation Research Board, National Research Council, Washington, D.C., 2000, 58 pp.
2. Atkins, P., *Local Intergovernmental Agreements: Strategies for Cooperation*, International City/ County Management Association, MIS Report, Vol. 29, No. 7, July 1997, 12 pp.
3. Official Website for the City of Fort Worth, Texas [Online]. Available: www.fortworthgov.org/development/ app-forms.
4. Callies, D., "Solutions After Dolan: Land Development Agreements," *Land Use Law & Zoning Digest*, Vol. 49, No. 10, Oct. 1997.

6.3.2 Role of a Concept of Operations in Identifying and Forging Agreements

Various types of agreements figure in the various iterations of Concept of Operations development. Initially, less formal agreements serve to facilitate the assembly of a writing team, buy-in by key stakeholders, and for defining the overall vision. This might include resolutions or Memoranda of Understanding (MOU). Formal agreements often require legal or other official review or authorization, and if sought too early in the process, can undermine momentum. The degree of formality may also depend upon the scope and nature of your integration effort or upon the composition of the current system; one transportation professional interviewed for this project favored a less formal agreement due to the established decentralization of the region:

Regional Expertise

"Our region has 25 cities and towns and 3 Native American jurisdictions. Except for freeways and some shared systems between the locality and the State DOT most local entities have their own signal control system. Also, cities have their own TMCs. Because of this commitment to decentralization, we decided to secure the necessary agreements (each entity signed an MOU) to establish an integrated system rather than establishing a regional TMC. This worked best for us; for other regions it may be more appropriate to establish a TMC."

Eventually, as the integration proceeds through the systems engineering process, more formal agreements will most likely be necessary. The Concept of Operations is useful for identifying the need for more formal agreements. The Colorado Department of Transportation addressed factors affecting the level of formality of required agreements (*Colorado Department of Transportation-Region 2 Intelligent Transportation Systems Architecture*, May 18th, 2001):

Regional Expertise

"Agreements are established to clearly define responsibilities among the involved parties. The level of formality generally increases as risks escalate and when financial transactions take place. Formality will also increase when the performance or lack of performance on the part of one organization impacts the operations of another. For example, if an agency maintains and operates the traffic signals of another agency, failure to restore a failed traffic signal in a timely fashion could have a significant impact. As different systems are linked together, they will depend upon each other. The clear definition of responsibilities for all parties will help ensure smooth operations "

A Concept of Operations for a regional integration project can be used to secure the agreements necessary for its own development and should also support the cooperative agreements needed to design, build and maintain the system. The following elements of a Concept of Operations are useful for identifying and supporting these agreements:

- Referenced Documents can provide information about any existing agreements that may be subsumed by the proposed integration, or that need to be modified in order to accommodate the new functionality. Resolutions or enabling legislation may also be referenced.

- The User-Oriented Operational Description component is invaluable for supporting the identification of needed agreements for regional integration, as it describes the intended system operation from a user vantage point. It addresses the strategies, policies, and constraints relative to achieving the goals and objectives of the proposed regional initiative. It identifies who the users are and what they do. The number and types of agreements necessary to support this activity should be discernable from a well-developed operational description.

- The Operational Environment is another rich source of support for identifying and informing agreements. This section describes the "world" in which the proposed system will operate. This information will support Operations and Maintenance budgeting and funding decisions. Facilities, hardware, software, personnel, communication and other needs are addressed here and this information will support the agreements that specify which regional entity will be responsible for supporting the various operations and maintenance activities.

- Scenarios will further clarify the roles and responsibilities of the various users and other stakeholders in operating and maintaining the system. The essential areas of need for communication, cooperation, and authority are cast in sharp relief when the proposed regional operations are described in the context of the real-world conditions under which they are expected to perform. This could reveal a needed agreement, or some additional provision to an existing agreement that may have been otherwise overlooked.

6.4 SUPPORT FOR PLANNING

While a Concept of Operations is not a planning document, it is nevertheless a useful resource for planning, and a Concept of Operations for a regional project is particularly useful for planning at the regional level. All of the transportation professionals interviewed for the writing of this guide, who developed a Concept of Operations, said that it has been used or will be used for regional planning.

A TRB letter report of the Committee on Developing a Regional Concept for Managing Surface Transportation Operations speaks to the role of a Concept of Operations in regional planning:

Regional Expertise

"The Regional Concept of Operations documents should provide the basis for the generation of a Regional Operations Action Agenda. An Operations Action Agenda can flow from the Regional Concept of Operations, usually as a separate document. This is a program of investments designed to fulfill the regional concept of operations. The action agenda creates a linkage to the formal planning process, providing information needed for inclusion in the Transportation Improvement Program (TIP) and Unified Planning Work Program (UPWP)."

A White Paper, *Planning for Operations*, from the Conference Proceedings of 4th ITMS Conference, offered the following guiding principles for integrated planning:

Regional Expertise

- "Planning for Operations is based upon collaboration (interagency, inter-jurisdictional) and integration (technological and system related). Collaboration and information sharing are critical keys to successful and continuous "planning for operations."
- Planning for Operations is visionary, strategic, and continuous. The planning does not end when the operational improvement is implemented.
- Planning for Operations is both short-term (problem-solving) and long-term (strategic).
- Planning for Operations is based upon customer expectations and service performance.
- Planning for Operations encompasses policy, programs, procedures, protocols, and projects that relate to or have an influence upon operations."

It is clear that a good Concept of Operations, with its emphasis on an overarching vision of the system, spatial and temporal scalability, life-cycle approach, user expectations/needs, stakeholder collaboration/agreements, and the promulgation of performance measures, provides the essential groundwork to support this kind of planning. At this juncture one should recognize the importance of Regional Transportation Operations Collaboration and Coordination (RTOCC), the RTOCC spawns various projects and these projects will require systems engineering and, as such, each will require the development of concepts of operations to start off. So there is a possibility of multiple concepts of operations being utilized concurrently. Concepts of Operations from constituent systems will inform, and eventually be informed by, the more comprehensive regional document. The following core elements contain information that is useful to the planning process:

- The Scope provides a useful context for planning in its delineation of the system boundaries, as it describes users and stakeholders who will be involved in system operations throughout the region as well as those who will be affected by it.

- Referenced Documents include other planning documents, reports, meeting minutes, concepts of operations and requirements documents (especially from the systems being integrated), and studies of operational needs. Identified resources might include consultation with systems experts and key personnel throughout the region, legal analysts, and elected officials. This kind of information can be helpful to the regional planner, who may be trying to identify existing procedures or agreements, technical or human resources, operational capabilities, and legal constraints.

- Describing the current infrastructure and institutional framework. "The description of the existing system provides an agreed context for system development. All of the participants need to understand the elements of all systems to be managed. As additional participants are added they will need this context for what they are building upon. The existing system description can probably be assembled, in large part, from existing planning documents and from the legacy systems description of the regional ITS architecture." (FHWA White Paper: Regional Concepts of Operations for Transportation System Management and Operations, Discussion Draft 2.1, February 6, 2003)

- The Operational and Support Environment addresses facilities, hardware, software, personnel, communication and other needs and thus supports various planning activities, especially business plans.

- The Operational Needs component, in addressing the question of what is required by the region that the current system or set of services does not provide, presents information to planners about the operational environment of both the current and proposed regional system.

- The System Overview describes all aspects of the integrated system at once. It can give planners a high-level view of the proposed system and as well as its interface with systems or services external to the proposed system.

6.5 CHAPTER SUMMARY

This chapter described how a Concept of Operations for a regional integration initiative can support the development of high-level functional requirements, the forging of regional cooperative agreements, and performance of regional planning. The description of the use of a Concept of Operations to support these activities was informed by the perspective of regional experts.

6.6 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

- Bay Area Regional Intelligent Transportation Systems (ITS) Plan, prepared by Iteris Inc. for the Metropolitan Transportation Commission (MTC), June 2004

http://www.mtc.ca.gov/planning/ITS/Bay_Area_ITS_Plan.pdf

- Harriet R. Smith, Brendon Hemily, PhD, Miomir Ivanovic (Gannett Fleming, Inc.), Transit Signal Priority (TSP): a Planning and Implementation Handbook, May 2005

http://www.itsa.org/itsa/files/pdf/TSPHandbook2005.pdf

- Cooperative Agreements for Corridor Management, NCHRP Synthesis Report

337, 2004

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7 Case Study

While the previous chapters in this Guidance Document address individual elements and issues related to Concepts of Operations for regional integration initiatives, this final chapter is designed to demonstrate the guidance principles provided in those chapters, using a single case study. We will present, as a comprehensive case study, a regional Concept of Operations developed by the Delaware Valley ITS Technical Task Force. This regional initiative is referred to as the Regional Integrated Multi-Modal Information Sharing (RIMIS) system. The referenced documents along with noteworthy material from participants' interviews are used to illustrate salient points.

7.1 CHAPTER OVERVIEW

The purpose of this chapter is to provide a detailed real-world example of the concepts and guidance provided in the handbook. Its objectives are:

- To illustrate how the elements of the Concept of Operations were developed to address the needs of the RIMIS system.
- To document lessons learned during the RIMIS Concept of Operations development process.
- To document lessons learned during the use of the Concept of Operations in the RIMIS development process.

7.1.1 Relationship to Previous Chapters

This chapter serves to illustrate, through a real-world example, how the information provided in the previous chapters is applied to the development and use of a particular regional Concept of Operations.

7.1.2 Chapter Sections

- Case Presentation Structure
- Case Study
- Lessons Learned

7.2 CASE PRESENTATION STRUCTURE

The material in this section describes how the case study will be organized and presented. This chapter parallels the organization of material in previous chapters of this handbook.

7.2.1 System Overview

This section will briefly describe the RIMIS initiative that serves as the subject of the case study.

7.2.2 Core Elements

This section will describe RIMIS's Concept of Operations with respect to each element of the Concept of Operations' standard.

7.2.3 Development Process

This section will focus on lessons learned during the development of RIMIS's Concept of Operations. Specific areas of focus will parallel the structure of the handbook. These will include issues concerning the following:

- Resources
- Performance Measures

7.2.4 Use of Concept of Operations

This section will focus on how RIMIS's Concept of Operations is being used. Specific areas of focus will parallel the structure of the handbook:

- Requirements Development
- Support for Cooperative Agreements
- Planning Support
- Lessons Learned

7.3 CASE STUDY

The case-study presented in this chapter is the Regional Integrated Multi-Modal Information Sharing (RIMIS) system being developed for use in the Delaware Valley Region, a region including Bucks, Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania; and Burlington, Camden, Gloucester and Mercer in New

Jersey. The objective of the RIMIS system is to provide a link among transportation agencies, emergency management agencies, traffic reporting services and others so that transportation information can be shared and events can be managed effectively through resource sharing. The client was the Delaware Valley Region Planning Council (DVRPC). This client represents different organizations. Lacking the power to change regional agreements, the DVRPC considered information sharing vital in avoiding "turf-wars". Accordingly, they proceeded step-wise to build consensus in conceiving the project.

7.3.1 System Overview

Background information on RIMIS is well presented in the Concept of Operations. The following excerpt from the Concept of Operations executive summary provides essential descriptive information on RIMIS.

Background of RIMIS

Background

Since June 1998, the Delaware Valley ITS Technical Task Force (TTF) has been responsible for coordinating ITS activities in the Delaware Valley. It is composed of technical staff from over 30 different organizations including departments of transportation, highway and bridge toll authorities, transit agencies, the City of Philadelphia, state and local police departments, transportation management associations, Federal Highway Administration, and other organizations involved in transportation operations.

A subcommittee of the TTF, composed of core regional agencies, was formed to actively guide RIMIS' development. This RIMIS Subcommittee includes representatives from the Delaware River Port Authority (DRPA), Delaware Valley Regional Planning Commission (DVRPC), New Jersey Department of Transportation (NJDOT), Pennsylvania Department of Transportation (PennDOT), the City of Philadelphia, SEPTA, Pennsylvania Turnpike Commission (PTC), and Federal Highway Administration (FHWA).

Regional agencies responsible for the safety, efficient operation, and management of the transportation network in the Delaware Valley have recognized the need for reliable inter-agency information sharing and coordination via enhanced communication technology. This need has become very clear in recent years, as the regional transportation network has reached, and -- at many times and locations -- exceeded its capacity.

In developing the Regional ITS Architecture, the TTF identified RIMIS as the mechanism to foster interagency information sharing and coordination. Six alternative coordination scenarios were evaluated to improve information-sharing among the agencies; a decentralized approach utilizing a message-based information exchange network (IEN) was selected as most appropriate. It was recognized that existing ad hoc communications do not work; however, creating a centralized regional operations center or a new regional agency similar to TRANSCOM would not be very practical from an institutional perspective.

Figure 7.1: Background: This section is an excerpt from the executive summary of the Concept of Operations of the RIMIS project, which was written by the Delaware Valley Regional Commission. This figure relates the origins of the RIMIS project, the entities involved and their responsibilities.

Current Situation

Current Situation

The Delaware Valley region includes nine counties in the Philadelphia metropolitan area and supports a residential population of over 5 million people, with employment of over 3 million. These people are served by an extensive intermodal transportation network consisting of expressways and toll facilities, key arterial highways, light and heavy rail lines, and express and local bus routes. A large sports and entertainment complex in South Philadelphia, the Philadelphia International Airport, 30th Street Station, and major freight terminals are some of the key nodes on the transportation network. The major bridges crossing the Delaware River in the region are among the key "links" on this network.

The population shares the network with commercial and industrial transporters of goods, bulk materials, and other commodities as well as with long-distance, inter-regional highway and rail traffic. This combined network demand regularly causes traffic congestion and delays, particularly during peak periods for weekday commuting, and directly before and after scheduled special events. Emergency events and incidents exhibit magnified impact in this environment, and their effects propagate rapidly throughout the network and beyond.

In this complex transportation environment, management and communications roles are shared by many agencies and institutions with various jurisdictional boundaries:

- Three state Departments of Transportation
- Philadelphia Streets Department
- Three State Police forces
- Five major transit agencies operating bus and rail services
- Four authorities operating Delaware River bridges
- Four Turnpike Authorities
- Philadelphia Police and Fire departments
- County 911 centers, Local Fire, Police and EMS
- County public works agencies
- Traffic reporting services, and multiple county and sub-regional transportation management associations (TMAs)

For the most part, the agencies involved in managing *regularly-occurring events and minor incidents* within the transportation network, have extensive experience in managing these situations. Some agencies have procedures and protocols for action and coordination with other agencies. Other agencies coordinate on a more ad-hoc basis. But these communication challenges are magnified greatly during *major incidents and unanticipated events.* For effective action, the key is timely notification to all parties with responsibility for responding -- and timely access to dependable information on status and conditions on the transportation network.

Figure 7.2: Current Situation: This section is an excerpt from the executive summary of the Concept of Operations of the RIMIS project, which was written by the Delaware Valley Regional Commission. This figure describes the current system.

7.3.2 Core Elements:

As discussed in Chapter 3, a complete Concept of Operations should cover the core elements as described in the ANSI/AIAA standard. The RIMIS Concept of Operations did address all ANSI/AIAA standard elements, with varying degrees of detail. Conforming to the approach contained in IEEE standards, the consultants considered and prominently discussed disadvantages of the system with respect to regional issues. The Concept of Operations was built based on regional ITS architecture technologies which have been established in other regions. At present, the consultant is reviewing offers from various software companies on the appropriate software product that could address the regional issues. This section illustrates how the RIMIS Concept of Operations addressed the core elements.

- Scope of the Project

The RIMIS Concept of Operations directly and succinctly addresses the project scope, as seen in the following excerpt (Figure 7.3). Transportation agencies in the Delaware Valley region have a common interest, which is to enhance the safety and efficiency of the region’s transportation network. Vital to this shared common interest is the need to create a system (RIMIS) to encourage better communications and information sharing between the many agencies in the region. This excerpt describes the benefits of better communication amongst the agencies, provides a list of operation centers which will be used by the decision makers to foster better communications, and details the kind of information that will be shared by the stakeholders that are involved with the RIMIS system.

Motivation and Scope of RIMIS

Motivation and Scope of RIMIS

Although transportation agencies in the Delaware Valley region are motivated by common interests in monitoring and enhancing the safety and efficiency of the region's transportation network and in managing the network's incidents when these occur, each agency has a primary mission and responsibility that determines operational priorities. In emergency situations, agency priorities often conflict. For example, an operational decision driven by concern for public safety often must trump concerns about traffic congestion. An important function of effective inter-agency communication is to ensure that all network agencies can recognize when such mission tradeoffs arise and to provide enough information for agencies to understand and mitigate the situation to the greatest extent possible.

Agencies involved in management of the transportation network have worked together through many events and incidents that have challenged the limited available channels of inter-agency communication. In this light, *the overall objective of RIMIS is to foster better communications and information-sharing between the many agencies in the region*. Meeting this objective is critical to the effective management of the complex transportation network in the Delaware Valley. The consensus among the stakeholders is that better inter-agency communications will:

- Enhance traffic management of recurring congestion and peak travel
- Provide for faster and more effective response to unexpected incidents and events
- Improve use of systems to inform and influence the decisions of travelers
- Help realize the full value of ITS/communications assets already deployed in the region
- Speed up the process of information request and transfer, which can be especially problematic during emergencies, when many normal staff or administrative functions are temporarily stopped or the situation has low priority in their agency
- Improve the region's incident and emergency response capabilities based on the analysis of past events, archived data exchanges, and communication patterns.

RIMIS will connect key decision makers and operations centers on an information network to make better use of existing information infrastructure (on both traffic and transit conditions) and to better respond to incidents and manage special events. These centers include:

- Traffic management centers
- Emergency management centers (including 911 centers, police, and fire departments),
- Transit Operations Centers
- Information service providers (e.g., traffic reporting services).

RIMIS will enable the following types of information to be shared to full potential among regional transportation stakeholders:

- Incident notification as soon as a problem is detected or reported
- Incident severity designation and expected duration
- Incident response decisions and activities
- Situational status on incidents and the "big picture" transportation context
- CCTV images to view traffic and incident conditions throughout the region
- Special events and management plans
- Traffic and transit conditions including route performance data
- Traffic management resources and status of current notifications and warnings
- Construction and maintenance activities that close lanes on expressways, detour routes, and bus routes.

Figure 7.3: THE SCOPE OF THE RIMIS PROJECT: This section is an excerpt from the Concept of Operations document for the RIMIS project, which was written by the Delaware Valley Regional Commission. It highlights the motivation behind the project as well as the benefits of better inter-agency communications. The operation centers involved in the RIMIS system are also mentioned in this passage, as well as potential regional transportation stakeholders.

- Referenced Documents

Documents referenced in the RIMIS Concept of Operations are described in the example below. Note in this case that there were no general planning documents (such as a regional Transportation Improvement Plan) among the references used by the RIMIS Concept of Operations document. The referenced documents included:

- ITS Architecture Document: Documentation on the Regional ITS Architecture for the Delaware Valley Region
- Concept of Operations: A review draft of the Concept of Operations of the RIMIS system which was prepared by the Consultant
- Communications for ITS Protocol. There are two documents referenced with regards to communications, one deals with ITS protocol from center to center and the other focuses on an updated version of the NTCIP.
- Assessment Documentation: This document evaluates the existing information sharing and analysis tools in use within the I-95 Corridor

Referenced Documents

2.0 REFERENCED DOCUMENTS

Delaware Valley Regional Planning Commission, *Regional ITS Architecture, Version 1.0,* March 2001.

Delaware Valley Regional Planning Commission, *Regional Integrated Multi-modal Information Sharing (RIMIS) System Concept of Operations, Report on Agency Needs and Constraints,* (Review Draft), prepared by Booz Allen Hamilton, Nov. 1, 2004.

ITE and AASHTO, *TMDD & MS/ETMCC Guide Standard for Functional Level Traffic Management Data Dictionary (TMDD) and Message Sets for External Traffic Management Center Communications, Version 1.0*, October 30, 2000.

NTCIP 9010 v01.07, *National Transportation Communications for ITS Protocol, XML in ITS Center-to-Center Communications,* Oct. 2003.

Joint Committee on the NTCIP, *The NTCIP Guide: An Updated Version 3 of NTCIP 9001: National Transportation Communications for ITS Protocol (V 03.02),* October 2002.

I-95 Corridor Coalition, *An Assessment of Existing Information Sharing and Analysis Tools,* Mixon/Hill, Inc., revised May 28, 2004.

Figure 7.4: REFERENCED DOCUMENTS: This figure details the reference sources used in the RIMIS Concept of Operations.

- User Oriented Description:

Ideally, a user-oriented description will detail the system operation from the user's perspective and, as such ,will identify how system specific goals and objectives are achieved, bearing in mind usual tactics, policies and constraints. In the case of this particular example (the RIMIS system), the approach taken was to list the particular user classes and describe their functions and their respective interaction with the RIMIS system.

User Classes

User Oriented Description

User Classes	Interaction with RIMIS
Operators/Dispatchers • Responsible for monitoring internal agency systems and operations • Notify other staff, supervisors, internal and external departments, and appropriate authorities of adverse conditions requiring a response • Coordinate with fleet or field personnel • Provide coordinated response to traffic and incident issues by dispatching appropriate resources • Troubleshoot system operations.	• Monitor and operate agency systems and input and initiate RIMIS communications as conditions warrant • Input data directly into RIMIS and monitor, extract, and interpret data from RIMIS for potential response.
Information Technology Staff • Responsible for implementation, repair, and maintenance of agency communications equipment and infrastructure and databases. • Assess system operations, databases, and networks to troubleshoot potential system errors • Specify, procure, and installs, telecommunications infrastructure to support agency operational objectives and functions • Implement appropriate network security measures consistent with agency policies.	• Are not directly involved in entering information to RIMIS or using information from the system • Are key in maintaining the communication networks to ensure data and information flows from the agency data systems to RIMIS • Coordinate appropriate interfaces between RIMIS and agency databases and systems; monitor interfaces and troubleshoots when necessary; and facilitate RIMIS access through agency firewalls.
Emergency Management Authorities and Public Safety Operators/Dispatcher Managers • Consist of regional, state, and county entities responsible for ensuring the safety and security of employees and the general public • Evaluate existing security programs and plans for security enhancements that are compliant with state and federal regulations • Establish protocols for large-scale emergency notification, response and multi-agency coordination.	• Use RIMIS construction schedules, emergency alerts, public safety notifications, weather, and roadway conditions, and other features • Initiate notifications through RIMIS about major emergencies or hazards, responses, and direct actions. • Use RIMIS capabilities to provide emergency alerts and directions to the public via VMS signs and HAR devices.
Public Safety Operators/Dispatchers • Include 911 operators at the various 911 call centers and dispatchers at police, fire, and other emergency responder communications facilities • Primarily responsible for answering emergency calls and dispatching them to the appropriate emergency response agency • Initiate CAD logs for incidents, including initial call, incident details, dispatch details, and updates.	• Input incident information to RIMIS and initiate appropriate notification messaging (respecting that RIMIS does not supersede established protocols for incident management notification and coordination between Public Safety Answering Points and emergency responders) • Use RIMIS video, traffic speeds, and construction information to determine how to route emergency responders to an incident site and to implement detours.
Emergency Response/Law Enforcement Personnel • Include police, fire, ambulance, and other emergency response staff from the states, cities, counties, toll authorities, transit agencies, and related organizations.	• Provide information and updates to the public safety operators and dispatchers who then update RIMIS • Do not interact directly with RIMIS during initial implementation of RIMIS when access will be limited to personnel at key centers only • Enter information via mobile/wireless devices when future phases of RIMIS include remote capability.

Figure7.5 THE USER CLASSES: This figure shows a list of the prospective users of the RIMIS system and individual descriptions of their functions as well as their interaction with the RIMIS system.

- Operational Constraints

In order to address operational constraints, the Delaware Valley Region Planning Commission developed the RIMIS system. They did this rather than select a single Department of Transportation (DOT) to create a system, which would be unique but may not be compatible with the needs of the other interested parties or stakeholders. The following excerpt from the Concept of Operations identifies both existing and anticipated constraints.

Operational Constraints

Potential Operational Constraints

Agencies have requested a certain level of customization and filtering at their respective endpoints, to be able to filter certain data, messages, or both. This presents an operational constraint because filtering certain features or data will limit accessibility to full RIMIS functionality.

Because they do not have a consistent, regional mapping and spatial referencing system, agencies in the Delaware Valley are currently using independent systems for their data/ information/device display needs. A comprehensive regional map showing real-time status of transportation facilities or devices to be generated from various agency systems will require the region to adopt a standard map and configure the interfaces appropriately.

Another operational constraint is the addition of new centers, new data sources/interfaces, or changes to agency systems or data that are already connected to RIMIS. Changes to data elements made at the RIMIS or agency level may impact the information content being shared.

One constraint of the initial RIMIS implementation is the system will be accessible only via workstations at the participating agency centers. In-the-field personnel will not have access for viewing or providing information directly to RIMIS. Enhancements to RIMIS for consideration should include wireless remote devices to provide access to in-the-field personnel.

Agencies have requested that RIMIS account for a single point of entry at each agency (for messages and data). A constraint or issue with a web-based GUI and the accessibility it offers may be that many people at an agency could access RIMIS simultaneously.

Some agencies have expressed interest in full integration with their systems (i.e., no stand-alone workstation); others have expressed serious concerns about any RIMIS interface with their respective systems and may require a stand-alone workstation.

To accommodate the GUI guidelines, local interfaces, and requested level of customization, some impact on existing agency software must be considered and accepted. Each agency will need to determine the extent of modification to its software that will be needed.

The proposed system is decentralized, which poses some constraints because the design does not rely on a prominent central database but rather on a virtual database used by all of the agencies.

Without a central staff to operate or maintain RIMIS, its stakeholders will rely on outside vendors for maintenance and support functions. Under this scenario however, agencies will still be required to provide management staff to oversee the performance of these vendors.

Figure 7.6: OPERATIONAL CONSTRAINTS: This figure details a list of constraints which the DVRPC and RIMIS stakeholders have identified that the RIMIS system could potentially face.

According to the RIMIS Concept of Operations document, the constraints mentioned in figure 7.6 are related primarily to the proposed design concept (of the RIMIS system), incompatibility of current system components, and local interface requirements that will make additional constraints likely.

- Operational Environment

The operational environment of the RIMIS system is described in the Concept of Operations as illustrated in Figure 7.7. The focus is placed on the promotion of communication, responsiveness, and trust between transportation network managers (i.e. emergency responders, information service providers and other RIMIS stakeholders). These factors are the staples of the operational environment of this particular system and a noteworthy fact is that agencies may permit an outside entity to gain access to certain data inside their firewalls. However, agencies that do not comply with National ITS Standards, data dictionaries and message sets will have to convert their data before they would be allowed such access.

Operational Environment

Operational Environment

In the regional operations environment, the system is intended to promote communication, responsiveness, and trust between transportation network managers; emergency responders; information service providers; and other RIMIS stakeholders. RIMIS represents the introduction of a new information-sharing medium in addition to the continued ability to use existing forms of network status information (i.e., TV media, agency source video) and communication (i.e., radio, telephone, push-to-talk, e-mail, and fax).

From a technical perspective, RIMIS may require agencies to permit an outside entity to gain access to certain data inside their firewalls. Agencies that do not comply with National ITS Standards, data dictionaries, and message sets may have to convert their data before allowing such access. It is also possible that this type of conversion may become a centralized RIMIS function if the data were "pushed" by participating agencies.

Figure 7.7: OPERATIONAL ENVIRONMENT: This figure shows the working environment, within which the RIMIS system will operate. This environment should be able to promote communication, responsiveness and trust between transportation network managers; emergency responders; information service providers etc.

- Support Environment

The RIMIS Concept of Operations directly addresses support requirements for the system. The excerpt below underscores the importance of identifying the requirements and costs of Operations and Maintenance in support of 24/7 system availability to users. In a multi-agency environment, it is critical to establish financial responsibility for ongoing operations and maintenance so that there is no interruption in service.

Support Environment

Support Environment

Once the first version of RIMIS is fully tested is operational, the project begins a phase that includes concurrent development of the next release and a routine Operations and Maintenance (O&M) cycle. O&M include hardware and software costs and the professional services expenditures needed to properly maintain any software application. In the case of RIMIS, these support requirements are key to providing users with a 24x7 system availability and exceptional technical support. Uptime is critical to realizing the system's potential as a collaborative information sharing tool among members. Included in these recurring software maintenance costs are annual maintenance contracts, upgrade cycle costs and costs related to "bug fixes" and application troubleshooting. Hardware costs include maintenance contracts and hardware upgrades to ensure the RIMISnet infrastructure has sufficient capacity to minimize network latency as the user base expands and network message traffic increases.

RIMIS is unusual in this context because no single agency can claim ownership of the project and, by extension, any of the noted recurring costs. This characteristic increases the chances that RIMIS members will not properly fund O&M costs, thereby reducing the reliability of RIMIS and its potential success. It is important that RIMIS member organizations understand that the success of RIMIS, on both technical terms and as a collaborative endeavor, will lay the groundwork for the FHWA's ITS architecture. If viewed from this perspective, RIMIS is an important proof of concept for the eventual rollout of the entire ITS infrastructure in the Delaware Valley.

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Figure 7.8: SUPPORT ENVIRONMENT: RIMIS Concept of Operations Document. This figure describes the support environment within which the RIMIS system would operate, detailing the requisite support requirements and the cost involved.

- Operational Scenarios

Drafters of the RIMIS Concept of Operations recognized the benefit of developing operational scenarios: "Operational scenarios provide a means of testing the RIMIS concept in the context of operational situations. They allow designers and implementers to derive operational assumptions of how the system needs to function and provides the basis for more detailed requirements to be developed following consensus on the operational concept." As part of this development RIMIS partner agencies participated in an Operational Scenario Workshop, which explored how RIMIS might function under different (planned and unplanned) event scenarios. The outcome of this exercise is described in Figure 7.9.

An important facet of the RIMIS Concept of Operations is the use of a "model" Graphical User Interface (GUI) with the proposed flexibility for participating agencies to customize their particular GUI in the design phase. Sample screen shots, such as the one in Figure 7.10, are used to convey basic RIMIS functions and those features that are expected to be used by various partners.

Operational Scenarios

Operational Scenarios

6.1 TESTING THE OPERATIONAL CONCEPT

As part of the CONOPS development, an Operational Scenario Workshop was held with RIMIS partner agencies to discuss how RIMIS could be used under different event scenarios. One scenario focused on an unplanned incident (e.g., an accident on the Walt Whitman Bridge) and how agencies could use RIMIS as part of their information exchange and response procedures. The other scenario focused on how RIMIS could support agencies as part of information exchanges and updates during a planned special event or multiple events (e.g., at the Philadelphia Sports Complex).

The outcome of the workshop showed that RIMIS will deliver the most benefit as information sharing medium and decision-making tool for participating agencies to use during an unplanned incident. For preplanned special events, it will benefit those agencies feeding traffic into and out of the general area of the event while for agencies managing the event, the RIMIS benefits are more limited. Although these are high-level depictions of several types of potential incidents that could affect the transportation network in the Delaware Valley, broad conclusions can be drawn from them.

For planned events, agencies have a well-established coordination strategy among traffic managers (state and local, bridge operations), police and public safety, event venue/promoters, and others. This coordination begins prior to event day, and established traffic management and parking strategies are put in motion depending on the type and timing of the event. In discussing some “what if” circumstances as part of a planned event, some participants did not identify a strong role for RIMIS as part of their overall event management strategies or missions. However, many other participants said they were not in the loop because agencies responsible for event coordination only focus on the event’s immediate vicinity and not on the roads leading to and from it. These participants suggested that RIMIS could be a mechanism to incorporate them into the coordination process by informing them of event activities and enabling them to send information about their operations to event planners.

The unplanned event, consisting of an incident, major road closure, and traffic diversion, showcased the best opportunity for agencies to use and benefit from the information exchanges provided by RIMIS. The unplanned event demonstrated where RIMIS could supplement and, in some cases, enhance current procedures and responses that agencies use in managing incident-generated traffic and congestion. In these instances, they could use RIMIS for broadcasting messages, thus minimizing the need for manually faxing or contacting individual agencies to notify of an incident or provide status updates. Participants also saw RIMIS as a valuable tool for informing other agencies that might otherwise not be in the contact loop for a particular event, closure, diversion, and any actions that have been taken. Because RIMIS does not disrupt or impede established agency response and management processes, the participants viewed its capability for coordinated and automated information dissemination and notifications as a benefit.

Figure 7.9 Operational Scenarios: This figure depicts operational scenarios related to unplanned and planned events.

Screen Shot

Screen Shot

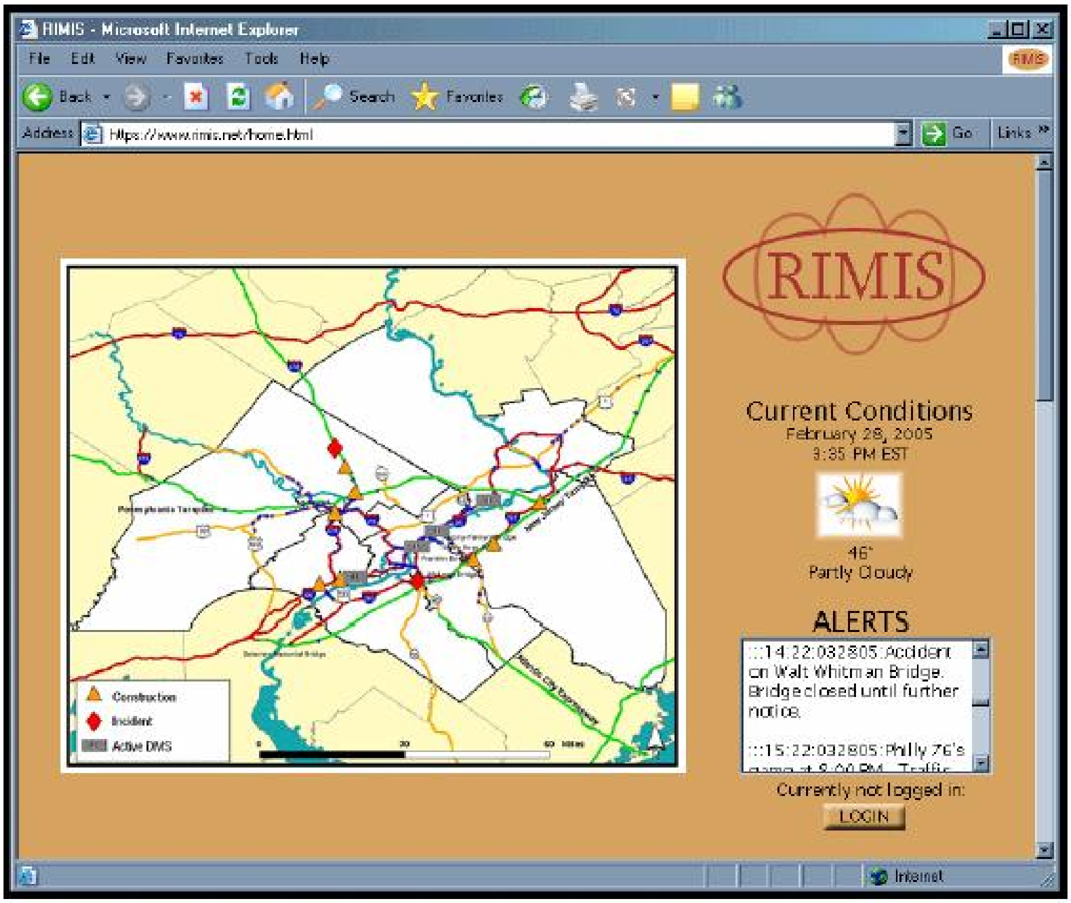

Figure 7.10: Graphical User Interface: This figure shows a sample screen shot of a Graphical User Interface which would be used by the users of the RIMIS system to access its functions and features. This particular screen shot provides users with the following features:

- Instant view of the region's transportation system via the GIS map
- Current date, time, and weather conditions
- Access to secure login screen.
- Daily view of major events (planned or unplanned) impacting the region's transportation system

7.3.3 Development Process

Staff from the Delaware Valley Region Planning Commission developed the Concept of Operations of the RIMIS system with the assistance of a systems engineering consulting firm. The Commission wanted to avoid creating any additional levels of bureaucracy. Three staff members of DVRPDC spent a considerable amount of time developing the RIMIS Concept of Operations over the course of 1 year. In general, they devoted 3 full days per week, each, to the project. In addition, a consultant was retained to support DVRPDC staff – the consultant contract was in the neighborhood of $100,000.

The consultant who was contracted to help in developing the RIMIS project assisted in the areas of software integration, developing functional requirements (ongoing process), outreach to the stakeholders and creating an RFI (Request for Information) document. From the beginning, the development team solicited input and support from agencies throughout the region. Using a collaborative process, they identified goals, initiative areas, and associated high-level functions in the development of a regional concept.

A stakeholder sub-committee called "Tier One" was formed to receive development progress reports from the consultant. The "Tier One" group was a collection of various stakeholders like the NJ DOT, Delaware DOT, Philadelphia Streets, Southeastern Pennsylvania Transportation Authority (SEPTA) etc. They performed the vital task of keeping local government officials informed about the progress of the project.

The RIMIS Concept of Operations calls for a permanent management structure, whose duties includes a range of technical and administrative activities, such as establishing performance measures to monitor the effectiveness of RIMIS.

7.3.4 Use of Concept of Operations

At the time of the writing of this guidance document, the DVRPDC consultant is in the process of developing high-level requirements based on the Concept of Operations document. To facilitate this, a Request for Information (RFI) is being utilized. Figure 7.11 describes the RFI and its objectives.

RFI Objectives

Request for Information Objectives

- Identify functionality of potential value to the RIMIS user community that may have been overlooked in developing the current RIMIS Concept of Operations (CONOPS). Conversely, the RFI may serve to correct misconceptions that may have arisen during the definition of the RIMIS CONOPS about what the center-to-center software market can provide.
- Identify the breadth of the center-to-center software market capable of addressing the functions and features desired by Delaware Valley agencies for RIMIS.
- Determine the maturity, sustainability and adaptability of possible solutions offered by the vendor community.
- Review the depth of the market's adoption of open standards promulgated by standards bodies such as the OMG (Object Management Group) and the W3C (World Wide Web Consortium).
- Review the depth of the market's adoption of relevant transportation industry standards that are adopted and under development by such groups as AASHTO, IEEE, ITE, NEMA, APTA, ANSI, and others which focus on transportation, incident management and the exchange of data.
- Permit DVRPC to ultimately issue a subsequent Request for Proposal (RFP) in order to procure an integrated center-to-center system. Only those respondents to this RFI who are subsequently selected by the RIMIS subcommittee for a in-person presentation will be pre-qualified (i.e., short listed) for the RFP.

Figure 7.11: RFI OBJECTIVES: This figure shows the objectives of using the Request For Information and how this supports the Concept of Operations of the RIMIS system.

The RFI approach acknowledges that the Concept of Operations, as produced, has limitations. Thus, as pointed out in Figure 7.11, the RFI seeks to identify functionality that is of potential value to the RIMIS user community that may have been overlooked in developing the current RIMIS Concept of Operations. This illustrates that a Concept of Operations is never "done" – it is a long-term process. The RFI is a good example of an addendum to the Concept of Operations document that addresses any loopholes or inadequacies.

As the RIMIS Concept of Operations points out, the regional nature of the project will require ongoing cooperation and communication amongst its participating agencies. The establishment and implementation of policies that allow the sharing of information and key data parameters will necessitate the effective use of cooperative agreements. This is illustrated by the following excerpt from the Concept of Operations (Figure 7.12).

Collaboration

Support for Cooperative Agreements:

"The DVRPC manages the development of RIMIS under the supervision of the RIMIS Subcommittee of the ITS Technical Task Force. In the future, RIMIS will require a permanent management structure and a formal agreement among the partnering agencies on how to fund and supervise RIMIS this is according to the RIMIS Concept of Operations document. Possible management configurations include assigning management functions to one of the agencies; rotating management functions among the agencies (e.g., yearly); contracting with a consultant to manage RIMIS administrative functions; hiring limited staff to oversee RIMIS; or some combination of these. Two examples of multi-agency coordination are TRANSCOM and the I-95 Corridor Coalition. The initial concept for TRANSCOM relied on agencies donating staff to TRANSCOM for brief time periods, which minimized hiring additional staff and fostered an interagency cooperation. The I-95 Corridor Coalition relied on a combination of permanent staff for administrative work and consultants who provided oversight of technical activities. As such the RIMIS project will seek to mimic aspects of the aforementioned collaboration (TRANSCOM and I-95 Corridor Coalition) by encouraging RIMIS management duties which includes the following types of activities:

- Establish and periodically update a multi-year business plan
- Approve annual budget including capital and operating costs
- Apply for federal funding
- Develop and update cost allocation plan
- Hold policy and technical meetings with RIMIS participating agencies
- Participate in coordinate meetings with the agencies
- Establish performance measures to monitor the effectiveness of RIMIS
- Determine when additional enhancements to RIMIS are required
- Prepare Requests for Proposals (RFP) and contracts for outside venders to manage RIMIS and technical consultants to enhance RIMIS
- Coordinate training programs and regional operation initiatives." (this is courtesy of the Institutional coordination of ITS in the Delaware Valley Region)

Figure 7.12: Regional Collaboration - This excerpt from the Concept of Operations illustrates collaboration and management issues associated with RIMIS.

The RIMIS Concept of Operations also supports various regional planning efforts. For example, as stated in the document, "each operating agency would have its own long range plan or vision for ITS deployment and would consider them along with the regional agencies and ITS regional vision (namely the RIMIS system) as they develop their capital plans. Individual agencies may request federal funding for ITS deployment through DVRPC's TIP, and would be required to certify that the expenditure of federal funds for ITS deployment would be consistent with the Regional ITS Architecture Requirements."

7.4 LESSONS LEARNED

This section highlights key lessons learned through an analysis of the RIMIS Concept of Operations and through discussion with personnel involved in its development and use.

- It is desirable to involve a local consultant who is privy to the inner workings of the region to be considered. This will eliminate unnecessary delays due to the consultant becoming familiar with the region, its politics, and its key players/stakeholders. As a transportation professional interviewed in the development of this guide pointed out, a lot of the consultations between the consultant and the various stakeholders were based on personal relationships of the individuals involved.

- Frequent review of the progress of work by supporting agencies is not only necessary, but vital. Agencies such as DOTS, emergency services, etc. must be actively involved; this will ensure that the final product will be a true reflection of a concerted effort, which will be beneficial to all.

- There must be no biases; particular stakeholders should not have the "edge" when it comes to making decisions so that the final product does not benefit an individual set of organizations more than others. In other words there must be equity.

- A Metropolitan Planning Organization (MPO) is well positioned to lead the effort in developing a regional Concept of Operations because it, generally, does not operate systems and, as such, is relatively objective.

- It is vital to have good coordination amongst participating agencies.

- Continuity of staff involvement is critical. In the development of the RIMIS Concept of Operations, there was significant staff turnover in many of the stakeholder agencies. This required frequent "re-education." To the extent possible, maintaining staff continuity will expedite the process.

7.5 SPECIFIC LITERATURE SUPPORTING THIS CHAPTER

- Delaware Valley Region Planning Commission. "*RIMIS Concepts of Operations (Conops) Document.*" April 2006

- Delaware Valley Region Planning Commission. "RIMIS Functional Requirements" http://www.dvrpc.org/about/rfps/2006-04_rimisreq.pdf May 4, 2006

- Delaware Valley Region Planning Commission. "Institutional Coordination of ITS in the Delaware Valley Region White-Paper" November 2000

- Delaware Valley Region Planning Commission. "Request for Information" May 4, 2006
http://www.dvrpc.org/about/rfps/2006-04_rimis.pdf