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TRANSIT OPERATIONS DECISION SUPPORT SYSTEM (TODSS) CORE REQUIREMENTS PROTOTYPE DEVELOPMENT CASE STUDY AND LESSONS LEARNED

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13. ABSTRACT (Maximum 200 words)
Transit Operations Decision Support Systems (TODSS) are systems designed to support dispatchers and others in real-time operations management in response to incidents, special events, and other changing conditions. As part of a joint Federal Transit Administration and Intelligent Transportation Systems Joint Program Office effort, the transit industry developed core functional requirements for service disruption identification and provision of service restoration options for TODSS in 2003. Pace Suburban Bus was selected to lead a demonstration project to develop and evaluate a prototype TODSS and to validate the TODSS core functional requirements. This report summarizes the TODSS Core Requirements Prototype development and provides lessons learned from the implementation and operation of the system. The summary highlights Pace's transit service and operating environment, the final TODSS prototype concept of operations, the system's architecture, issues encountered during the prototype development and implementation, the TODSS core requirements evaluation and update recommendations, and the operating experience from the time of implementation.

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Final Report

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Table of Contents

List of Tables

List of Figures

List of Acronyms

APTA	American Public Transportation Association
AVL	Automatic Vehicle Location
CTA	Chicago Transit Authority
FTA	Federal Transit Administration
GCM	Gary, Chicago, Milwaukee
IBS	Intelligent Bus System
ICM	Integrated Corridor Management
IDS	Intelligent Decision Support
ITS	Intelligent Transportation System
JPO	Joint Program Office
LAN	Local Area Network
MDT	Mobile Display Terminal
RITA	Research and Innovative Technology Administration
RSS	Rich Site Summary
RTA	Regional Transportation Authority of Northeastern Illinois
SDO	Standard Development Organization
TCIP	Transit Communications Interface Profiles
TODSS	Transit Operations Decision Support System
USDOT	United States Department of Transportation

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1 Introduction

Transit agencies were finding that Computer Aided Dispatch and Automated Vehicle Location (CAD/AVL) systems were delivering a wealth of data pertaining to the performance of their fleets but these systems were resulting in information overload for the dispatchers and they needed assistance in prioritizing their workloads and discerning patterns of operational problems. To address these issues, the United States Department of Transportation (USDOT) initiated the Transit Operations Decision Support System (TODSS) effort, and with transit agency and vendor input, proposed a set of core requirements for dispatcher decision support intended for use by transit agencies when defining their local requirements for a TODSS. The agencies and vendors involved with the TODSS initiative identified further needs if TODSS development was to occur including:

- Develop a common understanding between vendors and agencies of what TODSS can accomplish
- Minimize vendor customization costs for future CAD/AVL procurements
- Provide agencies with assistance to develop procurement specifications for a TODSS.

It was decided that a TODSS prototype development effort would provide the means to address the identified concerns of the transit agencies and vendors. In order to successfully deploy and demonstrate a TODSS, the USDOT defined a limited workable scope for the project. First, it must be feasible to add TODSS into an existing ITS environment. Second, TODSS should be deployed at a single transit agency using their existing radio dispatch center(s). Third, the prototype would focus on TODSS requirements and not center-to-center protocols. Fourth, the prototype should address fixed-route bus service. Finally, sources of information for TODSS should come exclusively from the transit agency implementing the prototype.

The primary goal of the prototype development was to validate and verify the TODSS core requirements.

The Federal Transit Administration (FTA) issued a request for proposals (RFP) to develop, test, and evaluate a prototype TODSS based on the core functional requirements. Pace's response to the solicitation for developing the prototype TODSS was selected by the FTA. Pace was the lead agency and would provide the test site for the prototype TODSS, with the Regional Transportation Authority (RTA) providing local funding, Continental serving as the system developer, and Booz Allen providing technical assistance and conducting the evaluation.

1.1 Project Summary

The project kickoff was in April 2006, with the discussion of the prior TODSS initiative including the needs analysis, feasibility study, concept of operations, and high-level industry-wide requirements for TODSS serving as the project baseline. The first task of the prototype development effort was to create a local concept of operations specific to the operational needs of Pace that were within the prototype boundaries set by the USDOT. The second task was to take the TODSS Core Requirements and identify how to apply them in the context of the Pace concept of operations. With the active involvement of a Pace TODSS working group, these activities were completed in January 2007.

Once those two tasks were completed, Pace developed a scope of work for Continental to begin work on the system architecture, detailed design, and prototype development. It was at this point that the project schedule slowed. Local funding arrangements and subcontract negotiations with Continental went on longer than expected. Neither Pace nor Continental had sufficient experience in contracting research related projects. Therefore, the development of the terms and conditions for the TODSS subcontract was difficult to reach due to the differences to the product oriented Intelligent Transportation Systems (ITS) procurement solicitations each was accustomed. The Regional Transportation Authority (RTA) came forward to provide the local funding of the project and contract negotiations were finally concluded in April 2008. Once the TODSS project started, the project moved quickly.

Continental received approval in June 2008 for the system architecture and detailed design for the prototype TODSS. Software development began in the summer of 2008, with unit testing conducted in January of 2009. Subsystem verification was completed in February 2009. Dispatcher training was delivered immediately after all pre-implementation testing was finished. The TODSS prototype software was installed and went into full-time operation at each of Pace’s nine operating divisions on March 3, 2009. The system verification and acceptance tests were completed during the operational test period that lasted through May 15, 2009. A self-evaluation was conducted and provided to the USDOT based on the findings that were documented during the operational test period.

1.2 Referenced Documents

The following documents prepared for the FTA Office of Mobility Innovation and the Research and Innovative Technology Administration (RITA) ITS Joint Program Office (JPO), and the other documents submitted as deliverables for this project, served as a reference for developing the final report summary.

- “Transit Operations Decision Support Systems (TODSS): Core Functional Requirements For Identification Of Service Disruptions And Provision Of Service Restoration Options 1.0”, Mitretek Systems, March 15, 2004
- “Transit Operations Decision Support System Project Plan Report”, Pace, May 2006
- “Pace Prototype Concept of Operations Technical Memorandum”, Pace, January 2007
- “Pace Definition of Operational Scenarios and System Parameters Technical Memorandum”, Pace, January 2007

- "Transit Operations Decision Support System (TODSS) Proof-of-Concept / Prototype Systems Requirements and Architecture", Continental Corporation, September 17, 2008
- "Transit Operations Decision Support System Results Of Implementation Tests Report", Pace, June 2009
- "Transit Operations Decision Support System Core Requirements Evaluation And Update Recommendations Technical Memorandum", Pace, October 2009

1.3 Document Overview

This project report summarizes the TODSS Core Requirements Prototype development as it progressed through the system engineering process and provides lessons learned from the implementation and operation of the system. The scope of the report covers the project team's experience in developing, implementing, and operating the TODSS Core Requirements Prototype. The organization of the remainder of this document summarizes the following project elements:

- Description of the Pace transit service and operating environment
- Summary of the local TODSS concept of operations
- Review of the TODSS system requirements and system architecture
- The project evaluation findings
- Lessons learned, benefits, and issues encountered
- Proposed recommendations for future TODSS requirements

2 Pace Service and Operating Environment

Pace offers a variety of test opportunities for TODSS. Serving the six northeastern counties of Illinois with fixed-route, paratransit, and vanpool service Pace has grown to become one of the largest operators in the country. Fixed-route operations include nine unique Pace owned and six contractor facilities. Each facility performs local dispatching of routes and vehicles assigned to their area. More than 240 routes operate in the 3,500 square mile service area with over 45 million trips provided in 2008.

RTA is the financial oversight and regional planning body for the three public transit operators in northeastern Illinois: the Chicago Transit Authority (CTA), Metra commuter rail and Pace suburban bus. The RTA provides regional trip planning and the Traveler Information Center serving the Chicagoland region. The Pace fixed-route service includes arterial, feeder, commuter, circulator, and planned special event routes. These Pace routes operate within 211 communities and connect with the CTA light rail, CTA bus routes, and Metra commuter rail.

Pace has been operating a CAD/AVL system supplied by Continental since 2004. The Pace system is known as the Intelligent Bus System (IBS). The IBS allows monitoring of each of the dispatch operations by either corporate staff or central dispatch operations. In general, each operational facility dispatches independently. At times, this results in inconsistencies in the handling of operational issues resulting from service interruptions.

When the last of the other divisional dispatcher centers go off line around ten p.m. the South Division acts as the Central Dispatch Center responsible for dispatching service to all divisions. They also answer after hours calls when the administrative offices are closed that includes calls from stranded Americans with Disabilities Act (ADA) passengers, contractor’s reporting accidents, or regional emergency notifications.

The real-time operational flow of operations is similar at each of the nine operating divisions. Upon the start of each day, the services that have been defined (e.g. Saturday, Sunday, School on, School off, and Weekday) are automatically loaded and define the fixed-route schedules for the day within IBS. Dispatchers at each division logon using their specific division logon to see only those vehicles and data messages assigned to their division.

Meanwhile drivers log on to their Mobile Display Terminal (MDT) prior to leaving the garage. Data messages are sent and received by the onboard system from the time the vehicle starts up to the time that the vehicle returns to the garage at the end of the service day. There is a two-minute polling cycle where each vehicle reports its current location. The only time the polling rate changes is when a vehicle is in an emergency alarm state. Other data messages are transmitted on an exception basis including vehicle alarms, timepoint crossings, passenger counts, driver violations, and driver initiated data messages. The vehicles have all the routes and schedules for their assigned division loaded and stored onboard. In the event of a loss of data communications, the vehicle continues to perform automated announcements, sign changes, and collection of passenger counts. The vehicle will automatically try to reconnect to the communications system. If re-connecting is unsuccessful, any stored data is uploaded to the central system in the garage at the end of the service day through the wireless local area network (LAN).

Vehicle locations are updated on the dispatcher map displays, and the arriving data messages, based upon parameter settings, are displayed in tabular format displays. In addition to vehicle related events, the IBS map and tabular screens provide alarms and icons that indicate system failures such as a loss of network connectivity, radio/data communications, or database connection.

When fixed-route service is impacted and deviates from the baseline schedule, the dispatcher must determine what restoration strategy to apply based upon constraining factors. They must consider:

- Demand for service including peak loads, the load of the entire route, or load over a segment of the route
- Traffic conditions
- Characteristics of the route including turn around points, detour routes, scheduled deadheads, route branches, common trunks, and the length of trip
- Operating environment including the garage location, relief points, headway intervals, and vehicle and operator availability
- The level of service affected such as arterial, feeder, express circulator, or planned special event routes

Dispatchers must communicate significant real–time service interruptions to the RTA Traveler Information Center and Pace Information Services for customer information updates. Dispatchers must communicate and coordinate actions in real-time with the Maintenance department, field supervision, and safety supervisors as required to manage service interruptions and restore service. It is important that they keep division, regional, and headquarters management informed of service disruptions as required by their internal escalation processes.

The Department Manager of Bus Operations at headquarters provides oversight of the IBS. The IBS Coordinator monitors and maintains the system on a daily basis. Pace IT plays a supporting role by providing data network, security, and database management services as needed. The South Holland Technical Services facility is responsible for all IBS onboard vehicle maintenance and radio repairs.

3 Pace TODSS Concept of Operations Summary

Early in the project, Pace developed their local concept of operations as part of the system engineering process. This forward-looking document described how TODSS would fit into Pace operations and was used to help internal stakeholders visualize the new system as well as serve as a guide during the validation phase of the project. The following concept of operations summary provides Pace's forward-looking view of the system before detailed requirements, system design, and development started.

The existing IBS provided a substantial portion of the TODSS core requirements. Examples of these requirements included functions such as the AVL map, integrated voice communications and data messaging, real-time message queues, tabular data displays, and other information tools to monitor and manage the fleet. In order to meet the remainder of the core TODSS requirements three functional areas were identified as lacking within IBS:

- Notification of service interruptions by external non-automatic data sources in order for TODSS to provide a complete set of source information to identify incidents. These sources within the Pace environment may include customer cell phone calls, contact from other control centers, or calls from local road commissions.
- A rules base to define when incoming data messages are, or have the potential to become, a service disruption. This event processing, based on Pace rules, includes setting priority levels for dispatchers to respond uniformly to events that are processed into service incidents.
- Service restoration options and strategies, based upon the nature of the incident notification and the associated operational scenario, need to be provided to dispatchers for a unified agency approach to service management.

3.1 Description of the Proposed TODSS

From the operator's perspective streamlining the set of data messages to include only the most frequently used messages limits the amount of time operators are delayed from driving. When operators communicate directly with dispatch by sending data messages, there is less reliance on lengthy voice calls and trying to determine the operational situation. Dispatchers benefit from data messaging since TODSS has the opportunity to automatically process data messages and then assign the operational scenario coupled with the ability to apply the thresholds and priorities to each individual data message.

IBS text messages, schedule adherence messages, system health messages, and mechanical alarms are examples of event message types used as sources of information for incident notification purposes. TODSS processing of these data messages and application of Pace defined business rules determine whether to display the message and the priority assigned for the dispatcher response.

The dispatch priorities to apply to operational scenarios, in decreasing order of criticality, include:

- Extra operations support required for immediate assistance
- Dispatcher and road supervisors immediate response
- Dispatcher response balanced with other operational demands
- Situation may require monitoring, no action required
- No action required

The TODSS supports manual input of external information sources that identify operational scenarios for TODSS to support dispatcher's actions. These manual inputs act as a service disruption notification, have a related service restoration response strategy, and include a priority level to be integrated with the IBS generated service incidents.

A TODSS configuration tool provides the means for creating the manual inputs, assigning priority levels to message types, and setting display thresholds for notification to the dispatcher. The identification of service disruptions is based upon the set of rules that takes into consideration the time of day, service level, and service (e.g. weekday, Saturday, Sunday) applied to the sources of information. Service levels such as Arterial, Feeder, Express, Circulator, or Planned Special will dictate their unique threshold settings.

The following diagram illustrates the TODSS processing of data messages that lead to a service disruption notification to the dispatcher. The top box represents the existing IBS system and the various CAD functions used to trace the impacts of service disruptions and adjustments. The two yellow boxes on the left side (TransitMaster™ or TM is the name of the Continental CAD/AVL known as IBS at Pace) represent data messages from the IBS system being sent to the Service Disruption Identification decision engine. Once a message is analyzed and associated with a known operational scenario, the appropriate response strategy is selected from the Rules Based Responses. Both the disruption and the response are sent to the TODSS user interface situated in the middle of the diagram. The user interface includes an area for manual entering of external sources of information directly into TODSS based on information such as severe weather conditions or traffic congestion provided by the Gary-Chicago-Milwaukee (GCM) website. The bottom of the user interface contains links to references, CAD functions, and other information sources that are automatically setup for dispatchers to trace the status and impacts of the disruption notification. Note that Continental Corporation acquired Siemens VDO during the life of this project and references to Siemens in this and following figures, tables, and text were originally made at the time of Siemens VDO ownership of the license rights to the Pace's IBS system.

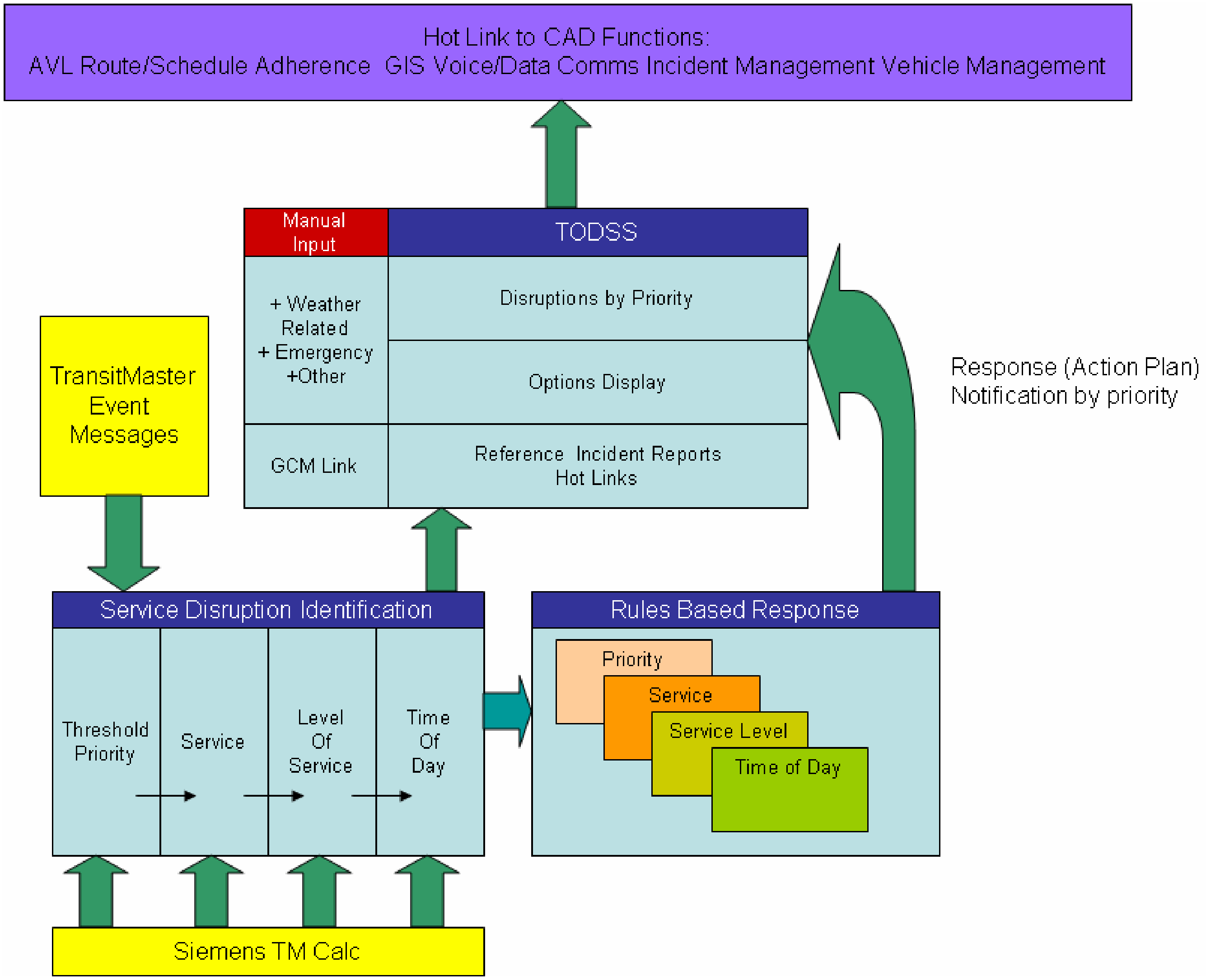

Figure 1 - Concept of Operations TODSS System Design

During the day, situations beyond a driver's control such as accidents, detours, or train crossings can adversely affect schedule and route adherence. For these service interruptions, the TODSS service restoration options include the appropriate service restoration strategies based upon the context of the operational scenario, the operational scenario priority, and other sources of information available at the time. Upon selection of a service restoration strategy TODSS implements the strategy based on the underlying rules base. Dispatchers make greater use of the IBS given TODSS automated parameter setup of driver, vehicle, and route information for tabular and graphical displays such as Playback, Route Ladder, and the Service Monitor. Playback is a map-based application that a dispatcher uses to replay all of the conditions and events leading up to an incident. Route Ladder graphically represents a route, or collection of routes, to recognize headway spacing and schedule adherence problems quickly. The Service Monitor provides a summarization of all current route and schedule performance statistics.

By TODSS limiting the number of service disruptions in queue through intelligent event processing, dispatchers are expected to spend more time managing service quality. Implementing dispatcher actions within the framework of IBS is critical since the changes captured in the data now support travelers growing need for accurate real-time customer information. TODSS encourages increased dispatcher communication of service disruptions for the benefit of other Pace staff and ITS systems to act upon in real-time.

3.2 User Roles and Responsibilities

To improve early notification of potential service disruptions, vehicle operators are expected to increase their use of data messaging within IBS, thus reducing their voice communications and taking advantage of the TODSS rule base to prioritize their requests for assistance. This takes advantage of the TODSS event processing capabilities that apply pre-defined priority and restoration actions as the data message enters the queue. Operators are expected to increase their participation in service restoration techniques, such as operator initiated short turns, set up by dispatchers.

Dispatchers are expected to manually enter inputs into TODSS from outside sources of information and act on service disruption incidents in a systematic and coordinated manner prescribed by TODSS. The final decision, based on all available information, is ultimately the dispatcher's responsibility. Road supervisors equipped with mobile dispatching capabilities follow the same training and guidelines as dispatchers.

The system administrator now has additional duties to setup and maintain the TODSS rules base. Incident triggers and associated response rules introduce a new set of parameters and settings to maintain. The system administrator becomes an important participant in operational business reviews to understand the accepted business processes and associate them with the TODSS definition of the critical operational scenarios. The system administrator assistance is key in translating the operational processes and procedures into the checklists, automated procedures, and response options within the TODSS configuration database.

The service development and scheduling functions have access to the historical record of service disruptions and adjustments made through TODSS. This provides another set of data to use for adjusting recovery time ratios, improving running times, and considering re-routes. Eventually through the TODSS experience and understanding of the historical data, the service development process will include pre-planned restoration strategies for new service based on anticipated service interruptions.

All levels of district management have access to the TODSS audit history to evaluate dispatcher performance and determine the effectiveness of their choices of restoration options in the context of the entire system performance. Headquarters and district management will have the information and means to initiate operational process improvements through improved restoration strategies and feedback to dispatchers. This provides the means to improve, measure, and raise the standards for the dispatcher function.

Traveler Services receive more timely and accurate information from dispatchers through TODSS automated incident reporting. Traveler Services integration of these real-time service updates into their existing processes increases the quality of real-time transit next stop and travel planning information provided to callers..

3.3 Stakeholder Training

During implementation and operation of TODSS, the dispatcher workforce needed to upgrade their skill levels related to integrating the IBS and other integrated software applications into their daily jobs. This required training programs and an implementation strategy based on a reasonable rate of change to their existing business processes. Through these efforts, anticipated operational related improvements included:

- Effective use of IBS tools (tabular and graphical information displays) to make decisions resulting from available information through TODSS provided guidance
- Consistent and uniform dispatcher performance resulting from the TODSS supplied response and restoration strategies
- Increased dispatcher time spent on incidents that have the greatest impact on service quality
- Active operational process improvements through lessons learned, dispatcher input, and analysis of TODSS historical information

3.4 Operational Scenarios

A thorough operational process and procedure review is necessary for developing the local requirements for each operational scenario. Each operational scenario is broken down into four parts to assist with developing the business rules to capture and implement within TODSS. The activities to consider include defining:

- Initial Actions that describe dispatcher tasks to complete after receiving a service disruption notification.
- Service Restoration Strategy that includes dispatcher response options to execute based upon the results of the initial actions.
- Follow-up Actions that the dispatcher should perform after exercising restoration options
- Dispatch Document References that contain supporting material for further information related to the operational scenario and is readily accessible to the dispatcher.

This process was followed while developing the initial concept of operations that included the following preliminary operational scenarios:

- Vehicle Breakdown
- Train Crossing and Bridge Up

- Late Startup and Pullout
- Bus Bridge
- IBS System Failure
- U.S. Postal Center Evacuation
- Pace Passenger Facilities Emergencies
- Emergency Phone Line
- Pace Contractor Accident Report
- Stranded Paratransit Customer

Service restoration strategies currently in use throughout the district identified by the TODSS Working Group for use within TODSS included:

- Vehicle jumping with an available vehicle (parked, staged, pulled-in) to replace one that became unavailable (breakdown, delayed)
- Shift the schedule time frame
- Eliminate a departure
- Insert a departure
- Modify schedule running times
- Wait at a bus stop or transfer point
- Bus changes
- Pass on the route
- Exchange drivers
- Route Deviations
- Short-turns
- Relay vehicles
- Re-routing

Further details of the set of operational scenarios included in the concept of operations are included in Appendix II of this report.

4 TODSS Local Requirements and System Architecture

Continuing along the system engineering path, the project team focused on completing the definition of the local requirements and system architecture. This section summarizes the resulting view of the system at the conclusion of this phase of the project.

4.1 TODSS Flow of Operations

The IBS flow of operations, that TODSS uses as a foundation, can be broken down into two distinct sets of activities. The first is the offline activities that include the system setup, configuration, review, and analysis. The second is the real-time operations activities. Each set of activities is vitally important and build upon the output of the other to continually update and improve the system.

TODSS requires an accurate baseline schedule to make the best possible decisions. IBS provides tools to update the schedule for permanent, short-term and same day schedule changes. Each time there is a permanent service change created in the Hastus scheduling system it is incorporated within the IBS and made available to the TODSS. Same day real-time service changes are made within the IBS that include canceling, adding, and changing service based upon the operational conditions.

TODSS requires many new setup parameters prior to implementation. The service disruption notification rules require new service parameters values such as time-of-day, route type, employee type, and revenue status to set for each of the operational scenarios. System administrators working together with dispatchers and other Pace staff define the operational scenarios and assist with defining the rules to use within the TODSS.

Upon receiving notification of service disruptions, the dispatcher’s initial actions include gathering all pertinent information. They may communicate with operators or other support personnel to ask a series of questions suggested by TODSS to gather a complete understanding of the disruption. TODSS guides them through the IBS tabular displays and assists with determining the impact on service including transfers, schedule adherence, vehicle spacing, vehicle health, and operator assignment.

Follow-up activities require the dispatcher to monitor the system until the schedule returns to normal. Pace's customer relations and the RTA Traveler Services are notified of service disruptions through actions recorded in incident reports, emails, and legacy systems (until they are phased out) that are available for later analysis. Many operational scenarios have related reference materials such as service bulletins, training materials, and process definitions. TODSS links to these dispatcher documents are easily access as supplemental information as needed.

4.2 Information Sources Identifying Service Disruptions

Dispatchers receive information that indicates service disruptions from multiple sources. TODSS prioritizes and presents this information to the dispatcher after determining the significance and severity of the disruption in relation to the transit system as a whole. The sources of information include automated IBS data messages, vehicle operator initiated voice and data communications, and external sources of information. Examples of each are listed below.

IBS Data Messages

- Late or missing logon
- Loss of data communications transmission
- Route early
- Route late
- System detection of vehicle off route
- System managed user requested connection
- System Late
- Vehicle early or late
- Vehicles are gapping and bunching along route (distance based)
- Vehicles are gapping and bunching at a point location (time point)
- Vehicles through time point early
- Vehicles through time point late
- Vehicle subsystem health
- Vehicle location

Driver Initiated Information

- Driver needs relief ASAP/personal
- Emergency alarm activated
- Railroad gates down
- Passenger inappropriate behavior (refuse belt, fare, asleep end of line)
- Passenger incapacitation or emergency
- Passenger requested transfer
- Passenger sick
- Vehicle involved in accident
- Vehicle mechanical problem (brakes, check engine, door, fluid leak, transmission)
- Wheelchair lift broken or wheelchair passed
- Passenger lost item
- Full bus
- Have a detour
- Road blocked
- No relief driver

External Sources of Information

- Driver inappropriate performance (customer complaint)
- Major traffic disruptions
- Major storms
- Metra or CTA rail system outage

- Public safety emergency support
- Special events
- Terrorist actions
- Accident requiring re-route
- Fires requiring re-route
- Localized flooding

Dispatchers receive external sources of information through telephone or other external communications. If this information fits into pre-defined operational scenarios, dispatchers manually enter the event into TODSS to record the information and initiate the response actions. TODSS also automatically processes incoming information from web sites that provide a Rich Site Summary (RSS) feed for information such as weather or traffic congestion as it relates to identifying service interruption operational scenarios.

4.3 Differences Between Pace TODSS Prototype Requirements and Generic TODSS Core Requirements

In the core TODSS requirements there are features described for detecting disruptions and strategies for restoring service that are not available in the IBS and were not included in the local TODSS requirements. These missing features include:

- Headway service disruptions are not detected between different routes within a shared segment (corridor) in IBS.
- IBS does not provide system managed connection protection. Connection protection is based upon passenger transfer requests.
- Although Pace is testing and preparing to institute bus signal priority, it is not an available strategy for service restoration today.

There are several core TODSS requirements that do not apply to existing Pace operations or available technological capabilities but are included in future plans. Local requirements for the TODSS prototype do not currently include corridor management until Pace implements their planned “arterial” service in the future. Additionally, Pace decided that since they do not have a large base of installed automatic passenger counter systems, that using load factors as a parameter for evaluating service disruptions would not be included in the local requirements.

It was also determined that it would be difficult to evaluate and prioritize recovery plans (action plans) without existing defined operating procedures and historical experience to draw upon. The TODSS prototype system design takes into account incorporating this core requirement in future development and growth of TODSS capabilities.

4.4 System Parameters

TODSS requires a scripting language or configuration utility that permits Pace to define the thresholds for notification and assign priorities to operational scenarios. The TODSS decision engine must permit Pace the flexibility to expand and add operational scenarios as they gain experience using the system and make improvements to their operational processes.

In the IBS, there are parameters such as time of day, day of week, or service that can be used to determine when to provide notification of a service disruption. TODSS requires that these existing parameters are available within the TODSS rules engine. TODSS requires additional variables and parameters that further define and refine service levels, priority schemes, the decomposition of aggregated data messages, and incident notification timing. New parameters such as route type to accommodate unique rules for Pace's arterial, feeder, commuter, circulator, and planned special event route types are required to expand the possibilities for refined schedule and headway adherence monitoring.

The following list is a sampling of the IBS events required for use within the TODSS rules engine and illustrates the range of inputs that influence core TODSS parameter requirements:

- Covert Emergency Alarm
- Overt Emergency Alarm
- Priority Request To Talk
- Request To Talk
- Route Status
- Headway Warning
- Schedule Adherence Warning
- Canned Message
- Priority Canned Message
- Mechanical Alarm
- Subsystem Health
- Farebox Alarm
- Driver Violation
- Logon Status
- Open Mic
- Critical Transfer

4.5 System Architecture

TODSS takes full advantage of the IBS infrastructure and the prototype design is a full featured end-to-end dispatcher decision support system. The system architecture supports all Pace defined operational scenarios both present and future. The following diagram depicts the TODSS prototype installed into the existing Pace IBS. The dashed line indicates the demarcation of TODSS to the existing IBS architecture.

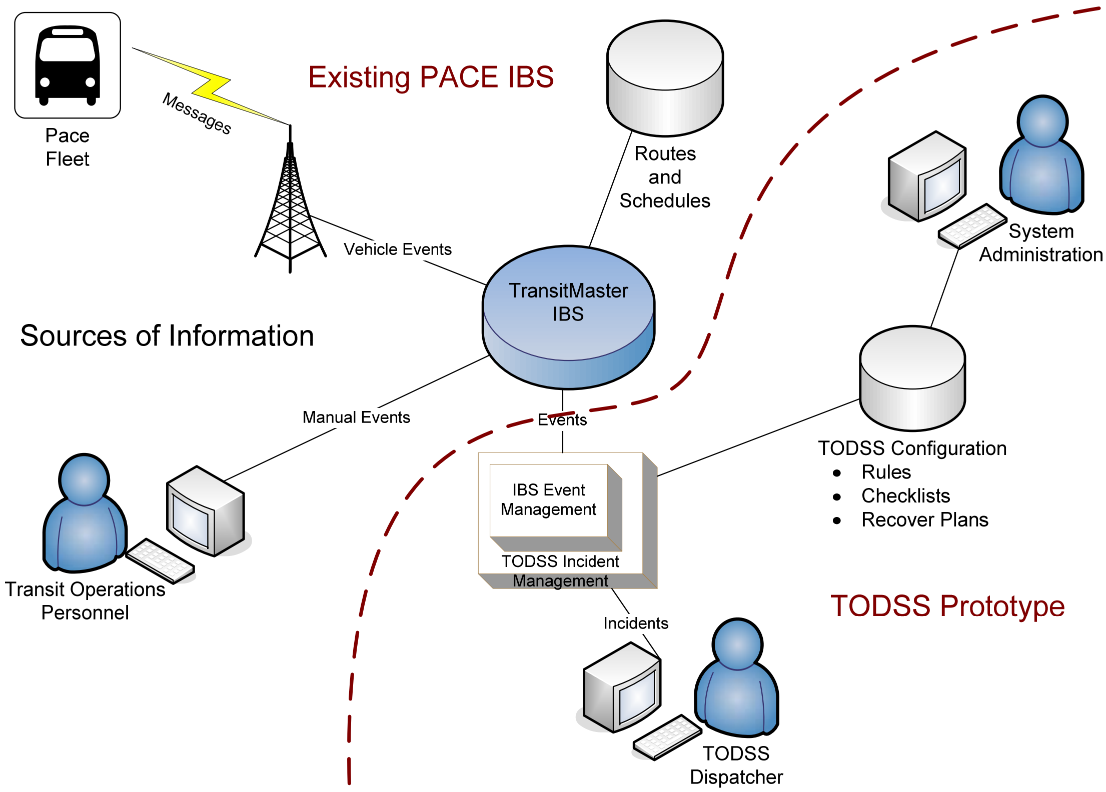

Figure 2 - TODSS Architecture within IBS Environment

Incidents are the output of the TODSS rule engine displayed in the dispatcher's incident queue. System administrators configure the TODSS parameters to identify operational scenarios and define the properties of each incident using the TODSS configuration application. The parameters and their thresholds values define TODSS Incidents, the incident triggering and update rules Checklists, and Recovery Plans.

A TODSS Incident Management service performs the following tasks:

- Process event messages from IBS vehicles and system components to generate the input to the rule-based creation of TODSS incidents
- Apply the TODSS event rules to create incidents as needed
- Manage ownership of incidents
- Apply work assignments
- Keep track of incident statuses as they are handled by dispatchers

- Update incident statuses according to the configured rules
- Prioritize/select of recovery actions
- Write an audit trail per incident to a database log table when an incident is deleted (by either the system or a dispatcher).

Removal of TODSS incidents may occur by one of the following methods:

- By the system when the incident expires
- By the system when the event parameter for an updating rule falls below the trigger threshold and the rule is configured to allow incident removal
- By the system as soon as the incident is completed, if there is any recovery plan attached
- By the dispatcher anytime, if no recovery plan is attached or the incident is flagged to allow such removal

The TODSS dispatch console will continue to support much of the existing IBS functionality for system status and actions. The new TODSS Incident Display will provide the interface through which dispatchers are informed of new incidents. It will also support the process to step through a recovery plan. By coupling this functionality along side existing IBS functionality, expedient links accomplish the service restoration tasks.

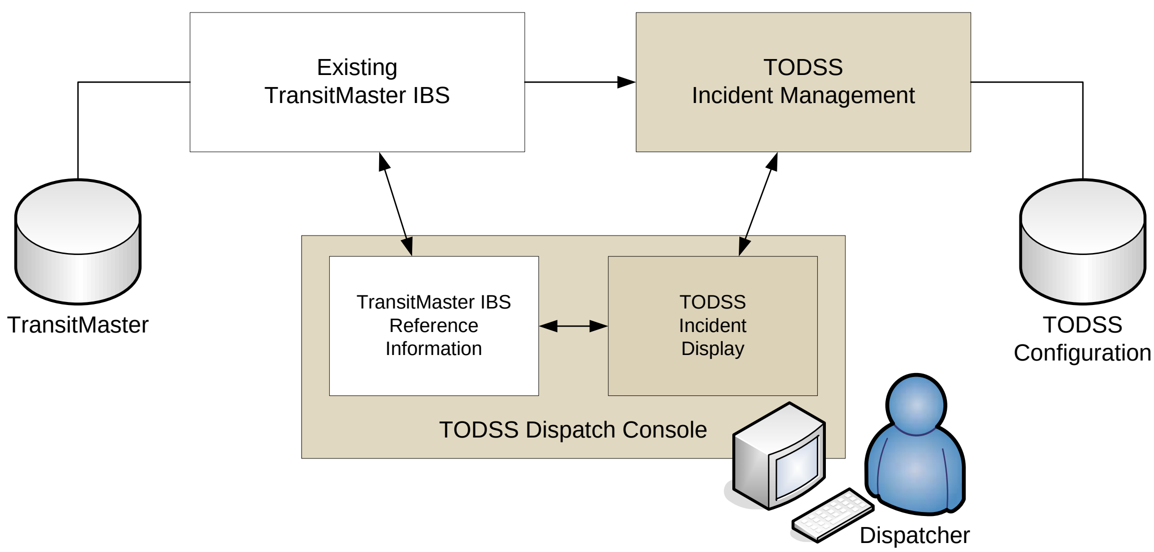

Figure 3 - TODSS Dispatch Console

5 TODSS Evaluation

The TODSS project evaluation focused on Pace's experience in implementing and operating the TODSS prototype to validate and verify the core TODSS requirements. Installation of the TODSS prototype completed and the system was operational on March 3, 2009. An operational test period for evaluation purposes lasted through May 15, 2009. The TODSS configuration was gradually refined and expanded during the operational test as users gained experience and understood how to take advantage of the new functionality. During this period many hours were spent observing users interacting with TODSS, monitoring system performance, and completing the system acceptance tests.

There was a similarity to the dispatcher's user interface going from the old IBS to the new TODSS. Each user interface is organized into four distinct windows for working on service disruptions. In the old IBS data messages were classified, but not prioritized, and displayed separately within emergency, talk, adherence, or other message queues. The messages came straight from the vehicles or the IBS system and placed in the appropriate queue. The adherence and other message queues would grow quickly, accumulating unattended messages as the day went on. The following figure depicts the message queue from the IBS system.

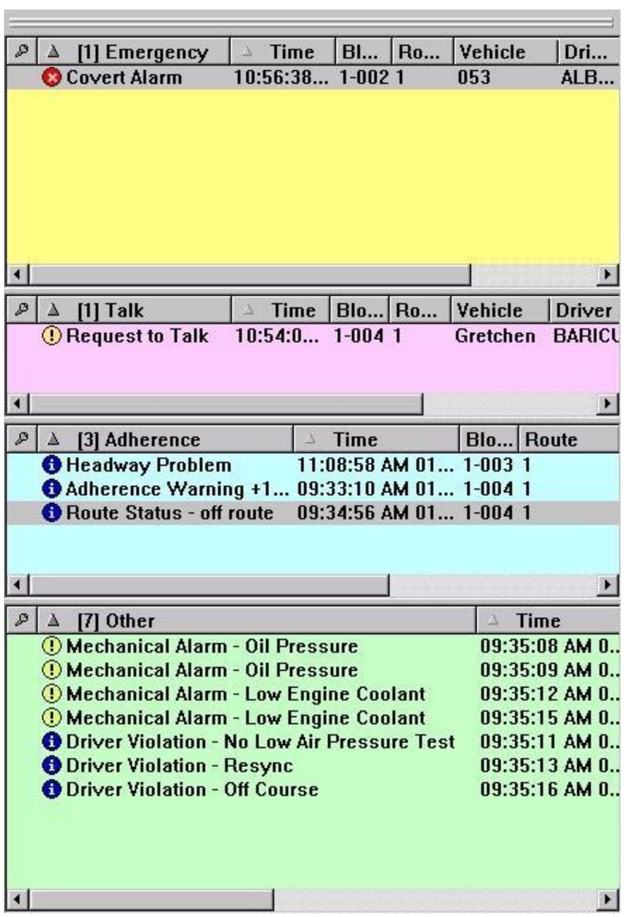

Figure 4 - Pre-TODSS Emergency, Talk, Adherence, and Other Queues

With TODSS, there are still four areas within the interface used in a much different manner. The TODSS business rule engine evaluates all data messages. If they meet pre-assigned threshold settings they become incidents, are assigned a priority, and are placed in the top window. Once a dispatcher selects an incident in the top window, the three windows below populate with the incident's related information and restoration strategy. The three associated windows include the Details window, Research window, and Action Plan window. Dispatchers have the option of choosing which incident to work on next within the incident queue with the assigned priority, based on agency policy, serving as a guide. The following figure depicts a TODSS incident queue illustrating the selection of a priority 70, Talk Request incident.

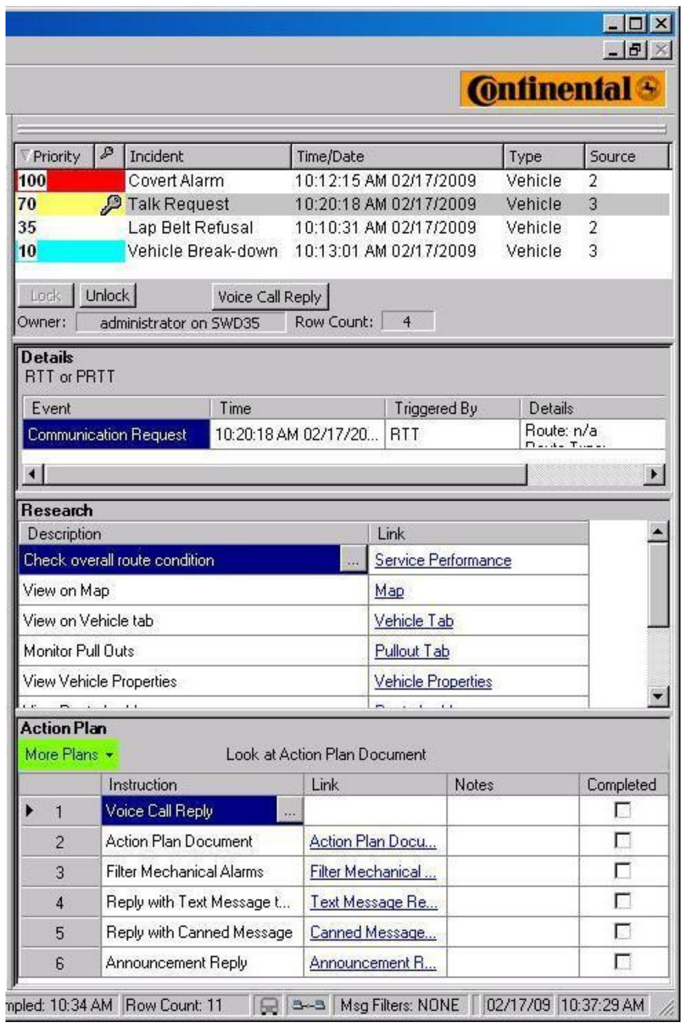

Figure 5 - TODSS Incident Queue

The evaluation included several methods of analysis. At the conclusion on the operational test period, data was gathered and compared with similar data from the previous year for the same period. In addition, a dispatcher survey was administered before TODSS went live and repeated after the operational test, key stakeholders were interviewed, and an independent investigator was brought in to verify and validate the findings. A recap of the findings as well as a discussion of the issues encountered follow in the remainder of this section.

5.1 Evaluation Results

TODSS proved that reducing the amount of information not directly related to actual service disruptions is possible resulting in dispatchers' ability to pay attention to all of the information presented. There were dramatically fewer incidents in the TODSS incident queues and it was observed that dispatchers acted on incidents soon after they entered the queue. Prior to TODSS, there were hundreds of messages not acted upon by the end of the day that were either not important, or important messages lost in the sheer quantity of messages in queue, or messages without any clear restoration actions. The following table demonstrates these finding by performing a comparison, using the database table that logs all system messages, to determine the difference in the number of messages sent in the pre-TODSS IBS system versus the number of incidents in the TODSS queue on a typical day.

Table 1 - Comparisons of Incidents Pre-TODSS versus TODSS

	Number of Incidents in Queue
Would have been in the pre-TODSS IBS	7,927 (not including adherence warnings)
Actually in TODSS	2,515 (including adherence warnings)

An attitude survey returned by over forty dispatchers and dispatcher/supervisors administered prior to the start of the project was repeated after the TODSS operational test period completed. A comparison of the survey results showed that the TODSS automation had a significant positive effect on dispatchers having the time to explore all related information provided by IBS related to an incident, knowing where to go to get the information they are looking for, and being able to access related information easily. The results also showed a positive change in dispatchers' use of printed material to make decisions implying that dispatchers may be acting in a uniform fashion throughout the agency.

Dispatchers praised TODSS for simplifying and streamlining their duties. Management praised the system for standardizing processes and, subsequently, providing detailed action plans to aid continuity among the division's responses to incidents. Management also commented on their expanded ability to receive real-time information through TODSS initiated emails at their desktop without the need to call or listen to the radio.

From the user's perspective, the TODSS requirements seem to have exceeded any expectations the Pace users may have had prior to implementation. All respondents felt that any similar agency would greatly benefit from having TODSS implemented. There appeared to be a clear need for a system like TODSS to fill gaps in the conversion of data into organized information to be acted on, and TODSS filled this gap successfully. Users seemed to recognize not only the direct positive impact TODSS had on their day-to-day operations but also the potential for a much larger impact as TODSS is expanded and familiarity with TODSS grows.

Other significant performance statistics support the TODSS hypothesis that providing dispatchers with decision support tools will improve their performance.

Table 2 - Before and After TODSS Performance Comparisons

Statistic	Pre-TODSS	TODSS
The number of data messages displayed to dispatchers decreased by over 60%	7,927 (not including schedule adherence warnings)	2,515 (including schedule adherence warnings)
Voice communications initiated by drivers to dispatchers (RTT) decreased by approximately 30%	More than 14,000	Less than 10,000
The standard deviation in dispatchers' response time to drivers' requests to talk dropped significantly	253 sec	171 sec
Incident reports decreased 36%	1417	907
Drivers' use of canned messages increased 7% (TODSS reduced the number of canned messages by 2/3)	12,286	13,187

5.2 Core Requirements Evaluation

The prototype development effort set out to validate the 120 core TODSS requirements. This project initially was envisioned to test several operational scenarios but ended up being a complete system that replaced Pace's previous IBS. A complete evaluation of all requirements is provided in the "Transit Operations Decision Support System Core Requirements Evaluation And Update Recommendations Technical Memorandum" available through the FTA and ITS JPO. The majority of the core requirements were included in the TODSS prototype development and proved valid and useful towards providing dispatcher support. There are three main functional requirements that given time should mature into a final product given more experience and industry feedback. These include:

- Summary status displays for all service disruptions is a core requirement. The configuration, presentation, and identification of the most important service indicators need to be better defined with broader feedback from transit agencies to make this a usable tool.
- Prioritization of restoration strategies as a core concept needs to evolve as more experience is gained. An agency and the industry need a mature theory of operations in order to build intelligence into the system to set these priorities automatically. The prototype development includes several methods to

accomplish this functionality but at this stage of development relies on manual intervention.

- Playback and fleet simulators that tests and demonstrates TODSS are provided for feedback to Pace. The next step is building a simulator to run an operational day's worth of data to allow testing of different responses. This will ultimately lead to greater simulation and prediction algorithms for better proactive management strategies.

5.3 Benefits

All levels of management and the dispatchers have confirmed that the TODSS has improved dispatcher service performance, the quality of the dispatcher responses has improved, there is greater uniformity of action among dispatchers, and that there is increased real-time operations communications from the dispatch center agency-wide. These responses are based upon the TODSS self evaluation results including:

- Documented reduction in incidents resulting in no backlog due to event processing based on Pace’s business rules
- Reduction in paperwork and double entry of data due to the greater accuracy in capturing data electronically within TODSS
- Prioritization of incidents and action plans removed guesswork by dispatcher’s to know what messages required a response
- Required restoration strategies, through action plans, result in a more uniform response within and throughout the divisions
- Integrated internet and email capabilities provide immediate internal and external operations communications, where management and line staff become more directly informed and aware of the day-to-day operations
- Greater use by dispatchers of the available CAD/AVL tools to find and review data related to incidents through TODSS automation

After using and experiencing TODSS, the user development environment was compared to having a visual programming language specific for transit operations. Using the conditional logic and syntax to manipulate the breadth of parameters and values for each real-time event became intuitive after training and hands-on experience. The flow of operations controlled through the TODSS business rule interpreter transformed the way the dispatcher now interacts with the CAD/AVL system. This “programming language” has the potential to support improvements in bus service management practices. The following figure illustrates the user interface and the definition of a triggering condition using an RSS feed parameter to trigger a Stevenson Expressway congestion incident.

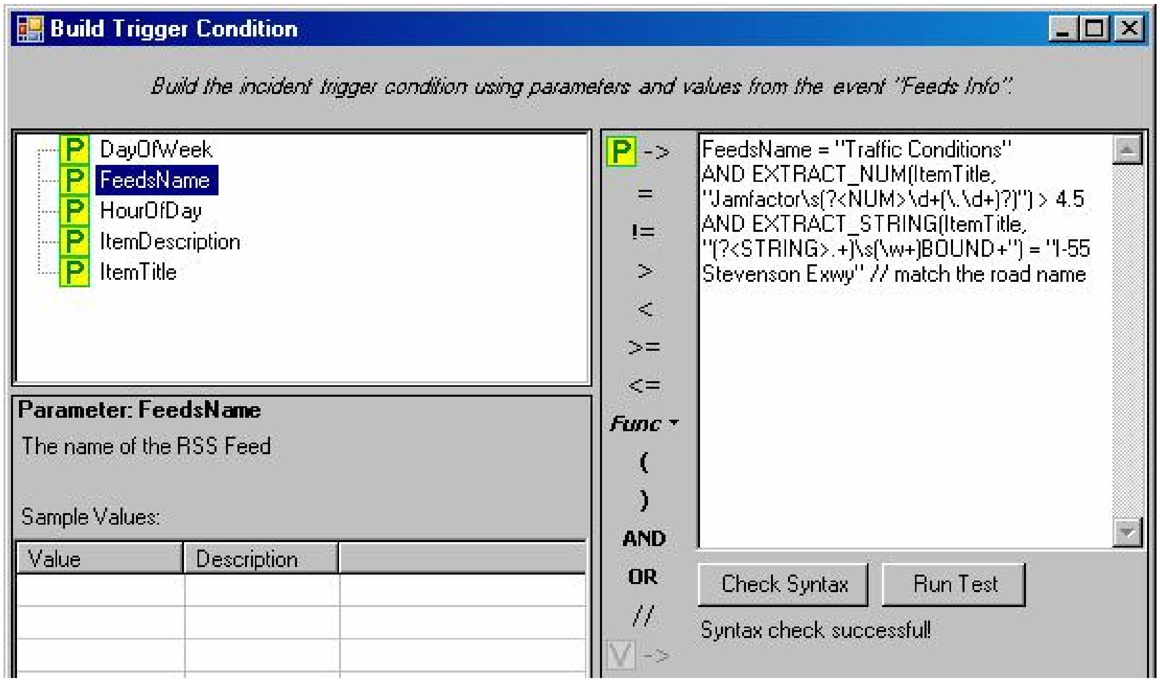

Figure 6 - Graphical Configuration of TODSS Parameters

The TODSS audit history made available through TODSS proved to be invaluable when making ongoing operational improvements. Pace operations management used the audit history to test the results of newly created incidents in a controlled work group and then make refinements based on analysis of the outcomes prior to the release to all dispatchers. The audit history was used to identify the performance level of individual dispatchers, to recognize the best practices, and identify those who need time and training to reach higher performance standards.

An unexpected benefit from TODSS was the ability to accurately define operational scenarios and isolate true service disruptions from those that were reported in the past based on faulty onboard equipment, communications problems, or operating conditions not pertinent to the service disruption. The TODSS "programming language" makes it possible to create compound rules to apply tests using onboard subsystem health messages and other parameters related to the vehicle or route. A compound triggering condition can narrowly define a specific operational condition using multiple parameters to test conditions such as:

- Does the vehicle have working GPS and a working odometer?
- Is the operator logged on and in revenue service?
- Is there available recovery time for this trip?
- Has a service waiver been placed on the trip segment?
- Is the vehicle in an exclusion zone?

The results from applying these compound rules is the ability to eliminate false alarms, ignore incidents addressed previously, or disregard issues that will resolve themselves thus freeing dispatchers from researching non-issues.

Pace demonstrated how TODSS could be used to help solve an operational issue through a targeted campaign quickly. During the operational test period, management was concerned that fixed-route operators may not be checking their lifts in a timely manner as required when leaving the garage. A TODSS incident was configured with a high priority with a detailed action plan for dispatchers to follow. The incident was tested and reviewed in the audit history by the TODSS administrator and it was determined that indeed there were some vehicle operators that were not performing the lift checks in a timely fashion. Within a week, after instructions were provided to all dispatchers, the incident was enabled in TODSS and the number of incidents was reduced by more than 50 percent. Compliance continued to improve during the next two weeks until this was no longer a serious problem by the agency working in unison to effect change.

During post implementation interviews with Continental Corporation, they anticipate that they could more easily meet new customer’s custom requirements with the new flexibility in configuring service disruptions. They can translate new operational scenarios into complex TODSS rules for an agency when they provide a clear concept of operation for a requested situation.

TODSS introduced many new route summary parameters not available in the previous IBS that can be used to determine when a service disruption reaches the threshold to become an incident. For example, distinguishing express service from feeder service permits each to have their own early and late operating parameters. In addition, actions can be tailored based on recognition on the over-all performance of all vehicles operating on a route. These new parameters are valuable for support of headway control, corridor management, and service reliability for customers.

5.4 Issues

A few core requirements were not as fully developed as others were due to this being a new venture. These requirements required experience working with TODSS to be able to understand how to develop them fully. Now that there is an understanding of how the dispatcher interacts with the TODSS and the capabilities of TODSS, these areas require future focus to realize the full potential of TODSS. An example of this type of issue was with prioritizing restoration strategies based upon operating conditions. In the prototype, this is primarily a manual function. With experience this should evolve into a more automated process

The first reaction of many transit professionals when first seeing the TODSS prototype was that this was going to be too hard for them to implement. The most challenging part of the project was the initial learning curve to implement the TODSS setup and configuration. Out of that experience, it was recognized that improvements in the configuration management of the TODSS rule base(s) needed to be made. These improvements would simplify the management of the various aspects of the rules, make it more understandable to operations personnel, and be more efficient for the TODSS administrator to manage. Once the project team understood the flow of operations within TODSS, it became easier to define operational scenarios within TODSS.

CAD/AVL in general and TODSS in particular need to get smarter at real-time routing changes. Changes to headways and schedules can currently be accommodated but when a new path of travel, which deviates from the planned schedule, is assigned then route and schedule adherence reporting falls apart. TODSS assistance with detour development is an area for potential growth. This would improve management of route deviations used to meet transit demand in out-lying areas with lower population densities. These cases of detours and adjusting service to meet passenger requests are becoming more prevalent in use by agencies of all sizes.

Much work has been done at the service planning level to improve quality of service. However, there has been little operational investment in developing a theory and practice of real-time bus service management that can be translated into improvements in the delivery of quality service. This effort is labor intensive, requires operational funding, and is difficult to demonstrate a return on investment in the short-term. Somehow, the word needs to get out that TODSS is an approach to actively manage the data from CAD/AVL systems and use it to improve the delivery of service. Experienced CAD/AVL users understand this better than first time users of CAD/AVL and recognize there is so much more the CAD/AVL system can be doing for them. There needs to be an effective means of sharing the positive findings from this TODSS prototype and relate it to active quality of service measures that agencies can institute. This will have a positive impact on the quality of real-time traveler information systems that are becoming more prevalent in transit systems of all sizes.

5.5 Lessons Learned

The project team learned many lessons as they worked on their understanding of the core TODSS requirements. Pace found that how the core requirements are implemented had a direct impact on their business processes and necessitated a change in their approach to daily operating procedures.

After several weeks of using TODSS, it was recognized that incident reporting by dispatchers was duplicating other dispatcher actions and was not nearly as important to complete as it was in the previous IBS system. A TODSS incident is easily linked to an automated email action with the ability to widely share all pertinent information in real-time to those with access to computers or internet enabled personal devices. The email option pushed the information out instead of users relying on after-the-fact printed reports.

After evaluating vehicle operator data messaging over the past three years, Pace determined that there was a better approach to this function. There was a safety concern that it took too long to find a message while operating the vehicle and became a distraction from operators’ other duties. Only those messages that were heavily used in the past were carried over into TODSS. Detailed messages were removed and the remaining data messages were at a level of detail such that the TODSS rules base could identify the operational scenario and apply the rules base to prioritize the incident and provide the associated action plans. The guiding principle was that if a data message was important enough for an operator to send, then it must be important enough for a dispatcher to take action. Dispatcher actions may be limited but the point is that agency policy dictates that every queued incident is deemed important enough to require research as part of maintaining situational awareness.

What became clear early on was the power of TODSS to manage and effect change in daily operations. However, this was only going to be realized through an investment in ongoing system management that required an agency focus on ongoing refinements and process improvements. Training would be critical to sustain this effort. There are three training programs needed for long-term success – training for system administrators, dispatchers, and operators:

- The TODSS system administrator(s) needs to grow with the system and broaden their understanding of the event-processing environment to make the refinements to the business rules that the agency requires.
- Dispatchers need to improve their TODSS and CAD/AVL skill levels and improve their understanding of the theory and practice of service management.
- Operator training and operator refresher training needs to emphasize role of operators in communicating early identification of service disruptions to the dispatch center by sending canned data messages.

It was found that the configuration and setup of TODSS is much easier if the agency has a theory of service management articulated in defined standard operating procedures. These can be translated into TODSS business rules easily without a major review process. In the absence of these procedures, TODSS forces a review of each scenario to a level of detail that can be translated into identification of the incident and the association with a thorough restoration strategy or strategies. This is typically what is in the experienced dispatcher’s head but not documented to share from dispatcher to dispatcher. This process of identifying service disruptions and defining the potential restoration strategies was of great benefit within Pace during the preliminary work setting up TODSS and ultimately TODSS became the repository where these business rules are captured.

One of the early suggestions provided by the dispatchers was the need to pay more attention to audible warnings to differentiate incidents as they enter the queue. The role that sound (and color) played in the dispatcher’s routine duties was underestimated during the initial setup and greater emphasis on the use of consistent sound cues was made by the TODSS administrator once this input was received. The reliance on these cues to supplement the information being presented is especially important when distracted by external events within the dispatch center.

5.5.1 TODSS Configuration Tool Planning

An approach, based on best practices learned during the initial training and use of the TODSS configuration tool, was outlined to make it easier for beginning users to start building their business rules within TODSS. The following list provides insight into how to think through an operational scenario and translate it into TODSS using the configuration tool.

- It is important to decide what incidents you want to appear in the TODSS queue. The philosophy to follow should be to include only those incidents that must be acted upon by dispatchers. Once decided, create the incident.
- If an incident is not triggered by an IBS event then create a manual event. These incidents will typically come from external sources such as a receiving an outside phone call. Create these manual events to be used in rule definition.
- Once an incident is created, then a rule that includes the associated event and trigger can be created. The rule will set the parameters that will insert an incident into the TODSS queue. Return to the incident later to complete the assignment of Action Plans and Research Lists.
- Action Items are the building blocks for both Research Lists and Action Plans. Try to create global or generic Action Items that can be reused in multiple Action Plans and Research Lists. Research Lists and Action Plans can be created once the Action Items are defined. Both are built by assigning one or more Action Items to the list or plan.
- Research lists guide the user in the initial fact finding while working on an incident. Suggestions provided in the form of an itemized list have links that takes the user to the various views and dialogs within the IBS application.
- The Action Plan is a list of recommended steps the dispatcher should follow to resolve the situation surrounding an incident. Each step includes a check box that must be checked by the dispatcher prior to closing the incident. Alternate actions can be documented in the comments field for each step.
- Take time to devise a naming convention that will facilitate the reuse of Action Items, Research Lists, and Action Plans. Also, devise a naming convention that easily correlates incidents to rules. Pace used a common set of prefixes to identify the source of information used by triggering rules for quick identification of incidents related to manual events, operator canned message events, emergency events, vehicle events, and external information.
- Always keep in mind:
  - What do you want dispatchers to see? These are your collection of incidents
  - What do you want dispatchers to do? Perform Actions contained in Action Plans and Research Lists.

The following screenshot from the TODSS Intelligent Decision Support (IDS) Configuration Application shows the user interface for working with and creating new

TODSS incidents. The top portion of the screen is a list of the existing incidents as defined by Pace. The bottom portion of the screen is the detailed settings for the first incident in the list. The left side of the screen provides the navigation tabs for the other configuration activities related to capturing the agency's business rules.

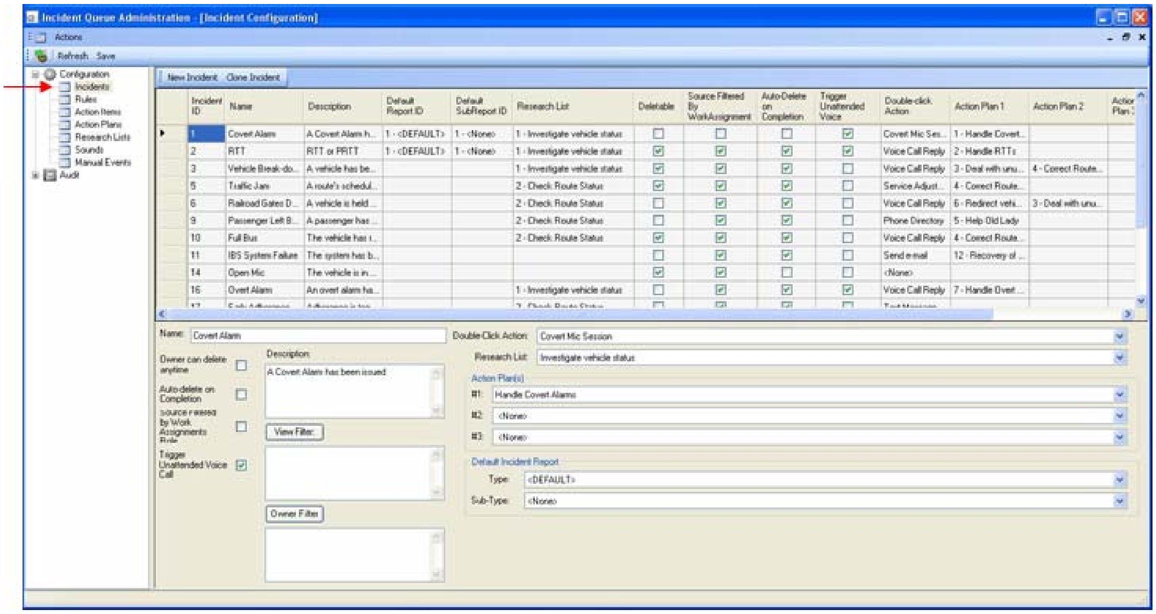

Figure 7 - IDS Configuration Application

5.6 Evaluation Summary

In summary, the technical evaluation validated and verified the core TODSS requirements. TODSS core requirements including information from outside sources, highly configurable parameters to identify service disruptions, and recommended service restoration strategies led to an organized and uniform approach to service management. A comparison of user performance before and after TODSS shows that voice calls reduced dramatically, dispatcher response times were more uniform, dispatchers were more comfortable using the systems information resources, and communications between centers and within the agency improved.

A key issue that transit agencies must recognize is that the setup of TODSS is much easier when the agency has a theory of service management articulated and defined in standard operating procedures. Training for system administrators, dispatchers, and operators is critical to sustain the TODSS effort and continually improve service management performance.

Early in the operational test period, it became clear that integrating internet and email capabilities into dispatcher action plans led to more active and direct management and line staff involvement in the day-to-day operations. Due to these capabilities, Incident Reports are less important given the process improvements initiated within TODSS and the easy access to the TODSS audit history that makes it simple to verify dispatcher actions.

During the operational test, it became clear that there was a need to improve existing CAD/AVL rerouting capabilities in support of unplanned detours due to any number of operational scenarios. Better real-time tools to change vehicle routing and schedules are a high priority for future development to make the most out of TODSS' ability to direct dispatcher focus and attention.

6 Recommendations

At the end of the operational test period, Pace and all those involved with the prototype development effort were convinced that the TODSS core requirements had the desired effect of improving dispatcher efficiency. The results showed that the core requirements were valid and that the prototype TODSS based on the core requirements was accepted by dispatchers and improved their job performance.

An outreach program needs to be developed in order to demonstrate to the vendor and transit agency communities the outcome of the prototype development. Both vendors and agencies need to share in the findings of this project to realize the TODSS project goal of developing a joint understanding of TODSS. Suggested actions include:

- Publicize and make the TODSS prototype reports publically available
- Make public presentations aimed at the transit industry at American Public Transportation Association (APTA) conferences such as the Annual Meeting and the Bus and Paratransit Conference
- Make public presentation aimed at a broader transportation audience where transit is involved such as regional and national ITS conferences, annual state transit conferences, the annual Transportation Research Board conference, and Transit ITS regional workshops
- Present articles to transit trade magazines and publications such as Metro Magazine, Mass Transit, Bus Ride, and Passenger Transport that provide the TODSS story to a wider audience
- Conduct online webinars such as a T3 webinar to share the TODSS prototype experience
- Provide peer-to-peer support and resources to promote TODSS deployment

In addition, it became obvious that the better the agency's internal business practices are documented, the easier it becomes to build the decision support rules. A synthesis of the current practices of bus service management techniques, strategies, and practices would be a first step in creating an inventory of service restoration strategies for general industry use that would have a direct impact on successful implementation of TODSS at other agencies. An expansion on the synthesis topic should include the theory behind the techniques. The theory should explore the conditions surrounding each strategy, the best alternative techniques to apply based on conditions, the necessary information, and expected outcomes. In addition to using this knowledge for real-time service management, guidance should be given on how to apply this knowledge into the route planning and service development process to provide operational guidance at a system level for anticipated service disruptions.

6.1 Recommended TODSS Prototype Improvements

As Pace used the TODSS prototype, the number and complexity of incidents and associated business rules grew steadily. A means for configuration management and assistance with a structured development process of the TODSS rules base would be beneficial. Further requirements definition is needed to identify methods to manage the library of active business rules and how to exercise version control on saved sets of business rules.

The view of historical data (currently 24 hours) was deemed useful to predict the severity of an incident. However, prediction capabilities would be greatly enhanced if the TODSS rules engine discerned patterns of operations based on longer date ranges. Daily, weekly, or seasonal patterns of operations and conditions could be examined and applied as parameters to better identify service incidents. Additionally, improved ability to prioritize restoration strategies would be possible using a longer historical record of changes related to the existing operating conditions. Expanding the domain of historical data beyond TODSS data to include access to fact tables or summary sets of data from external systems, such as traffic congestion, would also increase the utility of this function.

The prototype provides many methods to implement alternative restoration strategies, but all require manual input after a dispatcher review of the system information prompts a change in action plans. Further development of an automated restoration strategy prioritization process seems within reach given the successful experience of automated incident identification. Taking this a step further would include the automation and notification to change entire sets of active rules based on incoming sources of information such as severe weather alerts or emergency notifications.

TODSS uses RSS feeds to bring external sources of information into TODSS and make them available as parameters for event processing. This is used to assess traffic volumes, traffic speeds, road closures, weather, etc. TODSS should expand on this concept and export transit information by publishing selected TODSS incident information to external transportation management centers and other related entities. Core TODSS should consider web based internet standards for sharing data between centers.

However, requirements for TODSS integration with other transit agencies, traffic management centers, and other centers requires more definition and feasibility research to understand what information to provide and when that information is needed. Transit needs to understand what will be expected from them in the future based on other ongoing initiatives related to transportation management. In particular, the TODSS peers that are involved with the Integrated Corridor Management (ICM) program expressed a need for real-time transit and traffic data to complement their situational awareness to be aware of available transit assistance and to have current knowledge of the state of the transit and roadway networks. Further efforts and analysis to determine how to utilize a TODSS within the ICM should occur in the near future to reflect the ICM stakeholders' needs in requirements and design definition.

As more operational experience is gained, a good candidate for future research, if available, would be further development of simulation applications and new prediction algorithms. The TODSS prototype included a simulation tool to run the TODSS system using the complete configuration of Pace's schedule, fleet, employees, CAD/AVL settings, and the TODSS rules set. The simulator replicated the real-time system and was useful for training and testing purposes. Additional research that would define requirements and demonstrate the feasibility of applying different restoration strategies to the same incident for comparisons of the systemic effects would be useful. This additional simulation functionality would provide the basis for determining which alternative actions plans provide optimal results to adopt as standard operating procedures. Additionally, this would provide insight into developing better predictive capabilities for incident detection and service restoration processes. Developers of the TODSS prototype were hesitant to work in this area because of the lack of definition and the concern for future liability. The study needs to look at the technical and institutional issues related to predicting the future state and effect on the transit route, corridor, or system after applying alternative restoration strategies. The same tools could be used on historical data to test different strategies to determine the optimal solution for future consideration.

TODSS development is in step with the latest trends in business intelligence using the concept of complex real-time event processing for decision support just like what is being done in the finance and health care industries. Although the prototype TODSS was aimed at fixed-route bus service, there is no reason why it should not be applied to other transit modes operated by agencies including paratransit, flexible routes, and light rail operations.

6.2 Recommended Changes to the Core TODSS Requirements

TODSS requirements build upon existing CAD/AVL systems requirements and the core TODSS requirements interweaves specific AVL and CAD requirements together with decision support requirements. For example, core TODSS defines the detailed properties of an AVL map that are better off left to AVL requirements. TODSS only needs to reference the AVL map as an interface point for the data necessary to identify a service incident, monitor the situation, and support the TODSS real-time event processing. The specific CAD and AVL requirements in the TODSS requirements should be separated out and used as a best practice comparison for agencies with existing CAD/AVL systems or as a supplement to those developing the requirements for their first CAD/AVL system.

The following is a summary of proposed changes to chapter five of the core functional requirements document[1] based on the finding during the operational test of the TODSS prototype.

SI 3.4 Core TODSS shall have the ability to regulate the frequency of information updates (e.g. polling or event triggered reporting) in response to an event notification, service restoration action, or system status notification.

1 "Transit Operations Decision Support Systems (TODSS): Core Functional Requirements For Identification Of Service Disruptions and Provision Of Service Restoration Options 1.0" (Mitretek Systems for the FTA and USDOT ITS JPO; March 15, 2004)

(Suggest that the word "updates" be deleted, because it has several meanings within the TODSS environment, and replaced with "reporting".)

SI 3.5 Core TODSS shall have the ability to regulate the frequency of updates based upon the priority of the event or action being monitored and the data network's capacity to transmit and receive information. *(Suggest substituting "frequency of data reporting" instead of "frequency of updates". The updating process in TODSS is independent of the data reporting from the communications system. The term "updating" in TODSS is the concept of priority updating of an event that has been previously evaluated and generated as a TODSS incident based on changing conditions.*
This requirement may be better suited in the Service Disruptions section.)

SI 6 Core TODSS shall have the capability to accept overrides and modifications to threshold status for each source of information shown in Table 5-1. *(This requirement needs to be more specific and indicate if this refers to automated modifications, real-time user modifications, or near real-time modifications to system configuration. It is too ambiguous as written.)*

SI 8 Core TODSS design shall provide for modular implementation and incorporation of each Core source of information shown in Table 5-1. *(This requirement needs to be rewritten. An explanation of what a modular design means is needed. It is recommended that the requirement be changed to "…modular design that permits the addition of information sources as they become available in a local implementation of each Core source of information shown in Table 5-1.")*

SI.8.2.1. Core TODSS shall notify dispatchers when a source of information ceases to function on its status and the functions it impacts *(Recommend adding TODSS administrators and/or IT personnel to this requirement.)*

SD 1.1 [Desired but not required] The operational scenario should be identified based upon the sources of information shown in Table 5-2 and additional internal system variables (e.g. time of day, type of day) *(Recommendation is that this becomes a requirement. The power of TODSS was demonstrated when combining sources of information and internal system variables.)*

SD 1.3 System parameters for each operational scenario shall include: service disruption and other thresholds; prioritization criteria; and a response rules base. *(Recommend changing to "Properties for each operational scenario shall include: service disruption parameters and thresholds; prioritization ….")*

SD 1.4 Core TODSS shall have the ability to accept updates to the service baseline as required to identify service disruptions within the appropriate operational scenario. *(Recommend SD 1.4 and sub-sections 1.4.1, 1.4.2 be removed to a supporting CAD/AVL requirements section. SD 1.4 should be replaced with "Operational scenario parameters and thresholds shall be provided to recognize any planned or modified service changes. The level of sophistication of service modifications within the CAD/AVL shall be* *supported within TODSS by making available the appropriate parameters and thresholds to make intelligent decisions in identifying real service disruptions.")*

SD 2 Core TODSS shall have the ability to identify each service disruption type shown in Table 5-2 using the Core TODSS sources of information also shown in Table 5-2. *(Table 5-2 serves as a good model for identifying service disruptions. The introduction to the table should qualify that there are many other service disruptions encountered and those provided in the table serve as a guide to mapping inputs to disruptions Also, Connection Protection does not serve as a good disruption category. It should be renamed to Passenger Transfers with line items for Connection Protection (a connection that includes a spatial element), Protected Transfer (a known transfer to be actively managed), and Coordinated Transfers (route intersection where transfers are determined by the system upon request). A new transit input, Passenger Request, should be included.)*

SD 4.2 [Desired but not required] Core TODSS should also have the ability to set additional thresholds for each event. These should include: type of notification by contact (visual, audio, alarms), increased data collection, warnings of potential disruptions, or report generation. *(This requirement would make more sense if the word "properties" replaced the word "threshold". Thresholds imply some sort of test being applied whereas properties imply other associated behaviors. A threshold is simply a value of a variable that triggers an action according to the definition provided in Core Functional Requirements.)*

SD 6.3 Event tracking shall consist of monitoring the service associated with the service disruption and all service affected by the disruption identified in meeting functional requirement SD 4. *(Recommend this requirement be moved to 6.1 since it provides an explanation of the term "event tracking" that would be helpful for understanding the other requirements in SD 6)*

SD.6.4.2. Core TODSS shall provide notification to the dispatch center and others as called for in the response rules base when an end of event threshold is triggered. *(Recommend that the requirement be used sparingly if at all and follow the principle that dispatchers shall make all final decisions. The external communications should be left to dispatcher discretion and not automated based on end-of-life of an event.)*

SD 7 Core TODSS shall provide the ability to prioritize all service disruptions and notifications/actions triggered by defined thresholds in order to determine their importance/severity and order in event queues *(Recommend that SD 7.1 and 7.2 be removed. Recommend adding, "Priorities shall be assigned as part of the TODSS service disruption event processing based on the operational scenario requirements and associated parameters and values.)*

SD 8.1 The system status summary shall have the capability to summarize the amount (percentage) service by threshold value for each type of service disruption shown in Table 5-2. *(Recommend changing to "The system status summary shall have the capability to summarize the service by user-definable statistics including percentage* *values for route schedule, adherence, and load. The system status summary shall provide counts and other summary statistics as appropriate for the other service disruptions shown in Table 5-2.)"*

SD 8.2 [Desired but not required] The system status summary should have the capability to summarize the amount (percentage) of service by threshold value for additional thresholds and performance measures defined by the transit agency. *(Recommended change: "The system status summary shall have the capability to summarize multiple performance measures using different threshold values as defined by the transit agency.)*

SD 8.4 [Desired but not required] The system status summary should allow the playback, or display, of performance and trends for the time preceding the request, or of historic performance from previous days, weeks, or months. *(In practice, this is two requirements one for historical performance and one for historical system summarization and should be in separate line items.)*

SD 9 Core TODSS shall provide the ability to define and select as needed displays and notifications of current system performance and service disruption/event status *(SD 9 sub-sections are primarily CAD/AVL requirements. Public transit CAD/AVL products have matured to the point where this level of detail is no longer needed in TODSS requirements. Subsection 9.1 – 9.3 should be used as guidelines for CAD/AVL requirements.)*

SD 10 Core TODSS shall provide the capability to select and control the display of all potential screens and notifications identified in Requirement SD 9. *(SD 10 sub-sections are primarily CAD/AVL requirements. Public transit CAD/AVL products have matured to the point where this level of detail is no longer needed for TODSS requirements. Recommend subsection 10.1 – 10.4 be deleted and SD 10 changed to "Core TODSS shall provide the capability to select and control the display of all potential screens and notifications identified in Requirement SD 9 through filter capabilities, display order, and use of color, and screen size.)*

GS 1 Core TODSS shall provide the capability to select operators, supervisors, maintenance, public safety, and dispatch terminals individually or in groups for one or two way data and voice communications. *(Suggest that a more general requirement for GS 1 be written and delete the subsections.)*

GS 2 Core TODSS, hardware, software, and protocols shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the United States Department of Transportation (No ITS standards or interoperability tests have been officially adopted by the U.S. DOT as of January 2003) (*Recommend updating the requirement)*

GS 3 [Desired but not required] Core TODSS should use ITS standards that have been approved and published by their associated Standards Development Organization (SDO) where it is affordable and practicable to do so. These include but are not limited to the

SAE 1708/1587/1455 Vehicle Area Network standards for the vehicle sub-system, and the NTCIP Transit Communications Interface Profiles (TCIP) dialogues published by the American Public Transportation Association (APTA) when they become available *(Recommend updating the requirement; TCIP has been published by APTA)*

GS 4.1 [Desired but not required] Where functions and interfaces do not exist within the National ITS Architecture suggested additions should also be included. The Turbo Architecture Tool developed by the Federal Highway Administration's ITS Joint Program Office may be used for this purpose (*Recommend updating the requirement; the ITS Joint Program Office is now a part of the Research and Innovative Technology Administration)*

GS 5 Core TODSS shall have an open system architecture and provide for interoperability, interconnectivity, portability and scalability across various hardware platforms and networks. *(Scalability is important but not necessarily among hardware platforms and networks. What is most important today is that TODSS works in a TCP/IP network environment, that the CAD/AVL/TODSS data is publicly available, and the CAD/AVL system follows industry interface standards or provides open protocols for integrating ITS systems as they become available. If standards such as TCIP can be successfully demonstrated in the future then the prospects for a stand-alone TODSS application would be more likely.)*

GS 7 Core TODSS shall be modular in order to minimize the time and complexity involved in upgrading existing components, incorporating new sources of information and interfaces, or adding new functions and capabilities. *(Too much ambiguous detail in this section. Suggest GS 7 address meeting standard software engineering practices and require a Quality Assurance program. Delete GS 7.1 and GS 7.2.)*

GS 7.3 Where ever possible all system options and application logic shall be maintained as separate parameter files and not directly coded into the TODSS system. *(This is an important TODSS requirement and should be moved into the Service Disruption and Service Restoration requirements sections. The requirement should strongly state that setting parameters and values are a user defined activity).*

GS 8 Core TODSS shall provide the capability to update the service disruption identification thresholds, disruption and restoration strategy priority weights, and restoration strategy response rules using user supplied inputs and parameter values. *(This is an important TODSS requirement and needs to be moved into Service Disruption and Service Restoration sections.)*

GS 9 Core TODSS shall provide for identification and notification of the failure of key components of the system or its core information sources. *(This is an important TODSS requirement and should be moved into the Service Disruption section.)*

GS 10 Core TODSS shall provide the capability to monitor and archive an audit trail of all system events, parameters, data communications, screen displays, notifications and alarms, logons, and actions performed by the system and those interfacing with it (dispatch, supervisors, operators, public safety, maintenance and remote terminals) *(This is an important TODSS requirement and should be moved into the Service Restoration section. The focus of the requirement should be on TODSS and not CAD/AVL data. The audit should be on the displayed service interruptions, dispatcher actions, and all related rules and actions.)*

GS 11 [Desired but not required] Core TODSS should provide the capability to replay system conditions and events either from short term on-line storage or longer term archived information. *(This section is too detailed and sections GS 11.1 and 11.2 should be deleted. GS 11.3 is not a playback function but rather a simulation and modeling tool that should be a separate requirement.)*

GS 12 Core TODSS shall provide multi-level password protected access control through logon and logoff procedures for all terminals, monitors, and data ports. *(This section is too detailed and GS 12.1, 12.2, and 12.3 should be deleted. GS 12 should be in Service Disruption and Service Restoration sections with an express concern of adding TODSS to the CAD/AVL security scheme.)*

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Appendix I - TODSS Prototype Concept of Operations Technical Memorandum

Prepared by Pace for FTA Office of Mobility Innovation U.S. DOT ITS Joint Program Office
January 2007

LIST OF ACRONYMS

AVL	Automatic Vehicle Location
CAD	Computer Aided Dispatch
CTA	Chicago Transit Authority
DOT	Department of Transportation
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
FTP	File Transfer Protocol
GIS	Geographic Information System
IBS	Intelligent Bus System
ITS	Intelligent Transportation Systems
JPO	Joint Program Office
MDT	Mobile Display Terminal
OTA	Over the Air
RTA	Regional Transportation Authority
TMS	Transportation Management System
TODSS	Transit Operation Decision Support System
VLU	Vehicle Logic Unit
WLAN	Wireless local Area Network

1 Scope

1.1 Introduction

This document is intended to define the vision to advance the performance of Pace dispatchers by building a prototype decision support system based upon industry consensus core requirements. The intent of the prototype decision support system is to enhance the performance of the existing Computer Aided Dispatch (CAD) and Automatic Vehicle Location (AVL) system to realize an improved level of customer service through programmed assistance to dispatchers.

This document is intended to describe who is involved, how they will interact, and how they will operate and maintain a Transit Operations Decision Support System (TODSS). A complete set of core requirements for TODSS has been developed and Pace will tailor those requirements into their operating environment. This Concept of Operations is intended to set the context of the functional requirements and provide a guide for the operation and maintenance of the system.

1.2 TODSS Overview

Pace is the selected agency to demonstrate the feasibility of a decision support system for transit dispatchers based upon the TODSS requirements developed for the FTA Office of Mobility Innovation. Pace intends to enhance their existing Intelligent Bus System (IBS) so that dispatchers will be assisted with early detection of service disruptions linked with associated service restoration options. Today, IBS provides AVL and CAD functionality that includes a subset of the requirements for early detection of disruptions. The desire is to enhance IBS to better recognize patterns of disruption, prioritize dispatcher required actions, and suggest strategies and solutions to restore transit service that leads to minimal disruption to the transit riders.

Pace has been careful to implement the IBS methodically to ensure that all dispatchers are competent and actively using the IBS advanced communications as well as managing the drivers to ensure proper login to the IBS. However, the dispatchers are finding they don't have the time to take advantage of all the information that IBS is providing. Competing demands for Pace dispatcher attention, such as driver scheduling and assignment, prevent active study and attention to the IBS system. Individual events are reported faster than can be recognized and processed by the dispatchers. In addition, many of the advanced CAD functions are not being used. Pace's goal for the TODSS project is to enhance dispatcher focus, promote an organized proactive response to transit service disruptions, and provide consistent decision support for both the unusual and routine service disruptions for all dispatchers.

Pace will be working with Siemens VDO, the IBS system vendor, to develop the TODSS prototype based upon the defined core requirements and inputs based upon Pace's unique service and operating procedures. Areas targeted for development include improved assignment of threshold values of data messages that identify patterns of disruption, enhanced prioritization of events requiring dispatcher response, and incorporation of Pace business rules to provide response options to the dispatcher that requires their attention.

The Pace service area has a population of over eight million and a service area of 3,500 square miles. There are 807 fixed-route vehicles with total ridership in 2005 approaching thirty-seven (37) million. Pace is comprised of nine (9) independent operating divisions with the following characteristics:

- Provide their own dispatch, drivers, and vehicles
- Mix of small, large, urban, suburban transit services
- Diverse Geography
- Single face to the region
- Shared administration and infrastructure

A process of evaluation, restructuring and realignment of routes is underway as part of Pace's Vision 2020 plan. IBS is currently providing a wealth of data to serve this effort. An internal Pace cross functional team has been created as part of the TODSS project that seeks to apply the theory and design strategies of the service development effort with the realities of daily operations. The purpose of the Team TODSS is to assist with the definition of the business rules that will form the basis of the decision support system. It is anticipated that TODSS will play a part in system improvement within the evolving mix of transit services in Northeastern Illinois.

1.3 TODSS Boundaries

In order to successfully deploy and demonstrate the TODSS concept the FTA determined to place boundaries on the project. First, it is stated that the TODSS must be feasible to add into an existing ITS environment and at the same time meet the stakeholders needs. Second, the TODSS is intended to be deployed at a single agency using existing radio dispatch center(s). The prototype is intended to focus on TODSS requirements and not center-to-center protocols. Third, the industry outreach did not include paratransit participation. Therefore, the prototype's focus is on fixed-route bus service. Finally, the TODSS prototype is intended to use transit agency information exclusively.

1.4 Document Overview

This document is intended for those Pace employees that are involved with managing the day to day operations at the divisional level. Additionally, it is intended for any Pace employee that is involved with designing routes and schedules, monitoring or defining operational standards, or managing the fixed-route transit services provided by Pace. Stakeholders are encouraged to review and provide input regarding any concerns, priorities or needs that may require additional consideration. This document is also intended to provide the system designers and developers an understanding of how TODSS will be used.

The organization of the remainder of the document includes:

- Chapter 2 outlines resources used in developing this Concept of Operations
- Chapter 3 will describe the current IBS and the overall system and components of TODSS.
- Chapter 4 will discuss both primary and secondary stakeholders.
- Chapter 5 will provide an operational review including the roles and responsibilities of the primary stakeholders, interactions, and coordination of operating the TODSS.

1.5 Referenced Documents

The following resources were used as a reference for developing the Concept of Operations and can be used to advance an understanding of the system engineering process:

- TMS Pooled-Fund Study "Developing and Using Concept of Operations in Transportation Management Systems", 2005
- FHWA Report # FHWA-OP-02-046, "Building Quality Intelligent Transportation Systems Through Systems Engineering", 2002

Reference documents used to develop the operational plan included:

- "Core Functional Requirements For Identification Of Service Disruptions And Provision Of Service Restoration Options 1.0", Mitretek Systems For FTA Office of Mobility Innovation (TRI-10) U.S. DOT ITS Joint Program Office (JPO), May 2003
- Siemens VDO TransitMaster™ System Administration Overview
- Siemens VDO Operations System Dispatcher Manual

The Pace IBS Operations Support Group provided input on the current IBS. The Pace Team TODSS provided input on the operational details contained in this Concept of Operations.

2 Current System and the Need for Change

IBS is a sophisticated system combining radio communications, data networking, onboard vehicle computers, mobile displays, global positioning satellites, and a suite of software that provides computer aided dispatch for public transit. Voice and data messages are sent back and forth from the vehicles and the dispatchers. The dispatcher can locate a vehicle on a map or within tabular displays and find a wealth of information including such information as vehicle health, location, schedule adherence, and operator assignment. Vehicle communications are controlled by dispatch with data messaging used to keep the voice communications to a minimum.

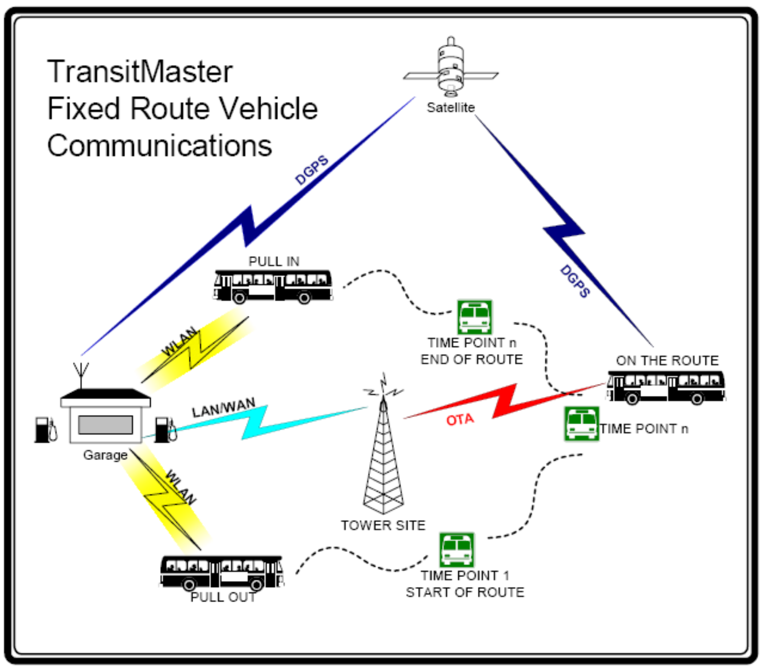

Figure 8 - Appendix 1 Vehicle Communications

Global Positioning System technology is used to track the location of a vehicle. There are two means of wireless data transfers to and from the vehicle, over-the-air (OTA) and wireless local area network (WLAN). There are five tower sites for OTA data communications and a separate trunked radio system for voice communications. The WLAN uses File Transfer Protocol (FTP) and supplies high-speed bi-directional communications. Vehicle Mobile Display Terminal (MDT) files and configuration information is transferred via uploads and downloads.

Real time data messages are transmitted to and from the vehicle using over the air (OTA) networking. These messages primarily provide vehicle status information regarding:

- Voice and data communication
- Schedule data
- Vehicle information

- Wide area - radio coverage domain information

The download of data (from IBS) occurs when the vehicle ignition is turned on or off. Information downloaded to the vehicle includes:

- Schedule data
- Annunciation data
- Vehicle firmware, hardware, and software configuration file settings
- MDT display formatting files
- Radio coverage polygons
- Text messaging files

The upload of data (from the vehicle) occurs when the vehicle ignition is turned off . Information uploaded from the vehicle to IBS includes:

- Passenger Counts
- Odometer Information
- Logged Events
- Non-delivered messages

Polled Location messages are transmitted using the OTA network only. If the OTA network is unavailable, these messages are not captured. See Appendix A for a complete system diagram of the data and communications infrastructure.

The IBS receives data from several existing Pace applications. Route, schedule and stop information is supplied from the Hastus Scheduling application. Driver, supervisor and mechanic badge number data is received from the Human Resources application. Vehicle information comes from the Transit Information System (TIS). Reports from the IBS are created and generated using Crystal Reports. Other onboard components of the IBS include automatic passenger counters, destination sign interface, transfer connection protection, fare box interface, automated next stop audio and visual announcements, and automated step well announcements.

The IBS system provides dispatchers with an enormous amount of data in real-time. Unfortunately, the dispatchers are unable to take full advantage of the service data and operational tools that IBS provides. One factor limiting the ability to respond to the IBS inputs are the external demands placed on Pace dispatchers including such tasks as recording incidents in multiple systems, scheduling operators to work assignments, and the check-in of operators at the report window. Another factor is the volume of incoming data is too much for a dispatcher to absorb and analyze in real-time. To address these obstacles, an assessment of the dispatchers' processes has started with an outcome of a set of business rules to be applied to form the basis of the dispatcher decision support system. The outcome of the assistance to the dispatchers include:

- A uniform set of response options readily available to all dispatchers

- Dispatchers able to take a more active role in applying appropriate service restoration strategies
- Review and analysis of the historical record of applied service restoration options to improve dispatcher performance
- An historical record of service disruptions to be used when planning new and/or improvements to existing service
- Greater service reliability and schedule adherence from improvements resulting from dispatcher's proactive application of restoration strategies

The IBS provides a substantial portion of the TODSS core requirements. Examples of these requirements include functions such as the AVL map, voice and text messaging, real-time message queues, tabular displays, and tools to monitor and manage the fleet. These tools include:

- Service Monitor that provides automatic system level adherence (early or late) and headway (percentage) status alarms
- Playback the provides a graphical display of historical data
- Planner where the assignment of services to each day, plan for pending sign-up periods, and assignment of service waivers are entered
- Route Ladder that graphically represents a route(s) for headway and schedule monitoring
- Survey Tool for recording location and attributes of stops and routes
- Route Manager where input of schedule information from Hastus, assignment of announcements, display sign changes, and parameter settings such as arrival and departure zones, announcement zones, and speed are coordinated
- Client Monitor to view system operation health
- MCC Monitor to view and configure data communications parameters
- TMSecurity Manager to setup and configure user access and privileges to IBS
- TMConfiguration Manager where the global system parameters are set

In order to meet the remainder of the core TODSS requirements the IBS requires that three functional areas be added to the IBS. First, core TODSS requires notification by external non-automatic data sources. These sources may include customers calling on cell phones, contact from other control centers, or calls from local road commissions. These outside sources of information need to be integrated with TransitMaster™ voice and data messaging to provide the TODSS a complete set of source information. Second, IBS needs to incorporate a rules base that defines when incoming data truly is, or will become, a service disruption and to set the priority level that dispatchers should respond. Third, service restoration options and strategies, based upon the nature of the notification or the identified operational scenario, should be provided to dispatchers for a unified agency approach to service management. TODSS will target these three areas for development in a user interface that will address the need to provide dispatchers the focus and assistance on the most critical events to maintain a high quality of service.

3 TODSS Stakeholders

To understand better this new system it is helpful to look at the users and their interactions with the TODSS. The users that will directly interact and use the TODSS are referred to as the primary stakeholders. They include the key IBS users. The secondary stakeholders are those users that will interact with the system indirectly through the outputs of the system or by providing data inputs to the system. The secondary stakeholders will rely on the TODSS functions in their roles as contributors to the delivery of transit services.

3.1 Primary Stakeholders

The primary TODSS stakeholders are those users that directly operate and interact with the TODSS. These primary users play a significant role in the system function

3.1.1 Operators

Operators log into the IBS at the start of their shift. They provide information either through data messages or voice communications that identify potential or actual service disruptions to their dispatcher. They work with dispatchers and road supervisors to make any corrections required to maintain service. Their vehicle is continuously sending data messages that provide important information about the vehicle that may lead to identifying a service disruption. Their supporting technology includes the onboard MDT, automatic passenger counters (APC), and mobile radios.

3.1.2 Dispatchers

Dispatchers are the primary users of the IBS and are responsible for situational awareness and recognition of service disruptions. Dispatchers provide work assignments, vehicle assignments, and materials to operators reporting for work at the garages. Dispatchers are responsible for ensuring operators log in to the IBS system and leave the garage according to schedule. The dispatcher is responsible for making the decisions that are best for maintaining the transit service based upon the available resources of operators, vehicles, supervisors, and support staff. Unplanned events and actions are documented in IBS incident reports, mainframe daily operation reports, and/or in one of several manual logs. Dispatchers coordinate the communications and actions of safety, maintenance, and supervisory personnel to respond to incidents as they occur in the field.

3.1.3 District Field Supervision

Field Supervisors support the dispatchers and operators by monitoring service, providing information to customers, and supporting the operators. They are typically the first responders to incidents to assist customers and coordinate the incident response at the scene. They have access to MDTs and in some instances IBS mobile laptops. With the laptops, the field supervisor has access to IBS and become more actively involved in monitoring service and incidents. They work closely with dispatchers to coordinate and prioritize their activities while on the road.

3.1.4 System Administrators

The system administrators are responsible for setting system parameters, system configuration, and system monitoring. The IBS is a highly configurable system capable of being setup to add vehicle hardware systems, change infrastructure, and edit operating parameters as operational policy changes. They must understand the system implications of the settings and apply the settings to meet the policy and service goals of Pace. These setting include the thresholds and priorities that determine the display of data to the dispatchers and users of the real-time IBS.

They work closely with the scheduling department to prepare new schedules and announcements for IBS in preparation for new operator picks and service changes. Currently, system administrators provide quality assurance for dispatcher response to emergencies, requests to talk, proper logon, and any system anomalies. System administrators oversee the maintenance of the historical data from IBS and ensure that data is accurately captured and properly stored.

3.1.5 Scheduling

The schedulers prepare the Hastus export files necessary for new transit schedules that include new service, modified service, and/or operator assignments. They work with the IBS system administrators to resolve any problems as the schedules are merged for use in the IBS.

3.1.6 Maintenance and Tech Services

Maintenance participates in real-time operations by consulting with dispatch when vehicle problems are identified. Maintenance assists dispatchers with troubleshooting vehicle problems and makes the decision when a road call is necessary. Maintenance includes the inspection of the IBS equipment as part of the fleet-wide preventive maintenance program. Tech services is responsible for the communications system. They monitor the communications system and respond to problems with the fixed end radio equipment. They also are responsible for the repair of IBS vehicle equipment.

3.2 Secondary Stakeholders

The secondary stakeholders interact with the system but are outside the scope of the daily operation of the IBS and TODSS.

3.2.1 District Level Management

District Superintendents and the Assistant District Superintendents monitor and assist dispatcher activities as required. They become involved in real-time operations when high priority service disruptions occur. They rely on historical data generated by the system to investigate and manage the transit operations.

The Safety Supervisor responds to the scene of any serious accident or incident where personal injury or substantial damage to property occurs.

Payroll Administrators are responsible for processing overtime request slips for payroll purposes. These slips are filled out and submitted by dispatchers to account for changes in operator’s daily scheduled payroll hours.

3.2.2 Headquarters Operations Management

Historical data is used for providing support for system performance measures such as on time performance. The data also supports analysis of regional and district operational performance. Operations Management is involved in high priority service disruptions and emergencies where they assume a leadership role.

The Sign and Shelter Crews report to headquarters management and work with the scheduling group and IBS system administrators for the proper maintenance and placement of active bus stops, signs, and shelters.

Service Monitors provide the GIS survey work of routes and stops. This information is included with new or adjusted route data prior to implementing changes in the IBS system. A survey to identify the precise location of time points and the path of travel is required for accurate schedule adherence and off course monitoring. The information is coordinated with IBS administrators, Scheduling, and the Sign and Shelter Crew.

3.2.3 Service Planning

The GIS group provides data layers for the IBS map display such as Metra train station locations, bus stop locations, and garage locations. GIS services are called upon for displaying historical data for informational purposes.

Service Planners use historical IBS data to adjust routes and schedules. Historical passenger loads and adherence data are one source of data for route design and service development. The Hastus ATP module has been introduced to determine trip segment running times and route recovery ratios based upon historical adherence data.

3.2.4 Marketing

Passenger Services is responsible for capturing all service disruptions for customer information purposes. They handle all, with the exception of trip planning requests, customer calls and use the IBS playback function to examine historical data to validate reported concerns, compliments, and complaints. They have access to real-time IBS information as a supplemental source of information for customer service calls. Incident information that affects the Pace service is provided to Passenger Services by dispatchers. Incidents may be included on the Pace internet web site as a “passenger notice”.

3.2.5 External Entities

The riding public is the end user of the service and benefits directly in time and convenience from more effective transit operations. More and more the riding public is becoming a source of information, by using their cell phones, to provide early notice of vehicle breakdowns, late trains, and transfer requests.

Metra and CTA are the other service boards that collaborate in transportation services in Northeast Illinois. They make connections with Pace service and their customers rely on transfers between carriers. These agencies rely on Pace to assist when they experience train delays. All three agencies are involved in emergency planning for the region.

The Regional Transportation Authority (RTA) is the financial review and oversight agency for Pace, Metra and CTA. The RTA hosts the Travel Center that provides trip planning, route and schedules, and other transit information for the region. Pace provides service updates as they occur to the Travel Center for dissemination to the public.

Municipalities fund and contract with Pace to provide local transit service. They are a regular source of information related to special event planning, street and road construction, and other service concerns in their jurisdiction.

4 Nature of TODSS

4.1 Description of desired changes

Pace desires a user configurable system that includes integration, enhancements and changes to the IBS. Taken together the changes will provide dispatchers with a decision support system that supports system regularity, active personnel management, punctuality, and transit service that meets the regional transportation demand. The communications dispatcher role will be supported by the following changes:

- Notification of only those service disruptions that require dispatcher attention
- Priority assistance for dispatcher guidance in addressing the most critical disruption notifications first
- Ability to include external sources of information into the dispatcher's support system
- The combination of enhanced service parameters and thresholds to classify incoming data for service disruption notifications
- Ability to associate and display response options to the notification of both potential and actual service disruptions
- Action plans that consistently guide dispatcher through all available IBS tools and restoration strategies
- Increased historical documentation of service problems and dispatcher actions for improved transit system analysis

4.2 Priorities among changes

- Look at time of day and service level to determine schedule and headway notifications
- A rule based configuration utility to provide the logic for recognizing problems and associating appropriate response options
- A reduction in notification messages that include only those that require attention in real-time
- Response options presented to dispatchers that follow Pace best practices
- Dispatchers implement and record restoration actions for accurate customer information displays and historical data
- Management review of dispatcher decisions for continuous improvement and to refine and build an improved set of restoration strategies

4.3 Description of the proposed system

From the Operators perspective there will be a refinement of the available text data messages that can be sent manually. By streamlining the set of data messages, including only the most frequently used messages, Operators will communicate directly by sending data messages with less reliance on lengthy voice calls. Notification to dispatchers and the return response to the Operator will be improved by the TODSS thresholds and priorities that can be matched to the individual text data messages.

IBS text messages, schedule adherence messages, system health messages, and mechanical alarms are examples of event message types used as sources of information for notification purposes. TODSS will process these data messages and apply Pace defined business rules to determine whether to display the message and the priority of response.

The dispatch priorities to apply to operational scenarios include:

1. Extra operations support required for immediate assistance
2. Dispatcher and Road Supervisors immediate response
3. Dispatcher response balanced with other operational demands
4. Situation may require monitoring, no action required
5. No action required

The TODSS will provide for manual input of operational scenarios by the dispatcher based upon external information sources. Examples of manual sources of information include weather related information or an emergency event based upon receipt of a telephone call. These manual inputs shall act as a service disruption notification, be related to a service restoration response strategy, and include a priority level to be integrated with the IBS generated notifications.

A TODSS configuration tool shall provide the means for creating the manual inputs, assigning priority levels to message types, and setting display thresholds for notification to the dispatcher. The identification of service disruptions shall be based upon the set of rules that takes into consideration the time of day, service level, and service (e.g. weekday, Saturday, Sunday) applied to the sources of information. Service levels such as Arterial, Feeder, Express, Circulator, or Planned Special routes will dictate their unique threshold settings.

The following diagram illustrates the TODSS processing of data messages that lead to a service notification to the dispatcher. The top box represents the existing IBS system and the various CAD functions used to trace the impacts of service disruptions and adjustments. The two yellow boxes on the left side represent data messages from the Siemens TransitMaster system being sent to the Service Disruption Identification decision engine. Once a message is analyzed and associated with a known operational scenario the appropriate response strategy is selected from the Rules Based Responses. Both the disruption and the response are sent to the TODSS user interface situated in the middle of the diagram. The user interface includes an area for external sources of information to be manually entered into the TODSS. The bottom of the user interface contains links to references, CAD functions, and tools to provide automated setup of CAD system views tracing the status and impacts of the disruption notification.

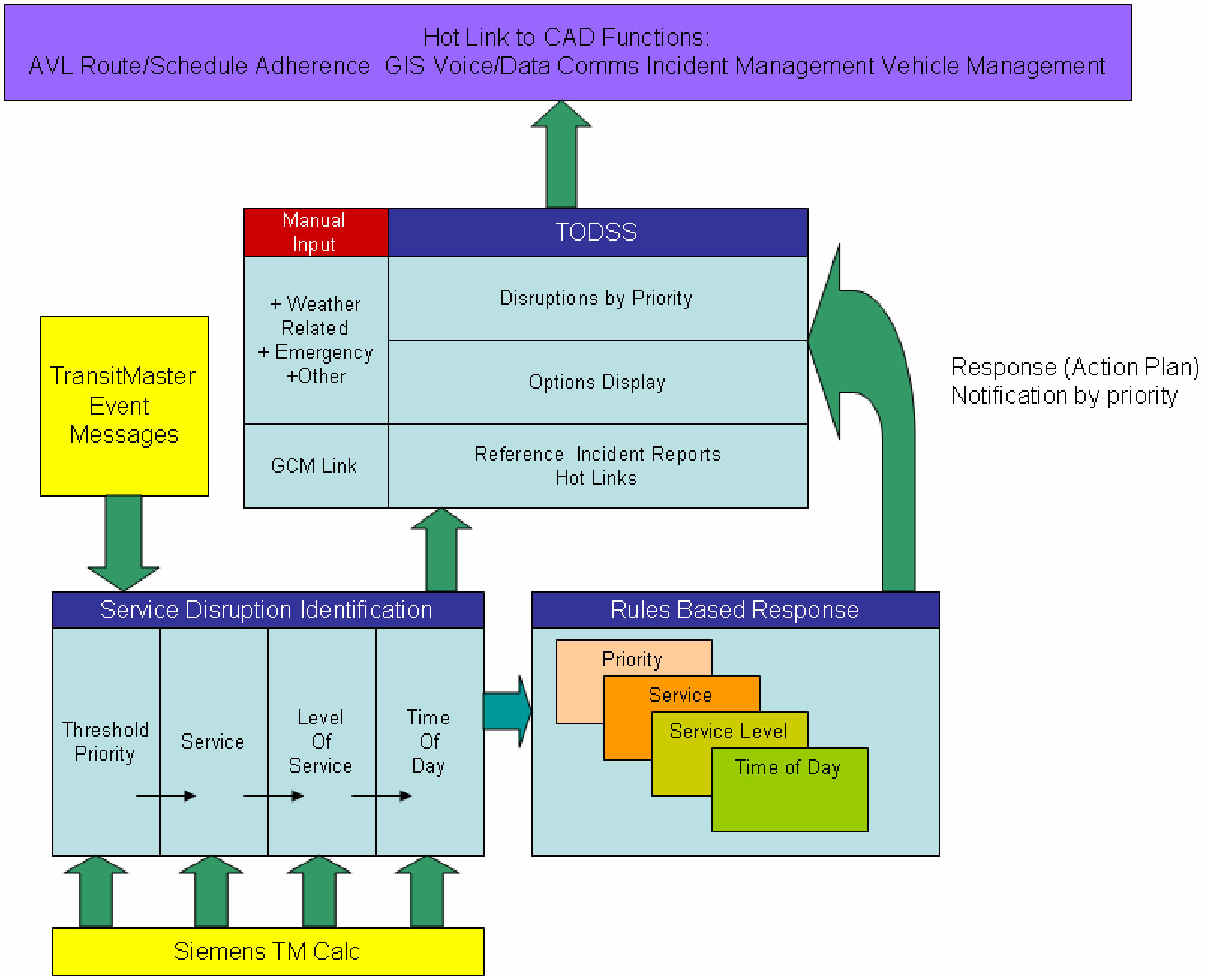

Figure 9 - Appendix 1 TODSS System Architecture

A service disruption notification is either removed from the TODSS display upon dispatcher input of completion or stay in "queue" based upon a dispatcher need for further monitoring. A summary display that gives a snapshot of the transit system performance and the status of the current service disruptions will assist in assessing the current state of the transit system.

TODSS shall determine the response and restoration options feasible for a given operational scenario based upon Pace supplied business rules. An interactive area in the TODSS display will provide the response and service restoration options when a disruption notification is selected. TODSS service restoration options shall include an easy link to associated dispatch reference documents such as service memorandum, policy and procedure manuals, or related material. The TODSS service restoration options may include an interactive checklist of operating procedures that forms the basis of the incident report, based upon the available data. The TODSS service restoration user interface will be closely linked to IBS Incident Reports for improved historical data capabilities.

TODSS service restoration options shall include the appropriate service restoration strategies based upon the context of the operational scenario, the operational scenario priority, and other sources of information available. A service restoration strategy may recommend a set of recommended actions. For example, a late running vehicle on express service may have a recommendation to use a standby vehicle, send a vehicle from the garage, or waive the adherence. The dispatcher based upon their training and experience will select the best option to implement.

During the day, situations beyond a driver's control such as accidents, detours, or train crossings can adversely affect schedule and route adherence. In such cases, the dispatcher may create adherence waivers for scheduled timepoints. The waivers are set within IBS and are automatically referenced during incoming data message processing to determine how the system should present information in real-time and historically. TODSS will suggest applying service waivers for appropriate service disruptions that affect routing of a partial trip, full trip, or an entire route. Dispatchers will be expected to set service waivers based on the restoration options provided by TODSS. Waivers are important to provide accurate real-time customer information, schedule adherence, and historical analysis of the system.

Upon selection of a service restoration strategy TODSS steps to implement the strategy using IBS will be provided based on the underlying rules base. It is expected that TODSS "tool icons" for dispatchers will provide functions such as show closest supervisor, show available extraboard, or show vehicle availability. Dispatchers will make greater use of the IBS by TODSS providing automated parameter setup of drivers, vehicles, and routes for tools such as Playback, Route Ladder, and Service Monitor applications.

TODSS will make the IBS tabular and graphical system information readily accessible through the hot-linking or "view on" capabilities to the AVLMap, Pullin/Pullout, Schedule, Roster, Route, Maintenance, Service Monitor, Route Adjustment, Playback, and Route Ladder displays when selecting a service notification and the associated restoration options display.

By TODSS reducing the displayed data to include only those notifications that require their attention dispatchers will be expected to spend more time managing service quality. Implementing their actions within IBS becomes important for accurate customer information and sharing of information. TODSS will force the increased use of incident reporting that has the benefit of distributing operations information automatically to other users and other ITS systems.

4.4 User roles and responsibilities

Operators will increase their use of data messaging within IBS to maximize the benefits of the TODSS functionality. By doing this they can help free dispatchers time to address the most urgent concerns first. Operators will be expected to increase their participation in service restoration techniques, such as operator initiated short turns, set up by dispatchers.

Dispatcher will be manually entering inputs into TODSS from outside sources of information. They will act on these inputs in addition to notifications based on IBS information in a systematic and coordinated manner. Road supervisors with mobile dispatch will follow the same training and guidelines as dispatchers. Dispatchers will be expected to act within the guidelines of the TODSS response options, utilize the IBS functionality to support and implement their decisions, and document their actions within the system. Other users will be counting on the dispatchers use of TODSS for their success when trying to apply the TODSS initiated outcomes into their daily jobs and processes.

System Administration will have additional duties to setup and maintain the TODSS rules base. Response rules introduce a completely new set of parameters and settings that IBS does not implement. TODSS changes the way the systems administrator goes about updating and initializing parameters for both the TODSS and IBS. The settings and parameters will be matched to operational scenarios in order to add rule(s) in the TODSS database that define the system inputs to identify operational scenarios. The system administrator facilitates an operational business review to capture the accepted business processes associated with the operational scenario. These processes are translated by the system administrator into checklists, automated procedures, and response options that are added to the TODSS rules database.

Working with the other users of the system they will be responsible for keeping the TODSS up to date with route and schedule configurations, implementing new rules based upon improvements identified by the system users, and making the new historical data accessible. The main areas of focus requiring setup include:

- Setting priorities and threshold parameters for notification purposes for routes, services, adherence, alarms, etc.
- Implementing newly defined operational scenarios and associated source of information
- Correlate restoration strategies assigned to the various parameter permutations for each scenario within the rules base

Advance notification of service disruptions need to be entered into the system. Fax, phone calls, or formal notices from municipal governments or other external entities are received that announce events that will lead to temporary service disruptions but do not necessitate a permanent schedule change. A system administrator will respond by entering service waivers to adjust the schedule within the IBS Planner application to keep the transit schedule up to date. This improves TODSS accuracy such that it will not process false messages from known service problems.

Service Planning will have additional sources of information to improve the transit system and assist with new service development. Working with Operations new service should be analyzed to identify potential disruption points (e.g. potential underpass flooding, railroad crossings, congestion) and associate restoration strategies to handle the situations. This information will form the basis for setting the rules within TODSS for the new service. Scheduling will have a historical record of service disruptions and adjustments as another set of data to use to adjust recovery ratios, improve running times, and re-route where required.

With the TODSS historical information such as waivers, adjustments, and communication information, District Management can begin to analyze the performance of real-time fleet management. Superintendents will be able to evaluate dispatcher performance and the effectiveness of their choices of restoration options in the context of all system data. District management will have the information to initiate process improvements that include improved restoration strategies and feedback to dispatchers. Headquarters and District Management will have the information to work together for service quality process improvements. This will lead to improving standards for real-time service levels for the dispatcher and their support functions.

TODSS actions will provide Marketing with improvements in schedule and route data that is necessary for real-time customer information systems such as kiosks, integrated voice response systems, and web applications. With timely and more accurate service information there should be an increase in “service notices” within web applications. Passenger Services will now monitor service waivers and service adjustments as part of their information sources to be better prepared to respond to customer inquiries quickly.

4.5 Interactions and Coordination

It will be necessary to coordinate the activities of the primary and secondary users to realize the potential benefits of the TODSS. A team that includes the primary and secondary users will need to communicate the changes brought about by the TODSS and the opportunities that it provides. Two phases need to be coordinated by a cross-functional representation of TODSS users.

The first phase includes training, mentoring, and guidance to the agency with respect to TODSS and the opportunities to integrate it into the daily jobs and business processes throughout Pace. The second stage takes on the role of facilitator to begin the process of service quality improvements. Informational needs from the historical data will be identified, process improvement initiatives started, and feedback mechanism put in place for the users. Process improvements that include improved skill levels, response strategies, and operating procedures will provide more time for dispatch focus on managing the transit service.

4.6 Train Crossing / Gate Down Operational Scenario Example

The TODSS Definition of Operation Technical Memorandum includes operational scenarios where the related Pace business processes and procedures have been defined, dispatcher responsibilities reviewed, and supporting actions documented. From those operational scenarios, the Train Crossing / Gate Down operation scenario is described to illustrate how the TODSS is integrated into daily operations.

It is common for Operators to be stopped for prolonged periods at drawbridges or at ‘at-grade’ freight rail crossings along many of the routes operating in the region. Operators that encounter a delay of five (5) minutes send a “Train Crossing” text message and/or a “Request Detour” text message to notify their dispatcher of the disruption. The TODSS business rules will have identified this message type as requiring “Dispatcher response balanced with other operational demands” and automatically place the event in the TODSS queue behind any immediate response or emergency response priority events.

Upon selecting the event, the dispatcher is presented with a checklist of recommended initial actions. A Train Delay Log Incident Report is automatically created with interactive fields included in the TODSS checklist. The checklist is automatically formulated from stored TODSS business rules and includes the following tasks:

- Observe a “Back in Service” 10-7 message from bus operator indicating obstruction cleared.
- Respond to a “Request Detour” text message (or RTT) sent by a bus operator with a voice call to approve or deny a bus operator suggested detour.
- If the 10-7 message is not received, or the Operator reports by voice call that the crossing will be prolonged, begin appropriate restoration strategy planning.
- Remind the Operator to pass out a Late Bus Slip to onboard customers.
- If the tracks are out of view of the stopped bus send a text message to the onboard sign indicating to the customers that the wait is due to a gate crossing down.

Service restoration strategy options are presented to the dispatcher in a corresponding area reserved within the TODSS display. Suggested actions provide links or instructions to utilize IBS to carry out the actions. The following options are stored TODSS business rules that are automatically retrieved and displayed.

- Send a group text message to all drivers on routes that pass through a blocked crossing that includes the location of the obstruction and detour instructions as required.
- Use the rubber band technique with automatic setup and view on the AVL Map or Route Ladder.)
- Determine if extraboard, pull-ins, or out of service vehicles are available to assist with covering service (especially for interlined routes).
- Use the automatic view on the Pullin/Pullout tab.
- Determine whether to pull trippers off their scheduled work to cover lost express or tripper service.
  - Use the automatic setup and view on the Route tab, AVL Map, or Route Ladder.

- Determine the best strategy to get a delayed vehicle back on schedule by a short turn, deadhead, or standby to get back on schedule. TODSS suggests a strategy based on the service type and/or time-of-day but review to confirm it is the best decision.
  - Use the schedule adjustment tool to implement the chosen strategy automatically.
  - Send a group text message indicating the end of the gate crossing obstruction and any detours.
  - Classify the event and record in the interactive checklist for inclusion in the Train Delay Log Incident Report.

The dispatcher closes and removes the event once they have decided upon the appropriate response options and taken action. The dispatcher will have the option to set a timer to continue to monitor the event for a set period before the event is removed from the TODSS queue. Closing the event will automatically send an incident report (via Email) to Customer Relations (and RTA after business hours) of any service disruptions or delays and save the Train Delay Log incident report.

In a defined area of the TODSS display a link to associated electronic documents is provided for additional reference material for use in the decision making process. Pace has identified that a pre-approved detour list for problem crossings and bridges would be beneficial to address regular occurrences of this service disruption. These pre-defined detours can be sent directly to the Operators.

5 Summary of Impacts

PACE, RTA, Siemens VDO, and Booz Allen are working together to design and develop a decision support system for dispatchers based on the FTA's requirements. The goal is to implement the system, and provide feedback to the FTA on the results, areas needing improvement, and lessons learned. Because of the TODSS project, it is anticipated that Pace will realize improvements to the IBS and to service quality.

5.1 Summary of improvements

- Effective use of IBS tools to make decisions resulting from the TODSS provided guidance
- Consistent and uniform dispatcher performance resulting from the TODSS supplied response and restoration strategies
- Increased Dispatcher time spent on incidents that have the greatest impact on service quality
- Active dispatch function process improvement possible with TODSS historical information

5.2 Operational impacts

During development of TODSS, the dispatcher force will be upgrading their skill levels as it relates to integrating the IBS and other computer software programs into their daily jobs. A foreshadowing of the coming changes will need to be presented at this time. This training will set a baseline for dispatcher attitudes and skill levels to base further training programs and to determine a reasonable rate of change.

Because of the need to evaluate the feasibility of a TODSS, it will be important to quickly train and start using the TODSS. As the TODSS training is rolled out-some dispatchers will be using the old methods while others begin to use the TODSS. A plan will be developed that includes a strategy to minimize the confusion from two different operating procedures in place at the same time. The confusion should be minimal but it is better that regions, garages, and headquarters are kept apprised of the status of the project so they can plan and react accordingly.

6 Appendix A – IBS Communications and Data Network Infrastructure

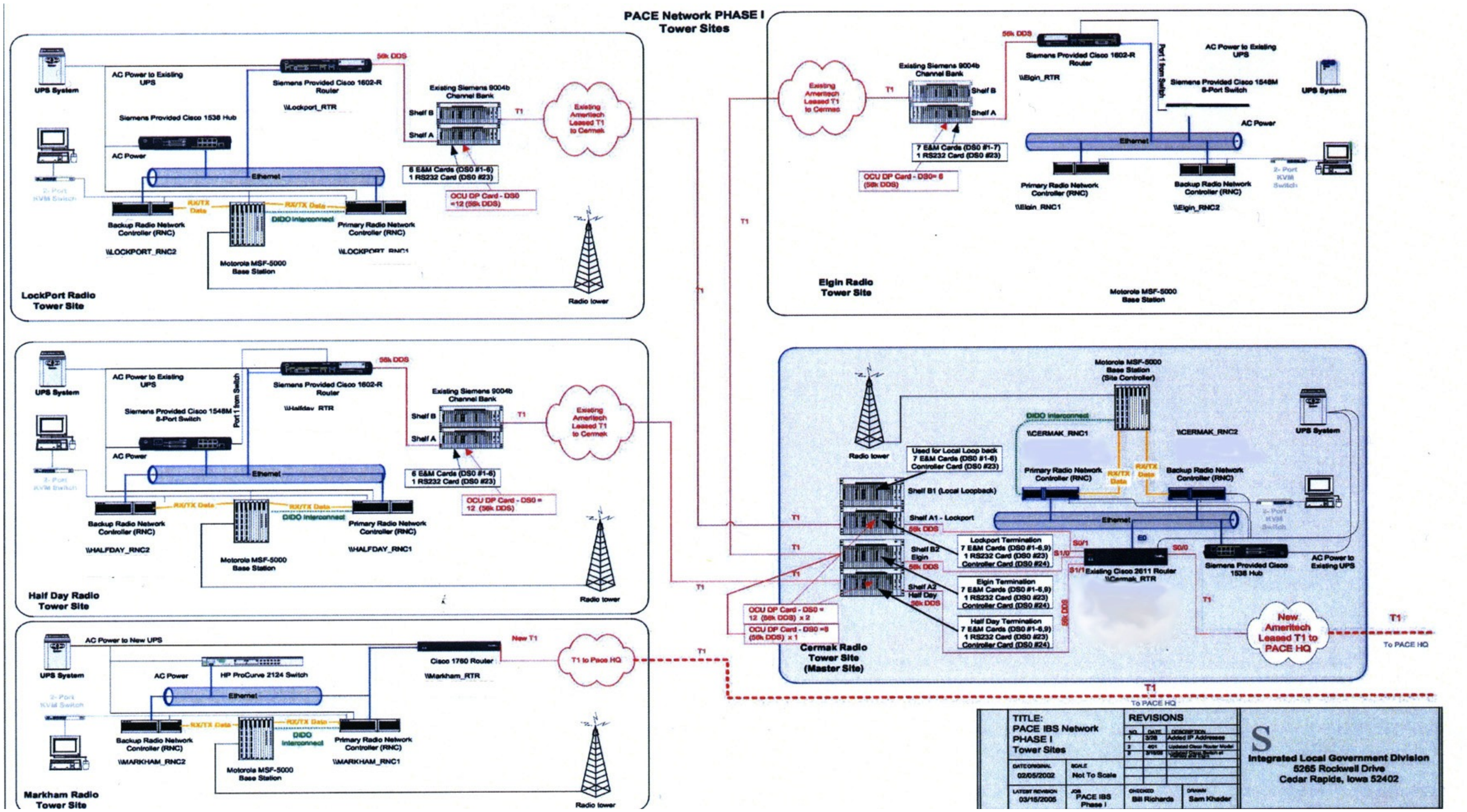

Figure 10 - Appendix 1 Pace Network Design

7 Appendix B – Pace District Dispatcher Training Topics

The following table is the result of a recent inventory of Pace dispatcher's job duties and responsibilities in preparation of creating a new dispatcher training program. The duties have been broken up into those related to the IBS and other administrative duties. At many large agencies these duties are spread out into two or even three different job descriptions such as Window Dispatchers, Radio Dispatchers, and Station Managers. This inventory demonstrates the need for a decision support system that can simply and help organize the Pace dispatcher's duties.

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
IBS	**Extra Board**
Overt alarm	Assignment of open work in accordance with union contract
Covert alarm	**Covering open work**
Text messaging	Use of Extra Work Book
Canned messages	RDO operators
Retrieving Communication History	Using operators before/after/during split of their regular runs
System Failure	Using part time operators
Handling Other Divisions	All the above, again in accordance with the union contract
Single vehicle announcements	Sick Elective Days (if applicable)
Multiple vehicle announcements	**Day off book**
IBS incident report	When it is open for operators to sign
Lift not cycled upon pull-out	How to use it
Schedule adherence	**Call offs**
Vehicle location	Proper documentation including date, time called, when we can expect him/her to return
Playback	Why? If they sick, ask "what is wrong?"
Accident/incident management & proper emergency services to be contacted	If they say "personal", tell them you need a specific reason, personal is not satisfactory
2-way radio system	If they book off FMLA, ask for whom? Yourself, spouse, child, parent?
Radio call codes	**Miss outs**
Proper channel	No show? Or call off?
Receiving a call	Make sure miss out form is properly filled out
Answering a call	If you talk to the operator, be sure to write on

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
	miss slip what he/she said
System failure	**Drivers' report time**
What questions to ask operators	Watch run report time to ensure run is not missed
2-way radio etiquette	Be aware of who is due to report
Alternative methods to contact an operator	**Section 15 assignments (APC) buses**
	Be sure an APC bus goes on the run or runs scheduled for the day
Dispatch log	**Processing lost & found items**
What goes in the log	Know the Lost & Found procedures
Information required, i.e. Bus, badge, location, direction, time, etc.	What to process and what to throw away
Road calls	Be sure items turned in are tagged & the operators' name & badge number are on the tag
Be sure to get the location, direction, bus number and badge number	**Relief vehicles**
What is problem? Get specifics & contact Maintenance	Issuing keys & vehicle log
No bus is to continue in service with a flat tire, front or rear	Be sure you issue matching keys & vehicle log
Any smoke, operator curbs bus, evacuates passengers and if he/she sees flames, uses fire extinguisher and call appropriate emergency services	If no vehicle is available, operator either needs a ride or a bus
Bus exchanges/Trade offs	Make sure you get keys back with each vehicle log received
How to use bus pull in sheet	**Scheduled vacations**
Make exchange as convenient as possible for passengers and the bus in service	Very important to ensure run is covered
Special services	If operators get VRD's, you must be aware on a daily basis
Be aware of any special procedures or instructions for the operator	**Farebox refund slips**
Know what the fare is and the route	Ensure slip is properly filled out when you get it from the operator
Accidents/Incidents and review of same prior to accepting and initialing reports	**Passenger questions and complaints**
When operator reports an accident or incident, remind the operator they need to complete report before leaving the property	Be courteous when talking to a passenger

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
Be sure to get EXACT location, direction, injuries, damage, and #of passengers on bus and in other vehicle	Be as helpful as possible
Get location in IBS which will provide emergency services phone numbers and make the calls for assistance	If a complaint, be sure to get all the information including passenger name, address and phone number
Contact Supervisor to respond to scene	Complaints without a name & address or name & phone number will be considered anonymous
Complete Accident/Incident notification form	Check IBS if complaint is about a late or no show bus
Contact appropriate Pace personnel	**Posting bulletins**
Record in log, in IBS and in Daily Report of Operations	Where to post what bulletins
Upon receipt of report, review report for completeness	Review and make sure you understand each bulletin
If complete, initial on bottom below the box marked "reviewed by"	Record date posted and removed
If not complete, return to operator so he/she can complete	**Overtime slips**
Daily Report of Operations	Check for completeness and accuracy to the best of your knowledge
VERY important that all information entered is accurate	**Accepting, time stamping and initialing receipt of grievances (if applicable)**
Information entered on report should match Dispatcher log and, if an accident, also match the information entered in the IBS Incident Report	Where to time stamp & where to initial and to whom to forward, if applicable at your division
Adherence to collective bargaining agreement	**School/No School calendar, trip sheets, adjusted report times**
Be aware of all sections of collective bargaining agreement which do or could affect the way you fulfill your job responsibilities	Check school calendar on a daily basis
Read, copy, memorize, whichever method works best for you	If a school has no school, be sure to adjust operator report time, even though operator should already know
Recording and RTA/Pace notification of delays and missed trips	Be aware of which runs service which schools
Recording on Dispatch Log	**School early dismissals**
Recording on Daily Report of Operations	Be sure to remind operators the day before of any early school dismissal
Notifying RTA/Pace Travel Center	**Issuing transfers to Bus Operators**

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
Farebox/BTU defect log	Be aware of how many each run is to be issued
How to record	Have packets ready to be issued by run report time, or, if applicable, inserted into run pouch
How to process	**Bus Operator appearance and following uniform policy**
IBS malfunction/problem log	Operators are expected to report to the Dispatch window in proper uniform, looking professional, in accordance with Pace Uniform & Appearance Policy
How to record	No sunglasses, cell phones or ear buds are allowed when reporting or while in service
How to process	**Bus Operator physical appearance**
Centralized dispatch	Does operator look physically able to operate bus safely?
What time Dispatch turns the division over to centralized dispatch	Does operator look impaired by an illegal substance or alcohol?
Driver & bus info needed for centralized dispatch	**Processing of all paperwork**
If appropriate, how to perform centralized dispatch duties	Ensure all paperwork is completed and accurate
Lift/Ramp malfunctions	Know to whom all paperwork gets forwarded to
How to have operator trouble shoot lift malfunctions	**Adherence to collective bargaining agreement**
How to have operator trouble shoot ramp malfunctions	Be aware of all sections of collective bargaining agreement which do or could affect the way you fulfill your job responsibilities
Vehicle in revenue service with lift or ramp malfunction	Read, copy, memorize, whichever method works best for you
Documentation of lift or ramp malfunction	**Split tickets**
ADA regulations if operator is unable to board/deboard passenger	Proper allocation of time to each operator who worked a piece of the run
Portable ramp	Necessity for accuracy
Bus failure troubleshooting	Calculating pay time for each operator
Get detailed information from operator when he/she calls with a problem	**Handling of Pre-Trip cards**
Contact Maintenance	What to look for
Troubleshooting	How to process
Calling out on phone	Where to file
How to get an outside line	**Facility alarm system**

COMMUNICATIONS DUTIES	**ADMINISTRATIVE DUTIES**
Paging an employee within the facility	How to set alarm
Paging/beeping an employee	How to turn alarm system off
Emergency paging/beeper calls	**I-Pass unit, cell phone and opener assignments (as applicable)**
4 digit dialing	How to determine which runs are issued an I-Pass
Phones are for Pace business	How to sign unit out
Chicago and suburban paratransit and Van Pool service	Receiving unit back
Be aware of procedures & Dispatcher responsibilities	How to instruct operator who fails to take unit when leaving the garage
What number to call when a Road Supervisor calls in a problem	**Assignment of buses**
Sorting and distribution of all paperwork	Identify which runs get which buses
Who gets what, where to put it and when they get it	Assigning APC buses
Detours	**Notify Safety Manager if employee is off 3 days**
Receiving a detour	Employee off 3 or more days may need release from doctor
Drawing up a detour route in conjunction with Safety Manager and/or Division Manager or Superintendent	Safety Manager needs to be aware of number of days employee has been off
Recording detour	**Answering phone**
In Dispatch log	Proper & courteous manner to answer calls
In IBS	How to put a call on HOLD
On Daily Report of Operations	How to transfer a call
When to remove a detour	Parking a call
Where to post	Conferencing a call
Service Disruptions	Retrieving a voice mail message
Late buses	How to retrieve call that was placed on HOLD
Missed trips	Phones are for Pace business
Restoring service	**Day off book**
Short routing	When book is open for operators to sign
Back up bus	How to assign work from the book
Overcrowding on a bus	How to make notations in book & what to notate
Terrorism Security Level	**Extra work sign up sheet/book**
How to handle each level of security	When book is open for operators to sign

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
Calling out on phone	How to assign work from the book
How to get an outside line	How to make notations in book & what to notate
Paging an employee within the facility	**Payroll exception list (if applicable)**
Paging/beeping an employee	What it is used for
Emergency paging/beeper calls	Effect on operator's pay
4 digit dialing	Importance of accuracy
Phones are for Pace business	How to process
	Issuing, receiving and sign out procedures for vault keys
	This is a high security item & must be handled in accordance with established procedures Pace wide
	Know the person you are issuing the keys to
	If keys are not returned by end of your shift, inform next Dispatcher
	Distribution of mail into Bus Operators' mail boxes
	Where mail boxes are located
	How to read which box belongs to which operator
	Fueling non-revenue vehicles
	Where to fuel
	Information required for each vehicle
	Who gets the documentation (receipts)
	Fuel pump keys (if applicable)
	Survey packets
	How to issue
	How to collect surveys
	Floating holiday, birthday and anniversary calendars
	How to use the calendars
	Restrictions regarding number of operators allowed off per day
	How to enter on Extra Board
	E-mail
	How to get into your e-mail
	Opening a message
	Replying to a message

COMMUNICATIONS DUTIES	ADMINISTRATIVE DUTIES
	Deleting a message
	Schedule inventory
	How to perform inventory
	How to use BUSLIT system for inventory
	Filing message to folder
	Terrorism Security Level
	How to handle each level of security
	Facility Emergencies
	Silent alarm
	Fire alarm
	Building evacuation
	Medical emergency
	Calling for emergency assistance
	On The Job Injuries
	First report of injury form
	Notify proper authorities if necessary
	Ask “Are You Okay?”
	Notify division Safety Manager
	Violations
	How to write violation
	How to process violation

Table 3 - Appendix 1 Pace Dispatcher Training Topics

Appendix II - Definition of Operational Scenarios and Parameters Technical Memorandum

Prepared by Pace for FTA Office of Mobility Innovation U.S. DOT ITS Joint Program Office
January 2007

1 Introduction

This is the second technical memorandum included as part of task three of the Pace prototype TODSS project. It complements the Concept of Operations technical memorandum and provides a description of the operational scenarios and the system parameters that represent the Pace operations within the context of the core TODSS requirements. This memorandum is intended to assist the software developers by providing Pace operational background information to supplement the TODSS core requirements and guide the design and development phase of the project.

The TODSS framework and proposed flow of operations is presented to illustrate how Pace will operate with the addition of the TODSS prototype to the IBS system. This document details the types of service disruptions and service restoration strategies that will be incorporated into the TODSS prototype. The differences from the core TODSS requirements resulting from the unique Pace infrastructure and operating procedures are presented.

This document includes the identification and documentation of the operational scenarios and system parameters around which that the TODSS prototype will be built. Other operational scenarios may be included after gaining more experience with the design and implementation of the prototype. This technical memorandum does not attempt to provide all of the specific values for each parameter or the resulting chain of actions. The intent is to provide the foundation and framework for the design of the TODSS setup and configuration activities.

2 TODSS Framework

The TODSS will use the information from the fleet-wide onboard vehicle systems to monitor the entire transit system performance and determine if any applicable operational scenarios reach a threshold level such that dispatcher notification and action is required. The TODSS data store, consisting of Pace business rules, define the operational scenarios, priority levels, threshold settings, and restoration strategies. Building upon the IBS event queues and system settings the TODSS will minimize the display of data messages to include only those that actually require dispatcher attention. The TODSS will result in a higher level of consistency of dispatcher performance and management of the real-time operations on an agency-wide basis.

Five levels of prioritization have been identified that an operational scenario falls within that determines the dispatcher’s response. In order of urgency the levels are:

- Extra operations support required for immediate assistance
- Dispatcher and Road Supervisors immediate response
- Dispatcher response balanced with other operational demands
- Situation may require monitoring, no action required
- No action required

Action plans identified with operational scenarios will be created and stored such that TODSS can access and suggest potential restoration options. TODSS will direct the dispatchers through the IBS system to trace and display the impacts of the disruptions and the corrective actions taken. TODSS will provide techniques such as hot-links to alternate system views of the same information, tools that provide access to related information, and pre-processed incident reporting.

Archived data is available in three different forms. Summarized data will be available for review and analysis of the daily activities. Actual data will be stored to recreate and replay all events surrounding a vehicle, route, or operator. In addition, the incident reporting will provide a historical record of the notifications and actions taken by the dispatchers for future evaluation.

3 TODSS Flow of Operations

The IBS flow of operations can be broken down into two distinct sets of activities. The first is the offline activities that include the system setup, configuration, review, and analysis. The second is the real-time operations activities. Each set of activities is vitally important and build upon the output of the other to continually update and improve the system. The TODSS prototype will be incorporated into this existing flow.

TODSS requires an accurate baseline schedule to make the best possible decisions. The IBS provides tools to update the schedule for permanent, short-term and same day schedule changes. Each time there is a permanent service change created in Hastus it is incorporated within the IBS and made available to the TODSS. This is accomplished by using the Route Manger application to update the onboard announcements, destination sign changes, routes, schedules, blocks, and runs. The Planner application is used to define and schedule temporary service changes such as parades, limited road closures, and temporary detours. Same day real-time service changes are made within the IBS that include canceling, adding, and changing service based upon the operational conditions.

There are many parameter set to configure the system to reflect the Pace hardware, infrastructure, and operating policies. These settings are global in nature and define everything from default data radio channel assignments to application access and security. End users also have parameters available to customize their personal setup of the system to match their operational requirements. These parameters and settings are discussed in detail later in the memorandum.

TODSS requires many new setup parameters prior to implementation. The notification rules require defining time-of-day, service, and level of service parameters with respect to the operational scenarios. System administrators will rely upon dispatchers and other Pace staff to provide the operational scenarios and assist with capturing and defining the rules to use within the TODSS.

Pace already is actively analyzing historical data that includes the use of the Hastus ATP application that analyzes historical schedule adherence data. These offline activities will expand to include analysis of the dispatcher responses, based upon the TODSS, to determine the effectiveness of the solutions they implement. Improvements in the TODSS rules base can be made based upon this system level review and analysis of the historical data. Experience has shown that as operational scenarios are defined and refined there is a greater awareness of the nature of potential disruptions with more thought given to improving the set of service responses.

The real-time operational flow of operations is similar at each of the nine operating divisions. Upon the start of each day the services that have been defined (e.g. Saturday, Sunday, School on, School off, and Weekday) within the Planner application are automatically loaded and define the schedule for the day within IBS. Dispatchers at each division logon using their specific division logon to see only those vehicles and data messages that are assigned to their division.

Meanwhile drivers log on to their MDT prior to leaving the garage. Data messages are sent and received by the onboard system from the time the vehicle starts up to the time that the vehicle returns to the garage at the end of the service day. There is a two-minute polling cycle where each vehicle reports its current location. Other data messages are transmitted on an exception basis including vehicle alarms, timepoint crossings, passenger counts, driver violations, and driver initiated transmissions. The vehicles have all the routes and schedules for their assigned division and in the event of a loss of data communications the vehicle continues to perform automated announcements, sign changes, and collection of passenger counts. The vehicle will automatically try to reconnect to the communications system. If re-connecting is unsuccessful any stored data is uploaded to the central system in the garage at the end of the day through the wireless LAN.

Vehicle locations are updated on the dispatcher map displays and the arriving data messages, based upon parameter settings, are displayed in a tabular format displays. The map and tabular screens provide alarms and icons that indicate system failures such as a loss of network connectivity, radio communications, or database connection. The TODSS uses all of this incoming data and applies the underlying rules base to decide whether the data meets a defined threshold that requires dispatcher notification and action.

When service is impacted and deviates from the baseline schedule the dispatcher must determine what restoration strategy to apply based upon constraining factors. They must consider:

- Demand for service including peak loads, the load of the entire route, or load over a segment of the route
- Traffic Conditions
- Characteristics of the route including turn around points, detour routes, scheduled deadheads, route branches, common trunks, and the length of trip
- Operating environment including the garage location, relief points, headway intervals, and vehicle and operator availability
- The level of service affected such as arterial, feeder, express circulator, or planned special event routes

The dispatcher's initial actions include gathering all pertinent information. They may communicate with operators or other support personnel to ask a series of questions suggested by TODSS to gather a complete understanding of the disruption. TODSS will guide them through the IBS system views to assist with determining the impact on service including transfers, schedule adherence, vehicle spacing, vehicle health, operator assignment, and historical data related to the TODSS notification.

Once all information is gathered the service restoration strategy is decided upon and implemented. For scenarios that require a transit center or terminal solution techniques include:

- Vehicle jumping that uses an available vehicle (parked, staged, pulled-in) to replace one that became unavailable (breakdown, delayed)
- Shift the schedule time frame
- Eliminate a departure
- Insert a departure

Restoration techniques made along the route may include:

- Modify schedule running times
- Wait at a bus stop or transfer point
- Bus changes
- Pass on the route
- Exchange drivers
- Route Deviations
- Short-turns
- Relay vehicles
- Re-routing

Follow-up activities require the dispatcher to monitor the system until the schedule returns to normal. Customer relations and the RTA information center are notified of the service impacts and the actions taken are recorded in incident reports, logs, and legacy systems for later analysis. Many operational scenarios have related reference materials such as service bulletins. TODSS will provide links to dispatcher documents for quick and easy access to supplemental information.

4 Information Sources Identifying Service Disruptions

Dispatchers receive information that indicates service disruptions from multiple sources. TODSS prioritizes and presents this information to the dispatcher after determining the significance and severity of the disruption in relation to the transit system as a whole. The sources include automated IBS data messages, Operator initiated voice and data communications, and outside sources as follows:

IBS Information

- Late or missing logon
- Loss of data communications transmission
- Missing logon
- Route early
- Route late
- System detection of vehicle off route
- System managed user requested connection
- System Late
- Vehicle early or late
- Vehicles are gapping and bunching along Route (Distance based)
- Vehicles are gapping and bunching at a point location (time point)
- Vehicles through time point early
- Vehicles through time point late
- Vehicle subsystem health
- Vehicle location

Driver Initiated Information

- Driver needs relief ASAP/personal
- Emergency alarm activated
- Railroad gates down
- Passenger inappropriate behavior (refuse belt, fare, asleep end of line)
- Passenger incapacitation or emergency
- Passenger requested transfer
- Passenger sick
- Vehicle involved in accident
- Vehicle mechanical problem (brakes, check engine, door, fluid leak, transmission)
- Wheelchair lift broken or wheel chair passed
- Passenger lost item
- Full bus
- Have a detour
- Road blocked
- No relief driver

External Sources of Information

- Driver inappropriate performance
- Major disruptions
- Major storms
- Metra or CTA rail system outage
- Public safety emergency support
- Special events
- Terrorist actions
- Accident requiring re-route
- Fires requiring re-route
- Localized flooding

5 Differences between the Pace TODSS Prototype and TODSS Core Concept of Operations

In the core TODSS requirements there are features described for detecting disruptions and strategies for restoring service that are not available in the IBS. These missing features include:

- Headway service disruptions are not detected between different routes within a shared segment in IBS today.
- The IBS does not provide system managed connection protection. Connection protection is based upon passenger request only.
- Although Pace is testing and preparing to institute bus signal priority it is not an available strategy for service restoration today.
- Identifying service disruptions based upon passenger loads is not being utilized from the vehicles with APC systems at Pace. The APC systems are not on all vehicles and therefore the data is not used for real-time purposes in operations to date.

In some instances, there are core TODSS requirements that will not be feasible to meet in the Pace TODSS Prototype because of the current architecture of the IBS. There were alternate solutions proposed for some of the desired and core TODSS requirements by Pace in the initial proposal. The following table provides a summary of those requirements that the Pace Prototype will differ from the original TODSS requirements.

RFP SECTION	PARAGRAPH DESCRIPTION	COMMENT
SI 2	[Desired but not required] Core TODSS should have the ability to interface with the non-core TODSS source on information also shown in Table 5-1	Non-core interfaces can be developed where regional standard interfaces exist.
SI 3.3	[Desired but not required] Core TODSS should have the ability to obtain information from each of the non-core TODSS sources on information also shown in Table 5-1 to obtain and display up-to-date information on the transportation system status and performance and assist in meeting the Core TODSS Identification and Notification of Service Disruption (SD.x.x in Section 5.2) and Provision of Service Restoration Options (SR.x.x in Section 5.3) requirements	Non-core interfaces can be developed where regional standard interfaces exist to provide sources of information for SD and SR requirements.
SI 3.4	Core TODSS shall have the ability to regulate the frequency of information updates (e.g.	Adjusting the polling frequency must not interfere with the

RFP SECTION	PARAGRAPH DESCRIPTION	COMMENT
	polling or event triggered reporting) in response to an event notification, service restoration action, or system status notification.	existing data throughput. Polling frequency currently is increased for emergencies. Any other increases would be subject to data through put analysis.
SI 3.5	Core TODSS shall have the ability to regulate the frequency of updates based upon the priority of the event or action being monitored and the data network's capacity to transmit and receive information.	Emergencies currently increase the frequency of updates.
SD.1.4.3	. [Desired but not required] Core TODSS should provide the ability to incorporate historic service performance and ridership levels into the service baseline	Separate module that may be included but most likely beyond first pilot project.
SD.1.4.4.	[Desired but not required] Core TODSS should provide the ability to adjust service baseline due to service restoration actions taken during real-time operations (e.g. the exchange of two trip schedules when a vehicle passes another on a route in response to "bunching".)	Switch between schedule adherence and headway management.
SD 5	Core TODSS shall trace the impacts of an event/disruption across the network to other fixed route service within the system	Traceability as it relates to corridor management.
SD 6	Core TODSS shall provide the ability to monitor a service disruption or event and the impacts of service restoration strategies applied in response	Monitor as it relates to corridor management.
SD 6.1	Core TODSS shall provide the capability to set thresholds for event tracking	Limited by network throughput constraints. (NOTE - The IBS is a polling system that utilizes limited communication bandwidth as efficiently as possible. The system is designed to include exception based data communications. The system would suffer degradation if unsystematic threshold changes were allowed. However, parameters are provided to change event tracking for emergencies.)
SD 9.1	Core TODSS shall provide the capability for geographic display on dispatch center, remote terminals, MDTS, and mobile devices of the current location and status of all revenue and	Geographic maps not provided for MDTs.

RFP SECTION	PARAGRAPH DESCRIPTION	COMMENT
	non-revenue vehicles logged on to the system	
SD.9.1.5	[Desired but not required] The geographic display should have the ability to show but not be limited to: predicted status of each service disruption; and service performance (e.g. headway, direction, speed, passenger load, or special passengers)	Requires historical analysis and knowledge base to provide real predictive value. Some performance measures will be beyond this phase of TODSS.
SD 9.3	Core TODSS shall provide the capability to produce graphical displays of service and headway performance to dispatch centers, remote terminals, and mobile devices. Examples include time based “race track” displays; vehicle time-space trajectories; and service histograms	Exists but will not be available on MDTs.
SR 5.3	[Desired but not required] Feasibility analysis should be carried out using Vehicle availability, Manpower availability, Work rules, and hours of operation, time and distance required to provide the relief	Only if Roster is maintained or third party Roster interface is implemented.
SR 5.4	[Desired but not required] Core TODSS should provide upon request non-feasible options with notification of additional requirements to make them feasible (e.g. insert vehicle with recommendation to call in operators when there are no available operators on duty)	Beyond the expertise of this phase of TODSS pilot.
SR 6	Core TODSS shall have the ability to trace the impacts of all feasible service restoration strategies across the network to other fixed route service within the system	New, as it relates to corridor management.
GS 5	Core TODSS shall have an open system architecture and provide for interoperability, interconnectivity, portability and scalability across various hardware platforms and networks	For this project the platform will be Microsoft Professional and Microsoft SQL network.
GS 10	Core TODSS shall provide the capability to monitor and archive an audit trail of all system events, parameters, data communications, screen displays, notifications and alarms, logons, and actions performed by the system and those interfacing with it (dispatch, supervisors, operators, public safety, maintenance and remote terminals)	Capability is based upon available storage and network throughput. Audit of TODSS strategies and parameters offered as base requirement.
GS 11.3	If implemented replay shall have the capability to use the TODSS and AVL/CAD features to view displays, analyze information, and enter	Entering commands that weren’t used beyond this phase of TODSS project.

RFP SECTION	PARAGRAPH DESCRIPTION	COMMENT
	commands that were not used when the original event occurred	

Table 4 - Appendix 2 Requirements That Deviate From TODSS Core Requirements

6 Existing and Future System Parameters

The Pace IBS system specific configuration parameters are set and stored in several different locations including the database, computer registries, and on the vehicle. System parameters that are stored in the database comprise nearly 70% of all the parameters. Qualified Pace personnel are authorized to set the values of the parameters. They exercise caution when making changes to guard against incorrect values that may result in system inaccuracies or downtime. Pace personnel may consult with the vendor to confirm the meaning and implication of a setting's options before making a change. Most of the parameters can be set by the Pace System Administrator using the TMConfiguration application, Security Manager, RegEdit, or within the IBS applications. Some settings are not property specific and are reserved for the exclusive use by the vendor to distinguish one customer site from another and for system diagnostics.

Many of the variables relate directly to the core TODSS requirements. The variables can be categorized as follows:

- Vehicle types
- Report configuration
- Real-time system settings
- Data file locations
- Radio information
- Fleet information
- Security rights
- Communications settings
- Program display properties

A typical TransitMaster system includes nearly 500 system configuration parameters that each agency may set based upon their operational requirements. The following variables are listed to illustrate the range of parameters that influence core TODSS requirements.

- Early Adherence
- Late Adherence
- Timepoint Adherence Early/Late
- Priority Message Filtering
- Pullout Interval Alarms
- Default Waiver Timeout
- Disable Route Adherence Warnings
- Dispatch Document Directory
- Garage Logon Tolerance
- Enable Schedule Download
- Headway Minimum/Maximum Percentage
- Late Pullout Limit
- Late Start Limit
- Log User Activity

- Transfer Hold-Time Limit
- Special Event Mode
- Turnback Resysnc Adherence Minimum/ Maximum
- Vehicle-to-Vehicle Call Timeout

The onboard vehicle logic unit (VLU) stores variables and parameters related to the unique hardware configuration of each vehicle type. A configuration tool (EESetup) is used by the Pace System Administrator to define and set the hardware operating parameters.

The VLU configuration program provides more than 500 configuration variables and parameters that each agency sets based upon the operational environment. In addition to the configuration files, the VLU stores the current and pending route files, announcement files, transfer files, zone files, and text message files. The Pace System Administrator coordinates all file updates using the WLAN in each of the garages. The following variables are listed to illustrate the range of onboard vehicle parameters that influence core TODSS requirements.

- GPS type
- Passenger counter type
- Voice mode channel
- Data rate
- Fallback mode timeout
- Return to network retry
- Movement alarm distance
- Off course distance
- Transfer look-ahead distance
- Arrival distance
- Departure distance
- Minimum dwell time
- Stop tolerance
- Schedule adherence display

TODSS will utilize these existing IBS configuration parameters as required for implementation. Additionally, TODSS requires a database to store the business rules that identify operational scenarios and provide response options. These data elements may use existing IBS structures or have TODSS specific data storage to meet TODSS unique needs.

In the IBS there are parameters, such as time of day and service that are not used to determine whether to provide notification of a service disruption. These existing parameters need to be incorporated into the TODSS as part of the notification process. TODSS will require additional variables and parameters to further define and refine service levels, priority schemes, the decomposition of grouped data messages, and

TODSS screen displays. These variables shall be configurable by TODSS users and/or the System Administrator based upon existing security and access levels.

TODSS will require a scripting language or configuration utility that will permit Pace to define the thresholds for notification and assign priorities to operational scenarios. The TODSS decision engine must permit Pace the flexibility to expand and add operational scenarios as they gain experience using the system and make improvements to their operational processes.

The TODSS prototype requires the addition of new parameters to distinguish the level of service. This attribute plays an important role for the TODSS decision engine to determine the appropriated restoration strategy. This parameter type needs to be dynamic as the Pace service mix evolves over time to meet the needs of the diverse population within the large service area. Today this service mix includes arterial, feeder, commuter, circulator, and planned special event routes.

7 Operational Scenarios

This section provides a subset of the operational scenarios a Pace dispatcher will encounter in the performance of their duties. These operational scenarios are documented with the intent to implement and test them within the TODSS. Other operational scenarios will be identified, documented, and addressed as the project progresses.

The operational scenarios that follow have gone through an operational process and procedure review. Each operational scenario is broken down into four parts to assist with developing the business rules to be captured and implemented by TODSS. The breakdown includes:

- Initial Actions describe Dispatcher tasks to complete after receiving a service disruption notification.
- Service Restoration Strategy that includes Dispatcher response options to execute based upon the results of the initial actions.
- Follow-up Actions that the Dispatcher should perform after exercising restoration options
- Dispatch Document References that contain supporting material for further information related to the operational scenario accessible to the Dispatcher.

7.1 Vehicle Breakdown Operational Scenario

Dispatcher notification of a vehicle breakdown comes from an Operator initiated RTT, PRTT, Overt Alarm, or Equipment Canned Message. Occasionally a notification may come from the Operator or a passenger via their personal cell phone.

7.1.1 Initial Actions

- Observe all IBS information related to the event including location, route, vehicle status and run.
- Initiate voice communications to gather incident specifics including safety implications, if the vehicle can move, the number of passengers onboard, and any vehicle self-diagnostic codes available (Orion I).
- If fire or smoke is reported call 911 and the safety inspector.
- If a lift or ramp prevents an ADA customer from boarding, note the time and initiate actions to make the pickup within thirty (30) minutes.
- If there is a reported fluid leak contact maintenance to provide an environmental cleanup.
- Contact Maintenance and work with them to determine the proper response.
- If a tow is required validate that maintenance has made the call.
- If a road call is required, validate that a road call slip is filled out by maintenance.

- Initiate voice communications with the Operator and give them direction to continue in service, continue in service and wait for further instructions, or wait for Maintenance.

7.1.2 Service Restoration Strategy

- Work with other divisions if the affected service is a shared route.
- Vehicle that can't continue in service;
  - If extraboard coverage (or an out of service operator) is available, cover the run with a vehicle from the garage, a staged vehicle, or an out of service vehicle.
    - Determine if the run will be covered from the point of breakdown, another point along the run, or not covered (the last trip of day must be covered).
    - Determine if the extraboard driver will switch vehicles with the original driver, cover the run and switch with the original driver when meeting in route, or cover the remainder of the run.
    - Fill out a Bus Trade Up By Transportation form as required.
  - If no Operator is available and the service is critical (express or feeder route) reroute another run to pick up stranded customers and cover all critical stops.
    - Cancel the service if it will be covered by the next scheduled trip.
    - Vehicle that can continue in service with a mechanical problem;
    - Plan a bus switch with an out of service vehicle and driver, standby vehicle, or with an available extraboard driver.
- Determine if any service will be covered, a relay of customers is necessary, or a driver switch is required to maintain schedule.
- Fill out a Bus Trade Up By Transportation form as required.
- Notify the operator and customers of the service restoration plan.

7.1.3 Follow-up

- Notify Customer Relations (and RTA after business hours) of any service disruptions or delays.
- Classify the event and record in the Daily Log and Jupiter (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, Tradeoff).

7.1.4 Dispatch Document References

- Road Call Slip
- Bus Trade Up By Transportation Form

7.2 Train Crossing/ Bridge Up Operational Scenario

It is common for Operators to be stopped for prolonged periods at drawbridges or at 'at-grade' freight rail crossings along many of the routes operating in the region. Operators that encounter a delay of five (5) minutes send a "Train Crossing" text message and/or a "Request Detour" text message to notify their dispatcher of the disruption. A similar process is planned to be implemented for bridge delays.

7.2.1 Initial Actions

- Observe a “Train Crossing” canned message from a bus operator indicating a wait of over 5 minutes at train or bridge crossing.
- Observe a “Back in Service” 10-7 message from bus operator indicating obstruction cleared.
- Respond to a “Request Detour” text message (or RTT) sent by a bus operator with a voice call to approve or deny a bus operator suggested detour.
- If the 10-7 message is not received, or the Operator reports by voice call, that the crossing will be prolonged begin appropriate restoration strategy planning.
- Remind the Operator to pass out a Late Bus Slip to onboard customers.
- If tracks are out of view of a stopped vehicle send a text message to the onboard sign indicating to the customers that the wait is due to a gate crossing down.

7.2.2 Service Restoration Strategy

- Send a group text message to all drivers on routes that pass through a blocked crossing that includes the location of the obstruction and detour instructions as required.
- Determine if extraboard, pull-ins, or out of service vehicles are available to assist with covering service (especially for interlined routes).
- Determine whether to pull trippers off their scheduled work to cover lost express or tripper service.
- Determine the best strategy to get a delayed vehicle back on schedule by a short turn, deadhead, or standby and wait to get back on schedule.
- Send a group text message indicating the end of the gate crossing obstruction and any detours.

7.2.3 Follow-up

- Notify Customer Relations (and RTA after business hours) of any service disruptions or delays.
- Classify the event and record in the Train Delay Log, Daily Log and Jupiter (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, Tradeoff).

7.2.4 Dispatch Document References

None at this time, but a pre-approved detour list for problem crossings and bridges may be helpful.

7.3 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 vehicle, and leave the garage as scheduled. The dispatcher is required to assist the Operator with their sign-in at the dispatcher window. Notification of a late IBS logon, late pullout, or missing pullout are provided as data messages and this status is displayed as warnings on the Pullout/Pullin tab within IBS.

7.3.1 Initial Actions

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

7.3.2 Service Restoration Strategy

- Reassign a vehicle if a reported vehicle problem cannot be fixed by the Lot Manager in a timely fashion
- Examine late pullout 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.

7.3.3 Follow-up

- Log the bus operator miss in the Daily Log and Jupiter
  - Full miss out if later than two minutes
  - One-half miss out if 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 and Jupiter (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, Tradeoff).
- Notify Customer Relations (and RTA after business hours) of any service disruptions or delays.

7.3.4 Dispatch Document References

None

7.4 Metra/CTA Bus Bridge Operational Scenario

Bus bridges are regularly provided by Pace buses as substitute service for Metra or CTA passengers when segments of those system are inoperable due to a variety of equipment, infrastructure or external factors. Rail system outages vary widely in terms of location, the number of track miles and stations affected, and duration. PACE is expected to meet the need for alternate service, often on very short notice.

7.4.1 Initial Actions

Normally a call is from METRA or CTA to Headquarters and received by Operations Management with a request for assistance. If Pace is first to detect a rail outage see page 5 of the listed reference for Pace Emergency Call Procedures. The Pace Operations Manager will verify the routes affected, the location, and the nature of assistance required. There is a documented contingency plan to use as a reference but experience has shown that the responses do not normally follow from the written procedures. They are typically defined by the requesting agency based upon the unique set of circumstances of the given situation. The service restoration strategy is directed by the Operations Manager with the assistance of the division dispatchers.

7.4.2 Service Restoration Strategy

- Locate any available vehicles and drivers by starting at the nearest division to the carrier's outage and work outward to the other divisions.
- Headquarters contacts the divisions to have them report on availability of pull-ins, trippers, staged vehicles, or extraboard/vehicle availability at their garage for potential bus bridge re-assignment.
- Pace schedules must be maintained before deploying any vehicles and operators to the bus bridge.
- Confirm that supervisory personnel have been assigned to accompany the redeployed Pace resources. Provide the supervisors with routing instructions, communication protocols, and logon instructions to pass along to the Operators.
- The Operations Manager will maintain communications with the requesting agency to coordinate and update the response working through the Pace dispatcher and supervisory personnel.

7.4.3 Follow-up

- Dispatcher monitor train locations by contacting METRA GPS control center (see page 6 of listed reference).
- Dispatchers, with assistance from supervisory staff, fill out the Pace Operations Management Emergency Assessment Checklist.

7.4.4 Dispatch Document References

- Suburban Bus Service Contingency Plans for Commuter Railroad Service Disruptions
- Operations Management Emergency Assessment Checklist

7.5 IBS System Failure Operational Scenario

The IBS system will fail at times to send and receive data messages. This could be the result of a system, network, or individual computer problem(s). Dispatchers should act to restore the system as soon as the situation arises.

7.5.1 Initial Actions

Dispatchers will observe an IBS failure when their computer locks up, all buses disappear from the map, all buses disappear from the communications list, or RTT and PRTT data messages are not being received. Dispatchers should try to confirm if all dispatch computers are experiencing a lock up, are unable to monitor buses, or unable to receive messages.

7.5.2 Service Restoration Strategy

- Problem with one dispatcher console

  - Call (except South Division) the South Division Dispatch center and alert them to monitor your division while you attempt to reestablish IBS operations. South Division should notify West and North Shore to monitor their division.
  - Shut down and restart the BusOps and Map applications if possible.
  - If problem continues, Re-boot the computer after closing all applications.
  - If Problem continues, page John Braband at (888) 706-7223 and notify South Dispatch to continue to monitor your division service.
- Problem with all dispatcher consoles
  - Page John Braband at (888) 706-7223
  - Verify that buses can communicate on home channel 1
  - If vehicles do not respond on home channel 1 shut down (turn off) computers. This should force the system to push vehicles to their home base channel 1.
  - South Division will only be able to monitor non-IBS buses that are able to tune to south 1 (failure during centralized dispatch).
  - Remaining IBS facilities must be monitored by West Division Dispatch or supervisors using portable radios either in dispatch or on the road.

7.5.3 Follow-up

- Record actions taken in the Daily Log

7.5.4 Dispatch Document References

None

7.6 United States Postal Distribution Center Evacuation

The United States Postal Service (USPS) has installed Bio Hazard Detection Systems (BDS) at their two primary distribution centers. Pace has agreed to provide buses in the event these facilities are to be evacuated.

7.6.1 Initial Actions

- A phone call is received from the USPS requesting that Pace activate the evacuation plan.

7.6.2 Service Restoration Strategy

- Immediately page the emergency pager (see referenced document for numbers).
- Immediately page Don McIntyre, Ken Grish, or John Braband (see page 2 of the referenced document for contact numbers).
- Southwest division will be contacted to assign two (2) Operators and vehicles and follow the instructions in the evacuation plan.
- If the call is received after the Southwest Division business hours, South division will act as responding division and deploy the two (2) Operators and buses.
- Refer to page 2 of the referenced document for USPS facility driving directions and evacuation procedures

7.6.3 Follow-up

- Record in Daily Log and Jupiter

7.6.4 Dispatch Document References

Pace After Hours Emergency Phone Line Procedures

7.7 Pace Passenger Facilities Emergencies

Calls are received from Operators, police, fire department, or a municipality reporting a damaged bus stop sign, shelter, a Park-and-Ride lot problem, or a problem at a Transit Center that requires immediate action.

7.7.1 Initial Actions

- Take down the information related as accurately as possible.
- Immediately contact Allen Lee, the Passenger Facilities Supervisor, and Don McIntyre Section Manager, Operating Services (see page 3 of the referenced document for contact numbers).

7.7.2 Follow-up

- Record the actions in the Daily Log and Jupiter

7.7.3 Dispatch Document References

Pace After Hours Emergency Phone Line Procedures

The following operational scenarios are presented as examples of information received by dispatchers (typically the after hours dispatch center) from outside sources. Pace desires that the TODSS integrate outside sources of information with the IBS notifications to provide a single point to view restoration actions and document dispatcher actions.

7.8 Pace Contractor Accident Report (fixed route or paratransit)

South Division dispatchers may receive an after hours call from a Pace fixed route or paratransit contracted carrier requesting to report an accident.

7.8.1 Initial Actions

- Determine if a drug and alcohol test is required because of the accident. Determination is based upon a person(s) transported from the accident scene, vehicle(s) involved in the accident are towed from the scene, or a fatality occurs.
- Immediately page the emergency contact number (page 3 of the referenced document) if a drug and alcohol test is required.
- Inform the caller to report the accident by calling the Pace Emergency phone number between 8:00 a.m. and 5:00 p.m. by the next business day if the drug and alcohol test is not required.

7.8.2 Follow-up

- Record in the Daily Log and Jupiter

7.8.3 Dispatch Document References

- Pace After Hours Emergency Phone Line Procedures

7.9 Stranded Paratransit Customer

A dispatcher may receive a call from a Pace paratransit rider claiming to be stranded due to their return ride not showing up on either the fixed route or paratransit service.

7.9.1 Initial Actions

- Immediately page the emergency contact number (page 3 of the referenced document).

7.9.2 Service Restoration Strategy

- Verify the fixed route passengers claim
- Determine what supervisory personnel are available to provide service if the fixed route claim is valid.

7.9.3 Follow-up

- Record in the Daily Log and Jupiter

7.9.4 Dispatch Document References

- Pace After Hours Emergency Phone Line Procedures

8 Conclusion

This memorandum, as previously stated, provides the TODSS users and developers background and specific operational scenarios upon which to base the TODSS design, development, operation, and maintenance. The Pace TODSS prototype follows the TODSS core requirements closely and should provide a thorough proof of concept for other agencies and vendors to evaluate.

The TODSS will fit into the exiting Pace IBS framework and flow of operations with the addition of a new dispatcher computer interface. The TODSS will coordinate the IBS data sources along with external sources of information through the development of new parameters and threshold settings. New data stores will provide the rules for the TODSS decision engine to provide dispatchers with a systematic representation of the information. Through recognition of operational scenarios, the TODSS will enhance the IBS by providing the restoration strategies appropriate for the identified conditions. By the development of a highly configurable parameter based decision support system, it is anticipated that the TODSS prototype will prove to be beneficial to Pace far into the future.

Appendix III - TODSS Prototype Requirements and Architecture

Prepared by Pace for FTA Office of Mobility Innovation U.S. DOT ITS Joint Program Office
September 2008

1 Scope

1.1 Identification

This document defines the detailed system-level requirements and architecture for a proof-of-concept prototype of a Transit Operations Decision Support System (TODSS). This prototype will be designed in cooperation with Pace and implemented in conjunction with their existing Intelligent Bus System (IBS).

1.2 System Overview

Initial deployments of CAD/AVL systems in the public transit industry have provided dispatchers with a wealth of real-time information regarding the performance of their in-service fleet. The next phase of this process will be to provide these dispatchers with tools and automated analysis processes to assist them in identifying service disruptions and making decisions necessary to restore planned levels of service.

The term Transit Operations Decisions Support System (TODSS) is being used to describe a layer of analysis tools and displays that encapsulates, consolidates, and summarizes standard CAD/AVL system data into a more efficient and meaningful form. These processes function along the same lines as a rule-based inference engine by filtering noise and highlighting underlying trends. They also aid in the application of business-rules and procedures to define and execute recovery options once service disruptions have been detected.

A proof-of-concept prototype system will be designed and developed by Continental Corporation in cooperation with Pace Transit (suburban Chicago) to operate in conjunction with their existing TransitMaster™ IBS.

1.3 Document Overview

There are three major sections to this document.

Section 3.0 provides architectural information describing how the TODSS Prototype will co-exist with the current Pace IBS.

Section 4.0 defines the detailed system-level requirements for the TODSS Prototype as well as requirements fulfilled through the current Pace IBS.

Section 5.0 contains a requirements traceability matrix to one of the following test verification methods: Demonstration, Test, Analysis, or Inspection.

2 References

Transit Operations Decision Support Systems (TODSS) Core Functional Requirements for Identification of Service Disruptions and Provision of Service Restoration Options 1.0 by Mitretek Systems (3 May 2003)

Pace Definition of Operational Scenarios and System Parameters Technical Memorandum, January 2007

Pace Prototype Concept of Operations Technical Memorandum, January 2007

Systems Engineering Guidebook for ITS – California Department of Transportation Division Research & Innovation, Version 2.0

3 Architecture

The following diagram depicts how the TODSS prototype will be installed into the existing Pace TransitMaster IBS.

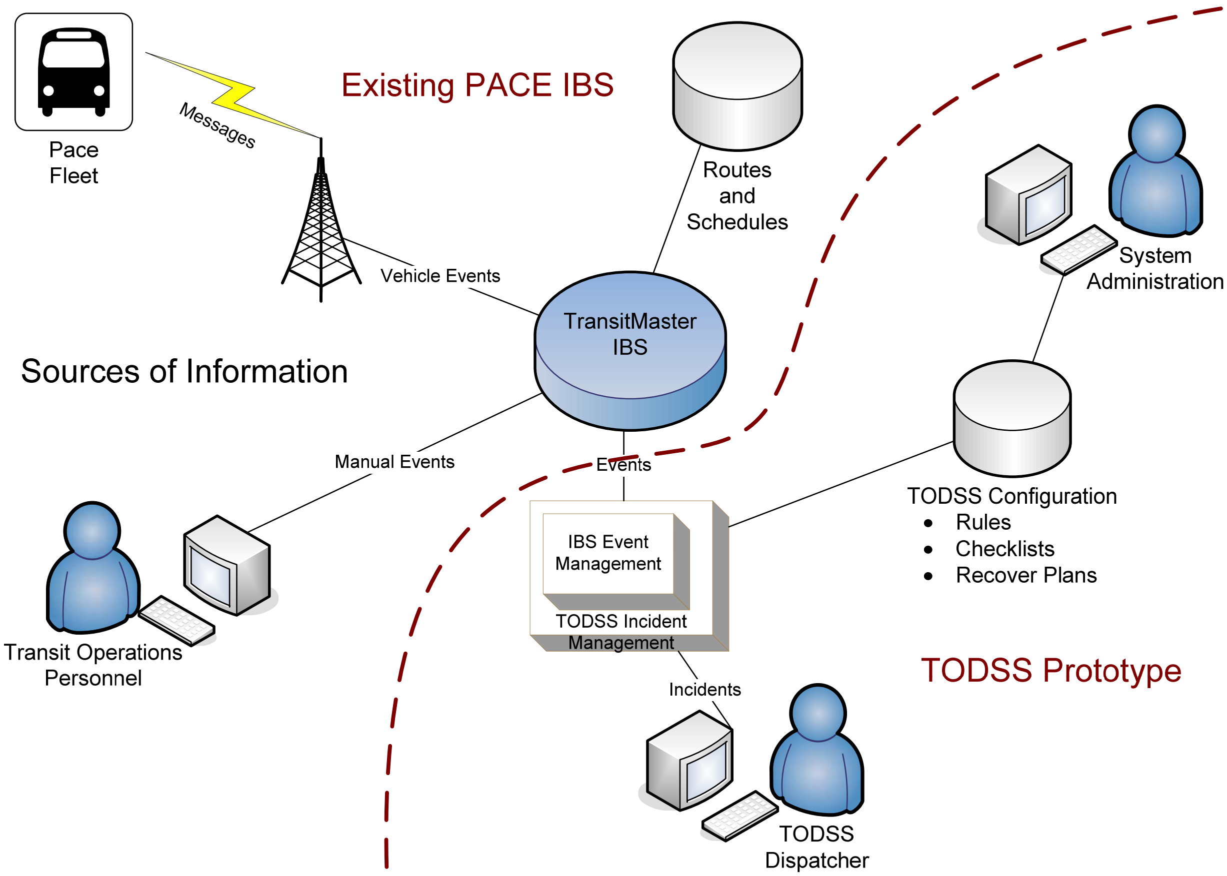

Figure 11 - Appendix 3 TODSS Prototype Installed Into the Pace TransitMaster™ IBS

There will be two primary sources of event information: the existing link of vehicle messages and a method for manually inserting "external" events through the TODSS Dispatch Console.

A configuration utility will be used by System Administrators to configure the TODSS parameters. These parameters will include the rules mapping raw events to TODSS Incidents, Incident Attributes, Initial Checklists, and Recovery Plans. The TODSS configuration tool will display a separate spreadsheet form for each set of parameters and the parameters will be stored into various database tables.

A TODSS Incident Management layer will encapsulate the existing IBS Event Management component and support an incident-level interface with the TODSS dispatcher. This service will perform the following tasks:

- Process event messages from IBS vehicles and system components to generate the input to the rule-based creation of TODSS incidents
- Apply the TODSS event rules to create incidents as needed
- Manage ownership of incidents
- Apply work assignment role filters
- Keep track of incident statuses as they are handled by dispatchers
- Update incident statuses according to the configured rules
- Prioritization/Selection of recovery actions
- Write an audit trail per incident to a database log table when an incident gets deleted (by either the system or a dispatcher). The audit trail will contain data from the underlying event(s) and date/time of each step of the recovery plan that was executed by the user

Figure 2 illustrates how the rule-created incident maintains connection with its source events as well as linkages to checklist and recovery procedures.

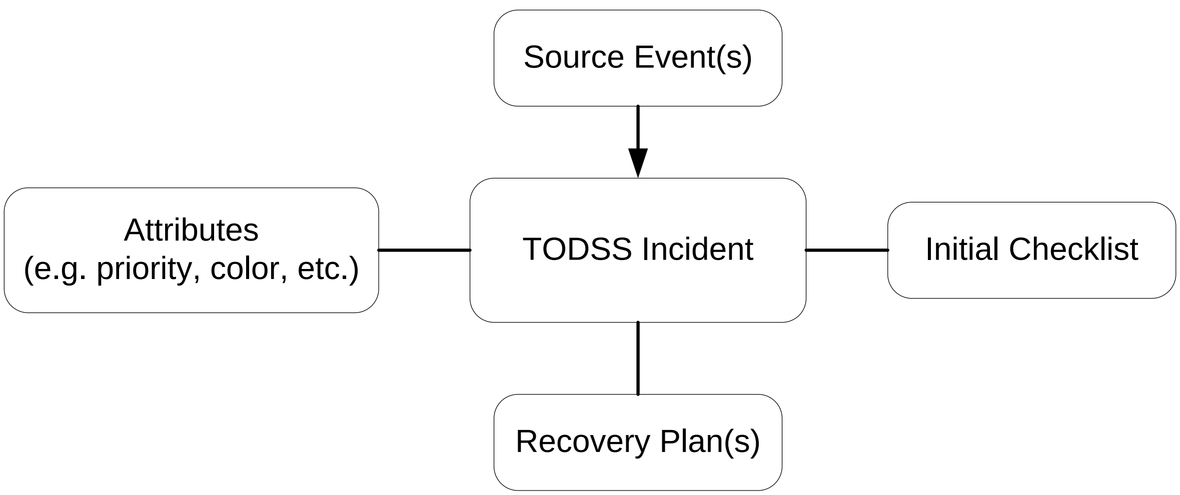

Figure 12 - Appendix 3 TODSS Incident

Removal of TODSS incidents may occur by one of the following methods:

- by the system when the incident expires
- by the system when the event parameter for an updating rule falls below the trigger threshold and the rule is configured to allow incident removal
- by the system as soon as the incident is completed, if there is any recovery plan attached

- by the dispatcher anytime, if no recovery plan is attached or the incident is flagged to allow such removal

The TODSS Dispatch console will continue to support much of the existing IBS functionality for system status and actions. The new TODSS Incident Display (see figure 3) will provide the interface through which dispatchers are informed of new incidents. It will also support the process to step through a recovery plan. By coupling this functionality along side existing IBS functionality, expedient linkages can be made to accomplish the service restoration tasks.

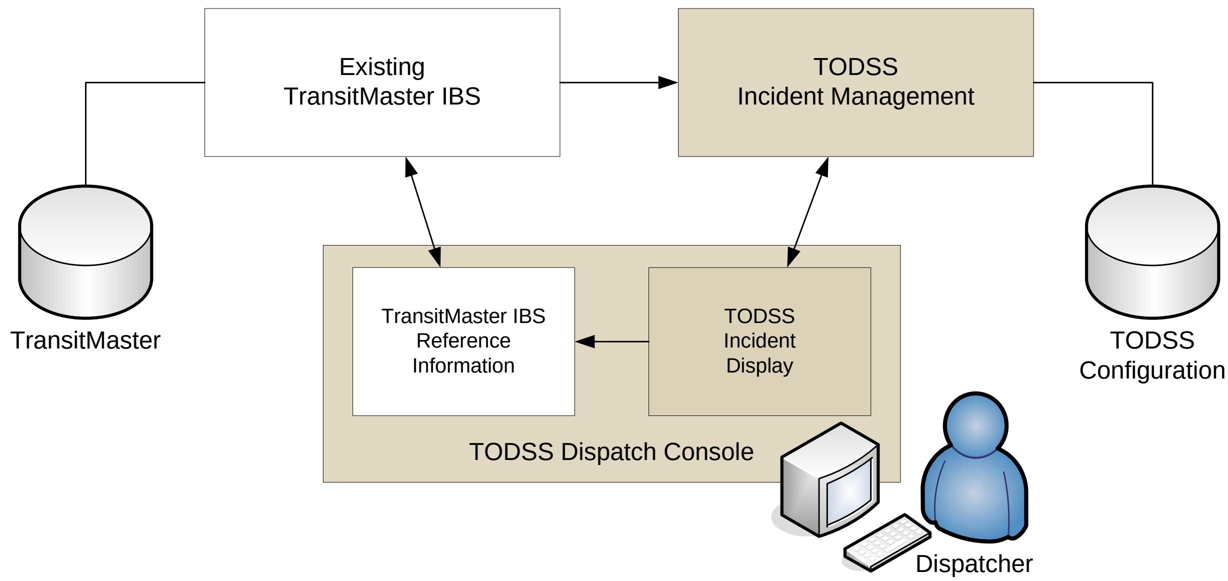

Figure 13 - Appendix 3 TODSS Dispatch Console

4 Requirements

4.1 Functional Requirements

The following sections define the functional requirements of the TODSS Prototype. These requirements were derived from the Core Functional Requirements provided in the RFP and tailored to incorporate those requirements unique to the Pace TransitMaster IBS. Section 5.0 includes the traceability back to these core requirements.

The requirements are organized by major functional areas: Configuration, Inputs, Detection, and Resolution. A separate paragraph is dedicated to those core functional requirements that are currently being fulfilled by the existing Pace TransitMaster IBS.

An “authorized user” is a person that has the ability to configure the system, define the rules and incidents that are created when events are triggered within the TODSS prototype. A “user” is a person that will respond to the incidents that are created within the TODSS prototype.

4.1.1 Configuration and Setup

REQ5 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

REQ138 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

REQ179 The TODSS Prototype shall consider Pace IBS System Administrators as "authorized users".

REQ59 The TODSS Prototype shall allow authorized users to create a set of dispatcher-initiated events (name and description).

REQ133 The TODSS Prototype shall be capable of performing the following actions mapped to new TODSS and existing Pace IBS functionality:

- Acknowledge an Incident
- Begin a Dispatch Chat
- Clear an Emergency
- Create an Incident Report
- Create a Manual Event
- Create a Service Adjustment
- Display an Action Plan Document
- Display a Dispatch Document
- Display the Phone Directory
- Downgrade a Covert Alarm
- Filter Mechanical Alarms
- Initiate a Covert Microphone Session
- Launch Instant Playback
- Perform a Remote Vehicle Logon
- Replace a Driver or Vehicle
- Reply to the incident source with a Canned Message
- Reply to the incident source with a Text Message
- Reply to the incident source with a Voice Call
- Send an E-mail
- Send an OnStreet™ Message
- Send a Canned Message
- Send a Text Message
- Send a Voice Call
- Set Operator Absent - Returned
- View Communication History
- View Map
- View Pullout Tab
- View Roster Tab
- View Route Ladder
- View Route Tab
- View Schedule Tab
- View Service Overview
- View Vehicle Properties
- View Vehicle Tab
- View a Web Page

4.1.1.1 Action Items

REQ135 The TODSS Prototype shall allow authorized users to create and manage action items.

REQ136 The action item shall have a text description of a dispatcher action and an action to be performed.

4.1.1.2 Research Checklists

REQ60 The TODSS Prototype shall allow authorized users to create and manage Research Checklists.

REQ61 A research checklist shall consist of a name and list of action items.

REQ155 A research checklist shall include space to provide functional impacts based upon prior dispatcher experiences.

REQ124 A research checklist shall include space to provide guidance for the impact and selection of a recovery plan.

4.1.1.3 Recovery Plans

REQ64 The TODSS Prototype shall allow authorized users to create and manage Recovery Plans.

REQ67 A recovery plan shall consist of a name and list of action items.

4.1.1.4 Incidents

REQ27 The TODSS Prototype shall allow authorized users to create and manage Incidents.

REQ19 The TODSS Prototype shall allow a given event to trigger multiple incidents.

REQ20 The TODSS Prototype shall allow different events to trigger the same incident.

REQ21 The TODSS Prototype shall allow a given incident to be triggered by different events.

REQ65 The TODSS Prototype shall allow authorized users to associate a Research Checklist to each incident.

REQ28 The TODSS Prototype shall allow authorized users to associate up to three (3) Recover Plans to each incident.

REQ66 The TODSS Prototype shall allow authorized users to associate one or more Pace IBS Work Assignment roles to each incident.

REQ176 The TODSS Prototype shall allow authorized users to associate a "quick task" (e.g. Voice Call, Canned Message, Text Message, or Open an Incident Report) to each incident.

4.1.1.5 Rules

REQ16 The TODSS Prototype shall allow authorized users to create rules for evaluating events and generating incidents.

REQ17 Each rule shall map a single event to a single incident.

REQ154 Each rule shall be assigned a type: Generating (new incident) or Updating (existing incident).

REQ18 The TODSS Prototype shall allow a given event to be used as the input to multiple rules (based upon context).

REQ22 The TODSS Prototype shall allow authorized users to define multiple rule parameters:

REQ32 The rule parameters shall include an event parameter threshold value and operator.

REQ33 The rule parameters shall include an incident priority value between 100 (highest) and 0 (lowest).

REQ34 The rule parameters shall include an incident suppression interval (i.e. minimum time between triggering a repeat incident).

REQ35 The rule parameters shall include an incident expiration interval (from 1 minute to 48 hours).

REQ36 The rule parameters shall include a method allowing automatic removal if the source event clears.

REQ37 The rule parameters shall include a link to an audio file to be played upon incident creation.

REQ38 The rule parameters shall include the selection of a display color.

REQ40 The rule parameters shall include an enable/disable flag.

REQ24 The TODSS Prototype shall allow the selection of a "context" under which a set of rules may be evaluated:

REQ29 The rule context shall include the selection of a service type (e.g. Weekend, Saturday, or Sunday).

REQ30 The rule context shall include the selection of a route type criterion (e.g. BRT).

REQ31 The rule context shall include the selection of a time-of-day criterion (e.g. AM Peak).

REQ139 The rule context shall include the selection of a day-of-week criterion.

REQ140 The rule context may include additional criteria specific to the selected event (e.g. vehicle state information).

REQ23 The TODSS Prototype shall treat each event/rule set as an independent entity (i.e. use OR logic).

4.1.2 Sources of Information

REQ73 The TODSS Prototype shall be capable of accessing route and schedule information from the Pace IBS database.

REQ6 The TODSS Prototype shall be capable of receiving real-time information from currently operating vehicles.

REQ13 The TODSS Prototype shall split the Pace IBS Mechanical Alarm message into separate events for each individual alarm.

REQ7 The TODSS Prototype shall be capable of receiving real-time information from other Pace IBS components.

REQ15 The TODSS Prototype shall include an event aggregation service to create a single output event based upon multiple events or real-time information.

REQ14 The TODSS Prototype shall use summarized schedule adherence by route events.

REQ8 The TODSS Prototype shall be capable of receiving manual events from TODSS dispatchers.

REQ75 The TODSS Prototype shall function as an integrated real-time component of the Pace IBS system.

REQ2 The TODSS Prototype shall utilize the Pace IBS MiniNet to receive real-time message information.

REQ3 The TODSS Prototype shall create events based upon receipt of real-time message information.

4.1.3 Service Disruptions

REQ58 The TODSS Prototype shall allow dispatchers to selectively trigger a manual event through the Bus Ops application.

REQ41 The TODSS Prototype shall evaluate configured rules upon receipt of an event.

REQ42 The TODSS Prototype shall create incidents based upon execution of configured rules.

REQ43 The TODSS Prototype shall automatically use the highest priority rule if multiple rules are triggered that would create the same incident.

REQ44 The TODSS Prototype shall display incidents to the dispatcher through the Pace IBS Bus Ops application.

REQ53 The incident shall be displayed in the configured background color.

REQ45 The TODSS Prototype shall be capable of playing an audio file associated with this incident.

REQ70 The TODSS Prototype shall suppress duplicate incidents per configuration.

REQ71 The TODSS Prototype shall allow a suppressed incident (user defined incident parameter) to update existing incident source event information.

REQ153 The TODSS Prototype shall be capable of removing an existing incident from the queue based upon future events.

REQ50 The TODSS Prototype shall allow the dispatcher to select and work with any incident from the queue.

REQ51 The TODSS Prototype shall support the configured Double-Click action (see configuration).

REQ52 The TODSS Prototype shall allow the dispatcher to display the Research Checklist for a selected incident.

REQ46 The TODSS Prototype shall treat any steps in the Research Checklist as additional/optional data gathering.

REQ47 The TODSS Prototype shall utilize the Pace IBS Work Assignments component to filter access to incidents.

REQ49 The TODSS Prototype shall automatically remove an incident from the queue after its expiration period.

REQ48 The TODSS Prototype shall automatically remove an incident from the queue if marked as allowed and its recovery plan has been completed.

4.1.4 Service Restoration

REQ76 The TODSS Prototype shall allow dispatchers to take ownership of an incident (i.e. lock/unlock).

REQ77 The TODSS Prototype shall utilize existing Incident Report capabilities in the Pace IBS system.

REQ12 The TODSS Prototype shall allow the dispatcher to view from the list of Recovery Plans associated with the selected incident.

REQ137 The TODSS Prototype shall allow the dispatcher to select a Recovery Plan for a given incident.

REQ54 The TODSS Prototype shall monitor the performance of each step in the Recovery Plan.

REQ55 The TODSS Prototype shall construct an audit trail for each incident.

REQ56 The audit trail shall include information from the triggering event and time stamps for each accomplished step in the Recovery Plan.

REQ57 The TODSS Prototype shall mark an incident as "Complete" once all Recovery Plan steps have been completed.

REQ72 The TODSS Prototype shall allow dispatchers to change to a different Recovery Plan and transfer over the status for any common task steps.

4.1.5 Existing Pace IBS Functionality

REQ84 The Pace IBS shall support same-day service adjustments:

REQ79 The service adjustments shall support detours through a timepoint waiver process.

REQ80 The service adjustments shall support the cancellation of scheduled service at the block-level.

REQ81 The service adjustments shall support the creation of overload blocks for extra or spacer service.

REQ82 The service adjustments shall support the splitting of existing blocks to accommodate operator or vehicle change-outs.

REQ83 The service adjustments shall support headway realignment using temporal adjustments to existing schedules (blocks).

REQ85 The Pace IBS shall support import and activation of new schedules.

REQ86 The Pace IBS shall support the detection of vehicle schedule adherence (early/late) events.

REQ87 The Pace IBS shall support the detection of overall route schedule adherence (early/late) events.

REQ88 The Pace IBS shall support the detection of missing/late logon events.

REQ92 The Pace IBS shall support the detection of route headway events.

REQ95 The Pace IBS shall support the automatic detection of passenger overload events.

REQ96 The Pace IBS shall support the manual (operator) indication of passenger overload events.

REQ98 The Pace IBS shall support coordinated vehicle turn back events.

REQ99 The Pace IBS shall support the detection of vehicle off-route events.

REQ100 The Pace IBS shall support mechanical alarm events.

REQ101 The Pace IBS shall support overt alarm events.

REQ102 The Pace IBS shall support covert alarm events.

REQ103 The Pace IBS shall support passenger-initiated transfer events.

REQ104 The Pace IBS shall support automated transfer connection protection events.

REQ105 The Pace IBS shall support voice fallback events.

REQ106 The Pace IBS shall allow authorized users to designate any event as requiring an incident report.

REQ108 The Pace IBS shall include displays of summarized tabular and graphical route performance.

REQ178 The Pace IBS shall support the definition of work assignment roles for event filtering by garage, route, region, and/or vehicle.

REQ177 The Pace IBS shall allow dispatchers to select their work assignment role(s).

REQ109 The Pace IBS shall direct events and incidents to appropriate personnel based upon work assignment roles.

REQ111 The Pace IBS shall include a geographic map display:

REQ112 The geographic map display shall support zoom in/out.

REQ113 The geographic map display shall include a base map with a road network and transit-related landmarks.

REQ114 The geographic map display shall be capable of displaying the current reported location of all active vehicles.

REQ115 The vehicle map icon shall be capable of displaying vehicle identification (e.g. route, block, fleet, etc.).

REQ116 The vehicle map icon shall be capable of displaying vehicle status (e.g. schedule adherence, route adherence, mechanical alarms, emergency, etc.).

REQ117 The geographic map display shall refresh as new vehicle information is received.

REQ118 The Pace IBS shall include tabular and graphical displays of a selected route.

REQ110 The Pace IBS shall include a display summarizing schedule adherence and headway disruptions.

REQ119 The Pace IBS shall support filtering of tabular displays by attributes (column values).

REQ122 The Pace IBS shall support sorting of tabular displays by attributes (column values).

REQ74 The Pace IBS shall automatically raise a vehicle's polling rate during an emergency (Covert or Overt alarm) condition.

REQ121 The Pace IBS shall support configurable colors by schedule adherence, headway, or route status (on Route Ladder and Map).

REQ120 The Pace IBS shall include resizable tabs and windows.

REQ26 The Pace IBS shall allow System Administrators to grant feature access rights to specific users.

REQ107 The Pace IBS shall trace system-wide adherence problems through Critical Transfer notifications.

REQ141 The Pace IBS shall notify dispatchers when a vehicle is dropped from the polling list.

REQ142 The Pace IBS shall notify dispatchers when the communications link is down.

REQ149 The Pace IBS shall notify dispatchers when essential system components have failed.

REQ144 The Pace IBS shall support group communications by fleet, route, and other predefined collections.

REQ145 The Pace IBS shall support a dispatcher-controlled voice communications network.

REQ146 The Pace IBS shall support vehicle-to-vehicle communications controlled through dispatch.

REQ147 The Pace IBS shall follow guidelines put forth in the NTCIP standards.

REQ148 The Pace IBS shall support interfaces to external clients through shared database access and software-controlled gateways.

REQ150 The Pace IBS shall archive all vehicle message events.

REQ151 The Pace IBS shall include a vehicle event playback feature.

REQ152 The Pace IBS shall utilize standard Windows logon and access features.

4.1.6 Future TODSS Functionality

There are several core TODSS requirements that do not apply to existing Pace operations and available technological capabilities but are included in their future plans. Local requirements for the TODSS prototype do not currently include corridor management until Pace implements their planned “arterial” service in the future. Additionally, Pace decided that since they do not have a large base of installed Automatic Passenger Counter systems that load factors would not be included as parameters for defining incidents. It was also determined that it would be difficult to evaluate and prioritize recovery plans (action plans) without existing defined operating procedures and any historical experience to draw upon. The TODSS prototype has been designed to take into account these requirements given their importance to the future growth of TODSS.

REQ90 The TODSS shall support the detection of corridor schedule adherence events.

REQ91 The TODSS shall support the detection of early/late timepoint crossing events.

REQ93 The TODSS shall support the detection of vehicles bunching at a location (stop/timepoint).

REQ94 The TODSS shall support the detection of corridor headway events.

REQ125 The TODSS shall be capable of prioritizing recovery plans based upon multiple factors:

- REQ126 The prioritization factors shall include the priority level of the incident.
- REQ127 The prioritization factors shall include the latency (age) of the incident.
- REQ128 The prioritization factors shall include the location of the incident.

REQ129 The prioritization factors shall include the availability of resources.

REQ130 The prioritization factors shall include the operational context.

REQ131 The TODSS shall evaluate recovery plan priorities as arithmetic or logical compositions of the given factors.

4.2 Performance Requirements

The following is a performance requirement of the TODSS Prototype.

REQ162 The TODSS prototype event / incident processing time shall not introduce noticeable delay (more than 2 seconds) from the response time of the current IBS.

4.3 Interface Requirements

This section defines the interface requirements of the TODSS Prototype.

REQ175 The TODSS parameters and thresholds shall be user definable by authorized users to protect system integrity.

REQ171 The Pace IBS shall support importing of Hastus schedule information.

REQ173 The Pace IBS shall support importing of base maps.

REQ174 The Pace IBS shall support e-mail capabilities.

REQ172 The TODSS prototype shall support Rich Site Summary protocol (RSS) via Internet connectivity.

4.4 Data Requirements

The following is a data requirement of the TODSS Prototype.

REQ170 The Pace IBS shall continue to support current IBS event logging and latest TransitMaster design.

4.5 Non-Functional Requirements

None

4.6 Constraints

REQ167 The TODSS prototype requires TransitMaster version 24 or higher.

REQ168 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.

5 Test Verification Method

The following table is an export from Continental's DOORS installation. This tool is used to capture core user requirements, assist in the decomposition and traceability to detailed, system-level product requirements, and traceability to design, development, and test functions.

The ID values are assigned through DOORS to provide traceability to downstream design and test items. The Ref # is created by the tools internal linkage back to the Core Functional Requirements. The Detailed Requirements refer back to Section 4.0 of this document and a verification method is given for each requirement. Because this is a software prototype system, most verification will be accomplished via Demonstration using the Pace IBS system and/or Inspection of display or database tables.

Table 5 - Appendix 3 TODSS Requirements and Traceability

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
		4.1.1 Configuration and Setup	
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	Demonstration
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	Demonstration

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
		• System Health • Workpiece Alert	
REQ179	N/A	The TODSS Prototype shall consider Pace IBS System Administrators as "authorized users".	
REQ59	SI 2 SI 6.1	The TODSS Prototype shall allow authorized users to create a set of dispatcher-initiated events (name and description).	Demonstration
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: • Acknowledge an Incident • Begin a Dispatch Chat • Clear an Emergency • Create an Incident Report • Create a Manual Event • Create a Service Adjustment • Display an Action Plan Document • Display a Dispatch Document • Display the Phone Directory • Downgrade a Covert Alarm • Filter Mechanical Alarms • Initiate a Covert Microphone Session • Launch Instant Playback • Perform a Remote Vehicle Logon • Replace a Driver or Vehicle • Reply to the incident source with a Canned Message • Reply to the incident source with a Text Message • Reply to the incident source with a Voice Call • Send an E-mail • Send an OnStreet Message • Send a Canned Message • Send a Text Message • Send a Voice Call • Set Operator Absent - Returned • View Communication History • View Map • View Pullout Tab • View Roster Tab • View Route Ladder • View Route Tab • View Schedule Tab • View Service Overview • View Vehicle Properties • View Vehicle Tab • View a Web Page	Demonstration
		4.1.1.1 Action Items	

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ135	N/A	The TODSS Prototype shall allow authorized users to create and manage action items.	Demonstration
REQ136	N/A	The action item shall have a text description of a dispatcher action and an action to be performed.	Inspection
		4.1.1.2 Research Checklists	
REQ60	SD 6.3 SR 8.1	The TODSS Prototype shall allow authorized users to create and manage Research Checklists.	Demonstration
REQ61	SD 6.3	A research checklist shall consist of a name and list of action items.	Inspection
REQ155	SI 8.2.1 SD 5 SD 6.3	A research checklist shall include space to provide functional impacts based upon prior dispatcher experiences.	Demonstration
REQ124	SR 2 SR 6 SR 9	A research checklist shall include space to provide guidance for the impact and selection of a recovery plan.	Demonstration
		4.1.1.3 Recovery Plans	
REQ64	SR 8.2 SR 8.3	The TODSS Prototype shall allow authorized users to create and manage Recovery Plans.	Demonstration
REQ67	N/A	A recovery plan shall consist of a name and list of action items.	Inspection
		4.1.1.4 Incidents	
REQ27	N/A	The TODSS Prototype shall allow authorized users to create and manage Incidents.	Demonstration
REQ19	N/A	The TODSS Prototype shall allow a given event to trigger multiple incidents.	Demonstration
REQ20	N/A	The TODSS Prototype shall allow different events to trigger the same incident.	Demonstration
REQ21	N/A	The TODSS Prototype shall allow a given incident to be triggered by different events.	Demonstration
REQ65	N/A	The TODSS Prototype shall allow authorized users to associate a Research Checklist to each incident.	Inspection
REQ28	SR 3 SR 5.1	The TODSS Prototype shall allow authorized users to associate up to three (3) Recover Plans to each incident.	Inspection
REQ66	N/A	The TODSS Prototype shall allow authorized users to associate one or more Pace IBS Work Assignment roles to each incident.	Inspection
REQ176	N/A	The TODSS Prototype shall allow authorized users to associate a "quick task" (e.g. Voice Call, Canned Message, Text Message, or Open an Incident Report) to each incident.	Inspection
		4.1.1.5 Rules	
REQ16	SD 4.1	The TODSS Prototype shall allow authorized users to create rules for evaluating events and generating incidents.	Demonstration
REQ17	N/A	Each rule shall map a single event to a single incident.	Inspection

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ154	N/A	Each rule shall be assigned a type: Generating (new incident) or Updating (existing incident).	Inspection
REQ18	N/A	The TODSS Prototype shall allow a given event to be used as the input to multiple rules (based upon context).	Demonstration
REQ22	SI 6.1 SD 1.3 GS 7.3 GS 8	The TODSS Prototype shall allow authorized users to define multiple rule parameters:	Demonstration
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.	Inspection
REQ33	SD 1.3 SD 7	The rule parameters shall include an incident priority value between 100 (highest) and 0 (lowest).	Inspection
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).	Inspection
REQ35	SD 1.3 SD 6.4.3	The rule parameters shall include an incident expiration interval (from 1 minute to 48 hours).	Inspection
REQ36	SD 1.3 SD 6.4.3	The rule parameters shall include a method allowing automatic removal if the source event clears.	Inspection
REQ37	SD 1.3 SD 4.2	The rule parameters shall include a link to an audio file to be played upon incident creation.	Inspection
REQ38	SD 1.3 SD 4.2	The rule parameters shall include the selection of a display color.	Inspection
REQ40	SI 6.1 SD 6.2	The rule parameters shall include an enable/disable flag.	Inspection
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:	Demonstration
REQ29	SD 3	The rule context shall include the selection of a service type (e.g. Weekend, Saturday, or Sunday).	Inspection
REQ30	SD 3 SD 7.1	The rule context shall include the selection of a route type criterion (e.g. BRT).	Inspection
REQ31	SD 3 SD 7.1	The rule context shall include the selection of a time-of-day criterion (e.g. AM Peak).	Inspection
REQ139	SD 3 SD 7.1	The rule context shall include the selection of a day-of-week criterion.	Inspection

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ140	SD 3 SD 7.1	The rule context may include additional criteria specific to the selected event (e.g. vehicle state information).	Inspection
REQ23	SI 8.1	The TODSS Prototype shall treat each event/rule set as an independent entity (i.e. use OR logic).	Analysis
		4.1.2 Sources of Information	
REQ73	SI 1 SI 3.1	The TODSS Prototype shall be capable of accessing route and schedule information from the Pace IBS database.	Demonstration
REQ6	SI 1 SD 1.2	The TODSS Prototype shall be capable of receiving real-time information from currently operating vehicles.	Demonstration
REQ13	N/A	The TODSS Prototype shall split the Pace IBS Mechanical Alarm message into separate events for each individual alarm.	Demonstration
REQ7	SI 1	The TODSS Prototype shall be capable of receiving real-time information from other Pace IBS components.	Demonstration
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.	Inspection
REQ14	N/A	The TODSS Prototype shall use summarized schedule adherence by route events.	Demonstration
REQ8	SI 2 SI 3.3 SI 5 SR 4	The TODSS Prototype shall be capable of receiving manual events from TODSS dispatchers.	Demonstration
REQ75	SI 4 SI 5	The TODSS Prototype shall function as an integrated real-time component of the Pace IBS system.	Analysis
REQ2	SI 3.2 SI 5	The TODSS Prototype shall utilize the Pace IBS MiniNet to receive real-time message information.	Inspection
REQ3	N/A	The TODSS Prototype shall create events based upon receipt of real-time message information.	Demonstration
		4.1.3 Service Disruptions	
REQ58	SD 1.2	The TODSS Prototype shall allow dispatchers to selectively trigger a manual event through the Bus Ops application.	Demonstration
REQ41	SD 4.1	The TODSS Prototype shall evaluate configured rules upon receipt of an event.	Analysis
REQ42	SD 4.1	The TODSS Prototype shall create incidents based upon execution of configured rules.	Demonstration
REQ43	N/A	The TODSS Prototype shall automatically use the highest priority rule if multiple rules are triggered that would create the same incident.	Demonstration
REQ44	SD 9.2.2	The TODSS Prototype shall display incidents to the dispatcher through the Pace IBS Bus Ops application.	Inspection
REQ53	N/A	The incident shall be displayed in the configured background color.	Demonstration
REQ45	N/A	The TODSS Prototype shall be capable of playing an audio file associated with this incident.	Demonstration
REQ70	N/A	The TODSS Prototype shall suppress duplicate incidents per configuration.	Demonstration

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ71	N/A	The TODSS Prototype shall allow a suppressed incident to update existing incident source event information.	Demonstration
REQ153	N/A	The TODSS Prototype shall be capable of removing an existing incident from the queue based upon future events.	Demonstration
REQ50	N/A	The TODSS Prototype shall allow the dispatcher to select and work with any incident from the queue.	Demonstration
REQ51	N/A	The TODSS Prototype shall support the configured Double-Click action (see configuration).	Demonstration
REQ52	SR 8.1	The TODSS Prototype shall allow the dispatcher to display the Research Checklist for a selected incident.	Demonstration
REQ46	SR 5.2	The TODSS Prototype shall treat any steps in the Research Checklist as additional/optional data gathering.	Analysis
REQ47	SD 10.1	The TODSS Prototype shall utilize the Pace IBS Work Assignments component to filter access to incidents.	Inspection
REQ49	N/A	The TODSS Prototype shall automatically remove an incident from the queue after its expiration period.	Demonstration
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.	Demonstration
		4.1.4 Service Restoration	
REQ76	SR 8.4	The TODSS Prototype shall allow dispatchers to take ownership of an incident (i.e. lock/unlock).	Demonstration
REQ77	N/A	The TODSS Prototype shall utilize existing Incident Report capabilities in the Pace IBS system.	Inspection
REQ12	SR 1	The TODSS Prototype shall allow the dispatcher to view from the list of Recovery Plans associated with the selected incident.	Demonstration
REQ137	SR 8.2 SR 8.3	The TODSS Prototype shall allow the dispatcher to select a Recovery Plan for a given incident.	Inspection
REQ54	N/A	The TODSS Prototype shall monitor the performance of each step in the Recovery Plan.	Analysis
REQ55	GS 10	The TODSS Prototype shall construct an audit trail for each incident.	Demonstration
REQ56	N/A	The audit trail shall include information from the triggering event and time stamps for each accomplished step in the Recovery Plan.	Inspection
REQ57	N/A	The TODSS Prototype shall mark an incident as "Complete" once all Recovery Plan steps have been completed.	Demonstration
REQ72	N/A	The TODSS Prototype shall allow dispatchers to change to a different Recovery Plan and transfer over the status for any common task steps.	Demonstration
		4.1.5 Existing Pace IBS Functionality	
REQ84	N/A	The Pace IBS shall support same-day service adjustments:	Inspection
REQ79	N/A	The service adjustments shall support detours through a timepoint waiver process.	Demonstration
REQ80	SD 1.4.2	The service adjustments shall support the cancellation of scheduled service at the block-level.	Demonstration
REQ81	SD 1.4.4	The service adjustments shall support the creation of overload blocks for extra or spacer service.	Demonstration
REQ82	SD 1.4.2	The service adjustments shall support the splitting of existing blocks to accommodate operator or vehicle change-outs.	Demonstration
REQ83	SD 1.4.4	The service adjustments shall support headway realignment using temporal adjustments to existing schedules (blocks).	Analysis

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ85	SD 1.4.1	The Pace IBS shall support import and activation of new schedules.	Inspection
REQ86	SD 2	The Pace IBS shall support the detection of vehicle schedule adherence (early/late) events.	Demonstration
REQ87	SD 2	The Pace IBS shall support the detection of overall route schedule adherence (early/late) events.	Demonstration
REQ88	SD 2	The Pace IBS shall support the detection of missing/late logon events.	Demonstration
REQ92	SD 2	The Pace IBS shall support the detection of route headway events.	Demonstration
REQ95	SD 2	The Pace IBS shall support the automatic detection of passenger overload events.	Demonstration
REQ96	SD 2	The Pace IBS shall support the manual (operator) indication of passenger overload events.	Demonstration
REQ98	SD 2	The Pace IBS shall support coordinated vehicle turn back events.	Demonstration
REQ99	SD 2	The Pace IBS shall support the detection of vehicle off-route events.	Demonstration
REQ100	SD 2	The Pace IBS shall support mechanical alarm events.	Demonstration
REQ101	SD 2	The Pace IBS shall support overt alarm events.	Demonstration
REQ102	SD 2	The Pace IBS shall support covert alarm events.	Demonstration
REQ103	SD 2	The Pace IBS shall support passenger-initiated transfer events.	Demonstration
REQ104	SD 2	The Pace IBS shall support automated transfer connection protection events.	Demonstration
REQ105	SD 2	The Pace IBS shall support voice fallback events.	Demonstration
REQ106	SD 4.2	The Pace IBS shall allow authorized users to designate any event as requiring an incident report.	Inspection
REQ108	SD 6.3 SD 6.4.4	The Pace IBS shall include displays of summarized tabular and graphical route performance.	Inspection
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
REQ177	N/A	The Pace IBS shall allow dispatchers to select their work assignment role(s).	Demonstration
REQ109	SD 6.4.2	The Pace IBS shall direct events and incidents to appropriate personnel based upon work assignment roles.	Demonstration
REQ111	N/A	The Pace IBS shall include a geographic map display:	Inspection
REQ112	SD 9.1.1	The geographic map display shall support zoom in/out.	Demonstration
REQ113	SD 9.1.2	The geographic map display shall include a base map with a road network and transit-related landmarks.	Inspection
REQ114	SD 9.1.3	The geographic map display shall be capable of displaying the current reported location of all active vehicles.	Demonstration
REQ115	SD 9.1.4	The vehicle map icon shall be capable of displaying vehicle identification (e.g. route, block, fleet, etc.).	Demonstration
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

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ117	SD 9.1.6	The geographic map display shall refresh as new vehicle information is received.	Demonstration
REQ118	SD 9.3	The Pace IBS shall include tabular and graphical displays of a selected route.	Inspection
REQ110	SD 8.1	The Pace IBS shall include a display summarizing schedule adherence and headway disruptions.	Inspection
REQ119	SD 9.3.1 SD 10.1	The Pace IBS shall support filtering of tabular displays by attributes (column values).	Demonstration
REQ122	SD 10.2	The Pace IBS shall support sorting of tabular displays by attributes (column values).	Demonstration
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
REQ121	SD 10.3	The Pace IBS shall support configurable colors by schedule adherence, headway, or route status (on Route Ladder and Map).	Demonstration
REQ120	SD 10.4	The Pace IBS shall include resizable tabs and windows.	Inspection
REQ26	GS 12.1	The Pace IBS shall allow System Administrators to grant feature access rights to specific users.	Demonstration
REQ107	SD 5	The Pace IBS shall trace system-wide adherence problems through Critical Transfer notifications.	Demonstration
REQ141	SI 8.2.1	The Pace IBS shall notify dispatchers when a vehicle is dropped from the polling list.	Demonstration
REQ142	SI 8.2.1	The Pace IBS shall notify dispatchers when the communications link is down.	Demonstration
REQ149	GS 9	The Pace IBS shall notify dispatchers when essential system components have failed.	Demonstration
REQ144	GS 1.1	The Pace IBS shall support group communications by fleet, route, and other predefined collections.	Demonstration
REQ145	GS 1.2	The Pace IBS shall support a dispatcher-controlled voice communications network.	Analysis
REQ146	GS 1.3	The Pace IBS shall support vehicle-to-vehicle communications controlled through dispatch.	Demonstration
REQ147	GS 2	The Pace IBS shall follow guidelines put forth in the NTCIP standards.	Analysis
REQ148	GS 6	The Pace IBS shall support interfaces to external clients through shared database access and software-controlled gateways.	Inspection
REQ150	GS 10 GS 13	The Pace IBS shall archive all vehicle message events.	Inspection
REQ151	GS 11	The Pace IBS shall include a vehicle event playback feature.	Inspection
REQ152	GS 12.2	The Pace IBS shall utilize standard Windows logon and access features.	Demonstration
		4.1.6 Future TODSS Functionality	
REQ90	SD 2	The TODSS shall support the detection of corridor schedule adherence events.	
REQ91	SD 2	The TODSS shall support the detection of early/late timepoint crossing events.	
REQ93	SD 2	The TODSS shall support the detection of vehicles bunching at a location (stop/timepoint).	

ID	Ref #	Detailed Requirements for the TODSS Prototype project	Verification
REQ94	SD 2	The TODSS shall support the detection of corridor headway events.	
REQ125	SR 7.1	The TODSS shall be capable of prioritizing recovery plans based upon multiple factors:	
REQ126	N/A	The prioritization factors shall include the priority level of the incident.	
REQ127	N/A	The prioritization factors shall include the latency (age) of the incident.	
REQ128	N/A	The prioritization factors shall include the location of the incident.	
REQ129	N/A	The prioritization factors shall include the availability of resources.	
REQ130	N/A	The prioritization factors shall include the operational context.	
REQ131	SR 7.2	The TODSS shall evaluate recovery plan priorities as arithmetic or logical compositions of the given factors.	
		4.2 Performance Requirements	
REQ162	N/A	The TODSS prototype event / incident processing time shall not introduce noticeable delay from the response time of the current IBS.	Analysis
		4.3 Interface Requirements	
REQ175	N/A	The TODSS parameters and thresholds shall be authorized user definable without compromising system integrity.	Analysis
REQ171	SI 3.1	The Pace IBS shall support importing of Hastus schedule information.	Inspection
REQ173	SI 3.1	The Pace IBS shall support importing of base maps.	Inspection
REQ174	SR 9	The Pace IBS shall support e-mail capabilities.	Inspection
REQ172	N/A	The TODSS prototype shall support RSS via Internet connectivity.	Demonstration
		4.4 Data Requirements	
REQ170	N/A	The Pace IBS shall continue to support current IBS event logging and latest TransitMaster design.	Inspection
		4.5 Non-Functional Requirements	
REQ169	N/A	None	
		4.6 Constraints	
REQ167	N/A	The TODSS prototype requires a TransitMaster upgrade from version 19 to version 24.	Inspection
REQ168	N/A	The TODSS prototype requires new servers to successfully migrate to current levels of Microsoft SQL Server that include expanded ADO functionality.	Inspection

6 Core Requirements Cross-reference

The following table cross references the original TODSS Core Requirements with the TODSS Prototype Derived Requirements.

Table 6 - Appendix 3 Cross Reference TODSS Core and Derived Requirements

Reference #	Compliance Matrix	Derived Requirements
SI 1	Core TODSS shall have the ability to interface with the core TODSS sources of information highlighted in Table 5-1.	REQ138 REQ5 REQ73 REQ6 REQ7
SI 2	[Desired but not required] Core TODSS should have the ability to interface with the non-core TODSS source on information also shown in Table 5-1.	REQ59 REQ8
SI 3	Core TODSS shall have the capability to obtain information from each source of information on a periodic basis to obtain up-to-date information on the transit system status and performance. How the information is obtained may vary based upon the design and architecture of the TODSS system. Examples include periodic polling by the dispatch center, requests to send data from field devices, or periodic data transmissions from field devices (without the request).	
SI 3.1	Core TODSS shall have the capability to obtain information from each of the "Transit Agency Static Information" sources shown in Table 5-1 based upon its update cycle, or when dispatch personnel have been notified that a change has occurred (e.g. daily, weekly, monthly, yearly).	REQ73
SI 3.2	Core TODSS shall have the capability to obtain information from each of the "Transit Agency Dynamic Information" sources shown in Table 5-1 on a periodic basis to provide up-to-date information on the transit system status and performance and meet the Core TODSS Identification and Notification of Service Disruption (SD.x.x in Section 5.2) and Provision of Service Restoration Options (SR.x.x in Section 5.3) requirements. Note, that the polling frequency will vary depending on the radio system and AVL design. First, the feasible polling rate is dependent on the radio system. Dedicated private mobile radio systems can poll vehicles as fast as every 100ms. Trunked radio systems share bandwidth and the feasible polling rate depends on the amount of information being sent and the size of the fleet. Second, the polling rate needed depends on whether the TODSS analysis is centralized within the computers at the dispatch center, or distributed/event driven where the threshold analysis is performed on each vehicle.	REQ2
SI 3.3	[Desired but not required] Core TODSS should have the ability to obtain information from each of the non-core TODSS sources on information also shown in Table 5-1 to obtain and display up-to-date information on the transportation system status and performance and assist in meeting the Core TODSS Identification and Notification of Service Disruption (SD.x.x in Section 5.2) and Provision of Service Restoration Options (SR.x.x in Section 5.3) requirements.	REQ8
SI 3.4	Core TODSS shall have the ability to regulate the frequency of information updates (e.g. polling or event triggered reporting) in response to an event notification, service restoration action, or system status notification.	REQ74
SI 3.5	Core TODSS shall have the ability to regulate the frequency of updates based upon the priority of the event or action being monitored and the data network's capacity to transmit and receive information.	REQ74
SI 4	Core TODSS shall have the capability to selectively request information by type (e.g. revenue vehicle location, automatic passenger count) or specific source (e.g. vehicle, field sensor, or dynamic data base) to obtain current status information.	REQ75
SI 5	Core TODSS shall have the capability to receive and process event notification and other data from each dynamic source of information shown in Table 5-1 within the time between its periodic updates (see requirement SI 3.2).	REQ2 REQ75

Reference #	Compliance Matrix	Derived Requirements
SI 6	Core TODSS shall have the capability to accept overrides and modifications to threshold status for each source of information shown in Table 5-1.	
SI 6.1	Core TODSS shall have the capability to provide access control to overrides and modifications to threshold status for each source of information shown in Table 5-1 as provided for in Core TODSS Requirement GS 12.	REQ22
SI 7	Core TODSS shall have the capability to combine and relate the sources of information shown in Table 5-1 as necessary to meet the Core TODSS Identification and Notification of Service Disruption (SD.x.x in Section 5.2) and Provision of Service Restoration Options (SR.x.x in Section 5.3) requirements.	REQ15
SI 8	Core TODSS design shall provide for modular implementation and incorporation of each Core source of information shown in Table 5-1.	
SI 8.1	Core TODSS shall have the ability to operate if one or more of the Core sources of information shown in Table 5-1 are not part of a specific system installation and provide reduced functionality based upon the information sources that have been implemented (see Table 5-2 and Table 5-3).	REQ23
SI 8.2	Core TODSS shall have the ability to operate if one or more of the Core sources of information shown in Table 5-1 ceases to function and provide reduced functionality based upon the information sources that continue to function (see Table 5-2 and Table 5-3).	
SI 8.2.1	Core TODSS shall notify dispatchers when a source of information ceases to function on its status and the functions it impacts.	REQ155 REQ142 REQ141
SD 1	Core TODSS shall have the ability to identify the operational scenario and apply the appropriate system parameters and response rules base at any point in time that they are operating.	
SD 1.1	[Desired but not required] The operational scenario should be identified based upon the sources of information shown in Table 5-2 and additional internal system variables (e.g. time of day, type of day).	
SD 1.2	Core TODSS shall also provide the ability for dispatch to directly set the operational scenario.	REQ24
SD 1.3	System parameters for each operational scenario shall include: service disruption and other thresholds; prioritization criteria; and a response rules base.	REQ22
SD 1.4	Core TODSS shall have the ability to accept updates to the service baseline as required to identify service disruptions within the appropriate operational scenario.	
SD 1.4.1	Core TODSS shall provide for entry of service changes due to release of a published schedule, or operator signup.	REQ85
SD 1.4.2	Core TODSS shall provide for daily entry of planned service modifications (e.g. schedule, trips, route, vehicle type, etc.) prior to pullout.	REQ80 REQ82
SD 1.4.3	[Desired but not required] Core TODSS should provide the ability to incorporate historic service performance and ridership levels into the service baseline.	
SD 1.4.4	[Desired but not required] Core TODSS should provide the ability to adjust service baseline due to service restoration actions taken during real-time operations (e.g. the exchange of two trip schedules when a vehicle passes another on a route in response to “bunching”.).	REQ83 REQ81

Reference #	Compliance Matrix	Derived Requirements
SD 2	Core TODSS shall have the ability to identify each service disruption type shown in Table 5-2 using the Core TODSS sources of information also shown in Table 5-2.	
	Table 5-2 Inputs Required to Identify Service Disruptions (table below) **Figure 14 - Appendix 3 Inputs Required to Identify Service Disruptions**	REQ105 REQ104 REQ103 REQ102 REQ101 REQ100 REQ99 REQ98 REQ96 REQ95 REQ94 REQ93 REQ92 REQ88 REQ91 REQ90 REQ87 REQ86

Table 5-2 Inputs Required to Identify Service Disruptions

Service Disruptions	Transit Inputs for Identification											
	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, inappropriate 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

Reference #	Compliance Matrix	Derived Requirements
SD 3	Thresholds defined within Core TODSS thresholds shall be parameterized based upon the operational scenario, the Core sources of information shown in Table 5-2, and the Service Baseline.	
SD 3.1	Core TODSS shall provide the ability to calculate thresholds using arithmetic, logical, and Boolean operators.	REQ32
SD 4	Core TODSS shall have the ability to define multiple thresholds for action for each type of service disruption defined in Table 5-2, or other event called for within the agency operational scenarios.	
SD 4.1	Core TODSS shall have the ability to set service disruption thresholds for each event (Table 5-2 ,or other as defined in operational scenario).	REQ32
SD 4.2	[Desired but not required] Core TODSS should also have the ability to set additional thresholds for each event. These should include: type of notification by contact (visual, audio, alarms), increased data collection, warnings of potential disruptions, or report generation.	REQ37 REQ38 REQ106
SD 5	Core TODSS shall trace the impacts of an event/disruption across the network to other fixed route service within the system.	REQ155 REQ107
SD 6	Core TODSS shall provide the ability to monitor a service disruption or event and the impacts of service restoration strategies applied in response.	
SD 6.1	Core TODSS shall provide the capability to set thresholds for event tracking.	REQ32
SD 6.2	Core TODSS shall provide the capability to toggle event tracking at any point in time.	REQ40
SD 6.3	Event tracking shall consist of monitoring the service associated with the service disruption and all service affected by the disruption identified in meeting functional requirement SD 4.	REQ108
SD 6.4	Core TODSS shall have the ability to set additional thresholds for determining the end of the event and conclusion of tracking.	
SD 6.4.1	Core TODSS shall include the ability to evaluate hysteresis (noise and fluctuation around each threshold) and filter for false notification of already identified service disruptions and events.	REQ34
SD 6.4.2	Core TODSS shall provide notification to the dispatch center and others as called for in the response rules base when an end of event threshold is triggered.	REQ109
SD 6.4.3	[Desired but not required] Core TODSS should provide for additional notification to check conditions by other means (e.g. consult operator, supervisor) where the end of the event cannot be determined using available inputs.	REQ35 REQ36
SD 6.4.4	Core TODSS shall provide the ability to continue to track the impacts of service disruptions or events for a specified time period after they are over.	REQ108

Reference #	Compliance Matrix	Derived Requirements
SD 7	Core TODSS shall provide the ability to prioritize all service disruptions and notifications/actions triggered by defined thresholds in order to determine their importance/severity and order in event queues.	REQ33
SD 7.1	Potential parameters for each priority calculation shall include Table 5-2 sources of information; Service characteristics (route, run, block); Threshold value (high, low); Latency (when was the threshold triggered); Geographic location (system, corridor, sub-area); Available resources; Dispatch supervisor; and the Operational scenario context (time of day, type of day, special event, overall system status).	
SD 7.2	Core TODSS shall provide the ability to calculate priority levels using arithmetic, logical, and Boolean operators.	
SD 8	Core TODSS shall provide the ability to display a summary of current and historic system status upon request.	
SD 8.1	The system status summary shall have the capability to summarize the amount (percentage) service by threshold value for each type of service disruption shown in Table 5-2.	REQ110
SD 8.2	[Desired but not required] The system status summary should have the capability to summarize the amount (percentage) of service by threshold value for additional thresholds and performance measures defined by the transit agency.	
SD 8.3	[Desired but not required] The system status summary should allow system performance to be broken out by Type of service disruption or threshold, Type of service (e.g. local, limited, express, commuter. BRT), Geographic location (e.g. system wide, corridor, sub area, facility assignment, or other criteria as defined by the transit agency.	
SD 8.4	[Desired but not required] The system status summary should allow the playback, or display, of performance and trends for the time preceding the request, or of historic performance from previous days, weeks, or months.	
SD 9	Core TODSS shall provide the ability to define and select as needed displays and notifications of current system performance and service disruption/event status.	
SD 9.1	Core TODSS shall provide the capability for geographic display on dispatch center, remote terminals, MDTS, and mobile devices of the current location and status of all revenue and non-revenue vehicles logged on to the system.	
SD 9.1.1	The scale of the geographic display shall be selectable and vary from displaying the complete system area to focusing on the operations of a single transit center or bus stop.	REQ112
SD 9.1.2	The geographic display shall be built upon a base map that should include but not be limited to: Background road network; major transportation facilities; and other significant geographic features; Location of bus stops, garages, terminals, turn-around and transfer points; Current baseline service footprints.	REQ113
SD 9.1.3	The geographic display of service shall include the current position of each vehicle based upon the most recent poll of the system by the GPS / AVL component.	REQ114
SD 9.1.4	The geographic display shall have the capability to show: vehicle identification by route, run, block and type; and current status of each service disruption shown in Table 5-2 (e.g. schedule adherence, off route status; and alarms).	REQ115 REQ116
SD 9.1.5	[Desired but not required] The geographic display should have the ability to show but not be limited to: predicted status of each service disruption; and service performance (e.g. headway, direction, speed, passenger load, or special passengers).	
SD 9.1.6	The scale, detail of information, and refresh frequency provided by the TODSS system shall determined by the geographic display characteristics and communications speed and capacity of the output device receiving the information.	REQ117

Reference #	**Compliance Matrix**	**Derived Requirements**
SD 9.2	Core TODSS shall provide the capability for tabular display and notification to dispatch center, remote terminals, MDTs, and mobile devices, of current system performance and service disruption/event status.	
SD 9.2.1	Core TODSS shall provide the capability to display but not be limited to separate tables of: Current status and performance of all revenue vehicles currently logged on the system identified by route, run, block and type; Current status of each service disruption shown in Table 5-2 (e.g. schedule adherence, off route status; and alarms); Predicted status of each service disruption; Emergency alarms.	
SD 9.2.2	Core TODSS shall provide the capability to display tables of prioritized service disruptions and events for both current and estimated/predicted conditions.	REQ44
SD 9.3	Core TODSS shall provide the capability to produce graphical displays of service and headway performance to dispatch centers, remote terminals, and mobile devices. Examples include time based “race track” displays; vehicle time-space trajectories; and service histograms.	REQ118
SD 9.3.1	Core TODSS shall provide the capability to filter the service shown by type of service, route, corridor, and sub-area.	REQ119
SD 10	Core TODSS shall provide the capability to select and control the display of all potential screens and notifications identified in Requirement SD 9.	
SD 10.1	Core TODSS shall provide the capability to apply filters defined by the user for all geographic displays, tables, and graphs. These shall include the ability to filter by:	
SD 10.1.1	•Service type (e.g. local, limited, express, commuter)	
SD 10.1.2	• Geographic location (route, corridor, sub-area, bus facility)	
SD 10.1.3	• Existing service disruptions and events (now occurring) by type (all)	
SD 10.1.4	• Predicted service disruptions and events (from propagation and arrival time estimates) by type (all)	
SD 10.1.5	• Emergency alarms	
SD 10.1.6	• Service restoration strategy applied (unplanned events where action has been taken)	
SD 10.2	Core TODSS shall provide the capability to set the display order of any screen based upon the service disruption priority or other criteria.	REQ122
SD 10.3	Core TODSS shall provide the capability for the user to control the colors used to display information on any screen.	REQ121
SD 10.4	Core TODSS shall provide the capability for the user to control the size and display order of any screen on the console.	REQ120
SR 1	Core TODSS shall provide service restoration strategy options for action to appropriate dispatch center personnel and others as identified by the rules response base for the applicable operational scenario.	REQ12
SR 2	Core TODSS shall have the capability to analyze each type of potential service restoration strategy shown in Table 5-3 using the sources of information also shown in Table 5-3.	REQ124
SR 3	Core TODSS shall have the ability to determine for each service disruption type shown the set of potential service restoration strategies as also identified in Table 5-4.	REQ28

Reference #	Compliance Matrix	Derived Requirements
SR 4	Core TODSS shall have the ability to accept other non-automated external information sources (operator, supervisors, maintenance vehicles, dispatch centers) to assist in identifying and providing options for potential restoration strategies for a given service disruption or event.	REQ8
SR 5	Core TODSS shall verify the feasibility of all potential restoration strategies based upon the available sources of information.	
SR 5.1	Core TODSS shall provide feasible options.	REQ28
SR 5.2	Core TODSS shall include notification that additional information must be obtained to verify feasibility as called for to implement an option (e.g. cumulative operating time of an operator).	REQ46
SR 5.3	[Desired but not required] Feasibility analysis should be carried out using Vehicle availability, Manpower availability, Work rules, and hours of operation, time and distance required to provide the relief.	
SR 5.4	[Desired but not required] Core TODSS should provide upon request non-feasible options with notification of additional requirements to make them feasible (e.g. insert vehicle with recommendation to call in operators when there are no available operators on duty).	
SR 6	Core TODSS shall have the ability to trace the impacts of all feasible service restoration strategies across the network to other fixed route service within the system.	REQ124
SR 7	Core TODSS shall provide the ability to prioritize all feasible service restoration strategies.	
SR 7.1	Potential parameters for each priority calculation shall include but not be limited to: The priority level of the service disruption being addressed; Table 5-3 sources of information; Service characteristics (route, run, block); Latency (when was the threshold triggered); Geographic location (system, corridor, sub-area); Available resources; Dispatch supervisor; and the Operational scenario context (time of day, type of day, special event, overall system status).	REQ125
SR 7.2	Core TODSS shall provide the ability to calculate priority levels using arithmetic, logical, and Boolean operators.	REQ131
SR 8	Core TODSS shall have the ability to incorporate transit agency standard operating procedures and rules under each operational scenario into the response rules base.	
SR 8.1	Core TODSS shall have the ability to carry out, or assist in carrying out, additional actions defined by the response rules base for an operational scenario to determine potential restoration strategies for specific service disruptions or events (e.g. the proper response to suspicious packages or activities).	REQ52 REQ60

Reference #	Compliance Matrix	Derived Requirements
SR 8.2	Once a restoration strategy is chosen Core TODSS shall have the capability to carry out, or assist in carrying out, the follow up communications to notify operators, supervisors, and other transit agency personnel responsible for executing the strategy.	REQ137 REQ64
SR 8.3	Once a restoration strategy is chosen Core TODSS shall have the capability to carry out, or assist in carrying out follow up communications to other management centers to provide both notification and request for action (Fire, Police, Public safety, Incident management, and Transportation management).	REQ137 REQ64
SR 8.4	Once a restoration strategy is chosen Core TODSS shall have the capability to shift command and control to appropriate locations based upon the response rules base for the applicable operations scenario. This may be to operators, field supervisors, other response personnel on the scene, or other command centers.	REQ76
SR 9	Core TODSS shall have the ability to incorporate "Work Flow" checks and supervisor approval for specific actions (e.g. violation of work rules, using a restoration strategy not on the recommended list) based upon the response rules base for the applicable operational scenario.	
GS 1	Core TODSS shall provide the capability to select operators, supervisors, maintenance, public safety, and dispatch terminals individually or in groups for one or two way data and voice communications.	
GS 1.1	Core TODSS shall provide the ability to pre-establish call groups by type of service, route, corridor, or other user defined parameters.	REQ144
GS 1.2	Access to communication channels and requests to transmit and/or receive information (voice and data) shall be controlled by the dispatch center.	REQ145
GS 1.3	Core TODSS shall provide the capability for operator to supervisor, or operator to operator data or voice communications based upon dispatch center permission.	REQ146
GS 2	Core TODSS, hardware, software, and protocols shall use applicable ITS standards and interoperability tests that have been officially adopted through rulemaking by the United States Department of Transportation (No ITS standards or interoperability tests have been officially adopted by the U.S. DOT as of January 2003).	REQ147
GS 3	[Desired but not required] Core TODSS should use ITS standards that have been approved and published by their associated Standards Development Organization (SDO) where it is affordable and practicable to do so. These include but are not limited to the SAE 1708/1587/1455 Vehicle Area Network standards for the vehicle sub-system, and the NTCIP Transit Communications Interface Profiles (TCIP) dialogues published by the American Public Transportation Association (APTA) when they become available.	
GS 4	[Desired but not required] To assist agencies in National ITS Architecture Conformity Analysis, Core TODSS software packages should include documentation that maps their functions, and potential interfaces to the current version of National ITS Architecture at the time of any specific implementation.	
GS 4.1	[Desired but not required] Where functions and interfaces do not exist within the National ITS Architecture suggested additions should also be included. The Turbo Architecture Tool developed by the Federal Highway Administration's ITS Joint Program Office may be used for this purpose.	
GS 5	Core TODSS shall have an open system architecture and provide for interoperability, interconnectivity, portability and scalability across various hardware platforms and networks.	
GS 6	Core TODSS shall provide for data access and transfer to external users, applications, and operations centers (e.g. remote terminals, passenger information, maintenance, public safety).	REQ148

Reference #	Compliance Matrix	Derived Requirements
GS 7	Core TODSS shall be modular in order to minimize the time and complexity involved in upgrading existing components, incorporating new sources of information and interfaces, or adding new functions and capabilities.	
GS 7.1	System design shall include the separation of hardware interface modules from other software modules.	
GS 7.2	Logic and data shall be separated into distinct modules.	
GS 7.3	Wherever possible all system options and application logic shall be maintained as separate parameter files and not directly coded into the TODSS system.	REQ22 REQ24
GS 8	Core TODSS shall provide the capability to update the service disruption identification thresholds, disruption and restoration strategy priority weights, and restoration strategy response rules using user supplied inputs and parameter values.	REQ24 REQ22
GS 9	Core TODSS shall provide for identification and notification of the failure of key components of the system or its core information sources.	REQ149
GS 10	Core TODSS shall provide the capability to monitor and archive an audit trail of all system events, parameters, data communications, screen displays, notifications and alarms, logons, and actions performed by the system and those interfacing with it (dispatch, supervisors, operators, public safety, maintenance and remote terminals).	REQ150 REQ55
GS 11	[Desired but not required] Core TODSS should provide the capability to replay system conditions and events either from short term on-line storage or longer term archived information.	REQ151
GS 11.1	If implemented, replay shall recreate the exact system conditions that occurred over the selected time interval.	
GS 11.2	If implemented, replay shall have the capability to recreate all system events parameters, data communications, screen displays, notifications and alarms performed by the system over the selected time interval.	
GS 11.3	If implemented replay shall have the capability to use the TODSS and AVL/CAD features to view displays, analyze information, and enter commands that were not used when the original event occurred.	
GS 12	Core TODSS shall provide multi-level password protected access control through logon and logoff procedures for all terminals, monitors, and data ports.	
GS 12.1	The ability to read, write, and modify real time displays, system parameters, data inputs, or historical reports shall be determined by rights granted through individual user access profiles.	REQ26
GS 12.2	Default security levels, which set the access rights on different types of information may also be used to simplify the management of security access to all TODSS interfaces and displays shall be password protected through logon and logoff procedures.	REQ152
GS 13	Core TODSS shall also provide the capability to archive information for use in performance monitoring, route and schedule planning, and subsequent operational analyses.	REQ150

7 Event Mapping

The following table describes how messages from the current PACE IBS TransitMaster system are mapped to TODSS events.

Table 7 - Appendix 3 Message Event Mapping Into TODSS

BusOps Message	TODSS Event	Event Parameter	Event Data	Threshold	Example of Incident
Covert	Covert	-	Ack button	-	Covert
Overt	Comm Request (*)	Urgency = 3	-	> 2	Communication Request
PRTT	Comm Request (*)	Urgency = 2	-	> 1	Communication Request
RTT	Comm Request (*)	Urgency = 1	-		Communication Request
Route Status	Route Status	0/1 (Off/on)	On Route/Off Route	> 0	Off Route
Headway warning	Vehicle Headway (*)	Headway percentage	Headway %	> x%	Headway warning
Adherence warning	Vehicle Adherence (*)	adherence	Adherence	> a	Vehicle Early
Adherence warning	Vehicle Adherence (*)	adherence	Adherence	< b	Vehicle Late
Canned message	Canned msg X (*)	-	Canned msg text		Driver sick
Priority Canned message	Canned msg X (*)	-	Canned msg text		Bus On Fire
Mechanical Alarm	Mech alarm X (*)	-	Mech alarm text		Vehicle unusable
Subsystem Health	Subsystem health X (*)	-	Subsystem health text		
Farebox Alarm	Farebox alarm X (*)	-	Farebox alarm text		
Driver Violation	Driver violation X (*)	-	Driver violation text		
Logon Status	Logon Denied	-	Denied reason		Logon Failed
Paratrip Problem	Paratrip problem	-	Problem text		
Engine Controller Warning	Engine controller (*)	-	Alarm text		
Message Delivery Failed	Message delivery failed	-	Which message failed		
Cadlink RTT	Cadlink rtt	-	-		
Vehicle Inspection	Vehicle inspection	0/1/2 (Failed/skipped/succeeded)	Vehicle inspection result	< 1	
Open Mic	Open Mic	0/1 (Off/on)	-	> 0	
Rail Consist Notify	Rail consist notify	-	Consist info		

BusOps Message	TODSS Event	Event Parameter	Event Data	Threshold	Example of Incident
Operator Absence	Operator absence	0/1 (Off/on)	Absence type, Start time, expected end time, absence status Operator Returned button	> 0	
Critical Transfer	Critical transfer	0/1 (Off/on)	Originating & destination vehicle details	> 0	
Announcement Disabled	Announcement disabled	0/1 (Off/on)	On/off status	> 0	
Service Area Alarm	Service area alarm	0/1 (Off/on)	On/ off status	> 0	
-	Aggregate headway	% of vehicles outside normal Headway range	Aggregate value		Route Headway warning
-	Aggregate adherence	Average adherence on route	Aggregate value		Route Adherence warning

8 List of Acronyms

BRT	Bus Rapid Transit
CAD/AVL	Computer Aided Dispatch / Automated Vehicle Location
DOORS	Dynamic Object Oriented Requirements System (Telelogic)
IBS	Intelligent Bus System
ITS	Intelligent Transportation Systems
RFP	Request For Proposal
RSS	Rich Site Summary
RTT	Request To Talk
TODSS	Transit Operations Decision Support System

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