How-To Guide

Transit Operations Decision Support Systems (TODSS)

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16. Abstract

Transit Operations Decision Support Systems (TODSS) are decision support systems designed to support dispatchers in real-time bus operations management in response to incidents, special events, and other changing conditions in order to restore service when disruptions occur. This How-To Guide is intended for use by agencies planning, deploying, operating, and maintaining (TODSS). It was developed based on the outcomes and lessons learned from the USDOT sponsored TODSS Prototype project with Pace in Chicago IL, and from interviews with agencies and vendors that have recently deployed TODSS and TODSS-like systems.

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Executive Summary

This “How To” Guide is intended for use by agencies planning, deploying, operating, and maintaining Transit Operations Decision Support Systems (TODSS) and TODSS-like systems. The TODSS initiative has a two-fold purpose:

1. To make Computer Aided Dispatch/Automatic Vehicle Location (CAD/AVL) systems more dispatcher-friendly by adding a Decision Support System (DSS) to prioritize incidents and assist dispatchers in responding to incidents in a manner consistent with agency policies and procedures.
2. To provide a common specification language in defining system requirements such that procurements become more standardized and require less customization by vendors.

With these goals, the TODSS initiative created a common set of core TODSS requirements that specify legacy CAD/AVL system features and Decision Support Systems capabilities to aid dispatchers in responding to incidents.

The TODSS requirements were piloted at Pace Suburban Bus in suburban Chicago in 2009. Following this pilot, many CAD/AVL system vendors began to add decision support tools to their products, and multiple systems have been deployed with TODSS-like decision support capabilities.

This document provides guidance to agencies that plan to deploy TODSS and TODSS like systems. It should be noted that most modern CAD/AVL Systems have adopted many of the TODSS requirements, and there are not significant differences in the best practices for deploying legacy versus TODSS-type systems. Additionally, this document is applicable for agencies that have legacy traditional CAD/AVL systems that are seeking to add TODSS functionality as part of an upgraded system.

This guide uses general guidance from FHWA’s *Systems Engineering Guidebook* as the starting point for each chapter followed by specific guidance on applying the system engineering process to a TODSS implementation based on best practices and lessons learned from early adopters of TODSS systems. The guide is intended to be used from concept development through system design and procurement, as well as during the project’s operations and maintenance phase.

The guide provides the following information for any TODSS or TODSS-like system development:

- Chapter 2 covers pertinent documentation and references that any agency project team should be aware of.
- Chapter 3 covers the initial scoping of the project through the development of the concept of operations or ConOps.
- Chapter 4 covers the development of the requirements and pertinent information to support the procurement activities of the project.
- Chapter 5 covers deployment of the system including final system design, installation, and testing.
- Chapter 6 covers information pertinent to the operations and maintenance of the system.

Appendix A includes the *Transit Operations Decision Support System Software System Logic and Interface Test Results* report published by the Federal Transit Administration in June 2009.

Appendix B includes the *Transit Operations Decision Support System Software System Results of Implementation Tests* report published by the Federal Transit Administration in June 2009.

Chapter 1 Introduction

Background

The Transit Operations Decision Support Systems (TODSS) initiative began in 2001 to address two common issues with Computer Aided Dispatch/Automatic Vehicle Location (CAD/AVL) systems. These issues were:

- Complex systems that made it difficult for dispatchers to recognize and consistently prioritize issues, and
- Perceptions of system procurements that had significant customization requirements because there was no standard language to request functionality for common transit operations issues.

The TODSS core requirements provide a standardized language for common dispatch functionality, including identifying sources of information, identifying service disruptions and notifying dispatchers, identifying provisions for service restoration, and addressing general systems requirements. These requirements reflect many legacy CAD/AVL system functionalities. The requirements also provide decision support requirements to assist dispatchers in prioritizing and responding to incidents based on the transit agency's business rules.

Between 2001 and 2003, multiple workshops were held with transit agencies, system vendors, transit associations, consultants, academics, and local, state, and federal officials. These workshops drove the development of several foundational documents (described in more detail in Chapter 2) that provided the basis for the initiative, defined the core TODSS functional requirements, and presented legal considerations related to TODSS.

Following the development of the TODSS requirements, the Federal Transit Administration (FTA) and the Intelligent Transportation Systems Joint Program Office deployed a pilot project to demonstrate the application of the TODSS core requirements at Pace Suburban Bus in suburban Chicago—the nation's 15th-largest bus transit operator in terms of number of buses operated in peak service (584 buses in 2012). This project was developed using the systems engineering process (as required for federally funded Intelligent Transportation Systems [ITS] projects) to plan, design, procure, and deploy the TODSS functionality as an upgrade to Pace's existing CAD/AVL System. The project successfully demonstrated the capabilities of the TODSS initiative and has since been replicated in many ways through subsequent deployments of similar systems at other transit agencies.

The only major difference between the TODSS requirements and many legacy CAD/AVL system requirements are the additional functionality for decision support capabilities, which assist dispatchers in prioritizing their activities in conformance with an agency's business rules, and the provision of tools that help dispatchers respond to incidents in a consistent manner that complies with their agency's business rules. More recently, these CAD/AVL systems have evolved to incorporate advanced decision support capabilities that have been defined by the TODSS core functional requirements for computer assisted service restoration.

The benefits of using the TODSS requirements are two-fold. The first benefit is that adding decision-support functionality to CAD/AVL systems for prioritizing incidents and recommending incident-response measures to restore service makes it easier for a transit agency to respond to incidents in a manner that is consistent and compliant with its business rules. The second benefit is that by standardizing the language within the requirements that transit agencies use to procure these systems, procurements will become more consistent and agencies will be less likely to find significant need to customize commercially available systems, thereby potentially reducing costs.

A TODSS system's decision-support capabilities can be configured to use an agency's standard operating procedures to support dispatchers in responding to incidents. The system alerts a dispatcher to pertinent incidents and assists the dispatcher with restoring service. Common applications are vehicle breakdowns, schedule adherence/headway management, and other common transit incidents.

This guide was developed through a review of prior research and results of TODSS and TODSS-like installations, interviews with agencies that have recently deployed TODSS and TODSS-like systems, and interviews with several vendors of TODSS and TODSS-like products. Lessons learned and the information in the blue boxes found throughout this document comes from the industry interviews.

The target audience for this guide consists of public sector transit operations, planning, engineering, and information technology staff at transit agencies of all sizes that are planning to deploy new fleet management systems that use TODSS specifically, or have TODSS-like functionality. TODSS-like functionality includes other types of decision-support systems such as those used on the highway side of the business for Integrated Corridor Management (ICM.).

This guide is not a systems engineering process manual, but it stresses using the systems engineering process to guide the planning, design, procurement, deployment, operations, and maintenance of new TODSS systems. The systems engineering process documentation is referenced in Chapter 2. This guide identifies key activities and deliverables that any new technology project should develop as part of each phase of the project lifecycle. The guide documents the benefits, challenges, and lessons learned by early adopters of this technology, during each phase of the project lifecycle and provides case studies to illustrate how these early adopters have resolved common problems in planning, designing, and deploying TODSS systems.

This guide's purpose is to help transit agencies develop the proper information during each project phase to support the successful deployment of the technology required by their project plans.

The guide's goal is to progress the principles of the TODSS program by giving transit agencies the information they need to enhance the performance of their dispatch centers, while making TODSS system planning, design, and deployment more standardized and consistent with the systems engineering process. The guide:

- Applies the applicable steps and deliverables from both the systems engineering process and the Pace pilot project;
- Focuses on functionality and benefits—including performance and incident management—as well as on developing good data for performance analysis;
- Adheres to existing FHWA and FTA rules, policy, and guidance (e.g., the FTA policy and the FHWA rule on ITS Architecture and Standards Conformity); and

- Provides references to other relevant information such as the systems engineering process and applicable Transit Cooperative Research Program (TCRP) reports.

How to Use This Guide

This guide is divided into six chapters. Chapters 1 and 2 provide an introduction to TODSS and offer pertinent reference information that anyone should be fully familiar with prior to starting a technology project of this type and complexity.

Chapters 3–6 walk the reader through the applicable project phases:

- Chapter 3 provides the approach and scope for project and system planning.
- Chapter 4 provides the approach and scope for system design and procurement.
- Chapter 5 provides the approach and scope for system deployment.
- Chapter 6 provides the approach and scope for system operations and maintenance.

Each of the project phase chapters includes an overview of the phase's key activities and deliverables and the applicable systems engineering principles, discusses the key TODSS and system-specific activities, and provides case studies and lessons learned from early adopters of TODSS technology.

Chapter 2 Support Materials Every Agency Should Be Familiar With

Implementing TODSS is generally similar to any ITS implementation process. It requires a careful understanding of the literature and background documentation, including ITS architecture, TCRP reports, and ICM practices. This chapter outlines the relevant literature that can help practitioners prepare a transit agency for implementing TODSS and TODSS-like systems.

Systems Engineering for ITS

This chapter builds on the systems engineering for ITS projects process as defined by FHWA [reference http://ops.fhwa.dot.gov/publications/seitsguide/section3.htm, http://ops.fhwa.dot.gov/publications/seitsguide/, and https://www.fhwa.dot.gov/cadiv/segb/]. FHWA Rule 940 and FTA's National ITS Architecture Policy ("Rule/Policy") require systems engineering for any ITS project implementation, including TODSS [reference http://ops.fhwa.dot.gov/its_arch_imp/policy.htm]. While the documentation required by the systems engineering process may seem overly detailed, careful planning and execution will save transit agencies time, money, and deployment problems in the long run, and will produce a useful, intended system.

Project Development Challenges

Systems engineering is composed of several fundamental challenges and important concepts:

- Project Initiation Euphoria. There is a need to temper grand ideas and optimism with real-world constraints such as technology, schedule, and funding.
- Cone of Uncertainty. Significant cost and schedule uncertainty exists early in any high-technology project, but decreases over time. Systems engineering helps minimize uncertainty early in a project.
- Procurement Method Selection. Traditional procurement methods, such as low bid, are often not suitable for ITS projects. In contrast, best-value approaches provide the flexibility to consider requirements and an integrator's experience in addition to the cost basis.
- Late Changes Drive Project Costs. Identifying problems or change orders late in the project compounds the costs of correcting them. Verification and validation early and often in the project maximize the chances of identifying defects early in the development process.
- The Odds are Against Absolute Success in Every Aspect of the Project. The majority of projects fail to meet every single criterion outlined for success. Thus, there ought to be compromise on less-critical project requirements when the project is meeting the core priority system requirements.

Systems Engineering Principles

The principles of systems engineering are outlined as follows:

- Start with Your Eye on the Finish Line. Reach consensus on how success is defined early in the process.
- Stakeholder Involvement is Key. Successful projects involve the customers, users, operators, and other stakeholders both in project development and throughout all subsequent stages of the project.
- Define the Problem before Implementing the Solution. Avoid identifying a solution and “backing into” requirements to meet that target.
- Delay Technology Choices. Technology is constantly evolving, and the choices available at the end of a project may be different from those at the beginning.
- Divide and Conquer. Decompose large and complex systems into smaller, more-manageable subsystems and hardware and software components, which are easier to understand and define.
- Connecting the Dots/Traceability. Relate items in each step of the process to one another to establish traceability. Traceability is a powerful concept that allows one to be certain that the system implemented at the end of the project is directly connected with the user needs that were identified at the beginning of the project.

Incremental Project Implementation

Managing design and build activities through iterative and incremental development processes can help mitigate the risk of project management overload. One example of this technique, known as *agile project management*, focuses on completing small portions of deliverables in each delivery cycle. Developing projects through iterations allows agencies to gather feedback and refine requirements as the project moves forward.

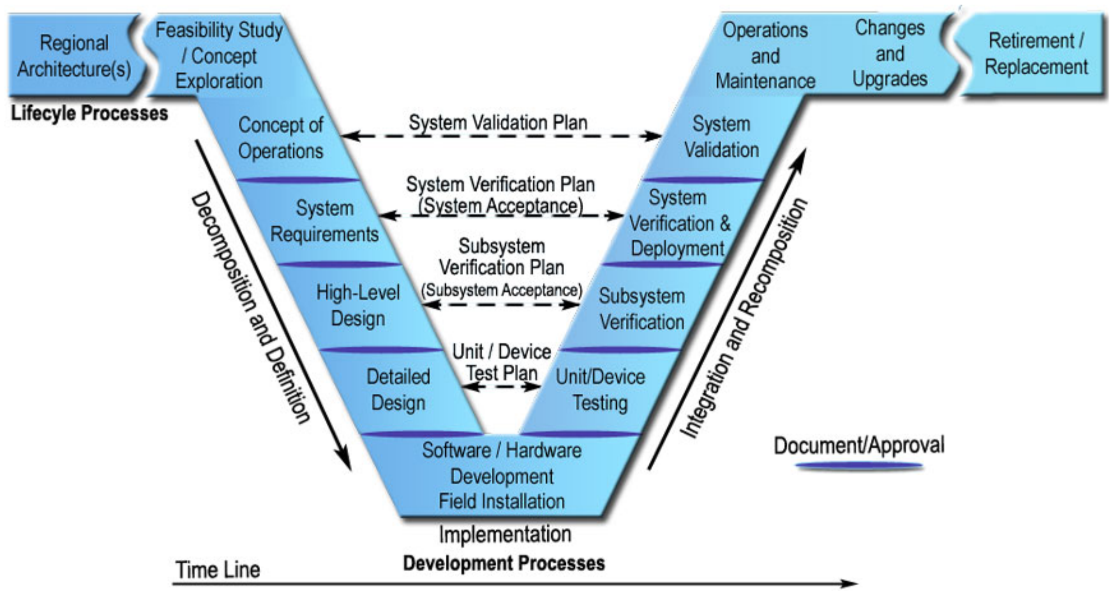
Another version of this concept is known as user-centered design (UCD), which tests deployed systems to ensure they meet user needs. UCD is an evidence based design methodology that optimizes a product based on how users actually want (or need) to use a technology. It employs a multistage process that begins with studies and predictions of how users will want to use a particular technology. The technology is then developed and tested in real-life situations to determine whether the initial assumptions about user behavior are correct.

Both methods create a “virtuous cycle” wherein the product is continuously improved over time, encouraging more use and testing.

The "V" Systems Engineering Model

The "V" model has emerged as the de facto standard way to represent systems engineering for ITS projects. (Figure 2-1)

Figure 2-1 Systems Engineering "V" Diagram



Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

As shown in the "V," the systems engineering approach defines project requirements before technology choices are made and before the system is implemented. On the left side of the "V," the system definition progresses from a general user view of the system to a detailed specification of the system design. The system is decomposed into subsystems, and the subsystems are decomposed into components—a large system may be broken into smaller and smaller pieces through many layers of decomposition. As the system is decomposed, the requirements are also decomposed into more-specific requirements that are allocated to the system components.

Regional ITS Architecture

The regional ITS architecture, based on the National ITS Architecture, provides a starting point for the systems engineering analyses that are performed during ITS project development. It provides region-level information that can be used and expanded upon in project development.

When an ITS project is initiated, there is a natural tendency to focus on the programmatic and technical details, thus losing sight of the broader regional context. Using the regional ITS architecture as a basis for project implementation provides this regional context. It provides each project sponsor with the opportunity to view the project in the context of the surrounding systems. It also prompts the sponsors to think about how the project fits within the region's overall transportation vision. Finally, it identifies the integration opportunities that should be considered and provides a head start for the systems engineering analysis.

The regional ITS architecture is a tool that is used in transportation planning, programming, and ITS project implementation. It is a framework for institutional agreement and technical integration for ITS projects and is the place to start when defining the project's basic scope.

Key Activities

Table 2-1 describes the key elements and activities to define the project within the Regional ITS Architecture. This set of activities identifies how the project fits within the Regional ITS Architecture and what changes to the current architecture will be required once the project is deployed.

Table 2-1 Key Elements of Project Definition

Element	Description
Objectives	• Identify where the project fits into the Regional Architecture • Identify surrounding systems that may support the planned project.
Input *Sources of Information*	• Current Regional Architecture • Projects Goals & Objectives
Process *Key Activities*	• Identify the regional ITS architecture(s) that is (are) relevant to the project. • Identify the applicable portions of the regional ITS architecture. • Verify consistency with the regional ITS architecture and identify any necessary changes to it to accurately depict the new system functionality.
Output *Process Results*	• Element(s) of the Regional Architecture applicable to the project • Recommended changes for the Regional Architecture
Review *Proceed only if you:*	• Receive approval of the planned new project within the Regional Architecture • Review planned changes with all stakeholders

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

While the Rule/Policy requires a subset of the regional ITS architecture to be identified, it does not define the components that should be included. Local guidelines or requirements should be consulted to help make this determination. In most cases, the following components will precisely define the project scope: (1) stakeholders, (2) inventory elements, (3) functional requirements, and (4) information flows.

These four components define the system(s) that will be created or impacted by the project, the affected stakeholders, the functionality that will be implemented, and the interfaces that will be added or updated. Other components may be identified, including market packages, roles and responsibilities, relevant ITS standards, and agreements. For very large ITS projects, this definition might result in several pages of information. For a small ITS project, it might fit on a single page. The information that is extracted will be used in the concept exploration, concept of operations, requirements, and design steps that follow.

TODSS Requirements and Reference Documentation

There are several key documents that any project team deploying a TODSS or TODSS-like system should be cognizant of.

TCRP Documentation

TCRP Synthesis 73: AVL Systems for Bus Transit: Update is a synthesis of the state-of-the-art (as of 2008) for CAD/AVL systems in the U.S. market. http://www.tcrponline.org/PDFDocuments/tsyn73.pdf

TCRP Report 113: Using Archived AVL–APC Data to Improve Performance and Management provides guidance on using CAD/AVL and Automatic Passenger Counter (APC) data for performance management. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_113.pdf

TCRP Report 8: The Quality Journey: A TQM Roadmap for Public Transportation provides guidance on Total Quality Management and includes metrics for measuring transit system performance. http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_08-a.pdf

USDOT Knowledge Resources

The ITS Knowledge Resources Portal provides links to information on ITS benefits, costs, applications, and deployments in the U.S. http://www.itskrs.its.dot.gov/

Transit Operations Decision Support Systems (*TODSS) Core Functional Requirements for Identification of Service Disruptions and Provision of Service Restoration Options* is a document that defines the standardized language for TODSS requirements development. http://ntl.bts.gov/lib/jpodocs/repts_te/13964.html

Transit Operations Decision Support Systems (TODSS) Core Requirements Evaluation and Update Recommendations Final Report is the self-evaluation and recommended updates to the core functional requirements following the Pace TODSS Pilot Project. http://www.fta.dot.gov/documents/Technical_Memorandum_TODSS_Core_Requirements_Evaluation_and_Update_Recommendations_Final_Report_v4_(final)_(2).pdf ,

Transit Operations Decision Support System (TODSS) Core Requirements Prototype Development Case Study and Lessons Learned is the final report for the Pace pilot project, which includes descriptions of the TODSS functionality, illustrates project development using TODSS requirements, and provides lessons learned from the pilot project. www.fta.dot.gov/documents/Task_7_Final_TODSS_Report_V3.pdf

Appendices A and B included with this document provide two additional pilot documents that are not currently available online that pertain to the pilot testing system software tests results and pilot test results that agencies my find to be a good example of system test planning and documentation.

Chapter 3 Planning Your New TODSS System

A necessary first step in planning a new TODSS system is determining that such a system is indeed the best feasible solution for the issues it is intended to address. The systems engineering process calls for a Feasibility Study as the means for making this determination. If a TODSS system is the preferred concept arising from the feasibility study, the process then continues with developing a concept of operations for the system.

This chapter starts by describing these steps generically within the systems engineering process, and then goes into the details of how the process can be applied specifically to planning a TODSS system.

Project Planning Using the Systems Engineering Process

The “planning” portion of the systems engineering V-diagram includes two steps: (1) conducting a feasibility study to explore the concept, and, (2) if feasible and preferred, developing a concept of operations.

Feasibility Study/Concept Exploration

Agencies exploring a new ITS project should develop a business case for the project that assesses the project’s technical, economic, and operational feasibility. The business case should also estimate costs and benefits, identify risks, and evaluate alternative concepts for meeting the project’s purpose and need. The feasibility study provides a basis for understanding and agreement among project decision-makers. The outcome of the feasibility study is a preferred concept that has been selected and justified with sound analysis.

An official agreement between agency stakeholders, such as a project charter, is recommended early in the process. Outlining the project at the outset, including clearly defining roles and responsibilities, helps keep agencies and individuals aligned throughout the process. A charter is typically drafted after the feasibility study but prior to moving forward.

Table 3-1 outlines the key elements of the Feasibility Study/Concept Exploration step.

Table 3-1 Key Elements of Conducting a Feasibility Study

Element	Description
Objectives	• Identify a superior, cost-effective concept, and document alternative concepts along with a rationale for selection • Verify project feasibility and identify preliminary risks • Garner management buy-in and necessary project approvals
Input *Sources of Information*	• State the project's goals and objectives • State the project's purpose and need • Identify project scope/subset of the regional ITS architecture
Process *Key Activities*	• Define evaluation criteria • Perform initial risk analysis • Identify alternative concepts • Evaluate alternatives • Document results
Output *Process Results*	• Feasibility study identifying alternative concepts and making the business case for the project and the selected concept
Review *Proceed only if you:*	• Receive approval on the feasibility study from project management, executive management, and controlling authorities, as required • Reach consensus on the selected alternative

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.2 Feasibility Study/Concept Exploration of the Systems Engineering for Intelligent Transportation Systems document.

Concept of Operations

The concept of operations (ConOps) is a foundation document that frames the overall system and sets the project's technical course. It may also document the current condition and describe the envisioned future system, goals and objectives, and use cases or scenarios. Its purpose is to clearly convey a high-level view of the system and to answer the following key questions:

- Who. Who are the stakeholders?
- What. What are the system's elements and high-level capabilities?
- Where. What is the system's geographic and physical extent?
- When. What is the sequence of activities that will be performed?
- Why. What is the problem or opportunity addressed by the system?
- How. How will the system be developed, operated, and maintained?

Table 3-2 outlines the key elements of the concept of operations phase.

Table 3-2 Key Elements of the Concept of Operations Phase

Element	Description
Objectives	• High-level identification of user needs and system capabilities in terms that all project stakeholders can understand • Stakeholder agreement on interrelationships and roles and responsibilities for the system • Shared understanding by system owners, operators, maintainers, and developers on the who, what, why, where, and how of the system • Agreement on key performance measures and a basic plan for how the system will be validated at the end of project development
Input *Sources of Information*	• Stakeholder lists, roles and responsibilities, and other components from the regional ITS architecture • Recommended concept and feasibility study from the previous step • Broad stakeholder input and review
Process *Key Activities*	• Identify the stakeholders associated with the system/project • Define the core group responsible for creating the concept of operations • Develop an initial concept of operations, review with a broader group of stakeholders, and iterate to agreement • Define stakeholder needs • Create a System Validation Plan
Output *Process Results*	• Concept of operations describing the who, what, why, where, and how of the project/system, including stakeholder needs and constraints • System Validation Plan defining the approach that will be used to validate the project delivery
Review *Proceed only if you:*	• Receive approval on the concept of operations from each stakeholder organization • Receive approval on the System Validation Plan from each stakeholder organization

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.3 Concept of Operations of the Systems Engineering for Intelligent Transportation Systems document. The Pace Suburban Bus ConOps is provided as an appendix to the final report that can be accessed at the following hyperlink: www.fta.dot.gov/documents/Task_7_Final_TODSS_Report_V3.pdf

Applying the Systems Engineering Process to a TODSS Feasibility Study and Concept Exploration

This section builds on the generic systems engineering approach to planning an ITS project by introducing the TODSS-specific elements that need to be considered. This phase of the project will define the business case for the TODSS system and will assess the technical, economic, and political feasibility of the proposed system at a high level. The goal of this project phase is to explore the alternatives that are available to meet the identified needs within the identified constraints.

Developing the Stakeholder Team

The stakeholder team should include the users of the system, the maintainers of the system, and others who provide or use information and data that the system is anticipated to consume or produce. The system development team should be a core part of the stakeholder team. Stakeholders for TODSS and TODSS-like systems should include, but are not necessarily limited to, the following staff types from within the transit agency:

- System Development Team
- Operations Management
- Operations Business Analyst
- Lead Dispatcher(s)
- Lead Operator(s)
- Planning Managers and/or Lead Planners
- Maintenance Management and/or Lead Electronics Maintenance Staff
- Marketing (if real time information or other customer-facing technology is involved)
- Information Technology
- Communications Engineering

External stakeholders should include any relevant external agencies (e.g., a local department of transportation) that may have approval authority over aspects of the project, that may be a source of data/information to be used by the system such as traffic or weather data, or that may be a user of information generated by the system. Other external stakeholders may be required, as appropriate, depending on specific transit agency or project goals.

Lessons Learned:

- When possible, find "super users" within technological, operations, planning, and maintenance areas as members of the system development team. These super users will be particularly helpful in developing the concept of operations later in this phase of the project. If the transit agency does not posess a complete set of skills, it should either hire staff with those skills (assuming a decision is made to proceed with the TODSS project) or hire a consultant to help guide them.
- Most transit agencies have no one who is fully capable of, or interested in, taking control of a TODSS project. There is a critical need to have an operations person who can drive the TODSS application. Typically, agencies do not have an operations business analyst to support the system. Agencies should hire or contract with skilled TODSS leaders or consultants in the industry to augment their project team.
- Do not design in isolation, procure, then hand over to the users.

Input/Sources of Information

The TODSS project should commence with the system development team developing the project's goals, objectives, scope, and needs. These activities develop the project's framework and describe the needs that the project is intended to address. The system development team should be a core group of staff and technical experts that are a central part of the project stakeholder team. The goal of this phase of the project is to generate information that will provide project stakeholders with a clear understanding of the project's context.

Goals and objectives developed during the project's definition phase may resemble the following list generated for a prior TODSS project:

- Radio coverage area needs to be increased to accommodate regional growth.
- Voice and vital data communication must always be available to meet the safety needs of our drivers and customers.
- Meaningful management information needs to be provided to measure success and improve customer service.
- Historical and real-time data need to be provided to appropriate agency staff to improve business processes and decision making.
- Integration capabilities need to support the addition of real-time traveler information through the internet, personal devices, and departure signs.
- The CAD/AVL/TODSS system must be easy to use and must support existing staff in becoming more effective and efficient in performing their jobs.
- Integration with the onboard ITS system needs to be provided to reduce operator workload, to reduce maintenance needs, and to minimize errors.

The input should also define where the system will be deployed and, at a high level, identify the key users of the system. For systems that will be installed on vehicles as well as in the agency back office, the input should detail the bus fleets the system will be installed on, including quantities (e.g., number of buses), dispatch sites, IT infrastructure locations, backup locations, and so on. Defining the system's users will assist the stakeholder team if the project continues on to the next step in the systems engineering process.

Once the project goals and objectives have been defined, the regional ITS architecture should be reviewed to determine if there are any existing systems that can be leveraged to help meet the new system's requirements. The regional architecture should also help identify sources of information about existing systems that may be available to support the new system, e.g., existing scheduling or Geographic Information System (GIS) data.

Key Activities for TODSS & TODSS-Like Systems

It is important for the system development team to educate the stakeholder group about the concept exploration process and to develop a schedule for performing the assessment. This activity prevents the process from being open-ended (i.e., never coming to a solution). At this stage, the stakeholder team should have, or be reviewing, the appropriate reference information that is pertinent to their background and role on the project (detailed in Section 2), and should meet with transit agencies that have similar systems to gather information on their successes and lessons learned. Gathering data from peers who have recently installed similar systems provides good opportunities to gather best practices and lessons learned.

Develop Evaluation Criteria

The project team and their senior management project sponsors should be tasked with developing project evaluation criteria that will set the limits for what would be considered an acceptable, feasible concept. Evaluation criteria should include cost, schedule, and any other system constraints. These criteria should help limit acceptable alternatives to those that are reasonably believed to satisfy the system's needs within the project's constraints.

A risk register that identifies any potential obstacles or other issues that may impact the project should be developed as part of the evaluation criteria. Typical issues include communications bandwidth, funding, and schedule constraints. TODSS applications often require intensive data communication between the fleet(s) and the back office applications.

A systems validation plan should be developed that defines how the stakeholders will measure the project's success. These evaluation measures will be used to evaluate the selected alternative once it has been deployed. These measures should also be included in the initial evaluation criteria to help screen out alternatives that cannot meet the stakeholders' definition of success.

Develop a Concept of Operations

The system development team should follow the systems engineering process in designing a concept of operations that includes a detailed operations analysis. Developing a concept of operations is an iterative process and should be reviewed by not only by the stakeholder group, but also by a broader audience of users and management as the document is developed.

The first activity in developing the concept of operations is conducting a detailed operations analysis, which should, at a minimum, include the agency's planning, scheduling, operations, dispatch, and maintenance functions. The review should start with the end users and work up the management chain to identify current business processes, rules and Standard Operating Procedures (SOP's) as well as how new technology or processes could be applied to improve current business practices. It should identify the agency's standard operating procedures, and any that are lacking. The review should also establish in which situations staff members are using spreadsheets, forms, and paper products to determine which TODSS tools or requirements would be beneficial to automate those processes. The review should also look at existing business processes and review whether the planned new technology can improve them. The review should focus on how the agency can conduct business better and more efficiently.

In addition, the agency's policies and procedures should be reviewed to identify all incident types that the new system will be expected to manage. These should be prioritized so that the system, once deployed, can present the incidents to dispatchers in a consistent manner. The *TODSS Core Systems Requirements Document* identifies the following operational needs/issues as key issues to address:

- Headway-based service support (bunching)
- Schedule-based service support (early/late)
- Incident/emergency event support
- Connection protection (scheduled)
- Real-time requests for transfer connections
- Variable thresholds for notices/alarms
- Early warning signs and impacts of actions
- Provision of recommended actions
- Prioritizing problems and solutions
- Systemwide impact analysis
- Two-way communication between vehicles, supervisors, and the management center
- Projecting emerging problems and preparing potential responses
- Integrating the system with other travel modes and ITS components
- Understandable display of information (human factors)
- User-defined reports and data screens
- Use of standards, open architecture, and data definitions
- Modular, incremental implementation of system functionality

The document's outline can help guide a transit agency through the process of gathering the necessary information for the Concept of Operations. The agency should carefully document the vocabulary of transit terms and acronyms to assist in communicating key needs clearly, as terminology can vary among agencies and regions. A typical outline includes the following:

- Introduction. Provides an overview of the project description and limits, and provides an overview of the Concept of Operations document organization.
- Reference Documents. Details the reference materials used thus far during project development.

- Overview of the Current System(s) and the Need for Change. Describes the current systems in place, including their shortcomings, to make the case for change. This description should include all existing tools associated with the current operations that are pertinent to the project, including any existing CAD/AVL systems, scheduling systems, crew management functions, incident management functions, incident reporting systems, performance management systems, and so on. The need for change should describe which TODSS functionalities are desired to increase effectiveness and efficiency and to meet the goals described for the project.
- Project Stakeholders. Identifies the primary (users) and secondary (consumers or providers of data) stakeholders.
- Nature of the New System. Describes the desired changes and their priorities, user roles and responsibilities, coordination needs, and operational scenarios. This section should also document operational scenarios that describe how users will interact with the new system.
- Summary of Impacts. Documents the proposed operational impacts and summarize the improvements the new system will provide.
- Appendices. Provide any useful information that has been gathered thus far that supports the need for change.

The operational scenarios that are developed as part of the "Nature of the New System" section should include the new system's highest-priority functions and should indicate who will operate the system, how events will be sensed, how the system should react to events, how users will interact with the system to apply agency-standard operating procedures to respond to an event, and how event information and actions taken to resolve an event will be documented. Conditions and circumstances that may be built into operational scenarios include, but are not limited to:

- Type of Service: peak, off-peak, holiday, weekend, etc.
- Normal Operations: dealing with schedule, headway, accidents, operator reliefs, etc.
- Severe Disruption: weather, strike, major event causing disruption of service
- Emergency Response: fires, hazardous material zones, terrorist events, evacuations due to natural or man-made events
- Following the development of the initial ConOps and operational scenarios, a thorough walkthrough should be performed with the stakeholder team and other parties within the agency that is interested in the development of the new system, e.g., a steering committee or senior staff.

Evaluation of Alternatives

Identify a broad range of alternatives that address the needs of the concept of operations, including the alternative to do nothing. Alternatives should be described in layman's language so that all stakeholders can grasp the concept of the alternative. Specific vendor solutions should not be considered at this point, as that effort is more appropriate later in the procurement process. Additionally, the alternatives at this point should be high-level—for example, implementing an in-house based system versus a hosted solution, or taking account of existing communications systems alternatives versus building out a new system.

It is important to not only evaluate the technical merit of each alternative, but also to determine how the alternative may be deployed (e.g., will the equipment/services be purchased or leased) and to estimate its capital- and operating-cost impacts.

Systematically evaluate each alternative, including the “do nothing” alternative, using the evaluation criteria developed previously. The evaluation should compare each alternative’s technical merit as well as capital and operating costs, life-cycle costs, risks, and benefits. There are many useful tools identified in Section 2 that provide tangible ITS system costs and both tangible and intangible benefits. The documentation of the alternatives analysis should also include a Strength, Weakness, Opportunity, and Threat (SWOT) analysis. Depending on the project’s complexity, this analysis could be fairly simple or it could be complex. A sample SWOT Diagram for a TODSS-like project alternative is detailed in Table 3-3.

Table 3-3 Strength, Weakness, Opportunity, Threat Analysis
Competitively bid a new radio only CAD/AVL system replacement with Tier I supplier

Strength	**Weakness**
• Competition for better price/performance potential • Choose from available products to select best fit • Exposure to different technologies and approaches	• Longer procurement process that extends system replacement • Requires establishing new business relationship • Potential for greater training needs
Opportunity	**Threat**
• System expansion and interface capabilities • Greater agency support	• New interfaces may force greater operational changes • May limit sharing real time information with regional agency without customized design

The results of the evaluation should be documented in sufficient detail to support the decision-makers who will decide whether or not it is worthwhile to pursue the project. The documentation should also provide an overview of the proposed solution and identify any known feasible solutions on the market or in development that will meet the project’s needs. It is important to remember that the audience that decides whether a project moves forward is management. This audience may or may not be as technologically savvy as the stakeholders developing the alternatives analysis and will require a concise description of the alternatives, their anticipated costs, and anticipated benefits.

Case Study

The Pace Pilot Project closely followed the systems engineering process. Pace had a variety of existing systems in place, including a CAD/AVL system. The steps involved in developing the concept of operations included:

- Identifying and documenting what TODSS functionality already existed within Pace.
- Documenting the desired TODSS functionality that was not currently provided by the existing systems.
- Prioritizing the missing functionality.

- Reviewing Pace's standard operating procedures and determining how TODSS functionality could be used to enhance responses to incidents.
- Developing operational scenarios for high-priority TODSS functionalities.

As part of the initial scan to identify current functionality, a detailed operational analysis was performed to identify how incidents were currently managed and also how operations, incidents, and other pertinent information were being documented. Highly manual and duplicative work was identified and targeted for automation using the TODSS tools.

A review of TODSS functionality that was not currently in the system was prioritized by the project's goals, objectives, and funding constraints and a final list of needs for the new system was defined.

The Concept of Operations was then developed to document the current system, its shortcomings, and planned improvements for both the existing highly manual and duplicative functionality as well as the prioritized TODSS functionality. Operational scenarios were developed for the key functions that the new system was being designed to automate using TODSS functionality. One example of an operational scenario is described below [Source: PACE Pilot ConOps Operational Scenarios].

Late Startup and Late Logon/Pullout Operational Scenario

Dispatchers must ensure that all scheduled work is assigned to an operator and that all operators report for duty, start and inspect their vehicles, and leave the garages as scheduled. The dispatcher is required to assist the operator with their sign-in at the dispatcher window. Notification of a late system logon, late pullout, or missing pull-out are provided as data messages and this status is displayed as warnings on the pull-out/pull-in tab within the TODSS System. The pull-out/pull-in tab provides visibility to the dispatcher of operator pull-outs and return to the garage (pull-in).

Initial Actions

- Observe each bus operator at the sign-in window to verify receipt of their run assignments, distribute pouches, and assign vehicles within no later than two minutes of the assigned report time.
- Monitor the pull-in/pull-out tab for late logon and late pull-out warning messages. Note that a driver violation data message for late logon is sent to the event queue.

Service Restoration Strategy

- Reassign a vehicle if a reported vehicle problem cannot be fixed by the Lot Manager in a timely fashion.
- Examine late pull-out alarms to verify if a run is covered by trying to locate the vehicle on the AVL map, establish voice communications with vehicle, examine the roster tab run listing, or view the vehicle properties on the vehicle tab.
- Verify a missing run by sending a field supervisor to track down the vehicle if all efforts to validate the vehicle status fail.
- Reassign a missed run to the extraboard, an overtime operator, or qualified staff.
- Determine whether to run late from first timepoint or cancel service and start the run at a point along the trip to be on time.

Follow-up

- Log the bus operator as a Miss in the Daily Log.
    - Assign as a full Miss if out later than two minutes.
    - Assign as a one-half Miss if out later than two minutes, but the operator performs their assignment as scheduled.
- If service is lost, classify the event and record in the Daily Log (Delay if less than 20 minute delay, Partial Miss if only a part of a trip is delayed greater than 20 minutes, Miss if more than 20 minute delay).
- Notify Customer Relations (and Chicago Regional Transportation Authority after business hours) of any service disruptions or delays.

This document was reviewed by each stakeholder's management team, and comments and critiques were implemented in the final concept of operations and operational scenarios.

Following the development and approval of the concept of operations, an alternatives analysis was performed to evaluate:

- Building a decision support system on top of the existing systems.
- Contracting with their current vendor to add additional functionality to the existing system.
- Doing nothing.

A complete replacement of the existing systems was not considered in this case due to funding constraints and because the current system was well within its anticipated service life.

Lessons Learned:

- Agencies should define a proper chain of command within the project team to help the team determine how functionality is installed and priorities. Agencies need control over the process to maintain project goals.
- Having more involvement by the operators and dispatchers is more effective. One agency has experienced "bargaining issues" with new technology and feels that if they had prepped their workforce better, those issues could have been averted.
- Many agencies do not have written standard operation procedures for responding to incidents. These are critical to properly implementing TODSS systems. Agencies should make a list of incidents that they encounter regularly and make sure they have procedures in place to manage them. These are the best candidates for automation using TODSS.
- Transit agencies should include mid-level management of operations, maintenance, planning/scheduling and human resources in identifying the roles and responsibilities they see for their staff and what information needs they would like to see covered with the new TODSS system.
- Many agency specifications have poorly written interface requirements to existing (or new) third party systems. There is generally not enough information within current specifications to accurately bid integration costs without having a fair amount of risk. There have been several instances in which a device is named within a bid, but upon installation different firmware versions of the device than anticipated were used, which has caused additional work to be performed in order to make the interface work.

Chapter 4 Designing and Procuring Your New TODSS System

Design and Procurement Using the Systems Engineering Process

Following the Feasibility Study/Concept Exploration, the next step in the system engineering process is to develop requirements and design the system.

System Requirements

Defining requirements that meet the stakeholders' needs is critical for a successful project. At the outset of the project, the stakeholders will likely identify a complex set of requirements, wish lists, technology preferences, and other disconnected thoughts and ideas. Careful analysis is required to develop a sound set of requirements from the initial list.

When defining system requirements, it is important to identify what is required rather than how to accomplish specific functions. This helps to avoid defining requirements that describe a specific design solution. Likewise, well-written requirements— necessary, unambiguous, complete, correct, feasible, and verifiable—facilitate a broader understanding and improve chances for success.

Every ITS project should have a documented set of requirements, traced to user needs, that are approved and baselined. TODSS core requirements were developed by the USDOT in collaboration with the transit industry and may be used as a starting point for developing a transit agency's own TODSS requirements. These core requirements are documented later in this chapter and outlined in Tables 4-3 through 4-6. They are designed to be used as a basis for developing requirements that agencies are interested in deploying and are not absolute requirements. The tables illustrated here are a subset of the requirements included in the TODSS Core Functional Requirements Document. Table 4-1 outlines the key elements of the System Requirements step.

Table 4-1 Key Elements of the Concept of Operations Phase

Element	Description
Objectives	• Develop a validated set of system requirements that meet the stakeholders' needs
Input *Sources of Information*	• Concept of Operations (stakeholder needs) • Functional requirements, interfaces, and applicable ITS standards from the regional ITS architecture • Applicable statutes, regulations, and policies • Constraints (required legacy system interfaces, hardware/software platform, etc.)
Process *Key Activities*	• Elicit requirements • Analyze requirements • Document requirements • Validate requirements • Manage requirements • Create a System Verification Plan • Create a System Acceptance Plan
Output *Process Results*	• System Requirements document • System Verification Plan • Traceability Matrix • System Acceptance Plan
Review *Proceed only if you have:*	• Received approval on the System Requirements document from each stakeholder organization, including those that will deploy, test, install, operate, and maintain the new system • Received approval on the System Verification Plan from the project sponsor, the test team, and other stakeholder organizations • Received approval on the System Acceptance Plan from the project sponsor, the Operations & Maintenance (O&M) team, and other stakeholder organizations

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.4 System Requirements of the Systems Engineering for Intelligent Transportation Systems document.

System Design

The next step is to create a system design based on the system requirements identified above. The high-level system design is defined by the overall framework for the system. Systems are decomposed into subsystems, and then further into components to which requirements are allocated and interfaces are specified. Detailed specifications are created for the hardware and software components to be developed, and the final product selections are made for off-the-shelf components.

There are two levels of design to be included in project design: high-level design and detailed design. High-level design, commonly referred to as *architectural design*, is a process for defining a collection of hardware and software components and their interfaces to establish the framework for the development of computer systems, communications networks, distributed services, facilities, or people. Detailed design is the complete specification of the software, hardware, and communications components defining how the components will be developed to meet the system requirements. Table 4-2 outlines the key elements of the system design step.

Table 4-2 Key Elements of the System Design Step

Element	Description
Objectives	• Produce a high-level design that meets the system requirements and defines key interfaces, and that facilitates development, integration, and future maintenance and upgrades • Develop detailed design specifications that support hardware and software development and procurement of off-the-shelf equipment
Input *Sources of Information*	• Concept of Operations • System Requirements document • Off-the-shelf products • Existing system design documentation • ITS standards • Other industry standards
Process *Key Activities*	• Evaluate off-the-shelf components • Develop and evaluate alternative high-level designs • Analyze and allocate requirements • Document interfaces and identify standards • Create Integration Plan, Subsystem Verification Plans, and Subsystem Acceptance Plans • Develop detailed component-level design specifications
Output *Process Results*	• Off-the-shelf evaluation and alternatives summary reports • High-level (architectural) design • Detailed design specifications for hardware and software • Integration Plans, Subsystem Verification Plans, Subsystem Acceptance Plans, and Unit/Device Test Plans
Review *Proceed only if you have:*	• Approved the high-level design for the project • Defined all system interfaces • Traced the system design specifications to the requirements • Approved detailed specifications for all hardware and software components

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.5 System Design of the Systems Engineering for Intelligent Transportation Systems document.

Applying the Systems Engineering Process to TODSS Design and Procurement

This section builds on the generic Systems Engineering approach to designing and procuring an ITS system by introducing the TODSS-specific elements that need to be considered. The key project activity in this phase is to begin the requirements-development process. However, developing a thorough set of functional requirements, as well as addressing the TODSS system's technical, security, maintenance, logistical, and project requirements, can be daunting.

Lesson Learned:

To develop a full set of project requirements, staff need to be skilled at putting together project technical and programmatic requirements. Transit agencies interviewed during the development of this guide advised that if an agency does not have staff capable of doing this, they should train or hire staff or procure consultant support that is well-versed in TODSS and TODSS-like systems.

Functional requirements should be developed that are concise and describe in very clear language what the system should do (e.g., "The system shall identify to the appropriate dispatcher when a vehicle is operated for a predefined distance without a proper login: Unauthorized Vehicle Movement"). The requirements should not describe how the system will look, but rather what the system should do. These requirements will need to be followed up during subsequent project phases to trace them to completion at project delivery.

There are many ways to develop requirements, including observation, interviews, group sessions, or charrettes, as well as from the operational scenarios or use cases generated as part of the Concept of Operations. For interviews and charrettes, it is important to have the right stakeholders involved in the process. This means not only having the right departments involved, but the staff from those departments who have a vision of how the system should operate for them.

It is often easiest to start by developing the TODSS system's key functional requirements and then build upon this list to flesh out the system requirements. Building an outline set of requirements for the system that define these key requirements will begin the process of fleshing out the rest of the functional requirements for the system. The key activities during this process should focus on the transit agency's needs for the TODSS system as opposed to describing the capabilities of TODSS systems on the market. In some cases it is fairly straight forward to build out the requirements. In large or complex systems, an iterative Agile or UCD approach is better suited to build out requirements and maintain stakeholder agreement.

It is also important that the requirements defining how the system should work are not so specific that no leeway is given to vendors to propose alternative solutions that may work better than the system requirements that the agency describes. A sample of the initial set of requirements that a project may start with include:
Voice and vital data communications must be available over >95% of the service area to meet the safety needs of our drivers and customers.

- Provide meaningful management information to measure success and improve customer service.

- Provide historical and real-time data to appropriate agency staff to improve business processes and decision making.
- Provide integration capabilities that support the addition of real-time traveler information through the Internet, personal devices, and departure signs.
- The CAD/AVL system must be easy to use and support, in order for existing staff to be more effective and efficient in performing their jobs.
- Integrate onboard ITS systems to reduce operator workload, reduce maintenance needs, and minimize errors.
- The CAD/AVL system must be secure in operations, communications, Information Technology, and data.

Once the primary requirements are defined, each of the primary requirements can be refined into a focused functional specification that is clear for vendors to read and respond to. For instance, for the requirement for reducing operator workload, a set of requirements may be developed similar to the following:

- The Mobile Data Terminal (MDT) shall be capable of serving as the single point of logon for the system and optional Audio-Visual Annunciation System (AVAS). Through the MDT, the AVAS shall be provided with transit data as input on the MDT.
- The logon shall capture the employee number and run and/or block number. This information can be shared with other future systems through industry standard interfaces and communication protocols. The vendor shall specify the standards and interfaces that will apply to future systems for this protocol.

As the detailed requirements for the systems operations are developed, it is also useful to look at each operational scenario and the agency's standard operation procedures to review potential service restoration strategies for each scenario. At this stage of project development, some of these strategies can be determined and documented within the system requirements, but others may be difficult to fully define and may need to be further developed during the preliminary and final design process with the vendor. It is important to develop *well-written* requirements, defined as requirements that are necessary, unambiguous, complete, correct, feasible, and verifiable. Table 4-3 provides the sample restoration strategies that were identified in the *TODSS Core Functional Requirements* document.

Lesson Learned:

- System functionality should be defined as basic and advanced. The basic set of functionality should mirror current operations or be a short stretch from that. During the deployment phase, it is important to first deploy this basic functionality, and then expand the capabilities as the system users gain experience with the system.
- Agencies are encouraged to take a "building block" approach to system deployment. They should get the base system running smoothly before adding new functionality, especially for functionality that heavily relies on input data.
- The complexity of the system and the learning curve it has taken to get the system running smoothly has been a big hurdle. Input of the data required to support the system on a daily basis has been a continual challenge.

Table 4-3 Service Restoration Strategies

Service Restoration Strategies

Service Disruptions	**Adjust Travel Time**	Selective Hold	Speed Control (along route)	Signal Prioritization	Schedule shift	**Adjust Travel Time & Passenger Access/Egress**	Egress Only	Express along route	Deadhead	Passing	Short Turn	**Adjust Travel Time, Passenger Access/Egress, Rou**	Re-Route	Express re-route	**Additional Driver**	Provide driver relief	**Additional Vehicle**	Insert/Replace vehicle	*From barn*	*From standby location*	*From other in service route*	*From other out of service route*	Relay Vehicle	*From barn*	*From standby location*	*From other route*	*From other out of service route*	**Field Support**	Transit Police	Public Safety	Maintenance Crew	Supervisor	**No Action**	Monitor
Schedule: Vehicles are either too early or late based upon thresholds																																		
Vehicle Early		1	1																															3
Vehicle Late				1	1			2	3	3	2		3	3					1	1	3	2		1	1	3	2							
Route Early		1	1																															
Route Late			1	1	2			2	3		2		3	3					1	1	3	2		1	1	3	2							
System/Corridor Late					1			3	3		3								2	2	2	2		2	2	2	2							
Vehicles through time point early		2	1																															3
Vehicles through time point late			1	1	2			2	3		3		3	3					2	2	3	2		3	3	3	3							
Missing / late logon																1			2	2		3										1		2
Headway: Vehicles are gapping and bunching along route, at a specific point, or along segment																																		
At point location (time point)		1	1		2		2	2	2	2	2																					2		
Along Route (Distance based)		1	1	2			2	2	2	2	2																							
Coordinated (shared segment)		1	1		2		2	2	2	2	2																							
Passenger Load: Passenger loads exceed thresholds (from APC or MDT)																																		
Automatic Vehicle Overload							1	1	1	1									1	1	3	2												
Manual Vehicle Overload							1	1	1	1									1	1	3	2												
Route overload							2	3		3									1	1	3	2										2		
Off Route: Vehicle leaves route																																		
Notified (approved)					1				1				1	1					2	2	3	2							3	2		1		2
Detected by System					1				1				1	1					1	1	3	2		1	1	1	1		1	2		1		1
Vehicle Performance: Vehicle is incapacitated or crippled																																		
Mechanical Breakdown					2				2				1	1					1	1	3	2									1	1		
Mechanical Malfunction					2		2	3	2				1	1					1	1	3	2									1	1		3
Accident					2			3	2				1	1					1	1	3	2							1	1	2	1		
Driver Incident: Driver sick, incapacitated/emergency, inappropropriate performance																																		
Driver Incident							2		2							1			2	2	3	2							2	2		1		
Passenger Incident: Passenger sick, incapacitation/emergency, inappriopriate behavior, crime																																		
Passenger Incident									2		3		2	2					1	1	3	2		2	2	3	2		1	1		1		
Emergency Alarm: Emergency alarm on vehicle is activated																																		
Emergency Alarm									1				1	1					1	1	3	2							1	1		1		
Connection Protection: Request for unscheduled transfer, or scheduled daily connection																																		
Passenger Requested		1	2	2				1						3																				
System Managed		1	2	2				1						3																		2		
Communication Status (on/off): Loss of communications with vehicle for unknown reason																																		
No Data Transmissions																															2	1		2
No Contact at All																			3	3	3	3							1			1		2
External Event: Notification of event from outside source. Event may have direct impact on service or request transit assist																																		
Event Notification					2				2		2		1	1					1	1	3	2							1	1		1		2

1 = Common practice, likely response
2 = Used by some agencies, in some situations
3 = May be applicable in certain situations

Source: Mitretek, TODSS Core Functional Requirements, March 2004.

It is important to identify and clearly describe the sources of information and existing systems that will interface with the TODSS system. Many vendors have user interfaces in place to connect with TODSS, but they may need to be updated. The best approach is to:

- Document the required functionality,
- Identify the vendor and version of the applications currently in operation, and
- Allow bidding vendors to contact system vendors during the bidding process to develop an interface plan as part of the bid.

Sample existing systems that typically provide sources of information are included in Table 4-4, which is taken from the *TODSS Core Functional Requirements* document.

Table 4-4 Typical TODSS Sources of Information

Sources of Information	Core Input	Service Disruptions	Restoration Strategies
TODSS System Parameters			
Detection Thresholds	X	X	
Response Thresholds	X		X
Prioritization Rules	X	X	X
Response Rules	X		X
Transit Agency Static Information			
GIS Data (Street, Route, Stop,Time Point)	X	X	X
Transit Schedule	X	X	X
Vehicle/Block Data	X	X	X
Driver/Run Data	X	X	X
Historical Passenger data (ons/offs/transfers)	X	X	X
Historical System Performance	X	X	X
Transit Agency Dynamic Information			
Operator Availability[1]	X		X
Vehicle Availability (Extra board)	X		X
Time Stamped Location: Flagged rev. vehicle	X	X	X
Time Stamped Location: Other rev, vehicles	X	X	X
Time Stamped Location: Potential responders[2]	X		X
Operator Initiated Data Messages	X	X	X
Voice Messages (Operator, Supervisor)	X	X	X
Silent Alarm/Security	X	X	X
Automatic Passenger Count	X	X	X
Vehicle & Equipment Status	X	X	X
Dispatch Console	X	X	
Other Sources			
Traffic volumes & speeds		x	x
Traffic signal phase and status		x	x
Network Status[3]		x	x
Highway/Rail Intersection status		x	x
ROW weather surface conditions		x	x
Other mode schedules and status		x	x
Special event data (schedules, demand)		x	x
Emergency Command Center Ops.		x	x

X = Part of Current TODSS Core, x = Desirable but not part of Core

1. Extra board, time on, work rules
2. Transit Police, Public Safetey (Fare, Ambulance, EMS), Maintenance, Supervisors)
3. Accidents, work zones, road closures, direction

Source: Mitretek, TODSS Core Functional Requirements, March 2004.

As the detailed requirements are being developed, it is also important to look at what service disruptions the system should detect, and document the transit inputs that can help identify them. Table 4-5 describes what inputs may be used to identify service disruptions.

Table 4-5 Inputs Required to Identify Service Disruptions

	Transit Inputs for Identification											
Service Disruptions	GIS Data (Street, Route, Stop, Time Point)	Transit Schedule	Vehicle/Block Data	Driver/Run Data	Time Stamped Location: revenue vehicle	Driver Initiated Data Messages	Voice Messages	Silent Alarm/Security	Automatic Passenger Count	Vehicle & Equipment Status	Detection Thresholds	Other External Data Source
Schedule: Vehicles are either too early or late based upon thresholds												
Vehicle Early	X	X	X		X						X	
Vehicle Late	X	X	X		X						X	
Route Early	X	X	X		X						X	
Route Late	X	X	X		X						X	
System/Corridor Late	X	X	X		X						X	
Vehicles through time point early	X	X	X		X						X	
Vehicles through time point late	X	X	X		X						X	
Missing / late logon		X	X	X		X					X	
Headway: Vehicles are gapping and bunching along route, at a specific point, or along segment												
At point location (time point)	X	X	X		X						X	
Along Route (Distance based)	X		X		X						X	
Coordinated (shared segment)	X	X	X		X						X	
Passenger Load: Passenger loads exceed thresholds (from APC or MDT)												
Automatic Vehicle Overload			X						X		X	
Manual Vehicle Overload			X			X						
Route overload			X						X		X	
Off Route: Vehicle leaves route												
Notified			X			X						
Detected by System	X		X		X						X	
Vehicle Performance: Vehicle is incapacitated or crippled												
Mechanical Breakdown			X							X	X	
Mechanical Malfunction			X							X	X	
Accident			X			X						X
Driver Incident: Driver sick, incapacitated/emergency, inappropriate performance												
			X	X		X						
Passenger Incident: Passenger sick, incapacitation/emergency, inappriopriate behavior, crime												
			X			X						
Emergency Alarm: Emergency alarm on vehicle is activated												
			X			X	X	X				
Connection Protection: Request for unscheduled transfer, or scheduled daily connection												
Passenger Requested	X	X	X		X	X					X	X
System Managed	X	X	X		X						X	
Communication Status (on/off): Loss of communications with vehicle for unknown reason												
No Data Transmissions										X	X	
No Contact at All										X	X	
External Event: Notification of event from outside source.												
External Event							X					X

Source: Mitretek, TODSS Core Functional Requirements, March 2004.

Service restoration strategies are the responses to service disruptions to restore service to normal or contingency levels based on the event. Strategies should take into account the time of day (e.g., peak or off-peak service), weather days, high congestion due to special events, etc. Table 4-6 provides potential service restoration strategies for typical transit events.

Table 4-6 Inputs Required to Identify Service Restoration Strategies

	Transit inputs for analysis and implementation																	Other Sources							
Potential Strategy	GIS Data (Street, Route, Stop, Time Point)	Transit Schedule	Vehicle/Block Data	Driver/Run Data	Operator Availability[4]	Vehicle Availability (Extra board)	Time Stamped Location: Flagged rev. vehicle	Time Stamped Location: Other rev. vehicles	Time Stamped Location: Potential responders[2]	Driver Initiated Data Messages	Voice Messages	Silent Alarm/Security	Automatic Passenger Count	Vehicle & Equipment Status	Historical Passenger data (ons/offs/transfers)	Historical System Performance	Response Thresholds	Traffic volumes & speeds	Traffic signal phase and status	Network Status[3]	Highway/Rail Intersection status	ROW weather surface conditions	Other mode schedules and status	Special event data (schedules, demand)	Emergency Command Center Ops.
Adjust Travel Time																									
Selective Hold	1	1	1				1	2					2		3	2		3		3	3	3	2		
Speed Control (along route)	1	1	1				1	2								2		3		3	3	3			
Signal Prioritization[1]	1	1	1				1	2					3		3	2		1	1	3	3	3			
Schedule shift	1	1	1				1	2								2		3		3	3	3	3		
Adjust Travel Time & Passenger Access/Egress																									
Egress Only	1	1	1				1	2					1		2	2		3		3	3	3			
Express along route	1	1	1				1	2					1		1	2		3		3	3	3			
Deadhead	1	1	1				1	1					1		1	2		3		3	3	3			
Passing		1	1				1	1					1		2	3		3		3	3	3			
Short Turn		1	1				1	1					1		2	3		3		3	3	3			
Adjust Travel Time, Passenger Access/Egress, Route																									
Re-Route	1	1	1				1	2	4	4	4		1		1	3	1	2		2	2	2		3	3
Express re-route	1	1	1				1	2	4	4	4		1		1	3	1	2		2	2	2		3	3
Additional Driver																									
Provide driver relief	1	1	1				1		1	2	3							3		3	3	3			
Additional Vehicle																									
Insert/Replace vehicle																									
From barn	1	1	1	1	1	1	1			4	4	3		2			1	2		2	2	2		3	3
From standby location	1	1	1	1	1	1	1		1	4	4	3		2			1	2		2	2	2		3	3
From other in service route	1	1	1	1	1	1	1	1		4	4	3	1	2	1		1	2		2	2	2		3	3
From other out of service route	1	1	1	1	1	1	1	1		4	4	3		2			1	2		2	2	2		3	3
Relay Vehicle																									
From barn	1	1	1	1	1	1	1			4	4	3		2			1	2		2	2	2		3	3
From standby location	1	1	1	1	1	1	1		1	4	4	3		2			1	2		2	2	2		3	3
From other in service route	1	1	1	1	1	1	1	1		4	4	3	1	2	1		1	2		2	2	2		3	3
From other out of service route	1	1	1	1	1	1	1	1		4	4	3		2			1	2		2	2	2		3	3
Field Support																									
Transit Police	1								1	2	3	1						2		2	3			3	3
Public Safety	1								1	2	3	1						2		2	3			3	3
Maintenance Crew	1								1	2	3			1				2		2	3			3	3
Supervisor	1								1	2	3	2						2		2	3			3	3
NoAction																									
Monitor	1	1	1	2				1		2	3	2													

1. Note: Transit Signal Priority requires inputs and communications to the traffic signal system. This is not part of the Core Inputs and interfaces.
2. Transit Police, Public Safety (Fire, Ambulance, EMS), Maintenance, Supervisors
3. Accidents, work zones, road closures, direction
4. Exra board, time on, work rules

1 = Necessary   2 = Desirable but not required   3 = Useful, or in rare cases needed   4 = When other data not available

Source: Mitretek, TODSS Core Functional Requirements, March 2004.

It is important to accurately document the infrastructure and fleet information that the TODSS system will need to be installed in, including vehicle types, model years, and quantities. This information is needed so that vendors gain an understanding of the level of effort it will take to survey the vehicles, design brackets, and install cables.

Information Technology stakeholders should document their current IT infrastructure, including server and data stores that the system may be able to use, any integration or segregation requirements for security, and any new infrastructure that will be required to support the project.

The communications coverage area should be defined, along with any existing or planned communication systems that are available for the TODSS system to use. TODSS systems are very data intensive, and special care should be taken to determine whether existing and planned systems will meet the planned application's needs. Waiting to let the vendors figure out whether the system will work or not in the short period they have to bid on the project adds significant risk and potential cost to the project.

It is also important to identify where any wireless local area network (LAN) communications will be required, such as inside buildings or serving parking lots where the fleet is located.

Additionally, requirements for system implementation, project management, quality control, training, maintainability, reliability, and environmental considerations must be developed. These requirements should include:

- Planned implementation schedule and milestones to guide expectations during the project's design, installation, and testing phases.
- Project management activities, including cost and scope control, risk management, quality assurance, quality control, and project communications.
- Maintainability, reliability, and environmental (including electromagnetic interference) considerations relevant to the agency's operational environment.

Once all of the requirements are created, a thorough formal systems requirements walkthrough should be completed with the stakeholder group. This review should be conducted paragraph by paragraph to ensure that the final product meets the system's needs and is defined accurately before the document is released for procurement activities. An agile management or user-centered design approach provides the opportunity to pick up requirements at later stages of the project as greater understanding of project needs is achieved.

During the development of all of the materials for the procurement, it is also important to be managing the capital and operating engineering cost estimates for the new system. These should be managed throughout the design process and should be reflected in the procurement of the new system by having each vendor provide capital costs as well as anticipated hardware and software maintenance costs. It is also a good approach to request each vendor suggest a staffing model for how best to operate and maintain their system to validate the engineering estimates used to define the system requirements.

Case Study

This case study is a compilation of multiple issues encountered by transit agencies during the deployment of TODSS-like systems. This case study addresses the importance of understanding the capabilities of the infrastructure available to support the new TODSS system after it is installed, and whether the new system will be able to meet all of the identified system requirements.

Agency A was in the process of designing a new system. They had investigated the capabilities of current TODSS systems on the market, had visited peer agencies that had recently deployed new systems, and had worked diligently within the agency to develop a good set of functional requirements, technical requirements, project management expectations, and implementation planning activities. When it came to radio and communications requirements, the agency documented the current system capabilities at a high level, and determined through their stakeholder interviews that their system had adequate coverage for their service area. Their documentation for the new TODSS system included a thorough description of their current system, covering the system infrastructure, age, and capabilities.

They received multiple bids from vendors. Each vendor's bid contained a caveat stating that the system met the requirements for bandwidth and coverage, but they absolved themselves of responsibility because they would be using the agency's system, which was already installed without their oversight. Many negotiations were held, and the agency decided to move forward and evaluate the situation when they deployed.

The agency went through the entire design process with the bandwidth/coverage problem lingering. Once the mini-fleet (i.e., representative vehicle type) and basic infrastructure were installed and mini-fleet testing began, it became apparent that the system did not meet the performance requirements and arguments ensued between the agency and the vendor as to who was at fault.

This situation is not unique to Agency A. In multiple cases, transit agencies have been left with systems that do not meet the stated communications requirements, causing update rates of 2–4 minutes instead of 30 seconds. These update rates will not effectively support a TODSS system.

Other transit agencies have had to put their projects on hold and move to a new communications system that will meet the communications requirements. Still others have converted to a commercial cellular system, which works fine during normal operations, but may be subject to slower operation or even denial of service in some events such as a region-wide major catastrophe.

It cannot be understated the importance for an agency to have a good understanding of the communications infrastructure requirements of TODSS related systems for both voice and data communications both in terms of bandwidth and having adequate coverage for the agencies service area. As part of the system design activities, the assessment of current systems capabilities to meet the needs of the new systems are crucial to the project's success.

Lessons Learned:

- Agencies that have been through the process alone would have engaged a consultant who understood CAD/AVL systems needs to guide them through the design and deployment of the system. They also learned that they needed a lead person to drive the program and bridge the different needs for operations, planning, and Information Technology (IT) staff.

- Agencies need to make an accurate assessment of current communications systems and the needs of the new system to make sure that there is adequate coverage and bandwidth to support the new TODSS system prior to going out to bid. Handing off the responsibility to the vendor to design the system within a short procurement cycle is inadequate to ensure that the system will meet their needs.

- Many agency specifications have poorly written interface requirements to existing (or new) third party systems. There is generally not enough information within current specifications to accurately bid integration costs without having a fair amount of risk.

- Having a standardized language between agencies to define route, run, trip, and patterns would definitely help to better address getting the agencies' data properly integrated within the system, e.g., Transit Communications Interface Profiles (TCIP), which standardizes definitions.

Chapter 5 Deploying Your New TODSS System

Deployment Using the Systems Engineering Process

Once the design and procurement are complete, the next step in the systems engineering process is to carry out the implementation and to test the system. This section describes the steps of the process through final requirements development.

Software/Hardware Development and Testing

Create hardware and software solutions for each of the components identified in the detailed design. The solutions may involve a combination of customized and off-the-shelf items. The identified solutions must then be tested and prepared for implementation. Table 5-1 identifies the key elements of software and hardware development and testing.

Table 5-1 Key Elements of Software and Hardware Development and Testing

Element	Description
Objectives	• Develop and/or purchase hardware and software components that meet the design specifications and requirements with minimum defects • Identify any required exceptions to the requirements or design specifications
Input *Sources of Information*	• System and subsystem requirements • System design • Off-the-shelf products • Industry standards • Unit and device test plans
Process *Key Activities*	• Plan software and hardware development • Establish development environment • Procure off-the-shelf products • Develop software and hardware • Perform unit and device testing
Output *Process Results*	• Software and hardware development plans • Hardware and software components, tested and ready for integration • Supporting documentation (e.g., training materials, user manuals, maintenance manuals, installation and test utilities)
Review *Proceed only if you have:*	• Conducted technical reviews of the hardware and software • Performed configuration and quality checks on the hardware and software • Received all supporting documentation • Verified that the unit and device testing has been successfully completed

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.6 Software/Hardware Development and Testing of the Systems Engineering for Intelligent Transportation Systems document.

Integration and Verification

In the integration and verification step, software and hardware components are individually verified and integrated to produce higher-level assemblies or subsystems. The assemblies themselves must also be individually verified before being integrated with others. Ultimately, they will be integrated with others to produce larger assemblies until the complete system has been integrated and verified. Table 5-2 outlines the key elements of the integration and validation steps.

Table 5-2 Key Elements of the Integration and Validation Steps

Element	Description
Objectives	• Integrate and verify the system in accordance with the high-level design, requirements, and verification plans and procedures • Confirm that all interfaces have been correctly implemented • Confirm that all requirements and constraints have been satisfied
Input *Sources of Information*	• System requirements document • High-level design specifications • Detailed design specifications • Hardware and software components • Integration plan • System and subsystem verification plans • Subsystem acceptance plans
Process *Key Activities*	• Add detail to integration plans • Establish integration and verification environment • Perform integration • Perform verification
Output *Process Results*	• Integration plan (updated) • Verification plan (updated) • Integration test and analysis results • Verification results, including corrective actions taken
Review *Proceed only if you have:*	• Documented evidence that the components, subsystems, and system meet the allocated requirements • Documented evidence that the external and internal interfaces are working consistent with interface specifications

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.7 Integration and Verification of the Systems Engineering for Intelligent Transportation Systems document.

Initial Deployment

Once the system has been fully validated and implemented, it is installed in the operational environment and transferred from the project development team to the organization that will own and operate it. Acceptance tests are conducted to confirm that the system performs as intended in the operational environment. Table 5-3 outlines the key aspects of the initial deployment.

Table 5-3 Key Aspects of the Initial Deployment

Element	Description
Objectives	• Uneventful transition to the new system
Input *Sources of Information*	• Integrated and verified system, ready for installation • System Acceptance Plan
Process *Key Activities*	• Plan for system installation and transition • Deliver the system • Prepare the facility • Install the system • Perform acceptance tests • Transition to operation
Output *Process Results*	• Hardware and software inventory • Final documentation and training materials • Delivery and installation plan, including shipping notices • Transition plan with checklists • Test issues and resolutions • Operations and maintenance plan and procedures
Review *Proceed only if you have:*	• Formally accepted the system • Documented acceptance test results, anomalies, and recommendations

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.8 Initial Deployment of the Systems Engineering for Intelligent Transportation Systems document.

System Validation

Once the system is installed and operational in the field, the owner should run a set of tests to make sure it meets the original needs identified in the Concept of Operations. Table 5-4 outlines the key aspects of the system validation step.

Table 5-4 Key Aspects of the System Validation Step

Element	Description
Objectives	• Confirm that the installed system meets the user's needs and is effective in meeting its intended purpose
Input *Sources of Information*	• Concept of Operations • Verified, installed, and operational system • System Validation Plan
Process *Key Activities*	• Update Validation Plan as necessary and develop procedures • Validate system • Document validation results, including any recommendations or corrective actions
Output *Process Results*	• System Validation Plan (update) and procedures • System Test Plan • Validation results
Review *Proceed only if you have:*	• Validated that the system is effectively meeting its intended purpose • Documented issues or shortcomings • Established ongoing mechanisms for monitoring performance and collecting recommendations for improvement • Made modifications to the Concept of Operations to reflect how the system is actually being used

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.9 System Validation of the Systems Engineering for Intelligent Transportation Systems document.

A thorough system test plan that details all of the testing phases for the system should be defined and, as appropriate, should include factory tests, mini-fleet testing, vehicle acceptance testing procedures, and system acceptance test procedures, as well as detailed testing of any new functionality. As new functionality is deployed, it is also important to do thorough regression testing be make sure new functionality has not caused any additional problems within the system.

Applying the Systems Engineering Process to TODSS Deployments

This section builds on the generic Systems Engineering approach to deploying an ITS system by introducing the TODSS-specific elements that need to be considered. The TODSS deployment process begins with a solid technical plan that validates requirements at multiple points during the deployment process. These checkpoints are designed to provide reviews during the vendors' design and deployment periods, configuring their system to meet the agency's TODSS requirements and defining any customization of their products to meet the agency's TODSS requirements. A good deployment plan includes the following checkpoints:

- Preliminary Design Review. Review of all off-the-shelf hardware and software; system architecture; communications paths, including coverage, bandwidth, and anticipated loading; and functional design for all new functionality. Any new functionality should be reviewed for the approach and ensure that it is consistent with the technical requirements and meets the user interface requirements. It is not uncommon for vendor development teams and client stakeholder teams to have different views of what the requirements mean. Contract negotiations and these key review points are the times to ensure that all parties have the same viewpoint on system functional requirements.
- Final Design Review. Review of completed system architecture, installation plan drawings, communications system racks, and all key functional requirements, as well as mock-ups of new functionality and a thorough review of all system requirements.
- System Validation Test Plan. The test plans should encompass the entire set of tests that the system will be subjected to in checking that the objectives of each development phase are met. These should include factory testing, mini-fleet testing, and vehicle installation tests, as well as the final acceptance test and system availability demonstrations.
- Factory Test. Factory installation or simulation of the system architecture. This test configuration should be as close to the final system architecture as possible and should only include simulation for the portions of the system that cannot be built on the factory site. All wireless functionality should be live tests using the hardware that is planned to be installed. A factory test plan and factory test procedures should be approved before stepping on site at the factory for this set of tests. Unit testing, as well as subsystem testing and as much of the full system testing as possible, should be completed at this stage of the deployment.
- Mini-Fleet Test. Onsite installation of the back-office and communications infrastructure as well as installation on at least one example of each vehicle type. Prior to commencing the mini-fleet installation and testing, documentation for each installation (fixed and mobile) and test procedure should have been completed, reviewed, and approved. This test should replicate factory testing and also include any additional tests that could not be performed in the factory test, such as coverage and bandwidth testing.
- Fleet Installation. Vehicles are run through a complete installation acceptance test. It is highly recommended that transit agency staff perform the testing with participation by the vendor, as the sooner that agency staff become familiar with operating, configuring, and troubleshooting the system, the better off they will be when they take over systems operations and maintenance.
- Acceptance Testing and System Availability Testing. A thorough set of tests developed for final acceptance testing. This effort includes developing a requirements traceability matrix that documents how each of the requirements will be tested, including inspection, demonstration, and testing. The matrix should document the scenarios for which functional and performance requirements will be measured, including testing thresholds and associated system functionality. System availability testing should be done over at least 30 consecutive days to measure system uptime and to demonstrate that the system can meet its availability requirements.

In most TODSS deployments, some customization or new functionality must be deployed as part of the project. Due to vendor product development cycles and the time necessary to design, test, and deploy the new functionality, it is common that not all functionality will be designed and ready for installation at the mini-fleet testing stage. It would be ideal if all functionality were available then, as full testing could be completed there and the remainder of the fleet installation would just be a “cookie cutter” exercise, but this is generally not the reality that a project team faces. Therefore, it is critical as new or updated software is installed that the transit agency and the vendor maintain configuration control of the system and perform appropriate regression testing to make sure that new functionality does not cause problems with any other system functionality.

Agency Data Management

One key issue in most TODSS projects is mastering both a new system and the data required to operate it. The sooner the project team can begin to work with these data and prepare for their input into the system, the faster the TODSS system will come on line with full functionality. Based on transit agency interviews, the process to master the data takes at least one year and, in many cases, two years with ongoing data evaluation. As agencies often change routes and schedules quarterly, it is strongly noted that mastering data is an ongoing process for any agency, and quality control procedures should be put in place for all processes related to agency data development and integration with the TODSS system. Additionally, many of these systems have real-time information components that are highly visible to the riding public. Mastering the data prior to full deployment of real-time information components is critical to keeping the staff’s and the riding public’s confidence in the system high.

Besides the typical timetable schedules, also known as run schedules (operator work pieces), there is generally a significant amount of Geographic Information System (GIS) data that must be developed for the system to operate. Agencies should push to be intimately involved in developing the initial GIS data for the system, and preferably should lead these activities with the vendor’s assistance. Additionally, the agency’s planning and operations staff should coordinate, given that deviations in planned schedules and routing will be reported in real time to dispatchers.

One recommendation for initial data development during the planning for mini-fleet installations is to develop data for 3–5 routes and thereby work through the process of developing these data to support the system. Test the data in operation before and during the mini-fleet testing. Once the data have been mastered, return and document the procedures required to replicate the data development process. Once these procedures have been identified, the remainder of the data can be developed, tested, and validated.

Lessons Learned:

- Agencies need to focus on the data side of the system early and often. They also should manage expectations regarding how long it will take to get the system running smoothly.
- In larger agencies, and some of the smaller ones, there is some built-in competition between planning and operations. It is important to take steps to get these two groups to work together. Operations wants clean data as close to operations as possible, while planning wants clean statistical data that do not require significant effort to produce useable information. Working together, a balance can be struck to make the system setup for each service day reliable such that they both succeed.
- We would encourage an agency to give themselves plenty of time to implement the system. Even once it is installed, they should anticipate a year or two of time to work with the system to get it fine-tuned. They also need to take the time to revisit their Standard Operating Procedures (SOPs) and business rules to incorporate the technology.

System Functionality Deployment

It is recommended that new TODSS systems initially be deployed with functionality that is similar to the prior system. This minimizes the change management risks associated with the system implementation. Trying to deploy many changes, coupled with the added complexity of a decision-support system and new sources of information to identify incidents, is too risky to attempt in one pass. Agencies should start with the basic functionality such as Automatic Vehicle Location, proper operator logins, basic schedule and route adherence (if data development is ready for that), and basic predefined and free text messaging as a basic set of tools to master.

Any changes in policy and procedures should be reviewed and adapted to the new system, and full operator and dispatcher training should be deployed prior to going live with the new system. Indeed, the new system itself may lead to new and better processes through advantages gained in automation and efficiency. It is important that during the first week of going live that adequate vendor and agency training and coaching support is available at dispatch and to the operators to make sure that their training has been successful and they can master the new system's basic functionality.

Once the basic functionality has been mastered, new functionality can be added. A subset of the project team should be formed to manage the deployment of new functionality and to properly test it within the system. This team should also be tasked as a failure review board to oversee any complaints or recommendations from system users to manage the system deployment as new functionality is added. Constant quality checks of the data are required when new functionality is added that uses new incident triggers and algorithms to present incidents to dispatchers to manage.

When developing new incident types to add to the system, the temporal aspect of the incident type should always be considered. For instance, for a basic schedule adherence alarm (e.g., report any vehicle 5 minutes late), the algorithm may want to test that condition over a period of time to make sure that the operator is consistently 5 or more minutes late to avoid a situation in which the incident is reported as soon as it occurs, but by the time the dispatcher responds to it, the operator has already recovered. All of these data are still recorded for later review, but may not be worthy of display to and response by dispatch unless the alarm condition persists.

Additionally, when considering new incident types, it is important to determine which incidents need to be dealt with immediately by dispatch, and which incidents only need to be logged and managed through reporting tools or automated notification (e.g., email or interface to other systems). For instance, a non-critical mechanical alarm may be logged and later transferred to a maintenance management system where maintenance can review alarms and determine if a work order is warranted to investigate the issue.

Common additional functionality areas for expansion of a TODSS system are noted in Table 5-5. Note, however, that depending on what an agency can measure and detect with the system, the power of TODSS applications is very broad, especially when external triggers might be incorporated such as road congestion and weather conditions.

Table 5-5 Summary of TODSS Core Types of Service Disruptions

Type of Disruption	Description
Schedule	Vehicles are either too early or late
Headway	Vehicles are gapping and bunching
Passenger Load	Passenger loads exceed thresholds
Off Route	Vehicle leaves route
Vehicle Performance	Vehicle is incapacitated or crippled
Driver Incident	Driver sick, emergency, performance
Passenger Incident	Passenger sick, emergency, behavior, crime
Emergency Alarm	Emergency alarm on vehicle is activated
Connection Protection	Expected transfer connection missed
Communication Status (on/off)	Loss of communications
Point Delay	Vehicles are consistently being delayed at location
External Event	Notification of event from outside source.
Disruption Resolution	Disruption is no longer a problem.

Source: CH2M HILL Inc., 2014.

System Testing

TODSS systems are very complex; therefore, attention to configuration control and rigorous testing is paramount to keeping the systems running smoothly. Mission-critical systems upgrades and bug-fix activity are typically limited to system downtime or to non-peak hours. Where possible, *configuration management* methods should be implemented to establish and maintain performance consistency. For example, implementing a test system prior to building out in the field will facilitate early identification of problems. This includes assigning responsibilities for approving configuration changes and differentiating between “minor” and “major” software releases.

During deployment, it is important to thoroughly test the system at every possible opportunity. Mini-fleet testing is the ideal time to wring as many bugs and other systems issues out of the system as possible prior to having the entire fleet reliant on the system. Typically, there is a 4–8 week period available after mini-fleet installs are approved that provides a good time for rigorous testing. Shortcuts should not be taken during this time period, and ample time should be planned for the project team to work with the system to gain experience with how it works.

Once the mini-fleet installs have been approved, as-built drawings should be updated. During the fleet install, all vehicles should be visually inspected to ensure compliance with the approved drawings. Agency staff should thoroughly test the system’s functionality using an approved test procedure. One helpful tool that can be developed to test system functionality onboard a vehicle is to deploy a “test route” around the garage area that allows the system to simulate operating a route on the street. This process allows the installed equipment’s functionality to be checked under similar conditions to those experienced on the road.

System Acceptance testing should be tied back to the requirements matrix, as noted earlier, and thorough testing should be performed to validate that the system as installed meets the stated requirements. There is a temptation to only test the functionality that was not tested during the mini-fleet install (as that is all that is new), but it is important to perform regression testing to make sure that the changes to the system have not created any additional issues.

Case Study

The Pace pilot project is used here as a case study for deployment experience, as there are several FTA deliverables that provide detailed information on the system testing program as well as the results of the pilot. In particular, these documents provide good descriptions of the implementation of the new TODSS tools into the Pace business environment.

Appendix A contains the *System Software Logic Test Results* document, which provides the testing results for the final Pace pilot system. It provides good information on the testing process for each of the new TODSS functionalities as well as regression testing of other key functionalities now managed by the DSS built into the product.

Appendix B contains the *Results from the Implementation Tests* document. This document provides good details on implementation planning, test planning and execution, the transition to full operations, and incorporation of the TODSS functionality. It also provides post-implementation stakeholder interview summaries and describes the next steps that Pace intended to make to grow the system’s functionality.

Chapter 6 Operations and Maintenance of the New System

Operations and Maintenance Using the Systems Engineering Process

Systems engineering continues through to operations and maintenance, which is described in this section.

After an ITS system has been transferred to its owner, it operates in its standard state. The system is maintained on a regular basis and its performance is monitored. As issues are identified, improvements are incorporated into the system. This step features an abbreviated version of the systems engineering process to evaluate and implement each change. Table 6-1 identifies the key aspects of the operations and maintenance step.

Table 6-1 Key Aspects of the Operations and Maintenance Step

Element	Description
Objectives	• Use and maintain the system over the course of its operational life
Input *Sources of Information*	• System requirements (operations and maintenance requirements) • Operations and Maintenance Plan and procedures • Training materials • Performance data • Evolving stakeholder needs
Process *Key Activities*	• Conduct Operations and Maintenance Plan reviews • Establish and maintain all operations and maintenance procedures • Provide user support • Collect system operational data • Change or upgrade the system • Maintain configuration control of the system • Provide maintenance activity support
Output *Process Results*	• System performance reports • Operations logs • Maintenance records • Updated operations and maintenance procedures • Identified defects and recommended enhancements • Record of changes and upgrades • Budget projections and requests
Review *Proceed only if you have:*	• Demonstrated that the system has reached the end of its useful life

Source: FHWA Systems Engineering for Intelligent Transportation Systems, January 2007.

More details on this phase are available in section 4.10 Operations and Maintenance of the Systems Engineering for Intelligent Transportation Systems document.

Operating and Maintaining TODSS Systems

A transit agency moves through three stages along the path to successfully operating and maintaining TODSS systems. The first stage includes mastering the data preparation necessary to run the system and the mechanics of taking care of the system. During the second stage, the system data are validated and the agency gains the confidence to embrace using data to drive their decision-making. The third stage of adoption occurs when the agency begins to make changes based on data from the system and the TODSS system is integrated into daily job performance throughout the organization. Most agencies are well on their way to mastery when they take over the system operation and continue on the path through the next stages over the following years.

It was clear to the transit agencies interviewed for this guide that their success required senior leadership to demonstrate commitment to change. Each agency saw this manifested in different ways, but all had the effect of adding a sense of purpose to the effort.

Those agencies that have made the most progress toward fully adopting their system stressed the need for patience. Having a road map, remaining flexible, and using a systematic approach were the themes most frequently stressed for moving towards a data-driven business model that leads to greater service quality improvements.

Other key areas stressed for successfully transitioning business practices using these new technologies are:

- Assignment of a Dedicated TODSS System Manager
    - It was observed that the TODSS System Manager role is critical for sustaining efforts of departmental cooperation and organizational change. To be effective, this role requires the capabilities to mentor, coach, train, initiate change, and communicate effectively. At times, these skills are as important as technical knowledge of the system.
    - One System Manager pointed out that discussion of integration should not center on technology, but rather on how to transform data into information that is integrated into the daily jobs of all aspects of the transit business. The System Manager and support staff roles and responsibilities will evolve as users adopt new ways to approach their jobs. Baselines, targets, and performance measures that are part of implementing a balanced scorecard performance system are supported by the real-time use of the system and its resulting data. Staffing levels for this support may vary based on agency size, how agencies are organized and how technical their user groups are.
- Dedicated Support Staff
    - Assigning sufficient adequately trained personnel to maintain the equipment, software, and data required to manage the system is necessary. For equipment maintenance, the staffing standard is 1.5 Full Time Equivalent (FTE) support staff for each 250 vehicles. Additional staff members are required to manage the data maintenance tasks to ensure accurate input data are available for the system to operate, and to provide for the maintenance and analysis of statistical data output by the system.
    - It should be noted if an agency is replacing a legacy CAD/AVL System, many of the staff identified above may already be in place and staffing levels may need to be adjusted based system and agency needs (e.g., staff time may be reduced since many logging and reporting functions would be streamlined or automated by TODSS).
- Preventative Maintenance Program
    - Successful agencies have either put into place a preventative maintenance program where equipment sensors are regularly checked, or they have developed extensive reporting tools that automatically monitor sensor data and check for anomalies for technicians to investigate.
- Updated Standard Operational Procedures
    - Transit agencies should review current operations procedures incorporating TODSS system capabilities and, as needed, should revise those procedures to incorporate knowledge management into the agency's business practices, to standardize operations, and to provide a training framework for new staff.
- Perform a Data Validation Effort
    - Identify, understand, and correct, if feasible, existing data anomalies and those that are discovered by users of the system, including off-route messages, adherence problems, satellite accessibility, data summarization, route interlining issues, and passenger counts. Additionally, to enhance data validation, assign an analyst to support the campaigns and manage the data validation process.

- Develop a Custom Report Library
    - o Report and data management should be performed in a very controlled manner to ensure that data are being used properly and within the constraints of the data. A process should be instituted to ensure data and report integrity.
- Develop Training and Outreach Programs
    - o For current users, institute TODSS training into such job training programs as driver training and dispatcher training. Through working groups and other outreach efforts, educate staff on how the system and its data can help them overcome problems, allowing their needs to drive how the technology is applied to the agency's business practices.
- Senior Management Involvement
    - o In all successful implementations, it is important for senior management to be visible in supporting the system, both in using the information and supporting the project team that is deploying the system across the agency.

Stage 1: Mastering the TODSS System: Organizing for Success

As noted above; deploying, operating, and maintaining TODSS systems are carried out in three phases: maintenance mastery, data validation, and adoption of the system into the business.

Maintenance mastery is the phase in which the agency becomes a master of managing the maintenance of the system's hardware, software, and data. Key to success in this phase is the assignment of a dedicated System Manager to manage, facilitate, and coordinate the activities required to operate and maintain the new system. The other activities in this phase include:

- Identifying and assigning all required system functional tasks that communicate the interdependencies of the various agency departments required to make the system work.
- Implementing a TODSS system onboard equipment maintenance plan that provides and trains electronics technicians, integrates technology inspections into the preventative maintenance cycle, and enters the inventory and new maintenance codes into the agency's maintenance management system to facilitate management review.
- Formalizing governance and decision rights by instituting a senior leadership forum that supports the efforts of the TODSS System Manager.

The **data validation** phase is critical to instill stakeholder confidence in the system and to demonstrate that the data collection process and the data quality are at a sufficient level that staff can confidently and reliably make changes in their daily job processes. The action plan for this phase includes:

- Establishing a report policy to protect information dissemination.
- Establishing routine TODSS system maintenance processes for fixed as well as mobile aspects of the system.
- Designing system health reports to improve the maintenance effort.
- Establishing a report creation process that meets users' needs.
- Developing an ongoing outreach program that informs staff of the system's capabilities.
- Applying knowledge management principles to protect against personnel changes.

By maintaining a focus on training, education, and outreach, transit agencies have developed a growing custom report library used by staff throughout the organization in their daily job functions. Successful agencies have used a step-wise plan to institute change in order to reach their goal of becoming a data-driven organization. Building upon the successes of the first two phases, the action plan for the **adoption** phase includes:

- Refining the TODSS System Manager role over time.
- Designing training and staff development programs that are an integral part of new hire training programs.
- Creating a cross-functional Service Improvement Team.

The outcome of these actions is a foundation for an agency environment that supports change and that moves towards data-driven decision making.

Table 6-2 provides recommended staffing support levels for managing the TODSS system and its associated data, scaled for an agency operating 250–500 vehicles. Note that these roles are not necessarily new hires. In many cases, agencies have modified job duties to support the system using personnel managing similar information within the organization. These staffing levels can be scaled fairly linearly up or down when comparing agencies of different sizes, with the exception that having multiple garages and IT Support locations may generate the need for additional support.

Table 6-2 Recommended Staffing Support

Role	Assignment (FTE = Full Time Equivalent)
System Manager	• 1 FTE position – requires understanding of transit operations
Programmer/Analyst	1 FTE IT Business Applications Support Analyst
Database Analyst	• ¼ FTE Business Support Specialist-Data Base Analyst (DBA)
Network/Sys Admin	• ¼ FTE IT Infrastructure Support ½ FTE of System Manager or designee
Route/GIS Data Steward	1 FTE Transit Data Analyst • Coordinates activities with scheduling Coordinates activities with Business Support Specialist-GIS
Maintenance	• Director of Maintenance or designee • Responsible for maintenance and inventory development and oversight 2 FTE electronic technicians • Troubleshooting, pull, and replace Initial response to radio trouble tickets De-install and re-install as required

Source: CH2M HILL Inc., 2014.

Stage 2: Validation of Agency Data Incorporation: Tasks Required to Reach Data Validation

Establish Routine TODSS System Data Maintenance Processes

Successful transit agencies assign routine system administration processes to maintain system integrity. These activities are typically assigned to in-house IT professionals. Alternatively, the agencies have contracted IT staff readily available in the event that a problem is discovered. The following are examples of the type of assigned activities:

- Daily monitoring of any nightly summarization process.
- Daily review of application and database server event logs.
- Daily review of any file transfer error logs.
- Routine review of database performance and statistics.
- Review and analysis of new route and schedule data, both before and after activation date.

Transit agencies interviewed for this guide identified that data validation is a need that doesn't often get the attention it deserves. The amount of time and effort required to operate and maintain these systems should not be underestimated. Agencies stated that it typically takes 1–2 years to get on top of the issues, and that data validation is an ongoing system maintenance need.

Establish System Health Reports

Data validation and vehicle maintenance response can be improved greatly by creating reports and datasets to measure system performance. Measures such as logon accuracy, vehicle equipment health, post-bid implementation errors, operator performance, dispatcher response, and vehicle firmware version control can usually be monitored through the routine running of these custom reports. Reports can be run and monitored by system administrators until users began to ask for their own access to reports to assist them with their job functions. These reports initially should be created by the Business Applications Support Analyst and the System Manager, with database manager assistance as required.

It is recommended that a Business Analyst position be identified to dedicate time to serve as a technical business analyst within Operations as well as to support other departments that wish to use the data to support their job functions for routine reporting needs. Where complex data sets are required, this position would be the point of contact with the Business Applications Support Analyst and the TODSS System Manager.

Establish a User-Defined Functional Reports Process

It is recommended that agencies create prototype reports, dashboards, and controlled access to the system components for users that have requested assistance and for those users most likely to embrace change and share their success through word of mouth. Once completed, the prototype reports and dashboards would be reviewed with the end users to gather input for further refinement.

This becomes a job analysis opportunity that provides a way to initiate thoughts on how to change the way of doing business. This change process is a way to demonstrate both the breadth and depth of the system data that could be applied to daily job activities. The System Manager is engaged in this process and responsible for gathering business requirements and the change management aspects of the activity. The designated Business Applications Support Analyst would be responsible for providing the technical support for the project.

Develop Ongoing Outreach Program

As staff members gain confidence with the system and its stored data, opportunities increase to apply the system throughout the agency. In addition to the prototype job analysis process described above, the System Manager should develop a strategy for providing system exposure and instilling confidence in the validated system data across all segments of the organization.

The outreach program will familiarize agency staff with potential information sources and will correlate the information with the agency's strategic goals and objectives. A variety of activities can be considered, such as conducting a series of brown bag meetings, attending department meetings, participating in new project planning initiatives, becoming active in scheduling activities, assisting with inventory analysis, and the Tom Peters strategy of “Manage by Wandering Around.”

Apply Knowledge Management Principles

As the agency documents its processes and procedures to complement the vendor-supplied system documentation during the design and deployment stages of implementation, it should be sure to document each functional task and standard operating procedure related to data validation processes, data management procedures, data preparation, and daily operations. This is an important step in knowledge management to provide the background material required for continuity during organization and staff changes, as well as for assigned backup personnel.

The System Manager facilitates, manages, and reports on the progress of this activity. In some instances, the activity will require a single staff member to document his or her assigned function, such as the “schedule merge” procedure. In the case of documenting dispatcher processes and procedures, a larger group may be involved in preparing and updating the procedures manual.

Stage 3: Tasks Required to Reach System Adoption —Transition to a Data Driven Organization

Refine the System Managers Role

In this step, the outreach techniques and report-creation processes found to work are institutionalized and integrated into the System Manager’s daily activities. The System Manager should continue to seek input on how to better support the practices, processes, and data required for agency-wide departmental activities, campaigns, and initiatives. It is recommended that the System Manager seek out a mentor within the transit agency to tap into the informal people networks that make the agency tick in order to disseminate best practices quickly throughout the organization.

Design Training and Staff Development Program

Training is a key component to widespread adoption of the TODSS system. There are different user groups that require training tailored to their specific needs, including operators, radio dispatchers, road supervisors, maintenance, facilities, customer service, risk management, service development, planning, scheduling, and system administrators. Training programs should be developed that address the needs of new hires and personnel assigned to new positions, as well as advanced training for personal growth and learning that can lead to promotion opportunities. As with any other complex software system, users can only begin to scratch the surface of a system’s capabilities without good training.

Agencies should budget for vendor-contracted training to cover instances in which in-house expertise may not be available, such as system administration training that covers program updates and advanced skills training.

During system deployment, most agencies integrate TODSS system training into the new bus operator training curriculum. The next steps include preparing training materials and programs for customer service, radio dispatchers, and maintenance. Training that focuses on the data capture methodology, data structures, and data meaning to provide a foundation for data consistency have been found by transit agencies to benefit service development, scheduling, and transit planning staff as they begin to integrate TODSS information into their processes.

The System Manager can play a role in training other users. Agencies should also identify several expert users and provide them with sufficient time to act as TODSS system trainers. Part of their job description would be dedicated to preparing training content, creating training materials, and delivering training. This method has proven to be successful at transit agencies that are well into the adoption phase.

Create a Cross-Functional Service Improvement Team

As the project team role diminishes (as the project moves from the deployment to the operations and maintenance phase), the best way to sustain momentum for instituting change and improving business processes is through a cross-functional team charged with creating strategies that leverage the system to address balanced scorecard focus areas. In most cases, on-time performance improvements were the starting point for these teams.

The TODSS System Manager, with senior leadership support, should seek motivated staff to establish a cross-functional work group to begin the process of using data and information to bring about sustained service improvements. The working group should identify goals and objectives, propose actions, and identify problems to take to senior leadership for approval to take action to improve transit service performance.

Lay a Foundation for Data-Driven Decision Making

The System Manager plays a primary role in spreading the concepts of using data and information as a basis for decision making. This position must form strategic alliances with both IT staff and the end-user community to establish the relationships required to institute fundamental changes in the way transit agency staff perform their daily job activities.

A series of activities led by the System Manager can set the foundation for making a cultural change that includes data as a key driver in the decision-making process. Activities include:

- Building upon the initial set of reports and dashboards by reaching out to all departments and consumers of TODSS system data;
- Gauging users' interest, change readiness, and requests for assistance to guide the progress of the outreach effort;
- Responding to user requests for information and continuing to perform job analyses to meet organizational changes and annual agency strategic goals and objectives; and,
- Expanding a custom report library that is easily accessible and usable by all staff.

User input is critical to seeking new ways for improvement, and the System Manager should lead by instituting new ways to gather input throughout the agency. Examples of agency efforts to improve input include:

- Having planners and other planning staff regularly spending time in the operators' day room to review routes and schedules;
- Encouraging operators to report service problems by setting standards to provide them with a timely response and follow-up report; and,
- Consolidating and automating dispatcher forms (electronically) to report system anomalies, radio problems, and maintenance-related issues.

Maintaining the practices described above will help an agency to not only get the most out of their new system, but will provide the routine care and upkeep of the system to keep it operating smoothly, allowing the agency to gain the benefits of being able to use the operations information to better plan and operate their service.

There are many ways that these systems can be expanded once the system is up and running with good route and schedule data and users are well adjusted to operating using these tools. Agencies should periodically reach out to peer agencies to see what new functionality they have added to their systems and review whether adding new functionality would benefit their operations as well.

Appendix A: Technical Memorandum Transit Operations Decision Support System Software System Logic and Interface Test Results

Technical Memorandum

TRANSIT OPERATIONS DECISION SUPPORT SYSTEM SOFTWARE SYSTEM LOGIC AND INTERFACE TEST RESULTS

March 2009

This report is confidential and intended solely for the use and information of the company to whom it is addressed.

TODSS SOFTWARE SYSTEM LOGIC AND INTERFACE TEST RESULTS

Description of the Test Process

The Transit Operations Decision Support System (TODSS) Software System Logic and Interface Test took place at Continental Corporation facilities in Cedar Rapids Iowa. All tests were conducted in Continental's deployment lab with testing conducted between 9:00 a.m. and 5:00 p.m. each day.

The testing procedure followed the TODSS Test Plan submitted and approved by FTA as part of the TODSS demonstration project.

The test was conducted in three parts. The first part of the test demonstrated the setup and functionality of the replacement hardware and infrastructure that supports Pace's Intelligent Bus System (IBS). The second part of the test demonstrated the system logic and interfaces of Continental's release 25 CAD/AVL and Customer Information Systems that includes the TODSS prototype development. The third part of the test included a review and validation by Continental's development group of Pace's configuration and setup of parameters and thresholds for each of their TODSS incidents, rules, action plans, research lists, and action items.

Testing occurred February 17, 2009 through February 19, 2009 and included the following participants:

- John Braband, Pace Department Manager of Operations, TODSS Project Manger
- Tariq Khan, Pace IBS Operations Coordinator
- Bill Hiller, Booz Allen, Pace TODSS Technical Support
- Mark Dema, Continental TODSS Project Manger
- Jason Stauffenberg, Continental TODSS Project Engineer

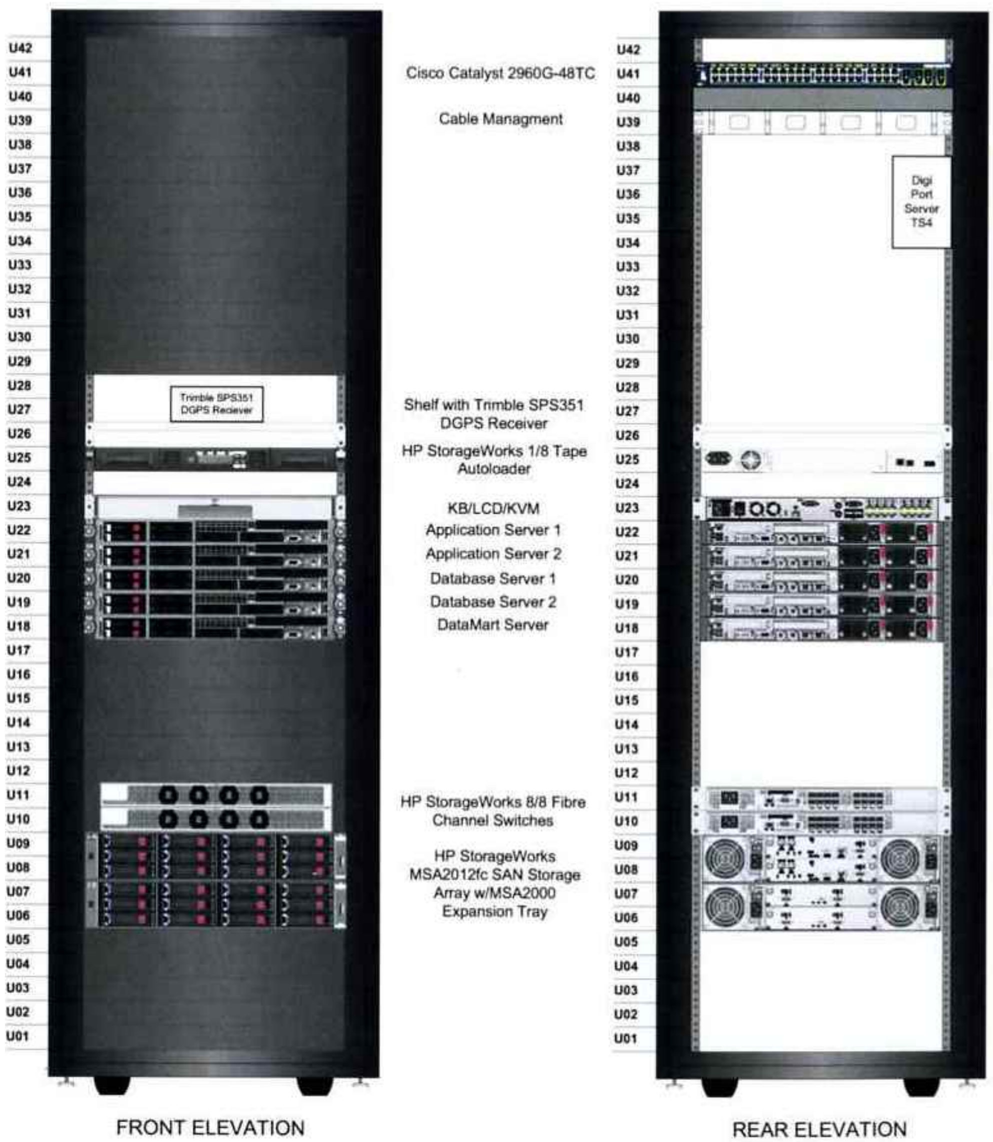
Other Continental personnel that supported the testing included:

- Thomas Funk, Software Engineer
- Mark Holt, Software Engineer
- Deborah Hiller, Software Technician
- Allen Pratt, Engineering Technician

Part I – Hardware Test Plan

A test of the technology refresh that included servers, routers, storage, and dispatcher workstations purchased by Pace in support of the TODSS prototype was conducted by Continental's Engineering Technician. The testing included a review of the Pace network equipment inventory, inspection of the network rack, review of the power distribution layout, review of the Ethernet switch fabric, and review of the Storage Area Network (SAN) configuration. The review and testing followed a step-by-step Test Plan for network redundancy including application server failover and autostart failover testing procedures. Two variances were corrected during the course of the test with no critical variances recorded at the conclusion of the test period. The following graphic represents Pace's rack configuration to be installed in their new administrative headquarters in Arlington Heights, Illinois.

Pace Rack Configuration



Part 2 – TODSS Test Plan

The software logic and interface test was conducted using Pace's new hardware and a low power radio network, dispatcher workstation, and two bus-in-a-boxes provided by Continental. The dispatcher workstation had internet capabilities to test external sources of information. This test environment supported the TODSS test plan in a real-time live mode of operations including vehicle voice and data messages, dispatcher voice and data messages, and system messages.

TODSS rules and configuration settings are stored in a database and can be exported to an Extensible Markup Language (XML) file. For this portion of the test a Continental control configuration XML file was imported into the test environment and the test procedures were executed against this pre-defined XML configuration. The Continental Project Manager conducted this portion of the test and went through all of the procedures included in the TODSS test plan. The results of this portion of the test are provided in the last section of this report. There were no critical variances recorded at the conclusion of the test period. The following table summarizes the non-critical variances that were recorded at the end of the testing period and will be tracked during the implementation phase of the project:

TODSS Test Plan Non-Critical Variance Summary

Test Procedure ID	Variance Description Summary
REQ 133	Item 19. Send an Email - An Email server and associated accounts were not configured as part of the test environment. Sending an email worked to the point of accessing MS Outlook and contacting the mail server.
REQ 51	The test specified that the double click action remove an RTT. The test action list included multiple action items therefore the RTT was not automatically removed by design and worked as configured.
REQ 77	Incident Reports have undergone a design change with a default incident report form available instead of type and subtype selection. Default form and type will need to be added to the TODSS incident configuration tab.
REQ 83	Pace local requirements include headway adherence as a future capability and their license agreement currently does not include the headway adjustments module at this time. We were able to use service adjustment/route offset to adjust headways.
REQ 104	Critical transfers (Req107) are available but are designed for limited use. Using complex trigger rules connection protection schemes were devised (combination of geographic region, adherence, and event suppression)

Part 3 – TODSS Configuration and Validation Test

The third portion of the test was led by the Continental Software Engineers. This portion of the test used the Pace XML TODSS configuration file. Continental technical support personnel went through and fine-tuned Pace’s configurations and settings. They provided suggestions and listened to concerns from the Pace team to take advantage of the TODSS capabilities. This portion of the test also reviewed areas of IBS and TODSS that Pace needed further clarification and guidance prior to the implementation phase including:

- Security Configuration
- Incident Report Management
- Incident Audit History
- System Events -vs.- Mobile/Driver Events
- Maintenance Reporting
- Work Assignment Roles for Dispatchers
- WebWatch Updates and Maps
- Route Manager Application for Configuring Routes and Route Types

With no critical variances reported at the conclusion of the testing period the equipment and software was cleared for shipping to begin the implementation phase of the project as scheduled.

Test Results

Key for Verification:

IDS Admin = IDS Administration application
BusOps = TransitMaster Operations application
FleetSim = Fleet Simulator application
RTT = Request to Talk
PRTT = Priority Request to Talk
BIAB = Bus in a Box

4.1.1 Configuration and Setup

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ5	SI 1 SD 2	The TODSS Prototype shall be capable of responding to the following events mapped to existing Pace IBS vehicle messages: • Canned Message • Communication Request • Covert Alarm • Driver Violation • Engine Controller • Farebox Alarm • Operator Absent • Overt Alarm • Paratrip Problem • Rail Consist • Service Area Alarm • Vehicle Inspection • Vehicle Status	Open IDS Admin / Rules* / Event drop down. *Use rule ID #65 "Test Rule" Note: IBS Subsystem events (req138) are in the same list	Verify that these messages are available in the dropdown list	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ138	SI 1 SD 2	The TODSS Prototype shall be capable of responding to the following events mapped to existing Pace IBS subsystem messages: • CADLink RTT • Critical Transfer • Feeds Info • Logon Failure • Message Delivery Failure • Route Performance Status • Sign Info • System Health • Workpiece Alert	Open IDS Admin / Rules* / Event drop down. *Use rule ID #65 "Test Rule" Note: Vehicle messages (req5) are in the same list	Verify that these messages are available in the dropdown list.	Passed
REQ179	N/A	The TODSS Prototype shall consider Pace IBS System Administrators as "authorized users".	Log onto workstation using Pace Administrator account and access IBS Admin. Log onto workstation using a Pace Administrator account and access IDS Admin	Verify logon successful.	Passed
REQ59	SI 2 SI 6.1	The TODSS Prototype shall allow authorized users to create a set of dispatcher-initiated events (name and description).	Open IDS Admin / Manual Events form. Select "Add Event". Enter desired name and description. Click SAVE. Open RULES form and highlight rule ID#19. Open "Compose Trigger" dialog and highlight Manual EventID parameter.	Verify the new value is available in the "Sample Values" list.	Passed
REQ133	SD 9.2.1 SR 9	The TODSS Prototype shall be capable of performing the following actions mapped to new TODSS and existing Pace IBS functionality: 1. Acknowledge an Incident 2. Begin a Dispatch Chat 3. Clear an Emergency	**Each paragraph indicates the Item number(s) for each of the sub requirements in REQ133.** 2.35. – Open BusOps. Right click in any queue. Select "'Create Event". Select radio button 1 "Pick on event from the Manual Event list". Click Next and select Event Name "Req133".	Verify all steps executed without errors.	Passed Note: Item 19. Send an Email - An Email server and associated accounts

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
		4. Create an Incident Report 5. Create a Manual Event 6. Create a Service Adjustment 7. Display an Action Plan Document 8. Display a Dispatch Document 9. Display the Phone Directory 10. Downgrade a Covert Alarm 11. Filter Mechanical Alarms (opens Enable/Disable Alarms) 12. Initiate a Covert Microphone Session 13. Launch Instant Playback 14. Perform a Remote Vehicle Logon 15. Replace a Driver or Vehicle 16. Reply to the incident source with a Canned Message 17. Reply to the incident source with a Text Message 18. Reply to the incident source with a Voice Call 19. Send an E-mail 20. Send an OnStreet Message 21. Send a Canned Message 22. Send a Text Message 23. Send a Voice Call 24. Set Operator Absent – Returned (Mobile CE only) 25. View Communication	Click Next and Create. This will trigger the "Wakeup a fellow dispatcher" incident and provide action plan links to Dispatch Chat and a web page. The covert alarm incident will address the following actions: 1.3.4.10.12.13.19.26.27.28.29.30.31.32.34. Open BusOps. Open FleetSim. Using the FleetSim tool, send a covert alarm from an active vehicle. Each of the above actions is demonstrated in BusOps on either the Action Plan tab, Research tab, or on the Incident Queue control bar. #1 "Acknowledge an Incident" is only seen on the mobile and occurs when the covert alarm is silenced. 5. Open BusOps. Right click in the Incident queue to create Manual Event "IBS System Failure". This will create an incident which is mapped to the action plan "Recovery of IBS system failure". 6.7.11.14.15.33. Open BusOps. Open FleetSim and send MDT canned message "Equipment – Engine Died". Verify that the "Vehicle Break-down" incident appears in the Incident queue. Lock the incident. From the Action Plan tab, click on "More Plans" and select the "Correct Route performance" plan. Select link to Service Adjustments and verify "Service Adjustments" dialog box appears with the correct run number pre-selected. Select action plan #3 "Look at Action Plan Document". Select link to Action Plan Document. (This feature is slated to be removed from IDS system). Close the action plan. Select "Filter Mechanical Alarms" link, which will open the "Enable/Disable Alarms" dialog box. #14 and 15 "Remote Logon" and "Replace Driver or Vehicle" are on the Action Plan "Deal with unusable vehicle". #33 is from the Research List, link to "Vehicle Properties". 8. From FleetSim, send MDT Canned Message / Schedule Issue "Passenger refused lap belt" from		were not configured as part of the test environment. Sending an email worked to the point of accessing MS Outlook and contacting the mail server.

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
		History 26. View Map 27. View Pullout Tab 28. View Roster Tab 29. View Route Ladder 30. View Route Tab 31. View Schedule Tab 32. View Service Overview 33. View Vehicle Properties 34. View Vehicle Tab 35. View a Web Page	FleetSim. The incident "Lap Belt Refusal" will appear in the BusOps queue. Go to Action Plan tab and click link to Dispatch Documents 9. From BusOps, send Manual Event "IBS System Failure". From the action plan queue, click the link "Phone Directory", which should be mapped to highlight Maurice Saunders Phone number. 16.17.25. From FleetSim, send MDT Canned Message/Schedule Issues "Wheelchair passed – by / 2 on board". Verify incident "Wheelchair Passenger" appears in the BusOps queue. The action plan link "Canned Message Reply" will open dialog with pre-selected canned message reply and the "Text Message Reply" link will open a pre-typed text msg. Double click action will open "Communications History" dialog. 18. From FleetSim, send a Request to Talk message. A double-click action will initiate the voice call reply. 20. From BusOps, send a Manual Event "Send Message to Sign". This will send incident "Create OnStreet Message", which has a double-click action to open the "OnStreet User Message" dialog box. 21.22.23. From BusOps, send Manual Event "Lost Item". The Incident "Lost item" will appear in the queue and contain an action plan that prompts to send a pre-defined canned message from the "Lost item / Person" section. The action plan will also contain "Text Message reply" and "Voice Call" links. 24. This item is available in CE only.		

4.1.1.1 Action Items

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ135	N/A	The TODSS Prototype shall allow authorized users to create and manage action items.	Open IDS Admin / Action Items form. Click "New Item". Define desired item with a title and description. Link Action/Parameter(s)	Verify all steps executed without errors.	Passed
REQ136	N/A	The action item shall have a text description of a dispatcher action and an associated action.	Same as REQ135. The "Description" text for each action item is displayed to the dispatcher when they double click in the "Instruction" field. The title text of the action item is seen in the Instruction field. For an example, send Manual Event 'Lost Item'. Double click on any of the Instructions ("Lost Purse", "Send Text Msg to.., or "Call vehicle") and view the text in the "Action Description" box.	Verify all steps executed without errors.	Passed

4.1.1.2 Research Checklists

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ60	SR 6.3 SR 8.1	The TODSS Prototype shall allow users to create and manage Research Checklists.	Open IDS Admin / Research Lists form. Click "Add List". Define desired title. Add, sort or delete desired Action Items to the list. Click "Save" and notify the database of the changes by clicking the green arrow icon.	Verify all steps executed without errors.	Passed
REQ61	SD 6.3	A research checklist shall consist of a name and list of action items.	Same as REQ60. Look at Research List ID #1 to see multiple action items are included.	Verify all steps executed without errors.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ155	SI 8.2.1 SD 5 SD 6.3	A research checklist may include functional impacts based upon prior dispatcher experiences.	Same as REQ60 and REQ61. Open IDS Admin / Research List form. Click on green Add/Remove/Sort arrows to show how Action Items may be added, deleted, or reordered based on dispatcher feedback.	Verify all steps executed without errors.	Passed
REQ124	SR 2 SR 6 SR 9	A research checklist may include guidance for the impact and selection of a recovery plan.	Research lists can include links to a variety of step by step instructions for determining the Action Plan to use. From FleetSim, send canned message "Equipment – Engine Died" from FleetSim. Lock the incident and click on the Research List tab. Click on link to Service Performance. Using this information, the dispatcher could determine the need to select an action plan to correct route performance.	Verify all steps executed without errors.	Passed

4.1.1.3 Recovery Plans

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ64	SR 8.2 SR 8.3	The TODSS Prototype shall allow users to create and manage Recovery Plans.	Open IDS Admin / Action Plans form. Add a new action plan and type in Title / Description. Click on green arrows to add, sort or delete Action Items.	Verify all steps executed without errors.	Passed
REQ67	N/A	A recovery plan shall consist of a name and list of action items.	Same as REQ64	Verify all steps executed without errors.	Passed

4.1.1.4 Incidents

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ27	N/A	The TODSS Prototype shall allow users to create and manage Incidents.	Open IDS Admin / Incident form. Click on "New Incident" or "Clone Incident".	Verify all steps executed without errors.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ19	N/A	The TODSS Prototype shall allow a given event to trigger multiple incidents.	Open IDS Admin / Rules form. Sort grid by event.	Verify all steps executed without errors. Note that a "Canned Message" event has been used to trigger many different types of incidents. A "Dispatch Event" has also been used to trigger such incidents as IBS System Failure, BDS Alarm, Lost Item, Passenger Left Behind, etc. Each of these incidents utilizes a different trigger condition.	Passed
REQ20	N/A	The TODSS Prototype shall allow different events to trigger the same incident.	Two separate incidents named "IBS System Failure" have been created, but each have different events and trigger conditions. Open IDS Admin / Rules form and highlight rule ID#14.	Verify all steps executed without errors. Note that the Event is "System Health" and will trigger when the TMCalc component is not detected. Highlight rule ID#19 and note that the event is "Dispatch Event" and will trigger when ManualEventID 2 is created. Both of these rules trigger the same incident.	Passed
REQ21	N/A	The TODSS Prototype shall allow a given incident to be triggered by different events.	A "Vehicle Break-down" incident can be triggered by a canned message event or a mechanical alarm event. Using FleetSim, send canned message "Flat Tire". The incident appears in the queue and the details describe the canned message event. Now send a mechanical alarm "Check Engine" from the same vehicle.	Verify all steps executed without errors. Notice that the incident details now include the vehicle status event. Also, a "Talk Request" incident can be triggered by a communication request event or a covert/overt alarm updating rule based on priority.	Passed
REQ65	N/A	The TODSS Prototype shall allow users to associate a Research Checklist to each incident.	Open IDS Admin / Incident form. Click on "Research List" drop-down to reveal all active Research lists.	Verify all steps executed without errors.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ28	SR 3 SR 5.1	The TODSS Prototype shall allow users to associate up to three (3) Recover Plans to each incident.	Open IDS Admin / Incident form. Click on "Action Plan(s)" fields #1, #2, and #3.	Show that all active action plans are available in the list.	Passed
REQ66	N/A	The TODSS Prototype shall allow users to associate one or more Pace IBS Work Assignment roles to each incident.	Open IDS Admin / Incident form. Check box for "Source Filtered by Work Assignments Role".	Verify each incident can be filtered based on work assignment roles and/or NT groups. These filters can be set up to determine who will receive and/or own an incident.	Passed
REQ176	N/A	The TODSS Prototype shall allow users to associate a "quick task" (e.g. Voice Call, Canned Message, Text Message, or Open an Incident Report) to each incident.	There are multiple demonstrations in REQ133 that verify this requirement. Various methods include double click action, links to various tabs in BusOps, and other links to dialogs such as Dispatch Documents, Phone Lists and Dispatch Chat.	See REQ 133	Passed

4.1.1.5 Rules

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ16	SD 4.1	The TODSS Prototype shall allow authorized users to create rules for evaluating events and generating incidents.	Open IDS Admin / Rules form. Create a rule based on a list of predefined system events (vehicle messages, aggregate statistics, system health messages, system events (vehicle messages, aggregate statistics, system health messages, and Manual Events). The event type will define trigger conditions used to fire the incident.	<u>Verify all steps executed without errors.</u>	Passed
REQ17	N/A	Each rule shall map a single event to a single incident.	Open IDS Admin / Rules form. Select one event from the drop-down list.	<u>Verify all steps executed without errors.</u>	Passed
REQ154	N/A	Each rule shall be assigned a type: Generating (new incident) or Updating (existing incident).	Open IDS Admin / Rules form. The "Type of Rule" box has radio buttons for generating or updating type.	<u>Verify all steps executed without errors.</u>	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ18	N/A	The TODSS Prototype shall allow a given event to be used as the input to multiple rules.	Open IDS Admin / Rules form. Sort by event.	Verify all steps executed without errors. Note that a "Vehicle Status" event, for example, can be used on multiple rules with various trigger conditions. Example: A covert alarm is a vehicle status event. One rule using this event can be to fire a covert alarm incident if "Emergency State = 2", and another updating rule can use the same event, but the trigger condition would be if "Emergency State > 2" with a lower priority. This would reduce the covert alarm incident priority in the BusOps queue.	Passed
REQ22	SI 6.1 SD 1.3 GS 7.3 GS 8	The TODSS Prototype shall allow the user to define multiple rule parameters:	Open IDS Admin / Rules form. Using test rule ID#65 select one event and open the "Compose Triggers" dialog. Notice the different parameters. Close the dialog box and select a different event type. Open the "Compose Triggers" dialog box.	Verify different parameters are now available.	Passed
REQ32	SD 1.3 SD 3.1 SD 4.1 SD 6.1 SD 7.1	The rule parameters shall include an event parameter threshold value and operator.	Same as Req22 (different parameter threshold values and various operations shall apply to each parameter)	See Req 122.	Passed
REQ33	SD 1.3 SD 7	The rule parameters shall include an incident priority value between 100 (highest) and 0 (lowest).	Open IDS Admin / Rules form. Each rule has a Priority (0 – 100) field. The same priority level can be used on multiple rules.	See Req 43	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ34	SD 1.3 SD 6.4.1	The rule parameters shall include an incident suppression interval (i.e. minimum time between triggering a repeat incident).	Open IDS Admin / Rules form.	Verify the "Suppression Interval (in minutes) setting is available.	Passed
REQ35	SD 1.3 SD 6.4.3	The rule parameters shall include an incident expiration interval (from 1 minute to 48 hours).	Open IDS Admin / Rules form.	Verify the "Life Span (in minutes) for a generating or updating rule.	Passed
REQ36	SD 1.3 SD 6.4.3	The rule parameters shall include a method allowing automatic removal if the source event clears.	Any updating rule shall automatically remove Incidents when the source event clears *and* the Priority = 0. Using FleetSim, create a late adherence warning on a vehicle. After the "Late Adherence" incident is sent, correct the adherence value to be on time.	Verify that Rule ID#71 will remove the late adherence incident from the queue.	Passed
REQ37	SD 1.3 SD 4.2	The rule parameters shall include a link to an audio file to be played upon incident creation.	Open IDS Admin / Rules form. Click on the "Sound" drop-down list containing all pre-defined sound names.	Verify sound.	Passed
REQ38	SD 1.3 SD 4.2	The rule parameters shall include the selection of a display color.	Open IDS Admin / Rules form. Click on the box to the right of the "Color of Incident" text. Select desired color. Each rule is allowed one "Color of Incident".	See REQ 53 for usage.	Passed
REQ40	SI 6.1 SD 6.2	The rule parameters shall include an enable/disable flag.	Open IDS Admin / Rules form.	Verify the check box labeled "Enabled" is clearly visible in the grid that displays which rules are enabled. In the pane below the grid, the "Enabled" check box can be activated or deactivated.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ24	SD 1.2 GS 7.3 GS 8	The TODSS Prototype shall allow the selection of a "context" under which a set of rules may be evaluated:	Open IDS Admin / Rules form. Select the test rule ID #65.	Verify using different events; examine the trigger options that determine how/when each rule is evaluated.	Passed
REQ29	SD 3	The rule context shall include the selection of a service type (e.g. Weekend, Saturday, or Sunday).	Open IDS Admin / Rules form. Highlight test rule ID #65 and select "Vehicle Status" from the drop-down list. Open the "'Compose Trigger" dialog.	Verify this will present trigger options for such parameters as Service Type, Route Type, Day of Week, Hr of Day, etc.	Passed
REQ30	SD 3 SD 7.1	The rule context shall include the selection of a route type criterion (e.g. BRT).	Same as REQ29 set up (parameter = Route Type)	Same as REQ 29.	Passed
REQ31	SD 3 SD 7.1	The rule context shall include the selection of a time-of-day criterion (e.g., AM Peak).	Same as REQ29 set up (parameter = HourOfDay)	Same as REQ 29.	Passed
REQ139	SD 3 SD 7.1	The rule context shall include the selection of a day-of-week criterion.	Same as REQ29 (parameter = DayOfWeek)	Same as REQ 29.	Passed
REQ140	SD 3 SD 7.1	The rule context may include additional criteria specific to the selected event (e.g. vehicle state information).	Same as REQ29 set up. Note that the trigger condition can be composed of multiple parameters, and each parameter may include multiple values (e.g. = , <, >, AND, OR, etc)	Same as REQ29 set up. Note that the trigger condition can be composed of multiple parameters, and each parameter may include multiple values (e.g. = , <, >, AND, OR, etc)	Passed
REQ23	SI 8.1	The TODSS Prototype shall treat each event/rule set as an independent entity (i.e. OR'd logic).	Open IDS Admin / Rules form Sort the incident column and scroll down to "Vehicle Break-down" Incidents.	Verify there are 2 such incidents that are governed by different event types and rules. Rule ID #5 (Vehicle Died) is triggered by a Canned Message event and rule ID #16 (Engine Blow-up) is triggered by a vehicle status event. They do not require the other rule for the trigger to fire.	Passed

4.1.2 Sources of Information

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ73	SI 1 SI 3.1	The TODSS Prototype shall be capable of accessing route and schedule information from the Pace IBS database.	Open BusOps. View Schedule, Route, Pull, Roster Vehicle tabs.	Verify access Route and Schedule information in the same way as current system.	Passed
REQ6	SI 1 SD 1.2	The TODSS Prototype shall be capable of receiving real-time information from currently operating vehicles.	With FleetSim running, observe the same tabs as in REQ73.	Observe real-time information.	Passed
REQ13	N/A	The TODSS Prototype shall split the Pace IBS Mechanical Alarm message into separate events for each individual alarm.	Open IDS Admin / Rules form. Use Rule ID #65 (Test Rule) and select "Vehicle Status" from the Event drop-down list. Click Compose Trigger.	Verify each IBS mechanical alarm message can have its own trigger conditions to fire separate Incidents.	Passed
REQ7	SI 1	The TODSS Prototype shall be capable of receiving real-time information from other Pace IBS components.	TMTracker will create location text info. Using FleetSim, assign vehicle to a block. Start up and send Location messages to simulate a time point crossing. From BusOps / Vehicle tab, double click on vehicle and observe textual location information in the "Vehicle Properties" dialog box. TMCalc will send Pullout alarms. Open IDS Admin / Rules form. Rule ID#72 triggers when AlarmStatus=3 and vehicle assigned to workpiece is powered up. Start vehicle using FleetSim.	Verify WA will filter updates. Same as REQ47.	Passed
REQ15	SI 7	The TODSS Prototype shall include an event aggregation service to create a single output event based upon multiple events or real-time information.	In BusOps, the "Service Performance" dialog takes input from a number of vehicles and averages them into a single output event or parameter. Use FleetSim to logon to multiple vehicles on a route. Offset adherence on a vehicle.	Verify this will trigger the "Traffic Jam" Incident.	Passed
REQ14	N/A	The TODSS Prototype shall create summarized schedule adherence events by route.	Same as REQ15	Same as REQ15	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ8	SI 2 SI 3.3 SI 5 SR 4	The TODSS Prototype shall be capable of receiving manual events from the Pace IBS dispatchers.	Open BusOps. Right Click in any TODSS Queue and select "Create Event".	Verify the dispatcher can select whether to generate an event from a Manual Event list, the Dispatch Canned Message list, or the Vehicle Canned Message list.	Passed
REQ75	SI 4 SI 5	The TODSS Prototype shall function as an integrated real-time component of the Pace IBS system.	The system receives real-time vehicle status updates via MiniNet. Open TMClient Monitor and turn on all messages.	Verify all messages are displayed within TM Client Monitor.	Passed
REQ2	SI 3.2 SI 5	The TODSS Prototype shall utilize the Pace IBS MiniNet to receive real-time message information.	Connection to the TMRouter ensures real-time message information. Open TMClient Monitor application and turn on all messages on the router side.	Verify all messages are displayed within TM Client Monitor.	Passed
REQ3	N/A	The TODSS Prototype shall create events based upon receipt of real-time message information.	Using FleetSim, send any vehicle canned message that is mapped to a rule (engine died, flat tire, road blocked, etc) to the fixed end.	Verify that the incident is fired into the queue within seconds.	Passed

4.1.3 Service Disruptions

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ58	SD 1.2	The TODSS Prototype shall allow the user to selectively trigger a manual event through the Pace IBS Bus Ops application.	Open BusOps. Right Click in any queue and select "Create Event". To fire an incident manually from a vehicle, select the "Pick an event from the Vehicle Canned Message list" option. A vehicle drop-down list is provided along with all vehicle canned messages. Send event.	Verify any canned message event that is configured to trigger an Incident can be sent through BusOps.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ41	SD 4.1	The TODSS Prototype shall evaluate configured rules upon receipt of an event.	Events are fed into rule engine and processed. Configure two rules for the same event but having different “contexts”. Then send the event under each context and verify the correct rule fires. An example of this would be the "Vehicle Break-down" incident, which uses a "Canned Message" event, and the "Wheelchair Passenger" incident, which also uses a "Canned Message" event.	Verify each incident contains different action plans and/or research lists.	Passed
REQ42	SD 4.1	The TODSS Prototype shall create incidents based upon execution of configured rules.	Same as REQ133.	Same as REQ133.	Passed
REQ43	N/A	The TODSS Prototype shall automatically select the highest priority instance if multiple occurrences of the same incident are triggered.	Open BusOps and FleetSim. Using FleetSim, send a "Request to Talk". The "Request to Talk" incident will appear in the queue with the configured priority. Then send PRTT (Higher priority).	Verify replacement.	Passed
REQ44	SD 9.2.2	The TODSS Prototype shall display incidents to the dispatcher through the Pace IBS Bus Ops application.	Open BusOps. Right click in a queue and select "Create Event". Select "Pick an event from the Manual Event list" radio button. Generate an "IBS System Failure" event.	Verify Incident "IBS System Failure" appears in the BusOps incident queue. *Do not delete the incident. This Incident is used in the next verification test.	Passed
REQ53	N/A	The incident shall be displayed in the configured background color.	Using REQ44 set up, open IDS Administration / Rules form. Select rule ID#19 (This is the rule that is triggered by the Dispatch Event "ManualEventId2).	Verify that the "Color of Incident" shade is the same as displayed in the BusOps Incident Queue.	Passed
REQ45	N/A	The TODSS Prototype shall play any audio file associated with this incident.	Use REQ44 setup.	Verify the sound played when the Incident comes into the BusOps queue.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ70	N/A	The TODSS Prototype shall suppress duplicate incidents per configuration.	Every instance is single-instance, i.e. at most one instance of a particular incident and source can be in the queue at any given moment. Example would be RTT.	Verify that only the first one is displayed in the queue.	Passed
REQ71	N/A	The TODSS Prototype shall update existing incident source event information if a new incident was triggered but suppressed.	The incident details are updated with details from incoming event. Send RTT, then update with PRTT.	Verify the details display updated source information.	Passed
REQ153	N/A	The TODSS Prototype shall be capable of removing an existing incident from the queue based upon future events.	Rules can be updated when the priority is set to "0". The existing incident is removed after a new event arrives. Using FleetSim, establish late adherence on a valid route. This will send the "Late Adherence" incident. Establish on-time adherence and the updating rule will remove the incident.	Verify this will send.	Passed
REQ50	N/A	The TODSS Prototype shall allow the dispatcher to select and work with any incident from the queue.	Using FleetSim, BIAB and/or Manual Events, fire multiple incidents into the queue.	Verify that the dispatcher is allowed to select any incident within the queue.	Passed
REQ51	N/A	The TODSS Prototype shall support the configured Double-Click action (see configuration).	Using FleetSim, send a RTT incident into the queue. Double click on the incident.	Verify that the incident is automatically removed and the "In Communications" window is open and initiating the RTT replies.	Passed – Double click action worked as configured. The test action list included multiple action items therefore the RTT was not automatically removed by design.

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ52	SR 8.1	The TODSS Prototype shall allow the dispatcher to display the Research Checklist for a selected incident.	Open BusOps and FleetSim. Send "Engine Died" canned message from FleetSim.	Verify that the "Vehicle Break-Down" incident appears in the queue. Highlight the incident and click on "Research" tab at the bottom of the screen.	Passed
REQ46	SR 5.2	The TODSS Prototype shall treat any steps in the Research Checklist as additional/optional data gathering.	Use same setup as REQ52.	Verify that the Research List contains links to informational tabs within BusOps. Open IDS Admin / Research Lists form. Note that any Research list can be comprised of any defined Action Item.	Passed
REQ47	SD 10.1	The TODSS Prototype shall utilize the Pace IBS Work Assignments component to filter access to incidents.	Open BusOps and select Work Assignment Roles icon. Check the Fox Valley Dispatch box. Open IDS Admin / Rule form. Select rule ID#45 (Late Adherence). Note trigger condition "AdherenceStatus=3//too late". Now click on the incident form and highlight incident ID#18 "Late Adherence". Note the View Filter for WA_Role includes "Fox Valley Dispatch". Use FleetSim to logon and run one vehicle from Fox Valley Garage and one that is from a different garage. Allow both vehicles to establish the route information by crossing at least one time point. Stop both vehicles to simulate a late adherence.	Verify that once adherence is > -4, only the Fox Valley vehicle fires a "Late Adherence" incident into the queue.	Passed
REQ49	N/A	The TODSS Prototype shall automatically remove an incident from the queue after its expiration period.	Open IDS Admin / Rules form. Highlight rule ID#54 "Fellow Dispatcher has fallen asleep". Note the "Life Span (minutes)" = 10. Open BusOps, right click in the incident queue and select "Create Event". Using 1st Radio button, click "Next" and select Event Name "REQ133". Click "Next" and "Create".	Verify that the incident is removed from the queue after 10 minutes.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ48	N/A	The TODSS Prototype shall automatically remove an incident from the queue if marked as allowed and its recovery plan has been completed.	Open IDS Admin / Incidents form. Highlight incident ID#9 "Passenger Left Behind". Verify check box "Auto-delete on Completion" is checked. Open BusOps and create Manual Event "Senior citizen missed last bus". Incident "Passenger Left Behind" should appear in the queue.	Complete the action plan steps and verify that the Incident is automatically removed.	Passed

4.1.4 Service Restoration

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ76	SR 8.4	The TODSS Prototype shall allow dispatchers to take ownership of an incident (i.e. lock/unlock).	Send any incident into the incident queue. Highlight the incident and observe "Lock" button in the bottom left corner of the queue.	Verify the "Unlock" button is currently disabled. Click on the "Lock" button and now the incident is owned by dispatcher. Now "Unlock" is active. A "Double-Click" action will also lock the incident.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ77	NA	The TODSS Prototype shall utilize existing Incident Report capabilities in the Pace IBS system.	Open IDS Admin / Incident form. Highlight incident ID#18 "Late Adherence" and select the "Default Incident Report Type/Sub-Type" needed for the specific incident. The incident needs to have an action plan that includes "Create Incident Report" action. Fire the incident and execute the IR creation link.	Verify that the desired report form pops up.	Passed Note that due to a design change only a default incident report form is available for selection. Type and sub-type were provided within the default form when it popped up.
REQ12	SR 1	The TODSS Prototype shall allow the dispatcher to view from the list of Recovery Plans associated with the selected incident.	Using FleetSim, send mechanical alarm "Engine Died". Highlight and lock the incident. Select the Action Plan tab. *Don't delete this Incident.	Same as REQ 137.	Passed
REQ137	SR 8.2 SR 8.3	The TODSS Prototype shall allow the dispatcher to select a Recovery Plan for a given incident.	Same set as REQ12. If the incident has multiple action plans assigned to it (up to 3 are allowed), the words "More Plans" will be highlighted in green to prompt the dispatcher to look at optional plans.	Same as REQ 12.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ54	N/A	The TODSS Prototype shall monitor the performance of each step in the Recovery Plan.	The IDS system records time of completion, user notes, and action results for certain actions (voice call reply, text/canned message reply, announcement reply, incident report ID). Open IDS Admin and query previous incidents from the "Audit / Incident History" form.	Verify the query results reveal times that the incidents were created and deleted. The reason for the deletion is recorded. The incident is stamped true/false to indicate whether the owner completed the action plan. The steps in the action plan are time-stamped as to when the "Completed" box was checked.	Passed
REQ55	GS 10	The TODSS Prototype shall construct an audit trail for each incident.	Open IDS Admin / Audit / Incident History	As the Incidents are removed from the BusOps queue, verify they can be queried from the Incident History form.	Passed
REQ56	N/A	The audit trail shall include information from the triggering event and time stamps for each accomplished step in the Recovery Plan.	*Incidents need to have been fired into the queue and either expired or completed. Open IDS Admin / Audit / Incident History. Run an incident query with valid Start/End date/times. Highlight an incident and the details will be displayed on the right side of the screen.	Verify the Event History will also display action steps included in the incident details.	Passed
REQ57	N/A	The TODSS Prototype shall mark an incident as "Complete" once all Recovery Plan steps have been completed.	Using FleetSim, send a MDT Equipment Canned Message, "Engine Died". From the Action Plan tab, place a check in any of the 3 action plans. An incident is considered "Complete" when all boxes in the "Completed" column of the desired action plan have been checked. Open BusOps / Incident queue. Right click in the queue and select "Create Event". Select "Pick an event from the Manual Event list" radio button. Generate a "BDS Alarm" event. From the action plan tab, complete each action item.	. Verify that the incident is then removed from the queue. Open IDS Admin / Audit / Incident History. Query for the date/time that the Incident was generated. Note the "Delete Reason": field = Completed.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ72	N/A	The TODSS Prototype shall allow the user to change to a different Recovery Plan and transfer over the status for any common task steps.	If there is a need to have the same action Item on multiple action plans in one Incident, completing the task on one plan will mark it as "Complete" on subsequent plans in the same incident. For an example, send a "Vehicle Died" canned message from FleetSim. The "Vehicle Break-down" incident contains 3 action plans. The "Deal with unusable vehicle" and the "Correct Route Performance" plans both contain the action item "Create Incident Report". Mark it as complete in one of the plans.	Verify that the "Completed" box is checked.	Passed

4.1.5 Existing Pace IBS Functionality

Testing will be executed based on the method listed below. Pace IBS Testing Procedures Dec. 2003.

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ84	N/A	The Pace IBS shall support same-day service adjustments:	Inspection		Passed
REQ79	N/A	The service adjustments shall support detours through a timepoint waiver process.	Demonstration		Passed
REQ80	SD 1.4.2	The service adjustments shall support the cancellation of scheduled service at the block-level.	Demonstration		Passed
REQ81	SD 1.4.4	The service adjustments shall support the creation of overload blocks for extra or spacer service.	Demonstration		Passed
REQ82	SD 1.4.2	The service adjustments shall support the splitting of existing blocks to accommodate operator or vehicle change-outs.	Demonstration		Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ83	SD 1.4.4	The service adjustments shall support headway realignment using temporal adjustments to existing schedules (blocks).	Analysis		Passed Using service adjustment/route offset we were able to adjust headways
REQ85	SD 1.4.1	The Pace IBS shall support import and activation of new schedules.	Inspection		Passed
REQ86	SD 2	The Pace IBS shall support the detection of vehicle schedule adherence (early/late) events.	Demonstration		Passed
REQ87	SD 2	The Pace IBS shall support the detection of overall route schedule adherence (early/late) events.	Demonstration		Passed
REQ88	SD 2	The Pace IBS shall support the detection of missing/late logon events.	Demonstration		Passed
REQ92	SD 2	The Pace IBS shall support the detection of route headway events.	Demonstration		Passed
REQ95	SD 2	The Pace IBS shall support the automatic detection of passenger overload events.	Demonstration		Passed
REQ96	SD 2	The Pace IBS shall support the manual (operator) indication of passenger overload events.	Demonstration		Passed
REQ98	SD 2	The Pace IBS shall support coordinated vehicle turn back events.	Demonstration		Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ99	SD 2	The Pace IBS shall support the detection of vehicle off-route events.	Demonstration		Passed
REQ100	SD 2	The Pace IBS shall support mechanical alarm events.	Demonstration		
REQ101	SD 2	The Pace IBS shall support overt alarm events.	Demonstration		Passed
REQ102	SD 2	The Pace IBS shall support covert alarm events.	Demonstration		Passed
REQ103	SD 2	The Pace IBS shall support passenger-initiated transfer events.	Demonstration		Passed
REQ104	SD 2	The Pace IBS shall support automated transfer connection protection events.	Demonstration		Passed Critical transfers (Req107) are available but are designed for limited use. Using complex trigger rules connection protection schemes were devised (combination of geographic region, adherence, and event suppression)

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ105	SD 2	The Pace IBS shall support voice fallback events.	Demonstration		Passed
REQ106	SD 4.2	The Pace IBS shall allow authorized users to designate any event as requiring an incident report.	Inspection		Passed
REQ108	SD 6.3 SD 6.4.4	The Pace IBS shall include displays of summarized tabular and graphical route performance.	Inspection		Passed
REQ178	N/A	The Pace IBS shall support the definition of work assignment roles for event filtering by garage, route, region, and/or vehicle.	Demonstration		Passed
REQ177	N/A	The Pace IBS shall allow dispatchers to select their work assignments role(s).	Demonstration		Passed
REQ109	SD 6.4.2	The Pace IBS shall direct events and incidents to appropriate personnel based upon work assignment roles.	Demonstration		Passed
REQ111	N/A	The Pace IBS shall include a geographic map display:	Inspection		Passed
REQ112	SD 9.1.1	The geographic map display shall support zoom in/out.	Demonstration		Passed
REQ113	SD 9.1.2	The geographic map display shall include a base map with a road network and transit-related landmarks.	Inspection		Passed
REQ114	SD 9.1.3	The geographic map display shall be capable of displaying the current reported location of all active vehicles.	Demonstration		Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ115	SD 9.1.4	The vehicle map icon shall be capable of displaying vehicle identification (e.g. route, block, fleet, etc.).	Demonstration		Passed
REQ116	SD 9.1.4	The vehicle map icon shall be capable of displaying vehicle status (e.g. schedule adherence, route adherence, mechanical alarms, emergency, etc.).	Inspection		Passed
REQ117	SD 9.1.6	The geographic map display shall refresh as new vehicle information is received.	Demonstration		Passed
REQ118	SD 9.3	The Pace IBS shall include tabular and graphical displays of a selected route.	Inspection		Passed
REQ110	SD 8.1	The Pace IBS shall include a display summarizing schedule adherence and headway disruptions.	Inspection		Passed
REQ119	SD 9.3.1 SD 10.1	The Pace IBS shall support filtering of tabular displays by attributes (column values).	Demonstration		Passed
REQ122	SD 10.2	The Pace IBS shall support sorting of tabular displays by attributes (column values).	Demonstration		Passed
REQ74	SI 3.4 SI 3.5	The Pace IBS shall automatically raise a vehicle's polling rate during an emergency (Covert or Overt alarm) condition.	Demonstration		Passed
REQ121	SD 10.3	The Pace IBS shall support configurable colors by schedule adherence, headway, or route status (on Route Ladder and Map).	Demonstration		Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ120	SD 10.4	The Pace IBS shall include resizable tabs and windows.	Inspection		Passed
REQ26	GS 12.1	The Pace IBS shall allow System Administrators to grant feature access rights to specific users.	Demonstration		Passed
REQ107	SD 5	The Pace IBS shall trace system-wide adherence problems through Critical Transfer notifications.	Demonstration		Passed
REQ141	SI 8.2.1	The Pace IBS shall notify dispatchers when a vehicle is dropped from the polling list.	Demonstration		Passed
REQ142	SI 8.2.1	The Pace IBS shall notify dispatchers when the communications link is down.	Demonstration		Passed
REQ149	GS 9	The Pace IBS shall notify dispatchers when essential system components have failed.	Demonstration		Passed
REQ144	GS 1.1	The Pace IBS shall support group communications by fleet, route, and other predefined collections.	Demonstration		Passed
REQ145	GS 1.2	The Pace IBS shall support a dispatcher-controlled voice communications network.	Analysis		Passed
REQ146	GS 1.3	The Pace IBS shall support vehicle-to-vehicle communications controlled through dispatch.	Demonstration		Passed
REQ147	GS 2	The Pace IBS shall follow guidelines put forth in the NTCIP standards.	Analysis		Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ148	GS 6	The Pace IBS shall support interfaces to external clients through shared database access and software-controlled gateways.	Inspection		Passed
REQ150	GS 10 GS 13	The Pace IBS shall archive all vehicle message events.	Inspection		Passed
REQ151	GS 11	The Pace IBS shall include a vehicle event playback feature.	Inspection		Passed
REQ152	GS 12.2	The Pace IBS shall utilize standard Windows® logon and access features.	Demonstration		Passed

4.2 Performance Requirements

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ162	N/A	The TODSS prototype event / incident processing time shall not introduce noticeable delay (more than 2 seconds) in response time from similar actions performed in the current IBS.	Demonstrated in REQ133		Passed

4.3 Interface Requirements

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ175	N/A	The TODSS parameters and thresholds shall be user definable to the greatest extent possible without compromising system integrity.	Open IDS Admin / Rules form. Highlight rule ID #56 "Test Rule". Click on "Compose Trigger..". Examine parameters details pane in the "Build Trigger Condition" dialog box.	Verify parameters are definable.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ171	SI 3.1	The Pace IBS shall support importing of Hastus™ schedule information.	Executed through the TMRouteManager application.	See IBS Testing Procedures	Passed
REQ173	SI 3.1	The Pace IBS shall support importing of base maps.	Executed through the TMMidMif application	See IBS Testing Procedures	Passed
REQ174	SR 9	The Pace IBS shall support e-mail capabilities.	Demonstrated in REQ133		Passed
REQ172	N/A	The TODSS prototype shall support RSS and Internet connectivity.	Demonstrated in REQ133		Passed

4.4 Data Requirements

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ170	N/A	The Pace IBS shall continue to support current IBS event logging and latest *TransitMaster*™ design.	Inspection	See IBS Testing Procedures	Passed

4.5 Non-Functional Requirements

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ169		None			Passed

4.6 Constraints

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ167	N/A	The TODSS prototype requires a *TransitMaster* upgrade from version 19 to version 24.	Inspection	Verify version is Build 24 or higher.	Passed

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Test Procedures	Acceptance Criteria	Result
REQ168	N/A	The TODSS prototype requires new servers that conform to the minimum standards specified in the Continental Hardware Recommendations provided to Pace to successfully migrate to current levels of Microsoft SQL Server that include expanded ADO functionality.	Inspection	Verify hardware specifications conform to minimum standards within the 45M0009-001-D_TODSS Prototype Requirements_9-8-2008, section 4.6	Passed

Appendix B: Technical Memorandum Transit Operations Decision Support System Results of Implementation Tests

Technical Memorandum

TRANSIT OPERATIONS DECISION SUPPORT SYSTEM RESULTS OF IMPLEMENTATION TESTS

June 2009

Table of Contents - Results of TODSS Implementation Tests

Tables

Revision No.	Date	Reason for Issue
1.0	5/15/2009	Initial draft
1.2	5/18/2009	Pace Input
1.3	6/2/2009	Accept Pace changes, reformat, move table to appendix, add functional test procedure
1.4	6/3/2009	Final Pace edits

GLOSSARY OF ACRONYMS

AVL	Automatic Vehicle Location
DGPS	Differential Global Position Satellite
FAT	Factory Acceptance Test
GUI	Graphical User Interface
IBS	Intelligent Bus System
IBS	Intelligent Bus System
IDS	Intelligent Decision Support
MDT	Mobile Display Terminal
PRTT	Priority Request to Talk
RNC	Radio Network Controller
RTA	Regional Transportation Authority of Northeastern Illinois
RTT	Request to Talk
TM	TransitMaster™
TODSS	Transit Operations Decision Support System
WA	Work Assignment
XML	Extensible Markup Language

INTRODUCTION

The TODSS prototype software was installed and went into full-time operation at each of Pace's nine operating divisions on March 3, 2009. Implementation planning started in December of 2008. At each stage of the installation process, the system had to perform as designed at each step described in the deployment task list. Once the system was successfully installed and operational implementation testing began to determine whether the system performed as expected.

This project is for the cooperative development of a prototype system and the acceptance tests were performed and reported on as performance measures only. The acceptance criteria related to the TODSS portion of the software development was tailored to the specific characteristics of the local Pace TODSS Prototype.

It is important to recognize that the TODSS prototype included an upgraded to Pace's existing Intelligent Bus System (IBS) that included some of the TODSS functional requirements. The upgrade included a technology refresh of the backend equipment including new servers, new data storage, operating system upgrades, and database management system upgrades. Additionally, occupancy in the new Pace Headquarters including telecommunications, computer, and network infrastructure to support Pace's IBS operations occurred as the TODSS prototype was being implemented and going operational. Given the scope of the upgrade, this process is similar to the steps required for the installation of a new system. The process that Pace went through is typical for a transit agency that may consider implementing a new TODSS at their agency in the future.

Prior to implementation planning the system had been developed and tested primarily in a lab environment. Pace was involved in the prototype design to provide feedback to the software development process including input on the user interface and operational representation of the requirements. This period ended in November of 2008 and the next steps were to prepare to ship the system to the actual deployment sites, install and check the system, and make sure the system and personnel were ready to transition to system operations and maintenance.

It is important that transit agencies recognize the effort that goes into the implementation planning and testing of a complex software system such as the TODSS Prototype. This report includes the steps that led up to the installation, the implementation testing, and finally the TODSS Prototype system acceptance. The steps discussed in this report include the implementation planning process, system delivery and site preparation, system implementation, and the transition period to full operations. The integration of the Continental TransitMaster™ system into Pace Suburban Bus's IBS operations required careful planning for system staging and preparation, a successful Factory Acceptance Test (FAT), a thorough deployment and cutover plan, and a set of acceptance test procedures.

IMPLEMENTATION PLANNING

This phase of the implementation process represents the handoff of the tested system from the development team to the operations and maintenance team. Continental assigned a project manager for the implementation process and the Pace project team began preparations for the operations and maintenance of the system. This process was documented in a System Delivery and Installation Plan. The new system required a smooth transition plan including a backup strategy to revert to the existing system in case the new system did not operate as intended. The deployment strategy took into consideration the complexity of the system, deployment at multiple sites, and the order of the deployments.

Weekly teleconferences commenced in December to coordinate and plan the IBS hardware replacement, software upgrade and TODSS development. The meetings included representatives from Pace, Continental, and Booz Allen. An implementation plan, provided by Continental, was the basis of the teleconferences with the schedule updated weekly until the completion of all action items in time for the onsite implementation scheduled to begin on February 28, 2009.

The new Pace headquarters building was not scheduled for occupancy until April 2009 but plans moved forward for all new IBS equipment to be located in the new facility prior to the March 3, 2009 go-live date.

Staging and Preparation

All new servers and equipment were delivered on-site to Continental's Cedar Rapids location. All items were staged in the deployment lab, and inventoried. All server equipment was installed and configured in its appropriate server rack. The summary of those activities related to the staging and preparations are as follow:

- Continental order and receive parts
  - √ Complete on 12/19/08
- Continental site survey of new Pace Headquarters building
  - √ Completed on 11/19-20/08
- Continental build server rack
  - √ Completed 02/02/09
- Continental install Windows OS, all updated security updates, and TransitMaster™
  - √ Complete 02/02/09
- Continental Test operations software, cluster server fallback
  - √ Complete 02/02/09
- Continental deliver Differential Global Position Satellite (DGPS) antenna, cable, and mounting equipment to Pace
  - √ Delivered to Pace on 01/08/09.
- Pace telecommunications infrastructure migrated over to new headquarters building
  - √ All fiber links operational 01/27/09
- Pace has new DGPS antenna to be installed
  - √ Completed 02/09/09

Pace TODSS Team Preparations

A two-day meeting of the Pace project team was conducted at Pace headquarters the end of January to determine project readiness. After a TODSS Prototype demonstration, the Pace project team had a positive reaction and reached consensus to proceed with the implementation as planned. The Pace project team resolved a few final setup and configuration issues and it was agreed that any further decisions related to changing the TODSS setup and configuration would require the full Pace TODSS team approval. The outcome of the meeting included:

- Final set of data messages available to bus operators
- Final set of TODSS incidents requiring dispatcher action
- Determination of the TODSS incident priority levels
- Identification of email distribution lists
- Identification of dispatcher references and display options
- Discussion of the impacts TODSS has on the daily report of operations
- Identification of initial external sources of information for TODSS processing
- Identification of training needs
- Determination of what to expect dispatchers to realistically handle on day one

Based on this meeting Pace finalized their configuration and setup of TODSS incidents, rules, action plans, research lists, and action items in preparation for operating the TODSS Prototype. Pace sent an Extensible Markup Language (XML) export of the TODSS configuration database to Continental for their review and comment prior to the Factory Acceptance Test (FAT).

Factory Acceptance Testing

The purpose of the FAT was to test the software logic and design while still in the test lab environment. TODSS, as part of the upgrade initiative by Pace, was one of two areas included in the testing process. The upgrade was required to provide Pace with the infrastructure necessary to support the TODSS functionality and required a separate verification test plan for the FAT. Local TODSS requirements that are part of the base IBS system were tested and verified within the specific TODSS test procedures that are described in the TODSS Test Plan Document submitted as Task 5.1 of the TODSS project.

A FAT variance tracking process was completed on January 12, 2009 in preparation for the FAT. The FAT plan was completed on February 2, 2009 that outlined the three day test to be conducted at Continental's Cedar Rapids facility. The Factory Acceptance Testing began on February 17, 2009 and ended on February 19, 2009. The successful results of the FAT were described in the TODSS System Software Logic Test Results Technical Memorandum submitted as Task 5.2 of the TODSS project.

TODSS Dispatcher Training

Upon successful completion of the FAT a training plan for Pace dispatchers was developed by Pace. The training program was delivered over a two week period to over forty dispatchers and supervisors. The training included a TODSS demonstration and hands-on experience using the final TODSS software loaded on a stand-alone laptop that provided a simulation of actual Pace transit service running in real-time. The training needed to be completed prior to the system going operational but not delivered too soon so that the content of the training would be forgotten. Training was well received and led to several suggestions that were shared with the project team that led to improvements in the TODSS configuration.

Dispatchers were placed into small groups and provided with one four hour training session per group that covered the following topics:

- Starting the application including the map and selecting work assignment roles
- Understanding and moving through the TODSS Incident Queue
- Understanding Action Lists, Research Lists, and Incident Details

- Completing a TODSS incident
- Entering manual events
- Understanding the new driver canned messages dispatcher requirements
- Incident Reporting changes including the use of type and subtype categorization
- Email distribution and addressing
- Source for Daily Report of Operations
- Traveller Information Notifications sources and requirements
- New IBS features

The results of the training sessions and the implementation plan status were shared with Pace senior management. It was determined by Pace senior staff that the set of Pace configured TODSS incidents should be phased in over time to minimize the impact on daily operations. There was a concern that the changes in the system could be overwhelming to the dispatchers. The implementation plan was changed to reduce the number of incidents enabled and start with a smaller set of incidents including only those incidents critical to daily operations such as communication requests and emergency requests. The remainder of the incidents would be introduced incrementally during the two month operational test period as dispatchers gained experience and became comfortable with the new system.

System Delivery and Installation

After the successful completion of the FAT the entire system was physically packed and shipped from Continental’s labs to the new Pace headquarters facility arriving on Thursday February 26, 2009. The hardware ownership changed hands to Pace and all asset tags were recorded into Pace’s internal asset management system. Prior to the server installation, the telecommunications, computer and radio networks were installed and placed into service. All installation activities were done in cooperation with the Pace Information Technology (IT) staff. Key milestones in this phase of the implementation plan included:

- Pace provided a workstation at new Pace Headquarters on 01/27/09
- Pace provided access badges for tower access and keys to access towers for the Continental implementation team completed 01/30/09
- Pace migrated the old network and telecommunications network and brought up the new network
- Pace verified the correct placement for the new server rack was ready for installation and arranged for on-site IT staff to assist the Continental team completed by 2/25/2009
- Pace received the equipment 2/26/2009 and stages the delivered server rack until installation
- Continental installed the new server rack completed on 02/27/09

As soon as the new equipment was integrated into the Pace network, the system was turned over to Continental's deployment staff to begin data migration, upgrade, deployment, and system functionality testing of the TransitMaster™ system including servers, dispatch workstations, Radio Network Controllers (RNC), and system software.

The deployment plan provided the installation tasks for the upgrade to version 25 of TransitMaster™ software that included the TODSS prototype development. The TODSS deployment occurred on Saturday, Feb 28, 2009 through Tuesday, March 3 2009. Outlined below are the summarized technical steps required and completed as part of the installation/upgrade of the TransitMaster™ system version 25.0.0.4 at PACE.

1. Backup all TransitMaster™ (TM) databases (TMMain, TMDailyLog, TMDataMart)
2. Put all vehicles into voice mode
3. Remove database replication
4. Convert primary TM databases on the production server
5. Configure replication
6. Upgrade/Install TM software on the secondary application server
7. Upgrade/Install TM software on all Radio Network Controllers
8. Upgrade/Install TM software on all dispatch workstations
9. Verify normal dispatch and vehicle communications
10. Convert TMDataMart databases
11. Upgrade/Install TM software on the database servers
12. Upgrade/Install TM software on all client FTP servers
13. Upgrade/Install TM software on the Citrix servers
14. Upgrade/Install TM software on designated administrative workstations
15. Upgrade/Install TM software on the primary application server
16. Move the TM cluster over to the primary node/application server
17. Conduct an application server cluster fail over test
18. Conduct a database server cluster fail over test
19. Put the vehicles into normal/data mode via primary application server
20. Configure/test secondary services
21. Configure/test new features
22. Backup database

These tasks were completed in the order listed and passed operational tests successfully prior to any mobile vehicles being added to the system. The first vehicle accepted and added “on-line” was the trigger for the system to be considered live. The verification test form used by the Continental deployment team for this phase of the implementation is included as Appendix A found at the end of this report.

The entire system was moved from the voice fallback mode used during the cutover period and placed into voice and data mode system-wide beginning the morning of Tuesday March 3, 2009.

TODSS ACCEPTANCE TEST

The TODSS acceptance test approach was broken down into two parts. The first part was to test the functional requirements within the new IBS upgrade as they related to the TODSS requirements. The second part was the test of the TODSS operational scenarios as defined in the complete set of TODSS incidents. The Pace test team consisted of the Pace Operations Manager, the IBS Operations Coordinator, and the Booz Allen consultant. This group spent many hours during the first two weeks monitoring the real-time dispatcher actions, testing TODSS parameters and values in the operational environment, and auditing the historical record of the TODSS activity. Using the TODSS audit function they were able to query up to 5 days of TODSS data to monitor dispatcher performance and the TODSS processing of data.

The approach to the functional requirements test process included interacting with the live system and navigating to and from the function, changing parameters within the function, observing functional behaviour in the live system, and reviewing in the audit history as applicable. The use of geo-regions as a parameter within TODSS was not included in the local Pace requirements and therefore no test was conducted. Every other functional area was determined to pass the test criteria by the end of the operational test period. Those functional areas that did not pass in the initial release were tracked as variances, retested, and subsequently passed when the software patch was applied mid-way into the operational test. Results of the functional test are included as Appendix B at the end of this report

The approach to the operational scenario testing was to review each of the TODSS incidents and evaluate their source of information, triggering rule(s), action and research plans, and the dispatcher historical performance. Problems, issues, or performance issues found were documented and submitted to Continental for tracking within the Variance Tracking system created prior to the FAT. Criteria used for passing the acceptance test required that each of the TODSS incidents (scenarios) trigger as designed and that the associated action lists worked as designed. As new incidents were added, they underwent testing within the test work assignment role prior to use by dispatchers. For those incidents that were enabled for dispatcher use the test concluded by gathering feedback through observations of dispatcher activity using the TODSS Audit capabilities during the period of April 15, 2009 through midday April 20, 2009. The completed scenario testing results are included as Appendix C at the end of this report.

TODSS provides functionality to enable/disable each incident. Based upon Pace management direction only communication requests, emergency notifications, and bus operator canned messages were enabled when the system went live on March 3, 2009. Not only were dispatchers slowly exposed to the TODSS capabilities by this approach but this also provided time for a thorough system review to identify any serious system bugs prior to a full TODSS deployment. No serious system bugs were found and preparations were made to begin phasing in more TODSS operational scenarios.

The Pace test team was able to create a separate work assignment role and test the disabled TODSS incidents in the live system without affecting the work of the dispatchers. By monitoring the real-time behavior and analyzing the historical record of these incidents in the test environment, configuration including parameters, values, and action items were fine-tuned and made ready for operational use.

There was one significant software problem that when a source of information delay parameter (e.g. wait five minutes before triggering the event) was used the messages were not being updated. This required a software fix prior to enabling adherence monitoring which was configured using the delay parameter. A software patch applied April 15, 2009 resolved this issue and adherence operational scenarios were then enabled.

The Continental development team were very responsive to user input and added several enhancements in the software patch based upon input from dispatchers received during their training sessions and issues discovered during Pace's initial operational testing period. An example is adding a new parameter to test whether a vehicle was in revenue service to improve several operational scenarios. No critical variances stopped the operational test and all reported variances were resolved to Pace's satisfaction in the software patch.

There are a few new variances reported that will be tracked beyond the sixty day operational test period. These include the observation early on of an intermittent problem with work assignments (has not been observed since the patch) and a concern that the NT groups from the Pace Active Directory available in TODSS is incomplete. The complete table of reported variances is included as Appendix D at the end of this report.

The TODSS acceptance test procedure started on March 5, 2009 and completed after applying the software patch with re-testing completed May 1, 2009.

TRANSITION TO FULL OPERATIONS

Once the system was installed successfully the next step was to transition to full operation of the initial set of TODSS incidents, identify and resolve any problems that were encountered, and make refinements to the configuration and setup based on the operational experience during the two-month operational test period. Given that the new system replaced an existing system the transition planning tried to minimize disruption of existing business processes until a comfort level and confidence in the system was reached at all levels of the Pace organization.

A good example of a business process change is the way Pace communicates service disruptions with Regional Transportation Authority of Northeastern Illinois (RTA). Prior to TODSS, if the dispatcher remembered and had time they reported delays over 15 minutes via phone call to the RTA center. Negotiations between Pace and RTA ended with an agreement to automate these service disruptions using TODSS initiated emails. The volume of email to RTA has grown dramatically using TODSS and the ultimate solution is for RTA and Pace to agree on RTA having a remote view of TODSS in real-time.

Another business process improvement that has made a significant impact on Pace operations is bus operator initiated data messages. Pace had the capability of bus operator initiated data messaging through an extensive list of canned messages available via the onboard Mobile Display Terminal (MDT). There were over 70 messages rarely used by the bus operators. Moreover, those canned data messages sent by the bus operators were lost in all the other incidents that were arriving at the dispatcher terminal. Pace decided to reduce the number of canned messages to include only those data messages that required dispatcher action reducing the number to twenty-six messages. The messages were loaded in the MDTs and laminated pocket guides were distributed to more than 1200 bus operator that provided instruction and guidance on the proper use of data messaging in a TODSS environment. This has resulted in increasing use of data messaging by bus operators with increased dispatcher priority acting on these canned messages.

Once determining that the system was performing correctly based on the initial implementation testing results, planning began to streamline other existing business processes including eliminating manual logs maintained by dispatchers and double entry into the legacy incident reporting system.

Dispatcher Input

Two weeks into the operational test period interviews conducted at Heritage, North Shore, and South Divisions were conducted designed to evaluate the implementation process, seek first impressions of the TODSS environment, and solicit input on improving the TODSS deployment. Interviews included division level management and dispatchers at the three divisions previously chosen to participate on the TODSS project team. Their input resulted in TODSS configuration rules and action plan modifications. The division manager's reactions and comments related to the more complex operational scenarios that were disabled led to refinements in action plans and approval to add them to the their dispatcher's workload. These included using a combination of adherence parameters including route, route type, time of day, incident suppression, and incident delay values to build complex schedule and route adherence incidents.

During this period, the TODSS system administrator assigned Incident Report form names, formats, types, and subtypes in preparation of dispatcher instructions for expanded use of the TODSS reporting capabilities once the software patch was installed.

Initial reactions were unanimously positive with a high level of satisfaction with the way the implementation had been planned and executed. The new TODSS environment greatly simplified their job by clearly presenting only those incidents that must be acted upon. It was now clearer to dispatchers knowing what needed to be done and the order of doing it.

The reactions and comments received during these interviews were instructive and helped implement improvements in the initial TODSS configuration and setup. The following list includes comments ands ideas offered during these interviews for future consideration.

- A Bridge/Railroad crossing report would be useful to the division manager where daily/weekly/ quarterly review of these incidents would be possible
- The Bridge Up dispatcher actions should include capturing what is in dispatcher heads and not documented to date
- Division management is supportive of ending incident reporting in Jupiter (legacy incident reporting system) and instead rely on TODSS reporting capabilities on a daily basis.
- There have been fewer voice calls since going live with no additional cell phone traffic
- Division managers see reduction in calls already based on the pulse point scenario using operator initiated data messaging
- Dispatchers appreciate the lack of clutter with the reduction in adherence and off-course messages due to the TODSS parameter and value settings
- The Performance Monitor that presents a graphical summary representation of late adherence used by dispatch is helpful for the Division Manager
- Dispatchers look forward to the next phases of implementation and appreciate the ability to simplify processes such as eliminating phone calls to RTA and maintaining duplicate manual logs
- Consider using TODSS to provide reminders to do trip deviation to cover special summer trips.

Those comments that led to changes during the operational test included:

- Test the use of critical transfer function at the Highland Park timepoint

- Need more use of sound to distinguish between the different incidents entering the TODSS queue
- Dispatchers wished route was displayed in the Incident Queue
- Need operator refresher training on use of canned message

Addition of TODSS Functions

The Pace system administrators started adding and continued to add new TODSS functions after the first two weeks of operation. This followed the implementation strategy to start with a scaled back set of TODSS and gradually add the disabled incidents as the dispatchers gained experience and confidence in the system. As new functions passed testing within the test work assignment role, they were configured for the dispatcher work assignment roles. Once in real-time operations they were monitored and refinements made as required. The following Action Plan Items were subsequently added to TODSS:

- Action plans for the Request-to-Talk and Canned Messages received in the TODSS queue from operators now include an action item called 'Create Matching Event'. When the bus operator fails to send a canned data message and instead uses a voice call then TODSS cannot provide the proper action list, the associated action items, and no audit. The 'Create Matching Event' is used in the transition while bus operators get familiar with sending canned data messages when appropriate.
- Send Email to Manager - This action item provides the details of the incident in an automated email that should be addressed to the appropriate Manager according to the division's notification policy.
- Send Email to Passenger Services and RTA -This action item is similar to the manager email except that it is already addressed to the Passenger Services staff and RTA. RTA agreed to accept this email in lieu of a phone call notification.
- Dispatch Document Phone Notification **-** This Action item will access the phone numbers of the division or regional managers and other appropriate staff.
- An Incident Report link in an Action Plan brings up a pre-assigned form. The Type field will be automatically selected. To further describe the event dispatchers will select the specific subtype available from a pull down field based upon their assessment of the incident. All other fields will be filled in automatically. Incident Reports included in the Action Plan are required to be completed by dispatchers going forward.

A new incident to improve fleet lift maintenance practices was introduced. A Driver Violation message 'Wheelchair Not Cycled' alerts the dispatcher whenever a vehicle moves 1000 feet after the system powers up on the bus. The Research list includes a link to Instant Playback to verify that the lift/ramp was not cycled. In some cases there may be an operational issue that justifies not cycling the lift. In some cases the lift may have been cycled shortly after the alarm was sent. If it is determined that this is a valid violation, the Action Plan includes an email link to the appropriate manager at the division. Finally, the Action Plan has a link to a text message to the operator to remind them to cycle their lift/ramp when it is safe to do so.

A Probationary Operator Alert incident triggered by the employee status was created as a way to provide dispatcher mentoring on new employees. The trigger for this scenario is a tightly controlled threshold of late/early adherence values with action items that direct the dispatcher in assisting and mentoring the new employee.

Each of the three divisions on the TODSS project team identified critical routes to manage to maintain schedule adherence. Targeted route adherence incidents were configured by building complex rules including route, equipment status, and revenue status.

A Critical Transfer incident was configured to remind the dispatcher to monitor and assist with an important transfer. The incident is triggered by identifying the timepoint and the trip time value to place the incident in the TODSS queue. This gets the dispatcher's attention and provides an action list to assist with the transfer's success.

An out-of-vehicle (10-7) and back-in-vehicle (10-8) set of bus operator initiated messages were configured to provide dispatchers a quick and easy way to evaluate bus operator availability. Queue congestion is controlled by parameters that limit the lifetime of the incidents and lower priority assignment.

STAKEHOLDER TODSS PERSPECTIVES

Findings from Post Deployment Dispatcher Interviews

At the conclusion of the of the implementation acceptance test period dispatchers at the three selected garages from the TODSS project team were observed at work with one key dispatcher interviewed at each location to determine how TODSS was being used, changes dispatchers experienced in operating procedures, and the effectiveness of TODSS in their daily job activities.

The follow-up observations and interviews focused on confirming the acceptance test results by seeking dispatcher confirmation on ease of use, automation capabilities, incident priority, and effectiveness of providing service restoration assistance. The outcome of the dispatcher feedback validated the findings of the test team and did not lead to any other system variances to report. The major themes and comments from the dispatchers provided below are instructive from the user perspective.

Implementation Process – Training needs to be equalized, follow-up training needs to occur, but otherwise the implementation went smoothly. Dispatchers would like the manuals distributed in hard copy for easy reference.

System Performance – IBS is significantly quicker to load, tab views load quicker, calls initiate faster, and the return of information after data queries is faster. The Mobile Dispatcher application is much quicker in all around performance and is a much more powerful tool with the TODSS interface by focusing attention on the trouble spots.

Important New Features – The Timepoint Tab is used to support field supervisor activities. The railroad-crossing incident with the 5-minute delay is useful especially the quick links for traveler services notification. Instant playback is great. The dispatcher chat function is powerful and there are hopes that more dispatchers get familiar with using it. Mobile Dispatcher is greatly improved by having the map in tab views. Action items with direct links for sending text messages are a time saver.

Functions to Improve – The channel talk group must be reset after a RTT reply (e.g. West 2 changes to Event1). Incident Reports open with several system errors the first time they are used each day (tracked in variance report). Need to re-consider locks on critical incidents and perhaps not allow deletion by anyone other than the original owner. It is time to eliminate the need to duplicate data entry into Jupiter since TODSS provides ample data notification methods. South Garage would like two dispatch workstations to meet the challenges of line management during peak operations. Double-click action that goes straight to voice not always good (the system administrator made changes related to this comment).

TODSS Incident Queue – The automation capabilities of TODSS are great and the more we use them the more we can streamline our current practices. It is much easier to find and respond to bus operator canned text message. Like the use of color codes for TODSS incident s (need to publish color code chart). Dispatchers would like the highway congestion incident enabled so that it is available to all dispatchers for monitoring I290 and I294 delays. Adding the Metra website action item to more action plans would be helpful. There are significantly fewer incidents in queue to work on with recognition that each incident in the queue requires attention and action.

Line Management - The 15-minute late schedule adherence warning for Traveler Services notification is a time saver and should be used for all routes system-wide. Early adherence incidents can be improved by looking at two timepoints to compare actual and predictive adherence. Currently, each early adherence has to be examined using the research list links to see if the predictive adherence is accurate.

External Sources of Data – Creating manual events is new and getting everyone to use it is a challenge but the potential for improvement of this function is great. The more you enter into TODSS the less work after the fact that will lead to elimination of duplication of effort.

Outside Communications –Many more email service bulletins are being sent to traveler services and RTA; more emails are being sent to management and maintenance related to lift alarms and equipment failure, more emails to division management are sent due to TODSS action items and action plans.

Use of Data Messaging With Operators – The new list of canned messages is an improvement. When drivers use their canned data messages the workflow is created and becomes much easier to follow through to completion. Dispatchers are training drivers by asking them to send the appropriate data message if a voice call (RTT) was used in place of a canned data message. Otherwise, the dispatchers are manually creating a ‘matching event’ which in effect is doing the bus operator’s job.

TODSS Next Steps for Pace Operations

The TODSS acceptance test completed successfully at the end of the sixty-day operational test. Both the functional and scenario acceptance tests were completed successfully and validated by field visits to the dispatch centers.

This is just the beginning for the TODSS implementation at Pace. The decision support concept proved to be successful and was effective at reducing and automating dispatcher real-time activities. The knowledge gained during the TODSS operational test period will be built upon as Pace continues to enhance TODSS rules, action lists, and real-time dispatcher processes to address a wider array of operational scenarios.

The next major process improvement is to eliminate Jupiter, the legacy incident reporting system, and rely exclusively on TODSS reporting capabilities. This will eliminate dispatcher double entry of data and rely on the automated reporting capabilities of TODSS.

The audit function is a valuable tool for division level and agency level monitoring of dispatcher activity. The audit history proved to be an effective tool for the testing process and will be valuable in the future for recognizing exceptional dispatcher performance and identifying under-performing dispatcher performance that may require remedial training. Prior to making the audit history available on a wider basis Pace will need to train the managers and enhance the security configuration.

As Pace determines the best ways to improve line management they are beginning the process of standardizing and documenting their restoration techniques that will translate into improved action lists and research lists within TODSS. The success of this effort depends of the collaboration of central, regional, and division management to develop effective line management strategies that meet the unique needs of each of the divisions yet use consistent techniques system-wide.

There are many parameters and associated values to explore within TODSS that were beyond the needs of the initial Pace set of TODSS operational scenarios. The use of map polygons to trigger incidents in a particular geographical area was not tested and could be an effective parameter for operational scenarios that include load monitoring and signal priority.

TODSS also has the ability to create events to evaluate as possible incidents by looking at historical data and making a decision based on user defined threshold criteria to create an incident. Currently, TODSS provides this capability for one day's service historical data. This is a requirement of TODSS core requirements but was not part of the Pace local requirements for the initial TODSS prototype. Testing of this concept in the future may lead to expanded use of historical external data sources as TODSS sources of information.

As the evaluation process continues in the next several months Pace will be learning what has been successful, where there are deficiencies to address, and what areas require additional focus in the future. The TODSS project final report scheduled for released in September 2009 will serve as a guide for these further improvements, lessons learned, and next steps for TODSS requirements.

APPENDIX A- NETWORK INSTALLATION TASK SCHEDULE

The following form serves as verification that the steps in the Pace TransitMaster™ version 25 deployment plan were executed as planned.

Friday, February 27, 2009

- ☒ Verify delivery of equipment and check for damage, missing items, etc.
- ☒ Verify location for server cabinet is open
- ☒ Move server cabinet into computer room (save shock pallet for return to CR)
- ☒ Place cabinet in proper position, raise casters, connect to exiting cabinet row
- ☒ Verify no loose power, network, KVM cabling. Correct as necessary
- ☒ Connect server cabinet PDUs to computer room UPS power source above cabinet
- ☒ Initial power up of computer room equipment to check for problems, failures, etc.
- ☒ Connect DGPS receiver to new antenna, verify that GPS and time data is being received through the designated serial ports
- ☒ Identify network jack for connectivity of new server rack switch to Pace network
- ☒ Run necessary patch cables for network connection (DO NOT CONNECT AT THIS TIME)
- ☒ Verify usernames and passwords for necessary domain accounts, create any new accounts if needed
  - o There is talk of changing passwords at this time
- ☒ Verify network connectivity to dispatch, towers, garages, etc. from new building
- ☒ Place TransitMaster™ system into voice fallback
- ☒ Remove old servers from the network
- ☒ Backup existing databases to removable storage (Deployment activity)
- ☒ Delete machine accounts for old servers from Pace Windows domain
- ☒ Connect patch cables previously staged for connectivity to Pace network
- ☒ Verify network connectivity for new equipment to dispatch, towers, garages, etc.
- ☒ Join the new servers to the Pace domain
- ☒ Restart servers to verify that all automatic services start correctly
- ☒ Review error logs for problems related to domain change
- ☒ Start Cluster resource groups and verify core system functionality
- ☒ Turn system over to Deployment for TransitMaster™ software updates on workstations, RNC's, etc.

Saturday, February 28, 2009

- ☒ Complete any cable labelling, management, etc. as necessary
- ☒ Collect configurations from all equipment
- ☒ Take notes, red-line drawings for completion of documentation
- ☒ Prepare Continental equipment for transport back to Cedar Rapids
- ☒ Monitor system as Deployment works to bring TransitMaster™ online.

Sunday, March 1, 2009

- ☒ Continue to monitor system as Deployment works to bring TransitMaster™ online.
- ☒ Verify connectivity to tower sites and garage WLAN.
- ☒ Verify FTP sessions are occurring with TMFTP

APPENDIX B - TODSS IMPLEMENTATION FUNCTIONAL TEST

The following table includes the test plan used during the TODSS implementation testing process. The test process included testing each of the listed functions by interacting with the live system and navigating to and from the function, changing parameters within the functions, observing functional behaviour in the live system, and reviewing in the audit history as applicable.

Table 3 - TODSS Functional Implementation Test Form

Functional Area	Function	Version 25.0.0.4	Version 25.0.1.4	Comment
Rules Configuration	Priority within main queue	Passed		Observed and sorted by ascending and descending
Rules Configuration	Priority within secondary queue	Passed		tested at different priority levels between 0-50
Rules Configuration	Suppression Interval	Passed		
Rules Configuration	Delay	Fail	Passed	Delay was working but caused bug in updating rules, fixed in patch
Rules Configuration	Color	Passed		Observed
Rules Configuration	Enabled	Passed		Observed changes between disabled and enabled
Rules Configuration	Generating Rule	Passed		Observed
Rules Configuration	Updating Rule	Fail	Passed	Some problems with delay status
Rules Configuration	Life Span	Passed		Observed
Incident Configuration	Owner Can Delete	Passed		Observed
Incident Configuration	Auto Delete on Completion	Passed		Observed
Incident Configuration	Source Triggered by Work Assignments Roles	Passed		Observed - created super user role to test
Incident Configuration	Default Incident Form	Fail	Passed	Fixed in patch , open in sorted view
Incident Configuration	Default Incident Type	Fail	Passed	Fixed in patch, open assigned with default incident
Incident Configuration	View Filter	Fail	Unresolved	NT groups available but not all groups
Incident Configuration	Owner Filter	Passed		Observed
Incident Configuration	Double Click Action	Passed		Observed
Incident Configuration	Research List	Passed		Observed
Work Assignments	Roles	Passed		Observed
Work Assignments	General	Passed		Observed
Incident Audit	Incident History Queries	Passed		Tested different query parameters
Incident Audit	Incident History Filters	Passed		Tested different filter applications
Other	Geo Regions	untested		not in Pace local rules

Functional Area	Function	Version 25.0.0.4	Version 25.0.1.4	Comment
TODSS GUI (BusOps)	Multiple Action Lists	Passed		Test with vehicle breakdown from BIAB
TODSS GUI (BusOps)	Canned Message	Work-around	Passed	Fixed 0 index problem in patch
TODSS GUI (BusOps)	Voice Message	Passed		Observed
TODSS GUI (BusOps)	Text Message	Passed		Observed
TODSS GUI (BusOps)	Dispatcher Chat	Passed		need more prominent display of chat notification
TODSS GUI (BusOps)	Communication History	Passed		Tested sorting, filtering, context menus
TODSS GUI (BusOps)	New Incident Report	Fail	Passed	Default form loading and with default type loading in patch
TODSS GUI (BusOps)	View Open Incident Reports	Passed		Observe
TODSS GUI (BusOps)	Query Incident Reports	Fail	Passed	Default form, type, and subtype Query fields added in patch
TODSS GUI (BusOps)	Default Map View	Passed		Change and save default views
TODSS GUI (BusOps)	Route Ladder	Passed		Test auto route from link and setup by user configuration
TODSS GUI (BusOps)	Service Performance Monitor	Passed		Configure and save late/early views
TODSS GUI (BusOps)	Work Assignment Roles	Passed		Observe and test with superuser group
TODSS GUI (BusOps)	View On …	Passed		Observed - auto location in tab setup of links tested
TODSS GUI (BusOps)	Employee List	Passed		Observed
TODSS GUI (BusOps)	Time Point Crossing	Passed		Observed from links and GUI
TODSS GUI (BusOps)	Telephone List	Passed		Observed from links and GUI
TODSS GUI (BusOps)	Dispatch Documents	Passed		Observed from links and GUI
TODSS GUI (BusOps)	Create Manual Event	Passed		Observed and tested
TODSS GUI (BusOps)	Create Manual Event Form Canned Message	Passed		Observed and tested
TODSS GUI (BusOps)	Schedule Tab	Passed		Observed and tested selection
TODSS GUI (BusOps)	Route Tab	Passed		Observed and tested selection
TODSS GUI (BusOps)	Pullin/Pullout Tab	Passed		Observed and tested sort and filter
TODSS GUI (BusOps)	Roster Tab	Passed		Observed from links and GUI

Functional Area	Function	Version 25.0.0.4	Version 25.0.1.4	Comment
TODSS GUI (BusOps)	Vehicle Tab	Passed		Observed and tested sort and filter
TODSS GUI (BusOps)	Transfer Tab	Passed		Observed from links and GUI
ACTION ITEMS	Email	Passed		Observed and tested
ACTION ITEMS	Instant Playback	Passed		Observed and tested query options and playback functions
ACTION ITEMS	Web	Passed		Observed in Metra manual event
ACTION ITEMS	RSS Feed	Passed		Observed feeds info

APPENDIX C - TODSS IMPLEMENTATION SCENARIO TEST

The following table includes the test plan for each of the TODSS incidents (scenarios) configured by Pace to meet their local requirements. For those incidents enabled for dispatcher use dispatcher activity was reviewed to learn how dispatchers were using TODSS and refine scenarios based on historical usage.

Table 4 - TODSS Implementation Scenario Test Form

TODSS Incident	Dispatcher Activity	Status
10-7 Out of Service	Over 100, no 10-8 updates	Passed
Bridge is Up	12 total with 5 completed and 7 deleted by owner	Passed
Bus Down Unable to Move	2	Passed
Bus Full Unable to Load	2	Passed
Bus Issue - Unable to Move	4 total with 2 completed 2 deleted	Passed
Contractors Accident Report	none	Passed
Covert Alarm	3 total with 1 with notes	Passed
Critical Transfer HLPK	4 that expired no actions checked	Passed
CTAN Alert	none	Passed
Drive Cam Manual Event	3 Completed	Passed
Early Adherence	Requires dispatcher review to validate. Pace suggested improvement is to check two time points and use actual and predicted adherence.	Passed
Engine Fire	none	Passed
Facilities Emergency	none	Passed
Fare Dispute	1 Expired 8 pm at South Division	Passed
Farebox Issue	18 total with 8 completed and 3 incident reports	Passed
Fleet Watch	none	Passed
I Need Relief ASAP	6 Total	Passed
IBS / Radio Issue	4 total with 2 completed and 1 incident form	Passed
Late Adherence	1025 on 4/17	Passed
Late due to Heavy Load	8 total with 4 completed, 3 deleted, 1 expired	Passed
Late due to Heavy Traffic	98 total with 17 deleted, 11 expired, the rest completed	Passed
Late Logon	448 late logons on 4/17	Passed
Late Other	12 Total with 1 expired	Passed
Lift Not Cycled	220 total with 87 deleted, 15 expired	Passed

TODSS Incident	Dispatcher Activity	Status
Lift Not Cycled_Contractor1	79 total with 17 assigned ownership	Passed
MCC Detects RNC Fallback	TBD	Passed
Metra Service Interruption	1	Passed
Need Detour	16, total with 4 expired, 12 completed	Passed
Need Transfer Assistant	none	Passed
Overt - Ignore Emergency Alarm	1	Passed
Overt - Involved in Accident	3 with 2 from dispatch, 1 from driver	Passed
Overt - Paramedics Required	none	Passed
Overt - Smoke on Bus	none	Passed
Overt - Unruly Passenger	none	Passed
Overt Alarm	11	Passed
Passenger Sleep End of Line	2	Passed
Post Office Evacuation	none	Passed
Priority Request to Talk (PRTT)	137 RTT, 8 upgrades, 5 prtts on 4/17	Passed
Railroad / Bridge - Back in Service	55 total with 3 expired	Passed
Railroad Gates Down over 10 minutes	77 total with 5 expired	Passed
Request to Talk (RTT)	137 see prtt	Passed
RNC Channel Load > 90%	not enabled	Passed
RNC is Dead	not enabled	Passed
Road Blocked	3	Passed
Road Flooded	none	Passed
Standees on Bus	not enabled	Passed
Stranded ADA Passenger	none	Passed
Target Route Adherence Routes Heritage	13	Passed
Target Route Adherence Routes North Shore	2	Passed
Target Route Adherence Routes South	not enabled	Passed
Unable to Board Wheelchair	none	Passed
Wait at Pulse Point	6 total with 2 completed, 4 deleted	Passed
ZZ Traffic Jam	5	Passed

APPENDIX D - TODSS VARIANCE TRACKING

The following table is a record of the reported problems found during the implementation testing and verification process of the TODSS prototype development. The initial version of software installed at Pace was version 25.0.0.4 and problems that were identified and subsequently resolved were included in version 25.0.1.3 which is the software patch installed at Pace on April 15, 2009. The release version between the initial installation version and the patch version were internal Continental releases that went through their system integration testing process. The patch was a cumulative release of all the tested releases.

The entries in the table without a release version are those problems reported after the patch was installed and will be tracked by Pace and resolved outside of the TODSS operational test period.

Table 5 - TODSS Variance Tracking Report

Item #	Software Issue Description	Software Component	State	Release Version
12801	User would like an Incident 'Type' default drop-down list	TMIDSAdministration	Passed	25.0.1.3
12948	Default type is not showing up on the Incident Report form	Bus Ops/Incident Reports	Passed	25.0.1.3
13050	Overload vehicles Block Abbreviation is not recognized	TMIDSAdministration	Passed	25.0.1.3
13051	Intelligent Decision Support (IDS) module needs to refresh information when updated or deleted	TMIDSAdministration	Passed	25.0.1.3
13054	Error message when opening Incident Report from an Incident	TM Incident Manager	Passed	25.0.1.3
12797	Query Report needs to have 'Query by Form' option	Bus Ops/Incident Reports	Passed	25.0.1.2
12818	Notes typed in the 'In Communications...' dialog box	Bus Ops/Voice-Text Calls	Passed	25.0.1.2
12858	Handle 'Overload' Source Item	Bus Ops	Passed	25.0.1.2
12904	After upgrading the Survey Tool, getting error messages	Survey Tool	Passed	25.0.1.2
12962	Service Adjustment dialog areas greyed out	Bus Ops	Passed	25.0.1.2
12968	Incident report created from OverLoad fills in wrong driver ID/Badge	Bus Ops/Incident Reports	Passed	25.0.1.2

Item #	Software Issue Description	Software Component	State	Release Version
12971	Can't open Automatic Vehicle Location (AVL) Map	AVL	Passed	25.0.1.2
12987	Find dialog doesn't sort on Form Name column	TM Incident Manager	Passed	25.0.1.2
12992	Application locks up when switching control focus within the message queue	Bus Ops/Message Queues	Passed	25.0.1.2
12777	TmCongiguration to IDS Configuration of canned messages	TmConfiguration/Canned Message Creation	Passed	25.0.1.1
12780	Blank form appears if default form not defined	Incident Report Tool	Passed	25.0.1.1
12784	Incident History 'Time Checked' column won't clear out prior date/time	TMIDSAdministration	Passed	25.0.1.1
12788	BusOps Icons become inoperable when Incident Queue is detached	Bus Ops	Passed	25.0.1.1
12806	ConditionDialog should allow double click to move items.	TMIDSAdministration	Passed	25.0.1.1
12820	Sort the 'Incident' drop down list alphabetically	TMIDSAdministration	Passed	25.0.1.1
12821	Need to restart IDS Admin after new work Assignment (WA) Role entry	TMIDSAdministration	Passed	25.0.1.1
12822	List the NT Groups as they appear in TMSecurity	TMIDSAdministration	Under Review	25.0.1.1
12834	Error 3707 when displaying Field Properties	TM Incident Manager	Passed	25.0.1.1
12848	BusOps is not warning user of open Incident Reports	Bus Ops/Incident Reports	Passed	25.0.1.1
12854	WA Roles unable to save Garage changes	TMIDSAdministration	Passed	25.0.1.1
12921	Incidents getting erroneously updated by stale vehicle status events	Work Assignments	Passed	25.0.1.1
12929	Dispatch need to see more columns in the Incident queue	Bus Ops	Passed	25.0.1.1
12930	Enable 'NonRevenue' trigger	TMIDSAdministration	Passed	25.0.1.1

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