

JANUARY 26, 2007

**TECHNICAL
PROPOSAL
FOR THE**



TXDOT
SH121
TOLL
PROJECT



D.4.1 OPERATIONS MANAGEMENT PLAN



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CHAPTER A: GENERAL INFORMATION

A.1 Purpose of Plan

This Operations Management Plan (OMP) will provide an overview of the Operational Management System that the Roadway Operations Director has provided and resourced to address his responsibilities and commitment as defined by the Policy Statement.

The OMP is a key component of our mandatory Integrated Management System (IMS) that embodies ISO 9001:2000 Quality Management Systems, ISO 14001 Environmental Management Systems and our Safety Management System, which complies with the requirements of OHSAS 18001.

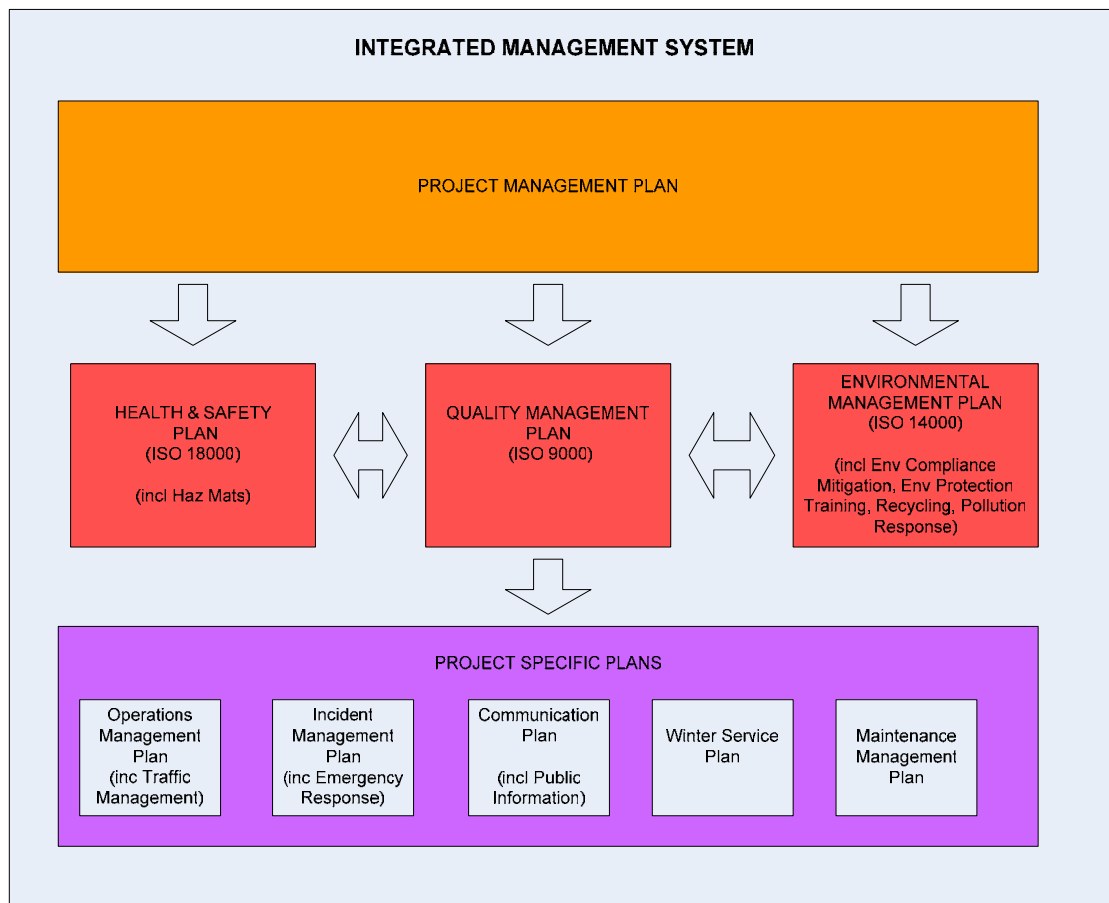


Figure 1 – Integrated Management System

The purpose of the Operational Management Plan (OMP) sets forth the approach, procedures, and implementation for the day to day management of the project, in particular:

- Employment and training of competent personnel to carry out all aspects of the Operations Management Plan

Coordination of activities of other entities with interests within the Project limits Incident response and reporting

Traffic operations restrictions, including periods of lane closure restrictions

Tolling integration with other tolling agencies

Standard operating and communication procedures for Emergency preparation, response, and recovery, including impacts from extreme weather conditions

Planning and coordination with all affected Governmental Entities, including Emergency Services

Liaison procedures with any Traffic Management Centers that TxDOT or other entities may establish

Analysis of vehicular accident patterns to identify safety issues and implement cost effective solutions to maximize safety

Containment and disposal of Hazardous Materials spills

Prompt investigation of reports or complaints received from all sources

Management and Policing of Abnormal Loads

A.2 Definitions

A.2.1 OMP SPECIFIC DEFINITIONS

Roadspace	The controlling or booking of sections of roadway by location, lane and time to coordinate conflicting maintenance programs and third party requirements.
Incident	An unplanned event caused by vehicular collision or severe weather causing the implementation of the Incident Management Plan (IMP)
Traffic Management	The closure or part closure of one or more trafficked roadway lanes, edged by delineators, closed by temporary or permanent coning
Control Room	Centre for the control of the movements and activities of each emergency service's personnel and equipment. Liaises with the other services' control rooms.
Incident Officer	An officer at the scene who commands the tactical response of his/her respective service.
Mutual Aid Arrangements	Cross-boundary arrangements under which emergency services, local authorities and other organizations request extra staff and/or equipment for use in a disaster.
Tactical	Actions taken in order to allocate priority in allocating resources, to plan and Co-ordinate and to manage the receipt and dissemination of information for an incident.

A.2.2 ROADWAY TECHNICAL DEFINITIONS

Access Roads	Those roadways located on the ITR that are closed to the general public and are intended only for use by maintenance, inspection or utility traffic. These are low-type pavements constructed of gravel, grindings, or earth.
Asphalt	A brown to black solid material, soluble in gasoline or naphtha.
Bleeding	An area where the Asphalt mix is too rich, causing the Asphalt material to ooze to the surface in puddles and leaving a slick and slippery area.
Bridge	A structure consisting of single or multiple spans more than 20 feet in length that provides a means of transit for vehicles and/or pedestrians above the land, water surface, roadway, rail road or other obstruction.
Debris	Litter, rubbish, vegetation, rocks, dead animals, spilled materials, brush or other items which are not part of or which impede drainage.
Litter	Trash, Debris, waste, refuse, accident and construction residue.

Heave or Settle	Displacement of rigid type pavement by a combination of vertical and horizontal stresses due to expansion or contraction of the Sub grade. When Heave or Settlement in a concrete pavement is caused by pavement expansion from excessive heat, it is also commonly referred to as a pavement blowup.
Mainline	The portion of the multi-lane traveled way extending from Shoulder line to Shoulder line or from curb line to curb line.
Pothole	An area where a piece of pavement has broken free and been removed, leaving a hole.
Ramp	The portion of the traveled way that provides access between the Mainline and the local street network, extending from Shoulder line to Shoulder line or from curb line to curb line.
Raveling	The progressive loosening of the material in the courses of a road as aggregates separate from the Asphalt binding material.
Resurfacing	Placing of one or more new layers of material on an existing pavement surface.
Rutted and Shoved Pavement	Deformations in which the surface of the pavement has worn into longitudinal ruts due to repetitive passes of vehicle tires, or transverse corrugations due to vehicle deceleration and acceleration.
Shoulder	The portion of the roadway extending from edge of the Mainline or Ramp pavement to the unpaved top of earth embankment, or to the base of a barrier wall.
Subbase	An auxiliary course to furnish needed stability, usually due to poor Subgrade.
Subgrade	That portion of the roadbed on which pavement, surfacing, base, Subbase, or a layer of any other material which may be specified, is to be placed.
Wedge and Level	Pavement surface treatment which consists of milling off approximately 1 ¼ " of surface and replacing it with new Asphalt surface material. This process is used to extend the life of relatively sound pavements that are beginning to show minor to moderate surface distresses.

A.3 References and Standards

Technical Standards

<i>Road Maintenance Standards</i>	TxDOT Maintenance Management Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/mmt.pdf	Section 2.2 (Definitions of Maintenance) defines standards; Section 2.3 provides guidance on developing maintenance plans; Chapter 5 defines Activities Requiring Permits
	TxDOT Maintenance Operations Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/ope.pdf	Chapters 1 and 2 provide guidance on routine maintenance activities and maintenance operations for pavement and roadside; Chapters 4 and 5 detail traffic and emergency management operations; Section 2.3 details vegetation management
<i>Pavement surface characteristics</i>	TxDOT Pavement Design Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/pdm.pdf	Chapter 2 provides Asphalt Cement Concrete design guidelines; Chapter 3 provides Portland Cement Concrete design guidelines; includes methods for new construction, reconstruction, and rehabilitation
	Pavement Management Information System (PMIS) User's Manual	TxDOT Pavement Design Manual refers to the PMIS User's Manual for pavement performance information
<i>Pavement structural characteristics</i>	Pavement Design Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/pdm.pdf	Chapter 2 provides Asphalt Cement Concrete design guidelines; Chapter 3 provides Portland Cement Concrete design guidelines; includes methods for new construction, reconstruction, and rehabilitation
<i>Structures maintenance</i>	Maintenance Management Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/mmt.pdf	Chapter 1 provides definitions and general requirements for routine, preventative, and major maintenance of drainage structures
	Maintenance Operations Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/ope.pdf	Chapter 3 provides policies, procedures and materials used in the maintenance of the state's bridges, moveable span bridges and ferries in order to assure uninterrupted, safe traffic flow and protection of investment.

	Bridge Inspection Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/ins.pdf	Manual provides guidance for bridge inspection personnel, provides a reference for consultants, and helps to ensure consistency in bridge inspection, rating, and evaluation
<i>Road markings</i>	2006 Texas MUTCD: http://www.dot.state.tx.us/trf/mutcd2006.htm	Part 3 provides pavement markings standards, guidelines, and drawings
	Pavement Marking Handbook: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/pmh.pdf	Provides information on material selection, installation, and inspection guidelines for pavement markings
<i>Road signs, drainage, fences</i>	Signs and Markings Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/smk.pdf	On-line version provides TOC only; references print version to be obtained from TxDOT; Chapter 7 does provide detailed information on Guide Signs and references the Texas MUTCD
	2006 Standard Highway Sign Designs For Texas (SHSD) (referenced in Book 3): http://www.dot.state.tx.us/trf/shsd/shsd.htm	Provides detailed drawings of the Standard Highway Signs for Texas prescribed or provided for in the Texas Manual on Uniform Traffic Control Devices (TMUTCD), 2005.
	TxDOT Sign Crew Field Book (referenced in Book 3): Available for purchase from TxDOT or the Texas Transportation Institute	Provides sign placement information in a manner that coordinates regulatory, warning, and guide signs and promotes statewide consistency
	Urban Freeway Signing and the Freeway Signing Handbook (referenced in Book 3): Available for purchase from TxDOT or the Texas Transportation Institute	Provides TxDOT staff and design consultants with information beyond that contained in the Texas MUTCD or the TxDOT Traffic Control Standard Sheets so that freeway signing can be designed and installed in a more uniform manner
	2006 Texas MUTCD: http://www.dot.state.tx.us/trf/mutcd2006.htm	Part 2 provides function/design characteristics and standards for signs; 2J provides specifications for toll road signing; Part 3 provides pavement markings

	<p>Texas Reference Marker System User's Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/trm.pdf</p>	<p>Provides Texas Reference Marker (TRM) System Highway Data File users with the necessary information to input data to, or extract data from TRM</p>
	<p>Roadway Design Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/rdw.pdf</p>	<p>Provides general criteria for design, location, and sight distance for signs</p>
	<p>TxDOT ROW Beautification Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/bet.pdf</p>	<p>Provides standards for advertising signage within the ROW.</p>
	<p>AASHTO Roadside Design Guide</p>	<p>Presents information on the latest state-of-the-practice in roadside safety and procedures to determine a recommended minimum clear zone on tangent sections of roadway with variable side slopes and adjustments for horizontal curvature; focus of this guide is on safety treatments that minimize the likelihood of serious injuries when a driver runs off the road</p>
	<p>AASHTO Green Book</p>	<p>Provides sight distance requirements; use as secondary reference to the TxDOT Roadway Design Manual</p>
	<p>FHWA Bridge Deck Drainage Manual (referenced in Book 3): http://www.fhwa.dot.gov/engineering/hydraulics/pubs/hec/hec21.pdf</p>	<p>Provides guidelines and procedures for designing bridge deck drainage systems</p>
<i>Lighting Requirements</i>	<p>TxDOT Highway Illumination Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/hwi.pdf</p>	<p>Provides procedures, guidelines, standards, and information concerning highway illumination</p>
	<p>TxDOT ROW Beautification Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/bet.pdf</p>	<p>Includes standard for toll plaza lighting (Chapter 4, Section 9, Illumination).</p>

	AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals	Provides criteria for structural support, breakaway, and safety
	AASHTO Roadway Lighting Design Guide (referenced in Book 3): Available for purchase from AASHTO	Provides a general overview of lighting systems and recommends minimum levels of quality
<i>Landscaping</i>	TxDOT ROW Beautification Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/bet.pdf	Manual provides the current information and operating practices for acquisition of right of way for transportation projects, property management relating to right of way, and the highway beautification program
	Landscape and Aesthetics Design Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/lad.pdf	Provides guidance in the selection of landscape and aesthetic design criteria for highway and street project development; provides a synthesis of current information and design practices related to development of landscape and aesthetic components for different classifications of roadway facilities
	AASHTO Roadside Design Guide	Presents information on the latest state-of-the-practice in roadside safety and procedures to determine a recommended minimum clear zone on tangent sections of roadway with variable side slopes and adjustments for horizontal curvature; focus of this guide is on safety treatments that minimize the likelihood of serious injuries when a driver runs off the road
<i>Cleaning</i>	TxDOT Maintenance Management Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/mmt.pdf	Chapter 1 provides definitions and general requirements for routine, preventative, and major clean-up operations; Chapter 7 provides general procedures for emergency clean-up and haz-mat spills
	TxDOT Maintenance Operations Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/ope.pdf	Chapter 5 Section 3 provides Emergency Spill Response guidelines for clean-up related to traffic incidents.

<i>Surveying</i>	TxDOT Survey Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/ess.pdf	Provides general reference for surveying procedures performed by and for the TxDOT; establishes minimum standards, policies, and procedures of surveying for TxDOT
	TxDOT ROW Manual, Books I and II: (reference in Book 3): http://www.dot.state.tx.us/services/general_services/manuals.htm	Referenced in CDA Book 3; various volumes of ROW Manual are available on TxDOT's Manuals website; however, no specific volumes relating directly to surveying were found
<i>Hand Back Requirements for Highways</i>	Comprehensive Development Agreement, TxDOT Statewide Open-Road Toll Collection System, Section 9: http://www.fhwa.dot.gov/ppp/toc.htm (one stipulation for warranty following handback)	Specific requirements for handback are defined in Book 2A Section 19.3 Handback Requirements; Table 19.3.4-1 provides Residual Life requirements including residual life at handback, useful life at handback, inspection requirements, and residual life methodology requirements. Book 2B Section 19.3 provides an overview of these handback requirements and a summary Table of Residual Life Requirements for handback.
<i>Environmental Protection Standards/Legislation</i>	TxDOT Environmental Manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/env.pdf (TxDOT ENV Division)	Chapter 1 Section 2 presents information on the federal and state laws governing environmental considerations related to all projects that TxDOT has oversight responsibilities; information is organized by subject matter, with the authorities grouped under the following headings: <ul style="list-style-type: none"> - Comprehensive environmental laws, regulations and policies - Natural resources - Cultural/socio-economic resources - Air quality - Hazardous materials.
	ASTM E-1527 Standard Practice for Environmental Assessments, Phase 1 Environmental Assessment Practices (referenced in Book 3)	Imposes specific educational, certification or licensing requirements, and relevant experience requirements, upon the person overseeing environmental assessment activities

	ASTM E-1528 Standard Practice for Environmental Assessments: Transaction Screen Process (referenced in Book 3)	Defines good commercial and customary practice for conducting an environmental site assessment of a parcel of commercial real estate with respect to the range of contaminants within the scope of the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) and petroleum products
<i>Toll Collection</i>	TxDOT Tolling Concept Guide: http://www.dot.state.tx.us/publications/tta/tolling_concept.pdf	Two-page flyer provides general information on TxDOT's tolling policy and initiatives.
	Texas House Bill 1340 Section 362: http://www.capitol.state.tx.us/tlo/78R/billtext/HB01340H.HTM	HB 1340 Section 362 provides interoperability legislation with respect to (toll) transponder technology used in (Texas).
	TxTag: http://www.txtag.org/	Provides integrated electronic tolling capability for all Texas toll roads; one tag to be used on all toll roads in the state.

Operational Standards

<i>Road Availability (lane closures for maintenance)</i>	2006 Texas MUTCD: http://www.dot.state.tx.us/trf/mutcd2006.htm	TxMUTCD Part 6 provides procedures for temporary traffic control (rehabilitation, maintenance, etc.).
<i>State Obligations (safety, patrolling, emergency response)</i>	Procedures for Establishing Speed Zones: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/szn.pdf	Provides information and procedures necessary for establishing speed zones and advisory speeds on the state highway system; required to be used by the TxDOT and cities when establishing speed zones on the state highway system.

	State Interagency Agreements with the Texas Highway Patrol	The Texas Highway Patrol works closely with the TxDOT which acts as the pass-through agency for funding from the National Highway Transportation Safety Administration (NHTSA) for federally funded Selective Traffic Enforcement Programs (STEP). Interagency agreements between the Department and TxDOT also provide funding for statewide overtime traffic enforcement, construction work zone enforcement, and ferry operation enforcement.
	TxDOT Maintenance Manual Chapter 7 - Emergency Management: ftp://ftp.dot.state.tx.us/pub/tx-dot-info/gsd/manuals/mmt.pdf	Chapter 7 provides guidance for emergency response for disasters and national emergencies, the federal reimbursement programs, and oil/hazardous materials spills.
	TxDOT Maintenance Operations Manual Chapter 5 - Emergency Operations: ftp://ftp.dot.state.tx.us/pub/tx-dot-info/gsd/manuals/ope.pdf	Chapter 5 defines procedures for snow and ice operations, emergency spill response, response to wildfires, and response to incidents and accidents.
<i>Accident Responsibility / Claims</i>	Hazard Elimination Program: ftp://ftp.dot.state.tx.us/pub/tx-dot-info/gsd/manuals/tfa.pdf	Hazard Elimination (HES) Program is part of the Highway Safety Improvement Program; basic objective of the HES Program is to reduce the number and severity of crashes.

Environmental Standards

	TxDOT Environmental Manual: ftp://ftp.dot.state.tx.us/pub/tx-dot-info/gsd/manuals/env.pdf (TxDOT ENV Division)	Provides procedures and practices related to environmental analysis and decision-making with TxDOT project development work; provides a guide to clearing transportation projects through the National Environmental Policy Act (NEPA) process.
<i>Water Quality Control</i>	TxDOT Environmental Manual: ftp://ftp.dot.state.tx.us/pub/tx-dot-info/gsd/manuals/env.pdf (TxDOT ENV Division)	Manual details process for all related environmental documentation which includes water quality; Chapter 3 Section 8 provides content details for documentation.

	<p>Texas Commission on Environmental Quality - Water Quality Management:</p> <p>http://www.tceq.state.tx.us/nav/eq/eq_wqmgmt.html</p>	Provides rules, policy, and legislation for water quality control.
	<p>US Army Corps of Engineers Wetlands Delineation Manual:</p> <p>http://www.wetlands.com/regs/tlpg02e.htm</p>	Provides users with guidelines and methods to determine whether an area is a wetland for purposes of Section 404 of the Clean Water Act
<i>Noise</i>	<p>TxDOT Environmental Manual:</p> <p>ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/env.pdf (TxDOT ENV Division)</p>	Section 4 describes roles and responsibilities related to noise analysis; manual details process for all related environmental documentation; Section 8 provides content details for documentation.
	<p>TxDOT's Guidance for the Analysis and Abatement of Highway Traffic Noise:</p> <p>http://www.dot.state.tx.us/env/pdf/resources/TxDOTnoise96.pdf</p>	Provides basic guidelines for performing traffic noise analyses for TxDOT highway projects and includes a discussion of the fundamentals of sound and traffic noise, the traffic noise analysis process, and associated documentation.
<i>Air Pollution</i>	<p>TxDOT Environmental Manual:</p> <p>ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/env.pdf (TxDOT ENV Division)</p>	Section 4 describes roles and responsibilities related to air quality; manual details process for all related environmental documentation; Section 8 provides content details for documentation.
	<p>TxDOT Air Quality Guidelines:</p> <p>http://www.dot.state.tx.us/publications/environmental_affairs/AQGuidelines0606.pdf</p>	Provides background information on air quality issues and terminology to clarify the air quality analysis and documentation requirements for environmental documents; guidelines include sample language which can be used when developing environmental documentation.
	<p>TxDOT Project Development Policy:</p> <p>ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/pol.pdf</p>	Describes air quality requirements with respect to project planning.

	<p>TCEQ Dallas-Fort Worth Non-attainment Area: http://www.tceq.state.tx.us/implementation/air/sip/dfw.html</p>	<p>Summarizes Dallas-Fort Worth's air quality challenges, air quality plan, and control strategies; contains links to rules, agreements and State implementation Plan (SIP) revisions.</p>
<i>Vegetation</i>	<p>Executive Memorandum on Beneficial Landscaping and the Executive Order on Invasive Species (EO 13112): http://www.fhwa.dot.gov/environment/020399em.htm</p>	<p>Issued to prevent and control the introduction and spread of invasive species</p>
	<p>Landscape and Aesthetics manual: ftp://ftp.dot.state.tx.us/pub/txdot-info/gsd/manuals/lad.pdf</p>	<p>Provides guidance in the selection of landscape and aesthetic design criteria for highway and street project development; provides a synthesis of current information and design practices related to development of landscape and aesthetic components for different classifications of roadway facilities.</p>

Required Operations and Environmental Permits

	<p>Comprehensive Development Agreement, TxDOT Statewide Open-Road Toll Collection System, Section 6.4; however, Book 2A provides comprehensive permitting information: http://www.fhwa.dot.gov/ppp/toc.htm</p>	<p>Table 4.1 in Book 2A lists all environmental permit requirements and the name of the coordinating agency; Chapter 6 in Book 2A describes utility adjustment requirements and procedures.</p>
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Insurance Standards

	<p>Comprehensive Development Agreement, TxDOT Statewide Open-Road Toll Collection System, Section 9: http://www.fhwa.dot.gov/ppp/toc.htm</p>	<p>Section 9 provides the insurance coverage required for all CDA development, including requirements for commercial liability insurance, workers' compensation insurance, and other liability insurance.</p>
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A.4 Systems and Procedures

For general Systems and Procedures please refer to the Quality Management Plan which includes inter alia procedures to cover the following:

- Control of quality records
- Management reviews
- Resource allocation
- Measurement of customer satisfaction
- Control of nonconforming products and services
- Internal audits
- Continual improvement

For Operational Management specific procedures please refer to Section B and Appendices below.

CHAPTER B: PLAN SPECIFIC INFORMATION

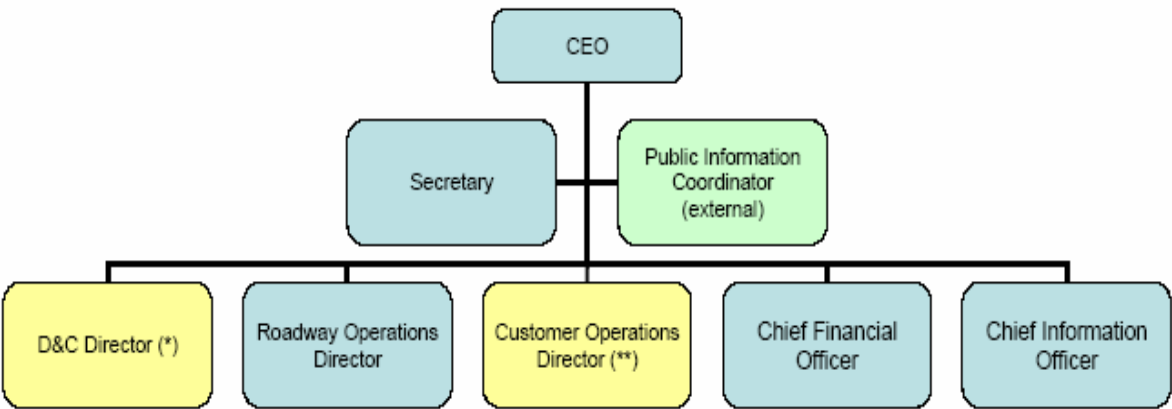
B.1 Roles and Responsibilities

B.1.1 Developer’s Management Structure

The Developer will establish an organization that will ensure a fast, safe, and reliable transportation route serving millions of commuters, various industries and geographical markets. In order to achieve these goals the organization’s management will be divided in the following five areas (see Figure 2: Developer’s Organization Chart – Management):

- **Roadway Operations:** to make sure that users ride in a safe road, traffic is smooth and that in case of accidents response is given urgently.
- **Customer Operations:** we acknowledge the importance of customer service and the number of issues generated when having video tolling. We aim to respond to all queries in a professional and timely manner. This area will only be created in case the NTTA tolling agreement is not renewed after the initial 5 year period.
- **Systems:** Open Toll Roads rely strongly on sophisticated technological equipment. Due to this fact it is important to make sure that all systems are operational at all times.
- **Finance and Administration:** encompass all regular support functions typical of any business (accounting, HR, buildings general services...).
- **Design & Construction:** to make sure that the D&C Team builds the remaining portions of the road a.k.a. Segments 3, 4 and 5 on time and according to quality requirements.

Each of these areas will have a head reporting directly to the CEO.



- (*) Only during the initial construction period
 (**) Only if the NTTA 5-year agreement is not renewed

Figure 2 – Developer’s Organization Chart – Management

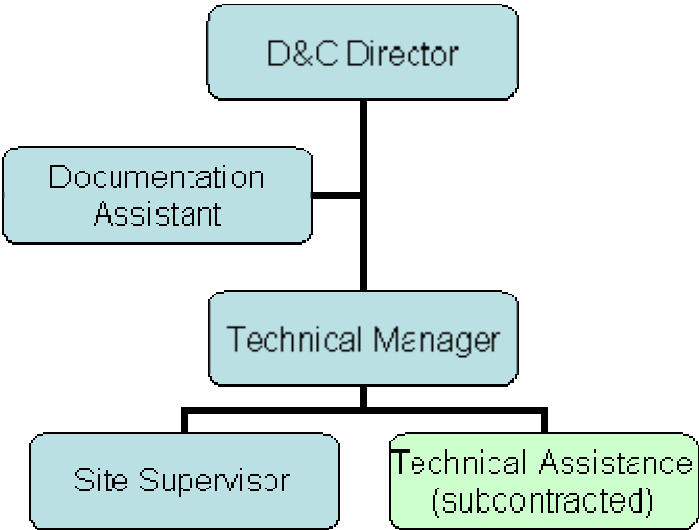
This organization will be responsible to maintain continuous, 24 hours-per-day, 365 days-per-year, operations of the highest quality consistent with the best highway management practices and the terms and conditions of the CDA. In addition, it will direct, coordinate, evaluate and amend, when necessary, the responsibilities of Developer’s lower sub-organizations. The

Responsibilities and minimum requirements for the heads of each area are described below:

Staff	Minimum Requirements	Roles/Responsibilities
Design and Construction (D&C) Director	10 years minimum experience in transportation design. 3 years minimum supervisory experience. Advanced degree and Chartered status preferred.	Responsible for quality and delivery of the initial construction period. Management of programmes, costs and client construction reporting. Development of capital road renewal design and construction team following initial construction phase.
Roadway Operations Director	10 years minimum experience in maintenance, operations, design and construction of major highways. 3 years supervisory experience.	Supervises the work of the Maintenance Manager, highway operations control center and traffic analysis/planning. Coordinates with Construction, Design, CFO, NTTA and state, federal and local entities and authorities. Main point of contact for access to the corridor by any other entity (city, TxDOT, Utilities) Develops Audit Inspection Regime and completes the Asset Condition Score in accordance with the Project Specific CDA Section 22.4. Acts as quality control for Technical Manager design work and oversees all new construction that occurs during the O and M phase (adding lanes), contracting,
Customer Operations Director	10 years experience in customer service, 5 years in transportation industry, 3 years supervisory experience.	Develops Complaint Resolution Procedure. Oversees call center for public, including toll related issues following 5 year NTTA involvement. Monitors feedback and Continuous Improvement of Communication Plan.
Chief Financial Officer	10 years minimum experience in transportation. 3 years minimum supervisory experience. 5 years experience in accounting and finance. Advanced degree preferred	Responsible for financial and management reporting, accounting, records management, document control, procurement, contracting, cash flow analysis, accounting, toll management, Human Resources and Public Information. Develop program and project controls. Coordinates with Construction, Design, COO, NTTA and state, federal and local entities and authorities
Chief Information Officer	Minimum 5 years experience in design and supervision of implementation and operation of ITS for the transportation industry. Advanced degree required.	Responsible for the design, implementation and operation of: <ul style="list-style-type: none"> ■ Toll Collection System and Intelligent Transport Systems (field and control centre elements, including all hardware and software and the communication network) ■ Back Office Systems (including all hardware and software needed and the communication network)

Design and Construction Department

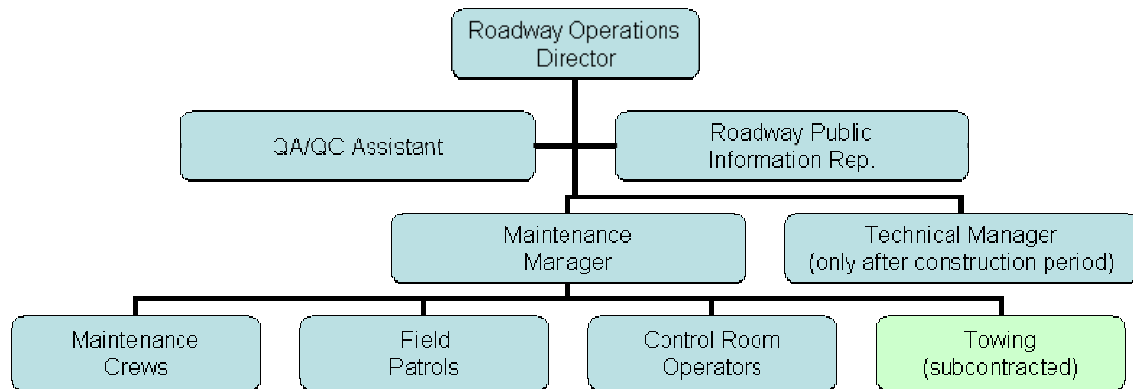
The Organizational chart as well as responsibilities and minimum requirements for key employees in this area are presented below:



Staff	Minimum Requirements	Roles/Responsibilities
Technical Manager	5 years minimum experience in transportation design. 3 years minimum supervisory experience. Advanced degree and Chartered status preferred.	Responsible for quality and delivery of the initial construction period, specification compliance and management of early operational input to design stage. Management of capital road renewal design and construction team following initial construction phase.
Site Supervisor	Minimum 5 years experience in civil works site supervision. PE	Supervision of construction phase and quality management. Interface with maintenance team and handover strategy. Management of 'as built records.

Roadway Operations Department

The Organizational chart as well as responsibilities and minimum requirements for key employees in this area are presented below:



Staff	Minimum Requirements	Roles/Responsibilities
Maintenance Manager	10 years minimum experience with state DOT, toll authority, county or city maintenance programs, 5 years minimum experience in pavement repair design, drainage design, sign design, maintenance materials, emergency weather/spills prevention planning, and managing equipment fleets.	Demonstrated ability to know when to call in expert specialized consultant or contractor. Coordinate with all other managers on O and M team. Responsible for ensuring that all crew and patrol members are trained in environmental compliance, recognizing category defects, and appropriate procedures for emergency incident situations. Responsible for the development of all required plans, co coordinating where appropriate with local responsible entities
Field Patrols	Experience of working in a high speed road environment.	Roadway Patrol will be trained in identifying environmental compliance and Category 1 defects as a back up to regular inspection and in appropriate procedures for emergency incident situations.
Control Room Operators	5 years experience in call center work. 3 years supervisory experience. Event monitoring and Incident response.	Event monitoring and Incident response. Coordinates will all local emergency/ utility/ city/county/environmental entities. 24/7 operation.

Customer Operations Department

The Organizational chart as well as responsibilities and minimum requirements for key employees in this area are presented below:



Staff	Minimum Requirements	Roles/Responsibilities
Invoicing / Collection Manager	Minimum 5 years experience in toll operations, 3 years minimum supervisory experience.	Coordinates Toll policy, technology, invoicing and procurement. Participates in regional planning for growth. Coordinates with Construction, Design, CFO, NTTA and state, federal and local entities and authorities.
Call Center Manager	10 years experience in customer service, 5 years in transportation industry, 3 years supervisory experience	Develops Complaint Resolution Procedure. Oversees call center for public.

B.2 Plan Specific Procedures

B.2.1 Recruitment, Training, Safety and Investment in People

Introduction

We believe that our employees are our most important asset, and key to business success. Our culture promotes training, personal development and workplace safety, and thereby encourages everyone to perform to their potential in a safe and controlled manner.

We have in place and will promote throughout the team the following key initiatives:

Staff Development and Opportunities

All employees, irrespective of position, location, or previous employer, have access to comparable and relevant training and development opportunities. We will ensure all employees, including any TUPE transferees, are inducted into our ethos.

All employees are encouraged to achieve vocational and professional qualifications. Competency based Personal Development Appraisals are used to identify training needs which are then enshrined in Personal Development Plans. These are developed through the appraisal process.

Career Progression

We recognize the value of planned career progression and the importance of minimizing employee turnover. We have progression systems and effective retention strategies for career development and promotion of employees. We engender an environment and culture which nurtures talent and within which people want to work. Our business requires the development of long term relationships and capabilities. We are a business that people, staff and operatives want to work for.

Promotion of Best Practice

Employees will have access to training sessions, technical workshops, literature and other publications relevant to their discipline. This ensures best and most consistent methods of working are practiced and a continuous improvement culture is promoted.

Communications

We promote positive employee relations by developing transparent HR policies and procedures. Teams will be engaged in regular communications and 'change management' activities to deliver a smooth and seamless transition. Effective communications will be enhanced by the use of briefing techniques, such as Team Talk, intranet and newsletters ensuring that our strategy, policies and procedures are easily accessible to employees.

B.2.2 Roadspace Management and Coordination of Third Party Works

General

This chapter sets out a number of considerations which should be taken into account by the Developer when planning traffic management for works on in-service roads. It draws upon experience

gained and supplemented by extensive analysis of road user and works costs. The note considers various options, but concentrates on the possible use of night-time only working.

Roadspace management will be web based and allow third party and stakeholder access allowing effective planning of road works and closures, minimising works clashes and allowing multiple tasks to be planned within each closure to maximize efficiency.

Third party Roadspace applications will be authorized and coordinated by the Maintenance Manager.

Definitions

In the context of road works on the trunk road network, the following terms are used:-

a). **"Night-time only working"** (NTO) describes activities which commence after the evening peak traffic flow has subsided, and are completed prior to the build-up of the morning peak traffic flow on the following day. In such circumstances, lane closures reduce the traffic carrying capacity of a road during the night, but all lanes are available for traffic use during the day.

b). **"24 hour working"** describes road works where the conventional daytime working is extended into a 24 hour operation by the use of shift working. The essential difference between 24 hour working and night-time only working is that during 24 hour working there is no specific requirement for the full carriageway to be restored to live traffic at the beginning of each day. Although this chapter is directed towards night-time only working, many of the considerations contained within it, also apply to 24 hour working.

Considerations

Safety must be the primary consideration at all road works, and during both works planning, and execution. We will address the safety needs of those engaged in the road works, the road user, and the general public.

Night-time work on electrical and electronic equipment systems often requires a considerably higher quality of illumination than that required for other activities. This arises from the need to identify small features and to distinguish between colours.

Technical Matters

Planning of the night-time programme should allow for factors such as lower temperatures and higher humidity, which can affect materials behaviour. At the planning stage of maintenance project, if night-time only working is being considered materials and construction techniques must be appraised with reference to their technical characteristics and suitability for night-time working. For example, it may be necessary to specify polymer modified cements rather than ordinary Portland cement, where mortars will be subject to traffic loading within hours of being placed, or to adjust the specification to incorporate additives to lower the freezing point for water based operations such as drain jetting on cold winter nights.

Some maintenance activities, particularly those requiring high levels of skill and involving fine visual judgment can, if poorly controlled, result in lower quality workmanship during night-time only working. Each aspect of work must be assessed at the planning stage to establish that the quality of work produced by a competent contractor can meet the specification under night-time only working conditions. Such assessments can be achieved by reference to previous experience. During construction, the daily reintroduction of traffic to the working area imposes access restrictions for

quality monitoring. Arrangements must be made for the systematic monitoring of quality, to ensure that specified standards are maintained.

Availability of Materials

At the planning stage of a maintenance project for which night-time working is being considered, the availability of materials must be guaranteed. In particular, it is necessary to ensure that within the locality of the road works, where such materials are required, there will be a certain and timely supply of materials such as asphalt and concrete when required. It will be necessary to check that local mixing plants are not affected by planning/environmental restraints before tenders are invited so that contractors are able to meet the requirements of the contract.

Publicity

Publicity should be planned and consistent and not be the result of crisis management. Well directed publicity prior to the commencement of works can be beneficial. Local residents often display greater tolerance of noise and disruption of which they have prior knowledge concerning timing and duration.

Experience indicates that the distribution of leaflets to all affected residents and other helpful information should always be considered. For more intrusive works, personal visits to affected homes and businesses can produce higher levels of acceptance and co-operation; such courteous advice to members of the public should always be considered and normally provided.

Decision Making

A major objective in the planning of road works is the reduction of overall traffic delays. However, the works cost associated with minimizing traffic delays by using night-time only working can be between 25% and 50% higher than the works costs incurred for the same work undertaken in daytime. However experience in night-time only working tends to reduce this premium. This chapter provides guidance for the evaluation of the additional works costs associated with night-time working against the benefits arising from the reduction in delays to road users.

Routine Maintenance

Routine maintenance activities should be combined and undertaken within a single lane closure or mobile lane closure wherever possible, and considered for night-time only working. Planned or routine tasks can often be undertaken to take advantage of traffic management provided for other parallel activities.

Routine maintenance operations also should be assessed to establish the optimum traffic management arrangement under which the works must proceed. The total assessed cost of the operation under each traffic management arrangement must comprise the works cost plus the cost of delays and incidents etc.

B.2.3 Incident Response and Reporting

Incident response procedures are set down in detail within the Incident Management Plan (IMP)

Incident notification, dispatch, management and recording is effected through the full time Traffic Management Centre utilizing CCTV access and communications with the Field Patrols and emergency services to maintain an incident log.

Real time information will be communicated to the TxDOT representative and traffic conditions, diversions and clear up timescales made available to road users by web access.

B.2.4 Traffic Management and Restrictions

Implementation

The requirements of traffic management must be taken into account for all works on live roads.

For some works there may be a range of appropriate traffic management methods. In such situations those planning the works must give due consideration to the needs of ensuring safety, minimizing traffic delay and producing the most cost-effective solution when selecting which methods to use.

Exceptionally a situation may arise which is not covered by standard Traffic Management layouts or which the Developer feels calls for a departure from the TxDOT requirements. In these cases approval must be obtained from the TxDOT and authorization obtained for the use of any non-prescribed signs.

Mobile Works

When a single vehicle operation is being considered for works which move steadily but at slower speed than normal road operating speeds, a risk assessment should be produced which takes into account the logistics of setting out and operating the various traffic management options. This assessment should include such factors as the normal traffic speed on the road, the difference between the speed of the works vehicle and normal traffic speed, the alignment/sightlines/width of the road, and the duration of exposure to risk for the operatives.

Where single vehicle works are appropriate, they can be used in conjunction with a Mobile Lane Closure block vehicle. This will afford the additional protection of being highly visible and being equipped with a crash cushion. It should be noted, however, that unless supported by the required level of advance signing, this arrangement does not constitute the provision of a MLC.

Responsibility for safety

Everyone on a site is now deemed to have a duty to take reasonable care of his own safety, and responsibility for the effect his actions may have on the safety of others. Site staff and visitors also have a duty to co-operate with their employer and assist him in fulfilling his statutory duties for site safety, including the reporting of any breaches that they observe.

B.2.5. Outline Traffic Operations Management Plan

Proposed Table of Contents

1. Introduction
2. Purpose
3. Scope
4. Definitions

5. Functional Management

- 5.1. Staffing
- 5.2. Training
- 5.3. Monitoring Procedures
- 5.4. Control Room Management
- 5.5. Traffic Control Supervision
- 5.6. Records and Data Management
- 5.7. Traffic Analysis
- 5.8. Traffic Alleviation Plans and Procedures
- 5.9. Information Dissemination
- 5.10. Cooperation with Local Police Department

6. Decision-Support Systems

- 6.1. Toll Collection System
- 6.2. Communications Systems
- 6.3. Surveillance and Detection Systems
- 6.4. Roadway Weather Information System (RWIS)
- 6.5. Other Systems

7. Multi-Agency Operations and Arrangements

8. Standards and Protocols - Work Zone Traffic Control

- 8.1. Material and Equipment Storage and Parking
- 8.2. Protection of Hazards
- 8.3. Temporary Lane Closures
- 8.4. Temporary Road Closures
- 8.5. Flagging in the Work Zones

9. Emergency Events

- 9.1. Event Management
- 9.2. Notification of Lane/Highway Closures
- 9.3. Emergency Detouring of Traffic
- 9.4. Disabled and Abandoned Vehicles
- 9.5. Standards and Protocol – Unusual Events

B.2.6 Tolling integration with other tolling agencies

The tolling integration with other agencies, meaning the necessary exchange of data to support state-wide interoperability, as mandated by TxDOT, will be managed through the Back Office System, as described in Appendix 4.

During the initial 5-year period of operations, most of the Back Office functions will be performed through the contract with NTTA, and all valid transactions will be submitted to NTTA for money collection purposes, including the transactions with non-NTTA valid tags. Therefore, interoperability will be achieved through NTTA.

In case the contract with NTTA is not renewed after the initial 5-year period, the BOS will need to be enhanced in order to support direct interface with the Clearing House to be set up by TxDOT. A complete pre-design of all the foreseen back office functions can be found in Appendix 4.

B.2.7 Emergency / Extreme Weather Preparation and Response

Incident response procedures are set down in detail within the Incident Management Plan (IMP) likewise the Winter Service Plan (WSP) sets out our approach and procedures for extreme cold weather.

In addition we will utilize flood sensors, measuring water levels on the roadway and water levels of creeks/streams/ditches to allow early deployment of resources and emergency plans in a significant rain event.

Location of winter and water level sensors will be reviewed on an annual basis to ensure optimum reporting allowing efficient and timely maintenance operations.

B.2.8 Coordination with Emergency Services

Incident coordination procedures are set down in detail within the Incident Management Plan (IMP) and summarized here.

For the incident management objectives to be achieved and to produce a combined and coordinated response to an emergency, a common management framework in line with those operated by police/emergency services, local authorities and other agencies must be adopted.

Under this framework the management of the response to an **incident** will be undertaken at one or more of three levels:

Operational	Manage at scene activities within respective organizations
Tactical	Determine priority in allocating resources, plan and coordinate response
Strategic	Establish strategic management. Ensure resources/expertise available for speedy return to normality

Incidents are likely to be managed at **Operational** level initially. **Tactical** and **Strategic** management levels to be activated as appropriate

Operational Level (Bronze) e.g. Field Patrol

This level reflects the normal day-to-day arrangements for responding to incidents. It is the level at which the management of 'hands-on' work is undertaken at the individual site.

Individual agencies retain full command of the resources that they apply within a geographical area or use for a specific purpose. The Developer will normally act as the co-ordinator of the response at an identifiable scene.

A key function of an **operational** commander or manager will be to consider whether circumstances warrant a **tactical** level of management.

Tactical Level (Silver) – Maintenance Manager

A **tactical** level of management is introduced to provide overall management of the response.

Tactical managers determine priorities in allocating resources; obtain further resources as required, and plan and co-ordinate when tasks will be undertaken. They must take appropriate risk reduction measures and give due regard to health and safety requirements.

Where there is an identifiable scene, **tactical** management is usually undertaken from an Incident Control Point established in the vicinity. Many **tactical** functions will then be discharged at or close to the scene. However, some agencies, (for example local authorities), will prefer to operate from their administrative offices but will often send liaison officers to enhance co-ordination. Planning must also take into account that there may be a number of individual scenes.

Tactical managers must concentrate on overall general management. While they need to be aware of what is happening at **operational** level they should leave the responsibility for dealing with that level to **operational** managers. When the situation warrants it a **strategic** level of management/command should be established as early as possible.

Strategic Level (Gold) – Roadway Operations Director

In exceptional circumstances, one or more agencies may find it necessary to implement a **strategic** level of management. **Incidents** can place considerable demands on the resources of the responding organizations, with consequent disruption to day-to-day activities. It should be remembered that there would also be a need to ensure that operational requirements elsewhere may still have to be met and such matters require attention by senior management.

Strategic command for **incidents** should be seen as standard practice not the exception. It is easy to dismantle if not required and removes the potential for **tactical** managers/commanders to be reluctant to ask for a **strategic** level of management/command. The need for a **strategic** level may arise if **tactical** management does not have the required resources or expertise available. It may also arise if there is a need to co-ordinate more than one incident/scene for which **tactical** command has been established. **Strategic** management is normally undertaken away from any **incident** scene.

The requirement for **strategic** management may be confined to one particular agency. However, certain incidents require a multi-agency response at the **strategic** level when the issues that arise affect the responsibilities or activities of more than one organization.

Whilst the communication procedures are prescriptive, we recognise the benefits of a partnered approach to incident management with the emergency services. To this end we have purposely

located of our proposed administration center adjacent to the Fire Dept building to facilitate communications and joint incident debrief and training exercises.

B.2.9 Analysis of Vehicular Accident Patterns

Early identification of network hotspots for accident clusters will be led by the Maintenance Manager, assessing junction and link sites to determine the quantity and geographic spread of injury accidents, from a rolling 5 year record of injury accidents, establishing those sites and links that exhibit an accident or severity level higher than the national average for the respective route type.

A prioritized list of injury accident sites is formed to focus scheme identification proposals. This gives greater confidence in study outputs and their development to a robust and effective works program.

Our Field Patrols will instigate regular layperson forums comprising of local people who regularly drive routes, with the aim of identifying clusters of non-injury collision and near miss locations. This information will facilitate action before serious incidents occur. Good feedback to the forums will ensure ongoing commitment.

We will champion providing quality real time information to the traveling public as they approach accident hot spots, extending this to other locations to inform on changing weather conditions that affect safe driving, such as possibility of ice and torrential rain.

We will promote high impact information signs such as 'Number of vehicle collisions this year compared to last year', measuring improvements year on year.

We will promote the use of speed actuated 'speed limit' signs at collision hot spots, high severity accident areas and at locations of Temporary Traffic Management.

Our safety engineers and accident investigators will work along side the emergency services investigators to determine if the condition of the network contributed to the incident, for example did an inadequate maintenance regime not identify and clear a blocked gulley, leading to the flooding that caused the driver to loose control?

Works portfolio is established from this statistical analysis of network accident sites supported by operational input:- feedback from Field Patrols and Control Center will be documented and analyzed to highlight trends and evident contributory factors arising from network incidents.

Quarterly routine police liaison and accident working groups established with the emergency services will further document incident trends. These forums will be encouraged to identify and prioritize areas of perceived risk, where either the accident statistics are non-representative or where the risks are so apparent that the majority of regular users employ greater care.

Stakeholder input and feedback will be formalized to ensure all parties are aware of progress towards improvements of high risk sites.

Workshop training of safety scheme identification and development will be rolled out to operational Field Patrols and crews to ensure accurate and useable feedback from the incident management process and give a greater understanding of network accident trends and risks.

Historical Data analysis

Historical Data Analysis carried out at any given moment during the term based on the information gathered during operations (Traffic, weather etc) has proven a very effective tool to identify and address recurrent issues, particularly when they can be predicted under certain circumstances, in order to improve the safety and comfort on the motorway.

This proposal includes a record system that will be uploaded into a software package to assist the Accident Information and Prevention Systems as well as to the Incident Management Plan. The main data to be recorded and stored for analysis can be summarized as follows:

Incident coefficient	
Unit	Value
Incidents per million veh x mile	
Incidents leading to a lane closure per hour per lane x mile	
Incidents leading to a lane closure for more than 45 min per 100 million veh x mile	

Capacity Reductions			
Incident	No of Lanes	Closed lanes due to incident	% Capacity Reduction
Incidents on the shoulder			
Vehicle damage only			
Accidents with injuries			
Accidents			

Typical Capacity in work sites				
No of Lanes	Closed lanes due to incident	Average Intensity (veh/hour)	% reduction	% Capacity Reduction

Accident Investigation and Prevention Studies

Further to the Incident Record included in the proposal, the proper approach to dealing with accident management with AIP studies has been developed from years of experience taking advantage of an accurate recollection of data, and has been successfully put in place in numerous road projects with immediate benefits in terms of safety. Although the Design of motorway and frontage roads is reviewed from a safety point of view at several stages, we feel that it is important to implement this tool as circumstances may change during the term of the concession.

The proposed system AIP is based on the identification of hotspots along the infrastructure (Main lanes and Frontage Roads), in terms of number of accidents and their yearly evolution for a second stage in which the data is statistically analyzed (Chi square test) and on site evaluation is carried out

resulting in the proposal phase when corrective measures for outstanding issues are put forward and prioritized in accordance to the expected benefits of each measure.

As previously mentioned, the key element of this analysis is the collation of accident data from all the sources available in the motorway

The creation of accident reports for each of the incidents will conform an easy to update and maintain database on which information can be requested for each section of the motorway.

The necessary inputs for the system will be received mainly from two different sources:

- Operations data gathering equipment
- Close collaboration with police department.

Our proposal is based on the assumption that only the first source will be available initially, but we will be making all endeavors to build up a strong relationship with relevant police departments to gather as much information as possible for the benefit of society.

Database

The essential data necessary for a thorough analysis is listed below:

- Date in which the incident occurred
- Time
- Exact location.
- Direction of travel.
- Weather (wet/dry).
- Visibility (night/day).
- Fog (yes/no).
- Seriousness [fatal / serious / slight – in accordance with reported injuries).
- Number of people injured/fatalities
- Number of vehicles involved.
- Type of vehicle.
- Classification of the incident according to the main cause behind it:
 - For example:
 - Vehicle parked on the shoulder
 - Flat tire.
 - Dangerous overtaking.
 - Right line overtaking.
 - Yield signs not observed.
 - Drink-driving.
 - Speeding.
 - Object-Oil stain on the carriageway.
 - Etc.
- 1 line Brief description of the incident.
- "Stick diagram": depicting the interactions between vehicles involved during the accident.

Other relevant information that could be useful although not critical for the analysis:

- Driver's age
- Injured people's age

Cluster Identification

Areas or spots where the majority of the people occur, and therefore where corrective measures should be studied. Typically a cluster would be 100m radii and therefore all the accidents in a 200m long section would fall in a cluster. These criteria can be modified if special circumstances make a spot have an impact on longer distances.

Chi Square Statistical Analysis

For each identified cluster, accidents with the same characteristics are grouped and a preliminary analysis of the evolution from previous years is carried out. Practical example: mile 12 Eastbound-accidents during night hour. The annual figure is compared with previous year's value to assess whether the changes are due to a physical factor that can be corrected or purely to random fluctuation. The same sort of analysis can be used for a BEFORE/AFTER assessment of the measures put in place. The figure below shows the simple structure of the calculation once the data has been collated

SH 121 TOLL PROJECT

Chi Squared Test

Used to determine whether the number of accidents of a particular type is "significantly" higher than at similar sites
Or to determine whether there has been a "significant" change in the number of accidents at a site after treatment has been carried out.

Input figures in yellow cells

Before/After Test

	Site	Control	Totals
Before	10	100	110
After	3	100	103
Totals	13	200	213

Chi squared = 2.55

Comparative Test

	Site	Control	Totals
Dark	9	442	451
Light	12	192	204
Totals	21	634	655

Chi squared = 5.64

If Chi sq >2.71 - result is significant at 10%

If Chi sq >3.84 - result is significant at 5%

If Chi sq >6.635 - result is significant at 1%

If Chi sq >10.83 - result is significant at 0.1%

Significance Levels

Significance Level	Confidence Level	Subjective Interpretation
1%	99%	Highly Acceptable
5%	95%	Acceptable
10%	90%	Fair
20%	80%	Indicative

If the outcome of the calculations shows that the increase in number of accidents of a certain type is not due to random fluctuation, specific measures will need to be developed to address the identified problem. Only in this case, further studies will be carried out.

Direct Observation

Further to all the preliminary analysis the team on site will be aware of the problems to look for and can properly assess the behavior of drivers on the section where problems occur. For instance, an statistically relevant increase in the number of accidents on a certain spot during night hours could indicate lack or defective illumination systems. In this case the team would carry out a night study to verify what the problem really is.

Conclusions and Proposals

The conclusions of the accident study will be reflected on a brief report. It will also include realistic proposals to address the problems detected.

Some examples of proposals could be:

- Installation of new lighting columns
- Expedite mowing or trimming if visibility has been reduced.
- Antiskid paving on certain sections
- Signing improvements

At the same time a preliminary cost estimate based on experience and as justified as possible is included together with the assumed reduction in accident thanks to the implementation of the measures proposed.

In addition, the estimated cost saving derived from the avoidance of 1 single road accident (Including Insurances, Hospitals others) is assessed. This figure needs yearly updating and 100.000\$/accident saved can be used as a initial working figure.

The described approach is a tool used to prioritize the implementation of measures. Each proposal's ranking is obtained through the calculation of the "First Year Rate of Return"

$$\text{FYRR} = \frac{\text{Number of accidents avoided} \times 100.000 \times 100}{\text{Estimated Cost}}$$

This criteria is a very important tool for the decision-making process when it comes to reduction in the number of accidents. This will result in safer journeys to users meeting one of the main objectives of the Road Developer.

B.2.10 Containment and Disposal of Hazardous Material Spills

Pollution response procedures are set down in detail within the Environmental Management Plan.

In addition we will develop an understanding of incident risks adjacent to the project with a comprehensive assessment of materials stored within ¼ mile of frontage roads.

This will allow clear risk appreciation and allow development of mitigation measures for incident management purposes and continuous improvement of the Incident Management Plan.

B.2.11 Investigation of Reports or Complaints

Complaint handling and reporting procedures are set down in detail within the Communications Plan and the Customer Service Plan (outline included in Appendix 3).

B.2.12 Abnormal Load Policing and Management

The routing of Abnormal or Indivisible Loads on the project road shall be managed by the Developer. Abnormal Indivisible Loads are those which cannot, without undue expense or damage, be divided into two or more loads for the purpose of carriage on the network.

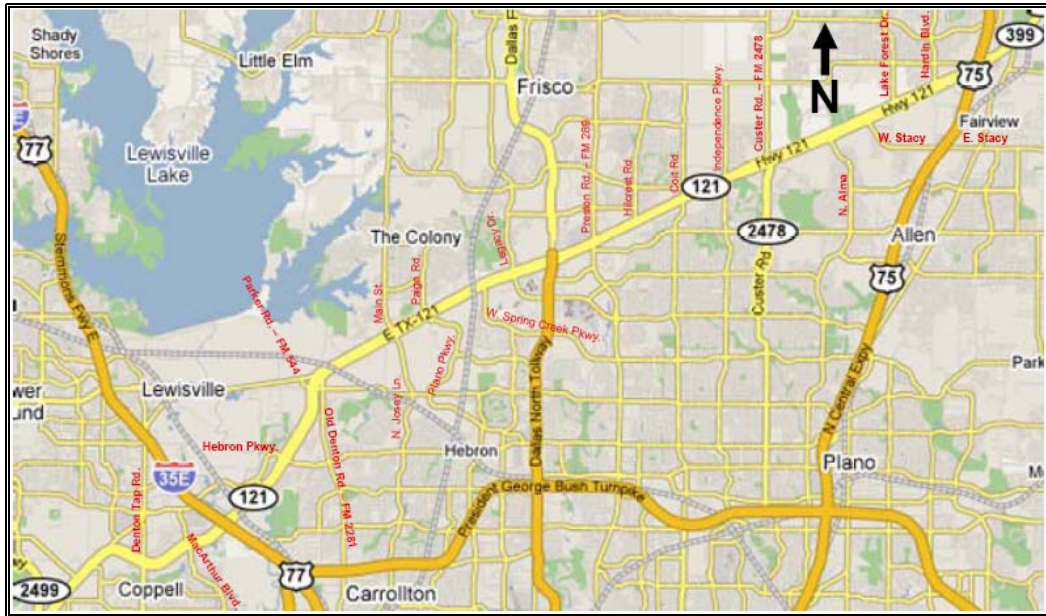
The Developer will work with all hauliers to programme and police the movement of Abnormal loads, effecting transportation timetable, where ever possible to minimize the impact to the road user.

Partnering with haulage companies, we will be able to effectively arrange convoy and traffic management requirements, and in exceptional circumstances, removal and reinstatement of road furniture.

APPENDICES: ROAD SPECIFIC APPENDICES

APPENDIX 1

Extent of Network



State Highway 121 (SH 121) is situated in North Central Texas. It is Collin County's principal route to the Dallas-Fort Worth International Airport, as well as an essential east-west link between US 75 in McKinney and Denton County.

The Texas Department of Transportation (TxDOT) has issued a Request for Proposals to develop, design, construct, finance, operate and maintain the SH-121 Toll Road Project through a comprehensive development agreement (Concession Agreement).

The major construction activity will take place in Collin County (Segments 3 and 4). In this section of SH 121 the Developer will improve the existing SH 121 by constructing 3 + 3 main lanes between the 3 + 3 frontage roads that are currently under construction in both sides. This will affect the last 9 miles of SH 121 from Hillcrest intersection up to the interchange with US 75.

There are 7 interchanges along this section: Colt Road, Independence Parkway, FM2478 - Custer Road (Currently under construction), Alma Drive, Stacey Road, Lake Forest Drive and Watters Road. All of them have the same typology with the main lanes crossing over the secondary roads.

The second main construction site will be located at the SH 121/US 75 five-level interchange (Segment 5). This new fully directional interchange will replace the existing one, which dates back to 1959. A careful study of the traffic detours and phasing will be necessary to demolish the existing structure, construct the new ones while maintaining the traffic flow.

The Developer will also have the obligation to provide finance, design and construct certain additional improvements, along each of the relevant sections, as well as the maintenance and renewal activities for the entire project.

APPENDIX 2

Performance and Measurement as TxDOT Attachment 11

APPENDIX 3

Customer Service Plan (Outline)

The following document summarizes the guidelines that the Developer will follow in order to develop the Customer Service Plan, as requested by Book 2A, section 21.

1. NTTA Period

During the initial 5-year period of operations, most of the Customer Service will be subcontracted to NTTA. In any case, the developer considers that there will be a Customer Service Plan in place, in order to process all complaints and requests for information from drivers, as well as to regulate the relationship with NTTA, which will be considered, indeed, as one of the most relevant clients for the motorway. The structure of this initial period Customer Service Plan shall be as follows:

1.1. Toll Collection Plan

This plan will outline the methodology for:

- a. The setting of tolls;
- b. Increasing the amount of the tolls; and
- c. Methods for collecting the tolls
 - Data transfer from front-end to back office
 - Video exception processing
 - Audit and reports
 - Emergency procedures.

1.2. NTTA relation plan

This plan will include the procedures of relationship with NTTA for the duration of the Customer Service agreement with them, including at least:

- a. Data transfer methodology
 - i. Infrastructure
 - ii. Data Management
 - 1. Transactions
 - 2. Settlements
 - 3. Adjustments
 - iii. Emergency Procedures. Alternative data transfer.
- b. NTTA's queries attention
 - i. Personnel
 - ii. Methodology
 - iii. Tracking (reports)
- c. Enforcement supervision
 - i. Annual revision of the Toll Enforcement Plan
 - ii. Toll Enforcement Audit Methodology. Reports.
- d. Customer service supervision
 - i. Annual revision of the Customer Service Plan
 - ii. Customer Service Audit Methodology. Reports.
- e. Interoperability supervision
 - i. Annual revision of the Interoperability Plan
 - ii. Interoperability Audit Methodology. Reports.

- f. Dispute resolution

1.3. CSC plan

- a. Personnel
 - i. Developer's personnel policies and procedures
 - ii. A list of all positions in the CSC organization with the job responsibilities and skill and knowledge requirements.
 - iii. Hiring policy.
 - iv. Training policy to ensure that employees are competent and certified to perform the duties of their job.
 - v. Orientation program to ensure that employees have adequate knowledge of their duties and potential work hazards.
 - vi. Access and management of personnel files.
 - vii.** Staffing Plan to address and identify peak periods of customer
- b. Infrastructure
 - i. Communications
 - ii. Hardware
 - iii. Software tools
 - 1. CSR package
 - 2.
 - iv. Web page
 - 1. Map of contents
 - 2. Information update methodology
 - v. Security and privacy of information
 - vi. Emergency procedures
- c. Queries attention methodology
 - i. Phone Calls
 - 1. IVR
 - 2. Agent assisted
 - ii. Web Page.
 - iii. Others (fax, e-mail, postal mail)
- d. Quality Control/Quality Assurance Program to monitor and ensure courteous and professional service to customers at all times.

1.4. Reporting

- a. Internal
- b. External
 - i. TxDOT. This will include the annual operational report, as requested by book 2A, apart from any other information that TxDOT may require.
 - ii. NTTA
 - iii. Other third parties

2. Post-NTTA Period

In case the initial 5-year period with NTTA is not renewed, the Developer shall assume all functions developed by NTTA up to that moment, basically:

- Direct management of enforcement
- Transponder issuance and distribution (to be decided)
- Direct relationship with the Central Clearing House for interoperability purposes

The structure of the Customer Service Plan shall be extended and modified be as follows:

2.1. Toll Collection Plan

This plan will outline the methodology for:

- a. The setting of tolls;
- b. Increasing the amount of the tolls; and
- c. Methods for collecting the tolls
 - i. Data transfer from front-end to back office
 - ii. Video exception processing
 - iii. Banks interfaces
 - iv. Central Clearing House interface. Interoperability.
 - v. Audit and reports
 - vi. Emergency procedures.

2.2. Toll Enforcement plan

- i. General procedure for enforcement
- ii. Interface with external agents involved
- iii. Tracking of enforcement cases
- iv. Program for debtors conversion into account holders

2.3. CSC plan

- a. Personnel
 - i. Developer's personnel policies and procedures
 - ii. A list of all positions in the CSC organization with the job responsibilities and skill and knowledge requirements.
 - iii. Hiring policy.
 - iv. Training policy to ensure that employees are competent and certified to perform the duties of their job.
 - v. Orientation program to ensure that employees have adequate knowledge of their duties and potential work hazards.
 - vi. Access and management of personnel files.
 - vii. Staffing Plan to address and identify peak periods of customer
- b. Infrastructure
 - i. Communications
 - ii. Hardware
 - iii. Software tools
 1. CSR package
 2. Others
 - iv. Web page
 1. Map of contents
 2. Information update methodology
 - v. Security and privacy of information
 - vi. Emergency procedures
- c. Customer attention methodology

- i. Front Desk
 - ii. Phone Calls
 - 1. IVR
 - 2. Agent assisted
 - iii. Web Page.
 - iv. Others (fax, e-mail, postal mail)
- d. Transponder related issues
 - i. Reception and stocking
 - ii. Accounts set up and management
 - 1. Pre-payment tags
 - 2. Post-payment tags
 - iii. Final tag distribution
 - 1. Pick up at commercial offices
 - 2. Mail distribution
 - 3. Others (retailers, etc)
 - iv. Marketing
- e. Quality Control/Quality Assurance Program to monitor and ensure courteous and professional service to customers at all times.

2.4. Reporting

- a. Internal
- b. External
 - i. TxDOT. This will include the annual operational report, as requested by book 2A, apart from any other information that TxDOT may require.
 - ii. Other third parties

APPENDIX 4

Back Office IT Systems

INTRODUCTION

This document considers two implementation phases of the Back Office:

Phase 1. The Back Office System will include only the transaction processing, understanding that all relationship with customers will be done through NTTA. In fact, the distribution of functions between the Developer's Back Office and NTTA's Back Office during this first phase will be as follows:

Developer

- Creation a of transaction per vehicle that contains all the needed data according to the Interface Control Document, which shall include, among other things, the extraction of the following vehicle identification, depending of the case:
 - o Transponder ID (if the vehicle is equipped with such device and the device is correctly mounted and in good operational condition).
 - o License Plate numbers of the vehicle: the toll collection system (field systems) will be designed to capture images of the front and rare license plates. These photographs will be then processed trthrough the VES module of the Back Office, in order to perform an accurate extraction of the license plate numbers.
- Rating of all transactions, i.e., determination of fare to be collected from user according to the fare applicable per gantry as per the current toll fares scheme.
- Connection with NTTA for the submission and reception of toll-related information, including:
 - o Transactions and pictures
 - o Tag Status List
 - o Other event messages
- Archiving and back up of tolling information.

NTTA

- Transponder issue and maintenance
- Account management and maintenance
- Enforcement
- Revenue handling and accounting, including users invoicing and processing of invoices submitted by the Developer with the payable transactions of a certain period.
- Customer service and support (according to the specifications of Book 2A)
- Clearing House service between the Developer and the rest of interoperable operators of toll roads in Texas. This shall include, without limitation, the following functions:
 - o Distribution to the Developer of a single and updated tag status list including all tags issued by the different interoperable operators under TxDOT regulations.
 - o Transference to the Developer of payment for any transaction that meets the conditions set in the CDA, notwithstanding which agency is the issuer of the detected tags.

Phase 2. The Back Office System will assume the whole relationship with customers, so it will include the web site, a call center solution and the processes supported by commercial offices,

again according to the requirements of Book 2A. As scheduled, this implementation will happen five years after the commencement of operations. It will need additional hardware and software licenses (call center architecture), which are described further on.

PHASE 1 FUNCTIONALITY

The proposed functionality for Motorway SH-121 Back Office System can be organized on the following modules:

- Host subsystem
- Transaction Distributor subsystem
- Reclassification subsystem
- OCR subsystem
- Video exception processing subsystem
- Rating subsystem
- NTTA interface subsystem
- Datawarehouse
- Archiving System
- System Information Maintenance and System Parametrization processes

Host subsystem

Retrieving Transactions

The BACK OFFICE SYSTEM will receive the transactions detected by the ORT Field System, through an interface with the Front-End.

This interface will run with high frequency.

It includes at least two pictures: front plate number and back plate number.

General Validations

Once the transactions are transferred from the Front-End to the Back Office System, they get ready to be validated by this process.

The following validations will be made independently if each transaction is a TAG one or not:

- General format validation of the registers received from the Front End's database.
- Verification that all the mandatory fields are informed, including information about the status of the field equipment at the moment of the transaction, that shall be analyzed, processed and sent back to the MOMS of the Field Systems in order to ensure correct levels of maintenance.

- Validation of the transaction date consistency so that it is not a future date or a past date before an established limit.

Specifically for transactions with a Transponder detected, the process will apply the following validations:

- Check the PAN with the TAG status list
- Verification of Luhn Algorithm (to be confirmed)
- Expiration date (to be confirmed)
- Vehicle Class detected against Vehicle Class assigned in TAG status list (see TAG status list validation)

These validation's results will be stored on the corresponding transaction's record in the database and will be used to decide its next stage within the commercial cycle. Furthermore, these results can be also be associated to possible reasons of Field System's anomalies, frauds, etc that will feed other processes.

All these validation results must be shown by the system with some reports. More detailed reports can be obtained in the informational system (data warehouse).

In special cases (according to business rules), when particular data is wrong or doesn't exist, an interface with maintenance system provides this information.

The system administrator will have the possibility of activate and deactivate all these validations in any moment. The deactivation will proceed when the quality of data is good and stabilised so the System Administrator is sure that the validation is no longer necessary.

Duplicated transactions

The system will be able to detect duplicate transactions, and eliminate them. The procedure to detect them will depend on the ORT Field System. According with the information registered by the ORT Field System in certain specific cases, the BACK OFFICE SYSTEM will define some system parameters to detect duplicated transactions.

For example, some criteria could be that if there are two transactions with the same TAG on the same plaza in the same direction within certain period of time (parameter) after the first transaction, the second transaction will be considered as possible duplicated transaction.

Optionally, in an on-line functionality, all these cases are showed to the Control user and he can decide if definitely are duplicated transactions or not. (to be confirmed)

As any other validation process, this one can be deactivated.

TAG status list Validation

This process will performed only for transactions paid with Transponders.

The idea is compare each TAG's transaction with the information contained in the TAG status list received from the Clearing House.

The validation will consist in:

- Verify that the TAG exists in the List and it is valid. If the tag doesn't exist or it is marked as "enforcement needed", then this module will attach the necessary pictures to the transaction for the following steps to be taken

- Verify if the vehicle class detected on the lane is the same of the one associated in to the TAG in the list.
- If there is not a tag detected, this submodule will also ensure that the transaction includes the photographs.

The results of these validations will determine the next transaction's stage.

Transaction Distributor subsystem

This module must automatically detect which will be the next processes for each transaction according to business rules.

- If the transaction includes all the mandatory information, including a valid transponder number and/or pictures together with the output of the registration plate number and State, the transactions shall be routed to the rating module.
- If the pictures are included but they don't include output of the registration plate number and the State, the transactions shall be transferred to the OCR module;
- If the pictures are included, and they already have the OCR output, but the reliability level didn't achieve the required values, or there are discrepancies between the outputs of both pictures, the transaction will be sent to the Video Exception Processing
- When the transaction has not the necessary data to be managed, the system includes it in an incidences report and reroutes it to the host subsystem, in order to retry a correct construction of the transaction before routing it to the rating and NTTA's interface modules.
- The Transaction Distribution module will also send to and receive information from the Maintenance Module of the Field Systems Software, in order to ensure that all relevant information coming from the field is correctly processed to ensure detection of current and foreseen field equipment failures.

Reclassification subsystem (optional in Phase 1)

The Toll Control users will be able to make transit reclassifications. These reclassifications can be useful to correct transactions amounts and to detect possible errors in road automatic devices. Reclassification of transits containing discrepancies between the detected class and the class of the TAG status list.

The system will show the data of the pending of reclassification transits and a volumetric picture (if it is available) of the selected vehicle. In case the user doesn't select a transit, these and their photographs will be selected sequentially.

The user can select and reclassify, if necessary:

- Individual transits selected one by one
- Groups of transits chosen by multiple selection or using different criteria such as date, payment mean, road, etc.
- The total number of transits pending of reclassification.

The process has got two phases:

- Automatic determination of the transits pending of reclassification (batch process)
- On line toll control user reclassification activity

The user can request for a selected transaction to reproduce on an integrated video player the video recorded by the ORT Field System.

Also can request to see the volumetric and OCR pictures of the transaction, if it exists.

The response time in show both (video and pictures) must be as minimal as possible.

OCR subsystem

License Plate Recognition process

When the transaction doesn't have associated a Plate Number or the accuracy percentage obtained at the field is lower than a certain value (parameter), the application will process the plate's pictures associated to the transaction.

This is a totally automatic process.

This subsystem will be in charge of sending the necessary plate information to the Clearing House (Texas DOT)

If after processing the LPR transaction's images the recognition accuracy percentage is not acceptable yet, the transaction will be aimed to the Video Exception Process.

Automatic license plate recognition (ALPR)

The ORC subsystem will have an License Plate Recognition engine that automatically detects toll enforcements and stores appropriated data for later treatment such as plate number and jurisdiction.

License plate recognition (LPR) is a type of technology, mainly software that enables computer systems to read automatically the registration number (license number) of vehicles from digital pictures. Reading automatically the registration number means transforming the pixels of the digital image into the ASCII text of the number plate.

Recognition algorithms and license plate technology

The license plate recognitions algorithms will be those that better adapt to the USA license plate conditions. Reason why, Soluziona will include a LPR software engine that meets with USA standard.

Automatic license plate recognition has two essential technological issues:

- The quality of the license plate recognition software with its applied recognition algorithms
- The quality of the image acquisition technology, the camera and the illumination

The very key factor is the license plate recognition software. The better the algorithms are, the highest the quality of the recognition software is:

- The highest recognition accuracy it has
- The fastest processing speed it has
- The most type of plates it can handle
- The widest range of picture quality it can handle
- The most tolerant against distortions of input data it is

For example, a good algorithm should read all plates from Europe and USA with the same level of quality. Actually, there is a wide variety of plate types in Europe and USA:

- Black (dark) characters on white (light) plate
- White characters on black plates
- One-row plates
- Two-row plates
- Plates with different character-size
- Latin and Cyrillic fonts
- Plates with or without region's shield or special mark, etc

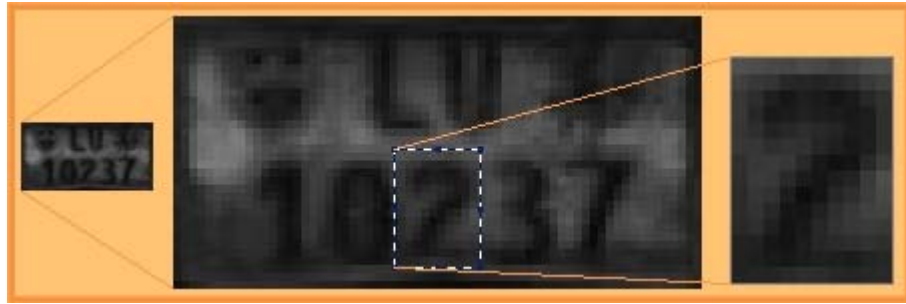
License plate recognition reliability rate

The reliability rate to be considered for the LPR engine will be more than a 90%.

Basically, that there are two key technological parts of a license plate recognition algorithm that basically determines its quality level:

- A robust, very high accuracy and intelligent optical character recognition technology
- A technology that allows intelligent structural analysis of complex higher structures

The robust, very high accuracy Optical Character Recognition (OCR) technology is a very essential requirement.



The OCR task

To get better perception of the nature of recognition accuracy, let's consider the following example: Assuming that the plates have an average of 7 (seven) characters as license plate number. If the overall plate recognition accuracy is required to be above 96% (over 90%), then the recognition accuracy of the individual characters should be at least 99.5%. Out of 1000 characters not more than 5 could be misread /misrecognised:

$$(99.5\%)^7 = 0.9957 = 0.995 * 0.995 * 0.995 * 0.995 * 0.995 * 0.995 * 0.995 = 0.9655 = 96.5\%$$

For a 99% overall recognition accuracy, then the recognition rate of the individual characters has to be at least 99.85%.

The above calculation is only a very simple estimation of the maximum acceptable OCR error rate. The real OCR error rate has to be much lower than the one given by the above estimation, as there are several other parts of the entire algorithm that can make a mistake. And the overall recognition accuracy is the multiplication of the accuracy of the individual (and independent) sub-algorithms.

For example, supposing that there are three additional sub-algorithms before the OCR:

- A plate localization sub-algorithm, responsible for finding the plate on the picture, having 98.7% accuracy
- A contrast/brightness normalization sub-algorithm, responsible to equalize the plate picture, having 99.2% accuracy
- A character segmentation sub-algorithm, responsible for finding and cutting out the individual characters on the plates and pass them to the OCR, having 99.6% accuracy.

The OCR has 99.5% recognition accuracy on the individual characters. The overall license plate recognition accuracy is then only 94.2%, as:

$$0.987 * 0.992 * 0.996 * 0.9957 = 94.2\%$$

The image acquisition technology determines the average image quality the license plate recognition algorithm has to work on. Needless to say that the better the quality of the input images are, the better conditions the license plate recognition algorithm has, and thus the higher license plate recognition accuracy can be expected to be achieved.

In order to expect reasonable results from a plate recognition algorithm, the processed images should contain a plate

- With reasonable good spatial resolution
- With reasonable good sharpness

- With reasonable high contrast
- Under reasonable good lighting conditions
- In a reasonable good position and angle of view

Here are some problematic images:



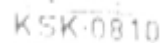
Low spatial resolution (too small characters on the plate)



Blurred image



Low contrast



Overexposure



Bad lighting conditions (shadow and strong light)



High distortion

An image acquisition system is considered to be good if it provides a stable, balanced, reasonable good image quality under all of its working conditions.

United States special case

The LPR engine to be included in the OCR subsystem will have to comply with USA license plate standards.

USA License plate characteristics

Many currently-issued North American license plates utilize a reflective aluminum blank (~12 x ~6 inch · 30.8 x 15.6 cm) from the 3M Company (Saint Paul, Minnesota US). Although proper display of license plates on all "road-legal" motor vehicles (passenger cars, municipal vehicles, police units, fire engines, ambulances, taxicabs, limousines, hearses, trucks, vans, apportioned vehicles, transporters, motor homes and buses) is centrally mandated, the program typically is administered by an agency at the state, provincial, commonwealth, republic or territorial level.

The major objective of LPR system will be to interpret license plate alphanumerics. Along with the letters and numbers, the jurisdiction which issued the plate will be included with that information. This latter task will be an onerous one because not all US States, for example, have the complete state name on the plate. Even when the name is present, it's usually too small to be captured by the image acquisition subsystem and, therefore, cannot be identified automatically.

Some distinctive plate features can be employed to help ascertain a plate's political origin. They are: font, syntax, number of character cells, special characters, excluded characters and fabrication process.

Font

Font refers to an alphanumeric character's shape and style (typeface). All plates are not made with the same font set. There are hundreds of fonts; a standard text on typesetting ("Linotron 202 Type Specimen Book One", Southern New England Typographic Service, Inc., Hamden, Connecticut US, 1983) illustrates most.

Syntax

Syntax is any consistent ordering of characters, defined by systematic placement of letters and/or numbers. Horizontal character spacing also is a component of syntax. When fewer than the maximum number of characters appears on the plate, justification (whether flush left, flush right, centered or full) is another attribute that can designate a particular issuing authority. With a "custom-ordered" or "personalized" plate (sometimes termed "vanity" plate), syntactic rules and regulations generally do not apply. Though, in a majority of such cases, the plate's character allowance (number of cells) is unchanged.

Character Cells

Every letter or number occupies a single cell. A cell nominally is three inches (7.6 cm) high; this measurement can vary slightly depending on the cell's vertical placement. Unusual "truncated" character cells are only two inches (5.1 cm) in height. Each cell's width and syntax (whether restricted to a letter or a number) act to determine the maximum number of cells which -- on North American plates -- is 8½.

Blank spaces, short hyphens, periods and bullets are narrower than most characters and occupy a half-cell. Half-height characters (in the vertical) can be stacked so two are accommodated within a single cell. On occasion, three may be stacked vertically as done by the State of Maryland, or embossed diagonally on some US Federal Government-issued plates. Even four diagonal characters are found on some State of Nevada dealer plates.

Special Characters

Special characters form a superset of the typical ones. They may be true letters (Ñ), numerals (Ø), symbols (&) or icons (like the "keystone" found on State of Pennsylvania plates).

Excluded Characters

An excluded character is absent from the set of standard letters and numbers (A through Z; zero through nine). On State of Wyoming plates, for example, the letters "I", "O" and "Q" are not used when all other characters are numbers. The number "1" may not be substituted for the letter "I" nor the number "0" for the letter "O". A four-character plate cannot contain more than two letters "W" nor two letters "M".

Fabrication

“Embossing” is the most commonly encountered means of plate manufacturing. A metal blank is placed face-down on an anvil and the character die is struck into it. After righting the plate, the letters and numbers appear in relief.

“Incusing” (also called debossing) is similar to embossing except the plate is face-up on the anvil. Viewed from the front, the characters seem to be pressed inward. Plates from Vermont are incused.

In a single-step technique (used by Alaska, Colorado, Delaware, the District of Columbia, Florida, Georgia, Indiana, Iowa, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New York, Ohio, Oregon, South Dakota, Tennessee, Texas, Virginia, Washington, Wyoming, the US Federal Government and the Department of State), the plate is not hammered at all. A graphic lamination process applies the materials so foreground characters remain flush with the background. Other locales are considering a transition to this newer methodology.

Varieties

Diversity among US plates is dramatic. Frequently, different plate designs are furnished within the same jurisdiction. An elective plate style is referred to as a variety. (The phrases “special” or “special design” also are synonymous.) Numerous varieties, for example, are offered by the States of Illinois and West Virginia.

The vehicle registrant may accept the “standard-issue” plate or select an alternate (such as local interest or Alma Mater commemoratives, bicentennials, Y2K issues, etc.), customarily at extra cost. Most optional varieties retain the font from the standard issue; however, there are exceptions.

USA License Plate samples

The following are some plate samples for which OCR Subsystem will need to be complied with:



Result transmission process

The final step will be the transmission of the OCR result process according to the following criteria:

- a) If the ALPR accuracy level is over the predefined level (more 90%) the subsystem will be in charge of sending the corresponding information to the Clearing House for its later treatment and management.

- b) IF the ALPR accuracy is under the threshold the ORC subsystem will be in charge of notifying to the video exception processing subsystem in order to continue with the validation process.

Video exception processing subsystem

This is an on-line functionality where the user will be able to manage transactions with the following detected problems:

- The vehicle plate number is no reliable due low accuracy of OCR recognition.
- No vehicle plate number.
- Differences between the two plate's images (front and back) obtained by the field's camera.
- Vehicles not registered on Texas jurisdiction.

This functionality is included in a window where the user can filter the transactions pending of treatment by different criteria.

Once the user determines the filter criteria, the system will retrieve from the BACK OFFICE SYSTEM database, those transactions that fulfill the filter conditions.

For each retrieved transaction, the BACK OFFICE SYSTEM show up several attributes, the corresponding videos and pictures that will help the user to perform one or more of the following actions:

- Confirm the vehicle plate number recognized by the OCR.
- Update the vehicle plate number
- Update some transaction's attribute value.
- Determine the reason why wasn't possible to recognize the vehicle plate number (technical problem or customer fraud, and the kind of fraud).
- Register of the detected anomalies on the ORT Field System equipments.

There are four main tasks within VEP:

- Plate Verify, in which operators enter jurisdiction and plate string or decide to route it to unreadable coding.
- Image Verify, in which operators are given the chance to cut sub-images in case the field systems have not been able to do so. After selecting a sub-image, the operator enters plate and jurisdiction, or again routes the transaction to Unreadable coding.
- Supervisor Plate Verify: in the event that two operators enter different plate strings, the toll supervisor will be given the chance to assess the picture.

- Unreadable Coding and the reason why this plate number cannot be read. This system must force the user to insert the reason why this plate number cannot be read: if it by technical reason or because the user is using device or material to evade or obstruct or interfere with the toll system.

Additionally, any time that the VEP operators handle a transaction they must classify the actions carried out by them. In such a way, that all the anomalies related to the ORT Field Systems must be transmitted to the maintenance on-line system.

Before a transaction exits this module back to the Transaction Distributor, any of the following circumstances must occur:

- Two agreements have been met, in the following terms:
 - The operator agrees with OCR read in terms of jurisdiction and plate string (in pictures with high levels of confidence)
 - Two operators agree in terms of jurisdiction and plate string
 - One operator and one supervisor agree in terms of jurisdiction and plate string
- For unreadable pictures, a reason for such classification must have been typed, again with coincidence between two operators or an operator plus a supervisor. This information will be used afterwards to feed the Maintenance Module of the Field Systems Software in order to anticipate as much as possible current or future field equipment failures.

For mismatch between two plate pictures of the same transaction, both pictures will have to pass through the general procedure independently, and once the final assessment of the each picture has been made, they will return to the Transaction Distributor, which will include rules to determine how to classify the transaction in case the mismatch keeps on existing. These rules will include, for instance, a correlation between the vehicle class and such a mismatch, which can be normal in the case of a truck towing a trailer. For other vehicle classes, different results will be given depending on track record or others.

Rating subsystem

Toll Charging process

This process is associating to each transaction the corresponding toll fare.
The system will be able to manage all the following toll charges criterias:

- Station
- Direction
- Vehicle Class
- Transaction type: different fares for Transponder and Video transactions.

The Fare Management will join the criterias with the Toll Rates schedule defined by the company:

- Time Period: date to date (includes the selection of an specific date)

- Timetable: peakhours, etc.
- Weekdays (all Mondays, all Tuesdays, etc)

Using this Toll Fare structure, the BACK OFFICE SYSTEM will easily charge the transactions with the corresponding fare.

Discounts process

After rating the transaction with the right toll fare, it's time to verify if it has discounts and apply them.

The system will be able to manage different types of discounts. It is necessary to determine the eligible transactions to receive the discount, the different type of discounts, if one transaction has associated more than one discount it is necessary to determine if they are combinable or not and also it is necessary to know the formula to compute it.

With all these information, the BACK OFFICE SYSTEM will be able to determine and compute the discounts per each transaction. So far were detected as possible discounts the following criterias:

- by Frequency
- by TAG (if the TAG List specifies the discount to apply for certain TAGs).

Frequency discount

In case of a Frequency discount, the system will have a functionality where the user can define, in a flexible way, the number of monthly transactions intervals/bands and the corresponding percentage discount per each of them.

In the batch process, for each transaction paid by electronic means, the system will check a table where the number of monthly transactions paid with TAGs are stored, then access to a discount table and finally it will apply the corresponding discount to compute the final amount.

Tag discount

The system must apply discounts to the TAGs which includes this discount in the TAG status file.

Another possibility can be studied: to apply discounts (even 100%) to the TAGs that the concessionaire decides. In this case it is necessary to coordinate this policy with TxDOT, and if it is a 100% discount the option of sending or not sending this transaction to the clearing hose must be defined.

NTTA interface subsystem

Charging List Generation process

According to some pre-established schedule, the system will close the existing Charging List in "Under Generation" stage, changing the status to "Closed" and opening a new one with the status "Under Generation".

Then, all the transactions associated to a "Closed" Charging List code, will be processed to generate the file physically in a specific file directory. This file will be generated with the structure agreed with NTTA. It can be done in txt or xml format.

As soon as the Charging List is completely generated, the system changes the status of the Charging List to "Generated".

It's only then, when the Charging List is ready to be transferred to NTTA.

Prior to the inclusion of any transaction in a Charging List, this module will verify, for transactions without transponder, whether the read plate number is associated in the Tag Status List with an existing valid transponder. If this is the case, the transaction will be completed with the Tag information, although it will be sent to NTTA together with the photographs and marked accordingly, in case NTTA wants to perform ulterior verifications or commercial actions with the tag holder.

Charging List Transference to NTTA

Once the Charging List is generated, the file is located on the specific file directory and is time to initiate the transference according the a predefined timetable the system will activate the transference.

The transference can use FTP or any other transference compatible protocol.

It will be established a politic of communication controls that will make possible to assure the succes of the transference. Within this politic of communication controls can be determined other channels of information exchange in case of communication problems or continuous errors. Furthermore, pictures files could be sent to NTTA.

Rejected transactions

NTTA can send rejected transactions. The system must be prepared to process them:

- To detect and access to the incoming file
- To search the transactions
- To mark it as rejected and fulfill the reason for rejection
- These rejected transaction are included in specific Data Warehouse reports

TAG status list management

The back-office system must be prepared to receive and process the list of all valid toll tags for the road (tag status list) and its updates.

The system updates the internal TAG list and send it to the open-road toll collection system (ORT)

If it is necessary to maitain historical list, the back-office system will operate with a single list with creation and remove dates.

Financial statements

The back-office system must send the financial statements to NTTA on a timely basis and must verify the the reconciliations between the due and paid transactions, issuing the necessary alarms in case of discrepancies.

Relationship with NTTA. Enforcement.

A motorway's employee will be the responsible of the relationship with NTTA, because it will be the single customer of the Developer. This employee will act as a reduced customer service and he/she will have access to several Data Warehouse reports (summarized and detailed ones) to solve questions and requirements. This employee will also be able to access the Transactional Service to perform advanced queries in order to be able to give NTTA accurate answers in case of doubts or questions about transactions.

Since the enforcement will be totally transferred to NTTA during the duration of the contract with them, this employee will also be in charge of performing periodical audits to NTTA enforcement services. For such purpose, NTTA shall provide the Developer with periodical reports regarding the transactions enforced in SH 121. These reports will be provided in electronic version, in order to be automatically processed and analyzed to a certain extent by the BOS.

Finally, this employee will also be in charge of verifying the reconciliation statements mentioned before, in order to track every single valid transaction sent to NTTA and having being sent back to the Developer.

Datawarehouse

Extraction an data load into the informational system (data warehouse)

The first step in the process is the data extraction from the transactional systems. The information extraction will be from:

- Back-office system. The greatest part of the data will come from this system
- Traffic counters database. Traffic intensity information
- Meteorological information Database

Data extraction from the ORT is not included.

The following steps are optional according to the design: validation and transformation.

Validation consists in the detection of errors in the data. These errors are related to formats (kind of field, mandatory informed data, etc) and are never business validations.

Data transformation can be necessary depending on the Technical design of the Transactional Back Office System and DWH. It consists in obtaining new data starting with the data in the Transactional, as a result of logical or mathematical operations, such as counting, adding, etc. For example, traffic intensity calculations. Anyway most of these operations will me made afterwards using the query&reporting tool (Business Objects).

The last step is the load of the data in the informational database (DWH). The n-dimensional cube for OLAP queries are also created.

The process periodicity will be daily, although an estimation will me made on the possibility of actualising certain tables only weekly.

Historical data will be stored for 3 to 5 years, although it will be determined if it is necessary to store that information for a longer period.

Obtention of queries and reports from the informational system (data warehouse)

The obtention of the information from the DWH by the users will be by using the query&reporting tool Business Objects. This will be the mean that the final users will use to "see" the informational database.

The targets of this application's exploitation are:

- To obtain reports and statistics on the motorway operation
- To obtain queries for the daily operation: data validation and contrasts that will be used to decide daily.

The kind of queries that will be made using the Business Objects application will be:

- OLAP queries (on line analysis process). The n-dimensional cube or cubes created during the load have got associated standard queries. These enable to access the data very quickly (just a few seconds). Anyway, the flexibility to manipulate data is limited, because it is impossible to access to more information that the one predefined in the n-dimensional cube. This technique is optimal for periodical and strongly standardised reports.
- Free query&reporting queries. Using these queries the users can access in a flexible way to all the information contained in the DWH. They are useful for specific queries, generally detailed, whose contents are not easily predictable. Their complexity can be much more. The inconvenience is that the obtention time is larger (minutes) because the information hasn't been pre-elaborated as in the OLAP case.

Anyway, the main application's characteristic is the easiness of its usage. This simplicity allows the obtention of very complex and flexible information without the need of any programming knowledge. Some of the most common queries can be:

- Traffic queries
 - AADT by gantry, AADT by light vehicle equivalent, AADT by method of payment for a period.
 - Analysis of the traffic evolution by segments in AADT light vehicle equivalent.
 - Summary and details of traffic at the stations.
 - Summary of the toll for the month.
 - Analysis of the evolution of the traffic by class vehicles.
 - Increase in traffic in a period.
 - Monthly traffic report.

- NTTA reports
 - Reconciliation and audit report with NTTA.
 - Rejection files reports
 - Valid TAG lists files
- Meteorological information, especially that referred to traffic intensity
- Commercial cycle reports
 - Transactions' validations
 - Reclassification report
 - OCR statistics
 - OCR reliability rate
 - OCR incorrect read rate
 - Video exception process statistics
 - Discounts reports
 - Etc.

Archiving System

After ninety days on-line (in the mainframe that will support the BACK OFFICE SYSTEM modules), transactions will be sent to a first level of archiving, in an specific server that will be able to receive on-line queries without affecting the performance of the mainframe. After one year in this first level of archiving, transactions will be classified as "historical" and will be definitely archived in removable storage units (tapes or similar). In case there is need to consult or restore any historical data, the on-line archive server will permanently have enough HW and SW resources to be used for this purpose. Related to disaster recovery, Soluziona proposes two geographical active-active distributed clusters, with one node at each site (see chapter 5).

System Information Maintenance and System Parametrization processes

Fares management

This module provides to the user with all the functionality to manage the Toll Rates schedules. The user will be able to register fares for future periods using the existing Toll Rates plan in order to make the task easier and faster.

Registry of a new fare

To register a new fare it is necessary to fill up the following data:

- Fare name and description
- Itinerary
- Rate class
- Price
- Date when the fare goes into effect
- Fare expiration date
- Week day
- Time interval

Fare modification

It is possible to modify the expiration date of a fare whenever that new date is not previous to the current date.

If a fare is currently effective, to modify its value, it is necessary to change the expiration date to the current date and then to register a new fare with the new amount.

Fare termination

It is possible to terminate a fare changing its expiration date.

Discounts management

The system will allow to maintain the discounts percentages as it was explained in the chapter 3.6.2.

Exchange Files format

The BACK OFFICE SYSTEM will have a functionality to convert format files txt and xml. This functionality will be very usefull to define the structure of the files to exchange information with NTTA or the Clearing House. These format can be change in a very flexible a powerful way.

Parameters maintenance

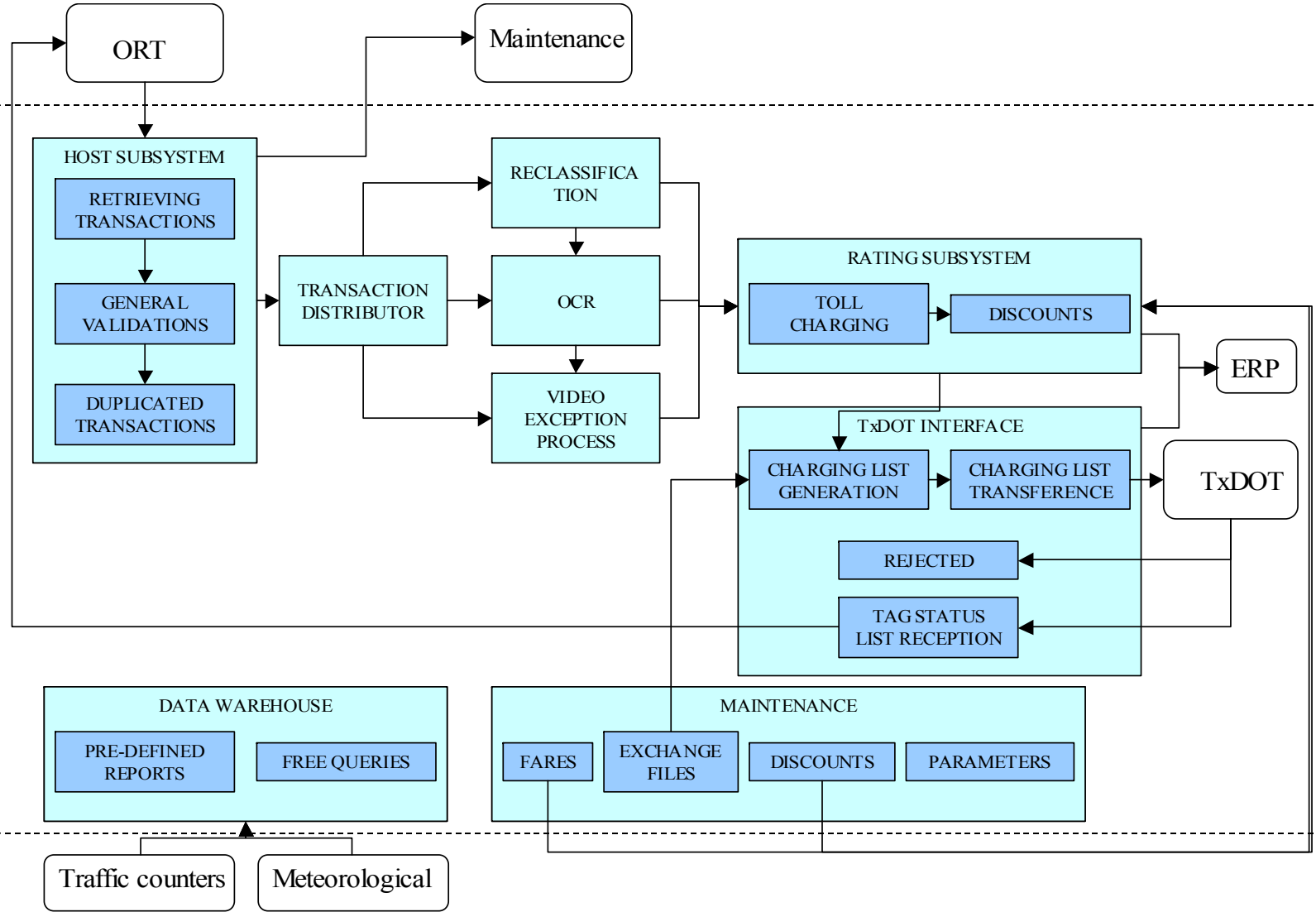
The system will allow to maintain the system parameters values, as:

- Batch validations processes activation/deactivation

- Process parameters like: time to consider duplicated transactions, limit of reliability of OCR results, etc.
- File director where to locate the Charging List
- FTP address where to send the Charging List
- File director where to receive the TAG status list
- etc

BLOCK DIAGRAM

The following diagram shows the identified processes and part of the information flow.



System Interfaces

Interfaces with NTTA

Basically, with NTTA will be exchanged the following information:

- TAG status list (from NTTA to BACK OFFICE SYSTEM)
- Charging List (from BACK OFFICE SYSTEM to NTTA)
- Rejected transaction (from NTTA to BACK OFFICE SYSTEM)
- Financial statement (from BACK OFFICE SYSTEM to NTTA)

The system could support the interchange of TAG security. A new security key provided by NTTA will be retrieved by the BACK OFFICE SYSTEM and sent to the ORT.

Interfaces with the ORT Field System

The Back Office system receives from the Front-End:

- Transactions data
- Transactions' pictures
- Transactions' videos (to be confirmed)
- Enforcement data
- Toll configuration (stations, lanes, etc,...)
- Lane equipment alarms (to be confirmed)

Interfaces with the ORT Maintenance System

The Back Office system will transfer to the Maintenance System the technical errors detected during the treatment of transactions. Every error will identify the station, gantry, related comments determined by the Control user and the selected and predefined error description. In the BACK OFFICE SYSTEM will be detected errors on the OCR, video camera, ETC antenna, etc.

ERP's interfaces

The BACK OFFICE SYSTEM will feed of information the ERP. For example, will be transferred information about:

- Incomings
- Taxes

- Losses – charges that were not included in Charging List because was not possible to determine neither the vehicle plate number nor the TAG.

Traffic counters and meteorological system

Several reports of Data Warehouse subsystem include this data

PHASE 2 ADDITIONAL FUNCTIONALITY

The second implementation is focused to manage all the relationship with customers through different channels. This implies to manage customer accounts, means of payment of the Developer, interfaces with banks and other entities and offender persecution.

Transactional System

The Transactional system will include the following integrated modules:

- Customer Account Management
- Tags Data Management
- Clearing House Information Management
- Customer Management and Invoicing
- Enforcement Management
- Customers' claims and information requests

Customer Account Management

The system supports this functionality because it is necessary for pre-payment TAGs management.

The clients registered in the system have an associated account. The balance in that account can be credit or debit. The clients will make charges to their account when they pay for a transit with a tag.

The customer could recharge their account in order to increase their balance. Automatic recharges are recommended, sending to banks remittances with these TAGs' recharges. These remittances (banks consignment) events can be related to the balance of this account.

The refused remittances can update the account balance. The grey, black and white list (or alternatively a single tag status list) can be changed depending on the balances of the customer accounts.

In case the debit balance is over an established limit, the customer will be processed by the unpaid debts management process.

Tags Data Management

Developer tags management

The system enables the management of tags either free or not, or issued by the Developer for employees or specific clients.

When issuing a new tag all the necessary data will be inserted in the system considering ATA protocol of the Transcore eGo Plus tag.

The data of the issued tags will be communicated to the tag encoder server using the proper interface. If this server does not exist, a report will be generated.

When the tag is coded its state will change in the system and it will be ready for delivery.

The system user must merge the coded tag to an existing customer just in the moment of the delivery.

The system provides the option for changing the security keys of the Developer TAGs.

Renewal of Developer tags management

The system will provide a procedure to manage the renewal of those Developer tags that will expire soon. There will be an automatic batch process that will identify those Developer tags that will expiry after certain number of days (system parameter). For each of them, the system will generate a letter/form (which format can be defined later) to inform the customer about the expiration of the means of payment and the needing of renewal.

If the customer applies to the renewal, the system user will be able to easily identify the corresponding record and automatically request to print-out the new updated tag.

Discounts management

In addition to the information mentioned in chapter 3 other types of discounts can be considered:

Customer discount

A specific discount can be associated to a tag of a selected VIP customer

Other social discounts

Different social discounts can be considered if these entitled discounts can be associated to tags of particular customers.

Other discounts applied in the tollbooths are not considered.

Information for banks: Consignment management

The consignment management process consists of a parameterization, where the characteristics of the collecting centers and the consignment format are defined and of an operational part where the consignments are sent to the bank as well as controlled.

Consignment parameterisation

The charging centre is an entity defined to manage all the communications between the Back Office system and the banks.

The maintenance of the charging centres includes the following functionality:

- Register, modification and termination of a charging centre

- Sending conditions and management costs definition

- Format parameterisation of the consignments sent to each charging centre, using a tool that enables a flexible file format definition.

- Association of each charging control centre to the list of tags handled by itself.

Consignment management

When the transits paid by tag have been validated (with their corresponding discounts, if it applies), the system groups the different tags according to the charging centre to which they belong to and then generates a consignment.

The user can consult the consignments. There is an automatic consignment when particular conditions are fulfilled taking into account the delivery periodicity of each charging centre. A consignments calendar per each charging center can be considered in the scope of the system.

The consignment generation is totally automatic, but the sending can be done manually or automatically (FTP for example).

When the consignment has already been sent, the state of each transit is updated to "charged".

The system manages all the communications with the charging centres processing the response files of each centre and updating the state of the consignments involved in the process.

In case the bank returns the consignments the system will have logical rules that conclude with a new consignment, movement to unpaid debts or bad debts.

Interchanged information with the Clearing house

The system must interchange information periodically with the Clearing House in order to be interoperable with the potential agencies that approved its reciprocity agreement.

Procedures to retry in case of transfer errors must be supported by the system, according to policies about number of tries and periods.

Lists

The system must send and receive lists of valid and invalid TAGs. The frequency of transfers can be easily modified, being a parameter of the system.

Tags charge interchange with other Developers

The Back Office System will send the transits paid with other Developers tags with their corresponding amount, according to the requirements of the clearing house.

The transactions are identified with a unique and intelligent code composed by the station code, date and hour of the transaction plus a sequential number.

Reciprocally, the transits that have taken place in other motorways and paid with Developer's tags will be received from the Clearing House so they can be properly invoiced and settled with the Clearing House.

A Developer can reject some toll charges. The system will be able to manage these situations in both directions by implementing the corresponding Disputed Toll / Adjustments and Rejected Transactions reports. Those Developer's TAGs with no balance in their account will be automatically included in the black list of TAGs.

Security keys

Optionally, the system will support the interchange of TAG security. A new security key provided by the Clearing House and sent from another concession will be retrieved by the BACK OFFICE SYSTEM and sent to the Front End. Reciprocally, a new security key of the Developer's own TAGs will be sent to the Clearing House.

Reports and settlement statement

The system will generate the Transactions Reconciliation reports with a determined periodicity with the gross toll amount due for valid transactions and other charges occurred on other motorways.

In the same way, the system is able to process the information coming from the Settlement Reports received from other agencies. Internally and automatically, the BACK OFFICE SYSTEM validates the funds wire transferred with the information of the Transactions Reconciliation reports.

Catalogue of considered interfaces with the Clearing House

The BACK OFFICE SYSTEM will have implemented all the necessary functionality to fulfill the requirements of the Interoperability Reciprocity Agreement with the clearing house.

Therefore, the BACK OFFICE SYSTEM will manage all the Customer Account Information of the customers and their TAGs, plus the generation, transmission and reception of the following possible types of files:

- TAG's validations files
- Transactions files
- Optionally, corrections
- Transmission Protocol
- Reports, as Settlement Statement

Toll Transactions

Rejected Transactions

Corrections

Reconciliation

Discount Plan Revenue

Disputed Toll & Adjustments

Customer Information and Invoicing

Customer Information Management

The Back Office system includes a customer management module where it is possible to make a query, to register or to modify customer data. Customers' personal data, contact data and payment means are managed. Customers can be registered in these cases:

- When a customer acquires a Developer's tag.
- When a customer asks for information or claims

Customer care: information and claims

Some users can access to a functionality focused to customers' demands:

When the customer asks for information about his bills, fares, discounts, tags, and so on.

When the customer claims. The user must have information enough to solve the most typical questions and claims. In any case he must registry the claim. If the demand is not possible to be solved on-line, other user can investigate the issue and contact the customer later.

The system must support different categories of claims and enable the necessary queries in order to solve the claims.

Mainly call center and walk-in service users must manage this functionality.

Invoicing

The Monthly Statement invoice will give information about last moth account transactions. During the first time the account is set up, there will be two options to select when the statement generation process will be triggered for the account:

- a) by Calendar: x days after account / tag activation date (normally 30 days)
- b) Fixed Date: the day x of each month (normally at the end of the month)

Invoicing cycle

Invoices for transits paid with tag

The invoices for the customers that pay with a tag containing their transits are issued monthly and as a batch process.

Those customers must, of course, identify themselves, by giving their fiscal data and indicating an address to which send the invoice.

Transit detail will be included in the invoice if the customers ask for it.

The possible actions are:

- Modification of the customer data (NIF/CIF) associated to the tags
- Association of a new tag to a specified customer

Refund Invoices

In case a refund consignment has been erroneously generated in a previous charge consignment, the system will automatically generate the refund invoices for those transits that have been already charged.

Other invoicing functionalities

Invoice consultation

The user can check historical invoices using different search criteria.

There is also a possibility to view in a display the invoice image and print it on line, for example in a PDF format.

Issuing of an invoice duplicate

The Back Office system enables the issuing of an invoice duplicate. To achieve this, the customer must hand in the number of the original invoice or the period of the invoices for which he is asking for a duplicate.

It is possible to issue a duplicate both for a charge and for a refund. The format will depend on the kind of invoice.

Printing and enveloping

The system will be able to print the invoices in different formats using a network printer or to generate a flat file containing all the invoice information for each monthly batch invoicing, in case the printing process wants to be externalized.

It will be necessary to define the concepts to include in the invoice. The bills are manually inserted in envelopes.

Concepts calculation

For concepts calculation the system will access to the fares and applied concepts tables-

The discounts and taxes will be taken into account.

Enforcement Management

After "License plate number recognition" and "Video exception processing subsystem" processes are performed over transactions without a valid transponder read at the field level, and after determining that the plate number does not match with any transponder in the databases, the system triggers the enforcement management procedures.

Firstly there will be an automatic interface with the Public Administration Drivers database. The system will send the plate numbers list by FTP (probably at the end of a daily batch process) and will later receive the necessary customer data for the submittal of statements/invoices, as per the procedure described in Exhibit 4 of the CDA. These data may include:

- Name and surname
- Address

- Plate number
- Optionally, other data such as phone number.

The system may have links to other entities and databases in order to verify the quality and accuracy of the received information, and will ultimately correct these data before triggering the printing of the first, second and final notices, which shall ensure that the notices are properly posted and received at the correct addresses.

The following step shall be, then, to contact by post with the offenders, according to the procedure established in Exhibit 4 of the CDA. The system generates the letters automatically, and may ultimately insert the notices together with the statements/invoices in envelopes.

In order to ensure flexibility at the event of changes in the procedure to send the different payment notices the system shall include at least two parameters:

- The number of mailings
- The period between mailings.

The offender can pay the debt by different means:

- Check
- Cash
- Bank transfer
- Credit card.

This can be done:

- In Developer's commercial offices
- Sending the check, cash or transfer receipt by mail.
- Through the commercial web page of the Developer

In the event of an off-line payment, the customer will be able to inform about the payment by e-mail or phone. In any case, the system will keep track of such payments, in order to acknowledge the cancellation of the debt and therefore aborting the continuation of the enforcement procedure.

If the customer doesn't pay in a pre-defined period (system parameter, initially 15 days after the 30-day period past the second notice elapses), the system will trigger an alarm about this particular customer in order to advise that the standard procedure has been completed without a payment and that further action must be taken. The system may include other interfaces with the relevant Authority and/or collection agencies in order to proceed with further steps, according to the law, and will in any case include the automatic preparation (as far as this is possible) of the offender's expedient, including all the relevant data in order to proceed with further legal actions (Court prosecution, etc.).

Other Processes

Office payment

This process makes the payment easier for those transits that are in the Back Office System in the state "chargeable". It can be made in the Toll Plazas or in the Administration Building. The customer can pay unpaid debts or eventually Developer's TAGs.

The first step consists in choosing the chargeable invoices/documents depending on different filtering criteria: customer, tag number, etc. When the invoices/documents are identified the user will select the payment mean that the customer wants to use to pay: Cash, card, banking order, etc. Each invoice/document will change its state and will change to paid or partially paid. It will be possible to print a receipt.

Entities management

Besides lists, some parameters to be used by the Toll Collector System must be managed and sent by the Back Office System: fares, currency, taxes. Other parameters are firm; these must be added in both systems before the operation phase (means of payment, pass modes).

Blacklist, Greylist and Whitelist management

The lists that the system handles are

- Tags status list
- Issuers black/white list

These lists are generated by the issuers or the Developer and can be interchanged by the exchange agent.

The tag status list includes a catalogue of the tags that are not admitted for the payment of the transits, and those tags with a debt balance that is above an established limit

The issuers list includes the list of the accepted TAGs issuers for toll motorways.

The system must join, after proper validations, the blacklists from other agents in an unique status list that will be periodically sent to the front end. An historical, containing when the tag entered/exited the tag status will be kept. It must also be possible for the user of the system to include a new tag manually.

Fares management

The management entity module helps the query, register and modification of the fares

Registry of a new fare

It is possible to register fares in different fares priority levels. The system foresees a display where it is possible to register a new fare inserting the following data.

Name and description

Itinerary

Rate class

Price

Date of the put into effect of the fare

Fare expiring date

Week day

Time interval

Season

Modification of a fare

It is possible to modify the expiring date of a fare whenever that date is not before the day in which the change is made.

If a fare is in effect, to modify its value, it is necessary to change the expiring date to the present day and then to register a new fare with the new amount.

Fare termination

It is possible to terminate a fare changing its expiring date.

Any fare register, modification or termination will be sent to the front-end so it can be actualised in the lanes.

Bank and collecting centres maintenance

Certain consignment formats can be assigned to collecting centres, as well as the consignment periodicity, so the payments made with a specific tag can be sent to each collecting centre.

Parameters maintenance

The system will allow to maintain a series of operation, that make it flexible if there are changes in the commercial operative, like for example, batch processes activation/deactivation, periods and non-payment warnings, thresholds of frequent reclassification categories.

Trail data audit

All the tables of the system have three specific fields:

- Creation date and hour
- Modification date and hour
- User

So the system administrator can control the changes to data made by the users.

Furthermore, the system saves the user (and date/hour) which have made any critical process in a register: reclassification, risky payment, duplication, TAG sale, liquidation fill-up, liquidation audit...

Customer care web application

Approach of the activities to be performed

As indicated in the requirements, you will find below the ideas, methodology and products used in every aspect required for the web:

Contents analysis and structuring

Look&feel design

Style Book

Accessibility Review Level A

Design, structuring and assembly of web templates.

Designing is to define the structural, physiognomic and functional features included in the physical and psychological functions needed to materialize a product and to meet effectually and efficiently the function for which it was created.

For this reason, the **design, the usability and the accessibility** must go together, since they are really important for a project like this one.

Image architecture

Among the objectives that the graphical proposal must meet, Soluziona points out the following:

Use of graphic and interactive resources.

Use of a web communication code to present the web: on one hand, as dynamics, different from the rest, creating the greatest interaction with the user, and on the other hand, as a steady and descriptive web throughout its range.

Design of an attractive and appealing visual style easy-to-navigate.

Special attention to the home page, which should be eye-catching, intuitive and user-friendly.

Besides this, in order to obtain a visual personality, it will be important to pay special attention to the navigation architecture and to the use architecture, which are closely related to the portal image.

The proposal of Soluziona will be also tailored to the application requirements of the customers' trademark and the resulting on-line version.

Methodology

Soluziona considers that the creation of a Graphic Design Proposal that suits the needs established for the web of the SH-121 must result from a previous dialogue and a subsequent analysis of its requirements and needs.

Which will be the process to reach the final approach of the job? Soluziona proposes the following initiatives or tasks to reach an image architecture:

Benchmarking

"On-going analysis of the best products and practices of the market leading to an excellent development". This means to know and internalize the best of other portals and their improvements. What do the end users demand and which is the answer we are giving to them?

Product to deliver: PPT with examples of webs from the sector including the best practices in developing this type of webs. This product will be reviewed between Soluziona and the customer. Following to this review we will be able to draw conclusions to be integrated in the proposal.

Briefing

This document will include all the strategic and interesting points to be taken into account when preparing a Graphic Design Proposal.

The following questions should raise: "where?, why?, how?, how much?".

It is necessary to know in detail the web location, its subject matter, to whom it is addressed (audience), which profit do you expect to obtain and which image does the Developer wants to transmit.

Product to deliver: A Word document including the requirements and the approach the customer wants for the product. Both parties must approve this document in order to check its accuracy.

Creation of a Graphic Design Proposal

It consists in defining a "look and feel" for the new web that will be reflected in the design and creation of a Graphic Design Proposal.

In this proposal, the following aspects will be included:

Implementation of the navigation, different types of interaction, resources, and distribution of the information according to its importance.

Definition of styles and features of the different graphic elements to be used. It will serve as the basis for drawing up the templates that will carry the new graphic concept to every content composing the web.

This look & Feel will be reflected in the presentation of *two graphic design proposals* consisting of:

- A home page

- A first navigation level

- Definition of the main colours

- Definition of the typography

- Navigation Architecture

****** In order to go to the next stages, the final graphic design proposal must be approved. There will be a 4 days deadline to discuss the proposal and to close the final version.

Product to deliver: Jpgs images in digital form and in paper to discuss the proposals and to close the final one. A copy out of two proposals will be made.

Creation of the portal Layout.

It will be following the previous steps in order to:

- Guarantee a correct graphical resolution;

- Guarantee an easy templates development to carry the new image to every page composing the portal;

- Allow to maximize the flexibility to organize contents, and information providing their evolution;

- Guarantee the readability and understanding without using too many effects or technical possibilities, making good use of graphic resources;

- Place the user in the appropriate navigation route, informing him/her where he/she is at any time;

- Provide the minimum possible navigation and the maximum information, enabling a suitable navigation both to new users and to expert users;

- Display images and graphs with different optimised graphic resources to reduce its weight as much as possible;

- Compatibility of the graphic solutions with the contents management platform managing the information.

In accordance with the previous points, this will be the moment to develop both in design and in code the templates and developments necessary to achieve the project.

A document will be created with the different types of templates which layout will be done for the development team to use them appropriately and to complete the sections or pages belonging to the model.

Product to deliver: Definition of templates and static pages. Html layout of static pages and dynamic templates.

*** The design team will not be in charge of incorporating the contents to the dynamic templates.*

Style Book

Once the graphic line has been approved, a Style Book will be developed that will set out in a clear and concise way the steps to follow to generate online documents within the SH-121 Web Page. The objective is that of establishing a coherent application communication code that will serve as the basis for subsequent developments and will be a guide for all those taking part in the current project development.

This Style Book will have a table of contents similar to the following one:

Presentation of the Style Book

Guidelines

Usability Recommendations

Accessibility

Design guidelines

Site organization

Dimensioning

Range of web colours

Web Design

Home Page

Inside

Tools and their use

Typography

Links

Style Sheets

Image processing

Tables and forms processing

Product to deliver: Style Book in pdf format

Commercial functionality supported by web site

Part of the processes done by conventional users in the transactional back-office system could be done by customers using the website subsystem.

The functionality of this website is the following:

- Consult general motorway information as:

Motorway information

Motorway map

Estimated drive times

Fares

Discounts

Questionnaires

Links

News

Road conditions

Contact information

- Access to customer information
- Request of customer information changes
- Complaints
- Open an account
- Consult of statement information
- Request of transponders
- Recharge the account
- Violation payments
- Consult invoices

Reports Subsystem

New reports must be included in the Data Warehouse in the second implementation. Some of these report would be:

- Customers reports
- Service objects and contacts through customer service channels (call center, walk-in service, web)
- Claims
- Sold tags
- Recharged tags

- Financial statements
- Annual operational reports for TxDOT:
 - o Quantity of transponders distributed
 - o Transponder distribution quantities by location
 - o Customer contact quantities
 - o Customer contact types and distribution
 - o Customer complaints and resolutions
 - o Customer demographic data
 - o Transaction quantities
 - o Interoperable transaction quantities
 - o Debt collection activities
 - o Court case quantities and outcomes

Call-center system

Automatic Call Distributor (ACD/PBX):

Automatic Call Distributor (ACD/PBX):

ACD definition

ACD is a system that efficiently and equally distributes all incoming calls to employees or available agents or IVR ports. With an ACD system, incoming calls may be routed to the first available agent or alternatively, to one who is least busy belonging to a group of agents. In the case of routing a call to an agent who is least busy, the call is routed to a person who has been available for the most amount of time in comparison with other agents belonging to the same group, this way guaranteeing an equal distribution of work among agents.

Agents assigned to work within an ACD environment are assigned to handle calls of a specific nature. All agents belonging to the group work on the same type of calls. Each group have their associated primary lines, their phone sets, recordings and call queues. Different options may be activated on the ACD with the objective to satisfy the requirements of each agent group.

ACD functionality

Calls are routed to an agent or IVR port who is most qualified to handle it. It is necessary to define a system of agent groups, each having their specific skill sets to attend calls.

Management of call queues according to a system of priorities. Depending on the type of the call, the system will associate it to a corresponding queue. The system associates a priority to each call, this way establishing a system to attend first those calls that are classified of the highest priority.

Delivery of messages in the queues. Identify the purpose of the call (identify the service which it is accessing), and associate a corresponding message.

Multiple types of music played during specific points during the call.

Strategy: It is necessary to establish a strategy in the treatment of calls:

- Prioritization of calls that have spent most time in the call queue

- Prioritization of calls classified as very important.

Based on the information received for the implementation of a Contact Center System for the Developer, the following scales will be used:

Contact Center IP with 25 agents inbound and 5 agents outbound

Attending the demand, Soluziona proposes the implementation of the Central System of Nortel (CS1000S) IP for the Contact Center.

Reach

The proposal of Soluziona to implement the Contact Center system will be detailed in this document. The final size of the Contact Center in this economic proposal is determined as follows:

- Contact Center IP

- 20 agents inbound

- 5 agents inbound/outbound

- 25 IP Softphone 2050 with USB audio kit

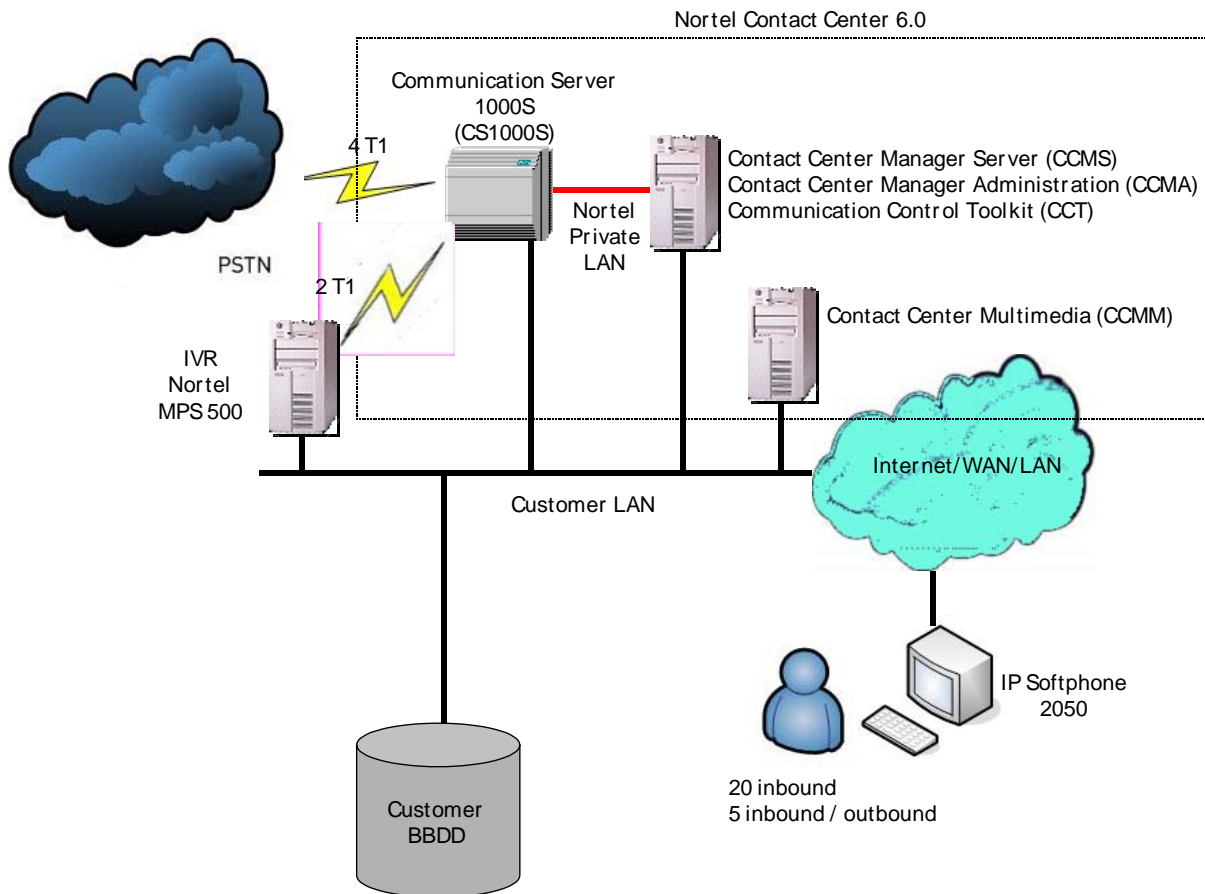
- 4 primaries (T1) for the PBX with a total of 96 channels for 96 simultaneous calls in the Contact Center (agents+Automatic services).

- 2 primaries (T1) for the IVR connected to the ACD system with a total of 48 channels for 48 simultaneous calls delivered to automatic services.

- 64 conversion ports TDM to IP

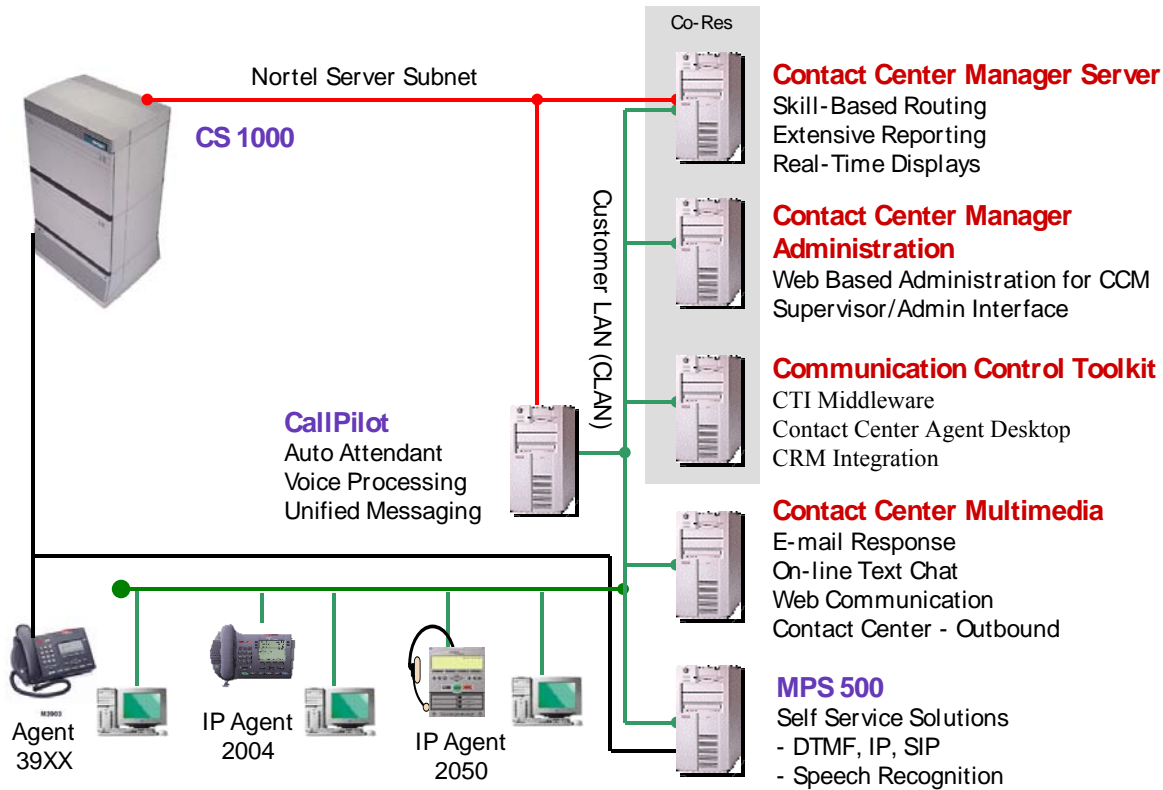
Description

The architecture is shown in the next scheme, referring only to the infrastructure of the telephone, to give support to all the requirements. This scheme represents the Contact Center IP.



Continuously the functional architecture is represented of the different components that holds the Nortel Contact Center 6.0 suite of products.

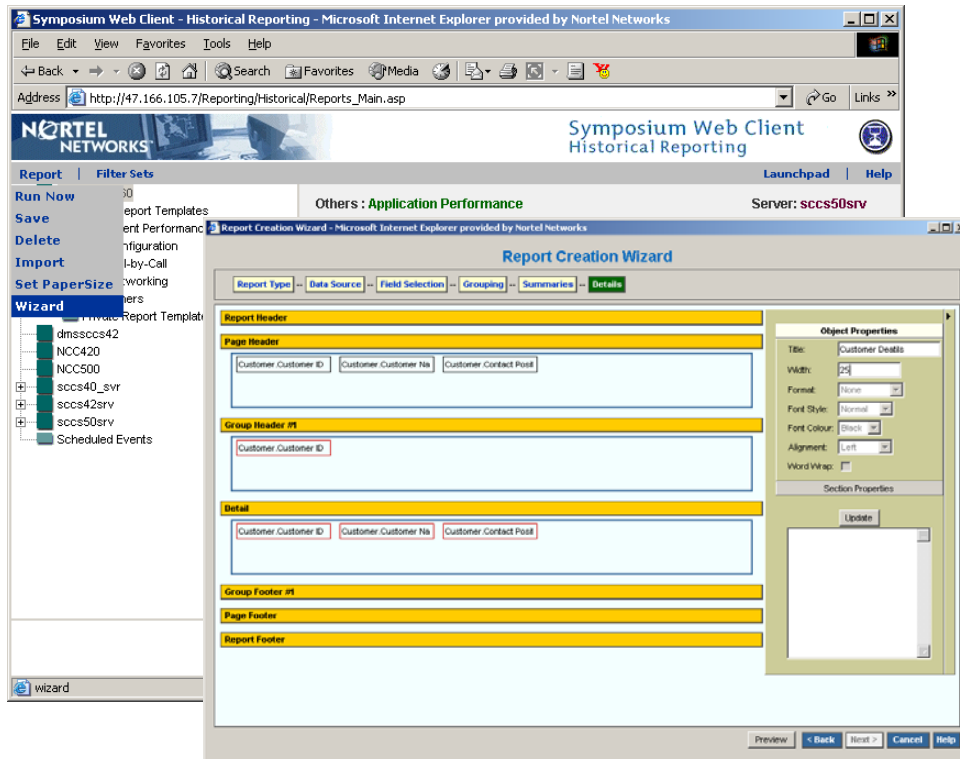
In the next scheme the components of the Contact Center of Nortel products suite is represented:



CCMS 6.0 for reporting (historical data) and real time, as well as the distribution of the calls by skill. It includes the tool of creation of reports based on a Wizard, as predefined reports which can be accessed by a navigator (web based tools).

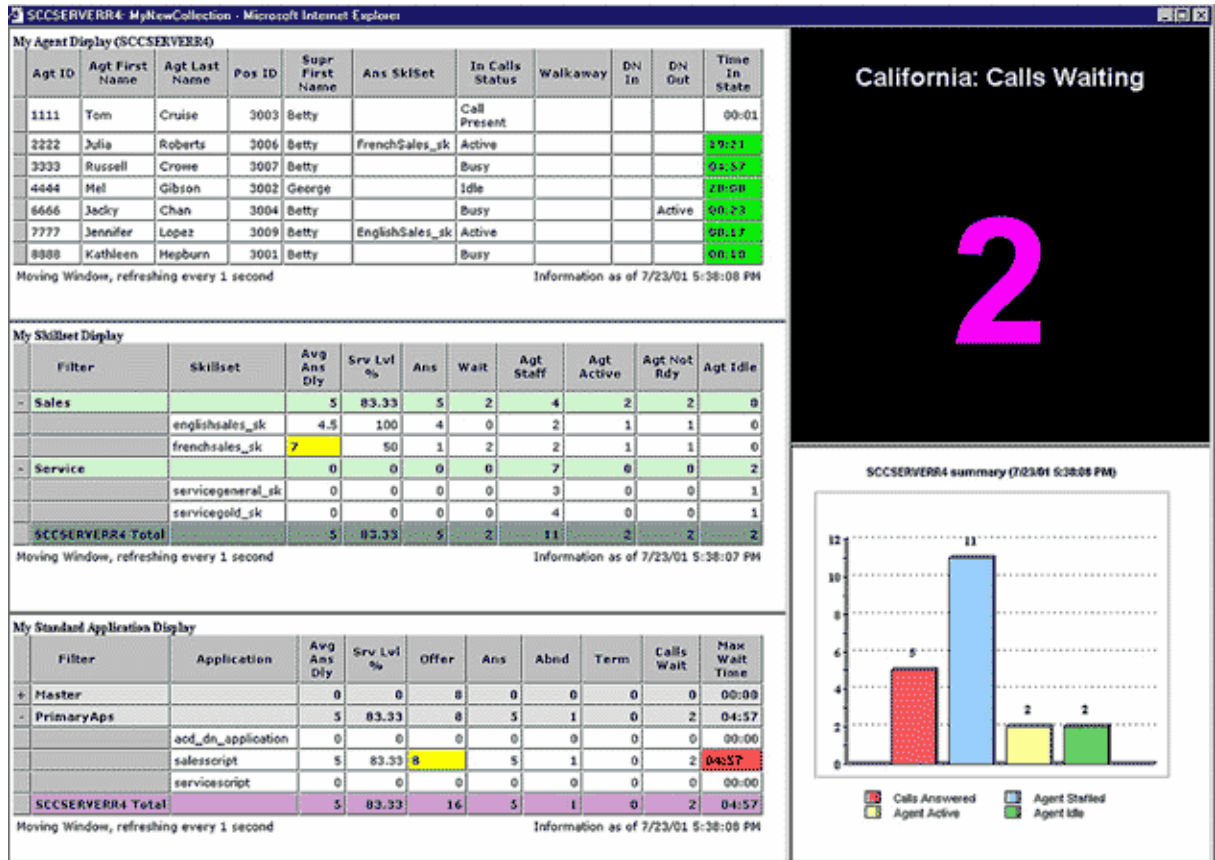


The tool to create reports holds an intuitive and easy-to-use interface that permits the user to defines reports integrated with the Contact Center activity, including inbound, outbound and multimedia (e-mail, chat, web collaboration) activities.

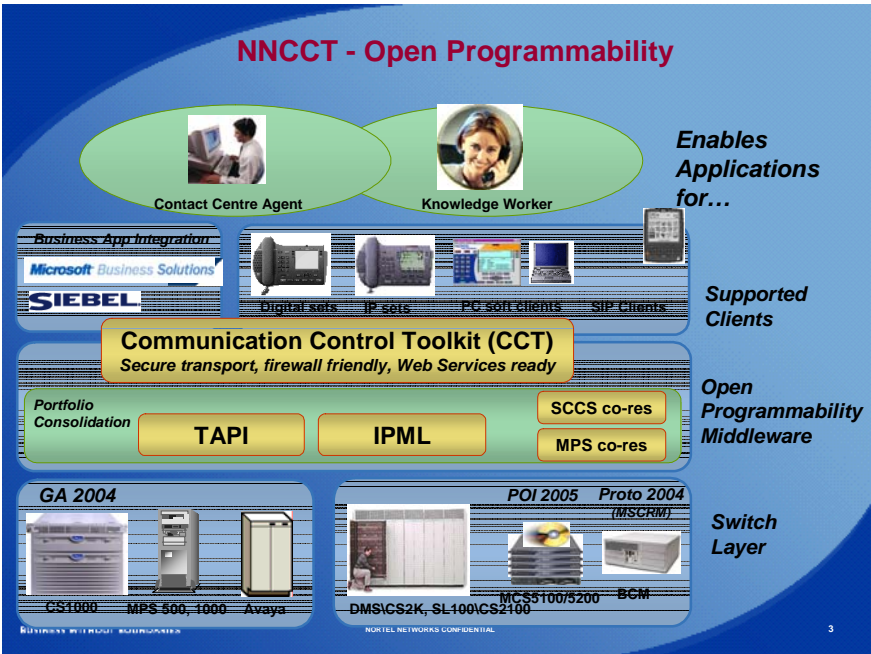


CCMA 6.0 web tool for the CCMS administration for administrators and supervisors of the centralized Contact Center.

Allows the supervisors to control and check the activity of the Contact Center in real-time in an intuitive and easy-to-use way.



CCT 6.0 to allow CTI integration with external applications.
Middleware CTI based on TAPI that allows the CTI integration of CRM systems, or any external application desired. It Includes compatibility with Microsoft TAPI 2.1 y 3.0, as well as integration with Microsoft .net.

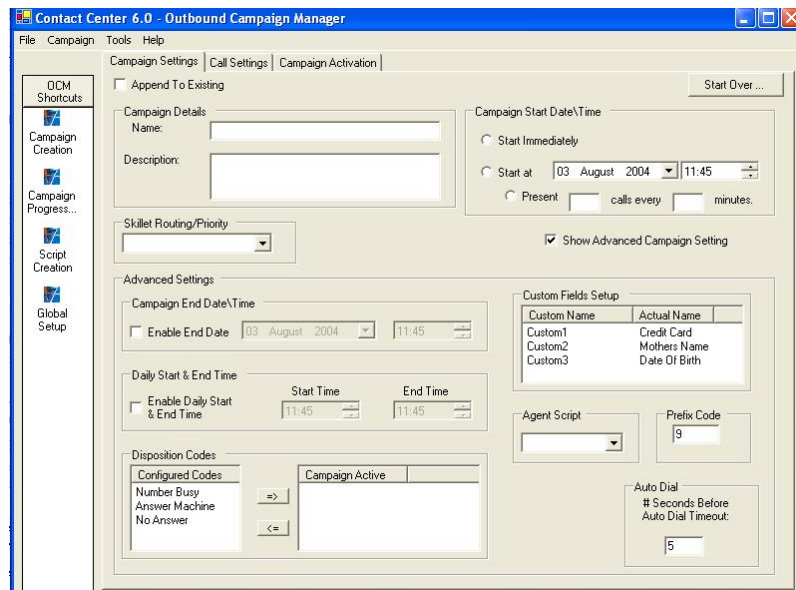


CCMM 6.0 for outbound management of the Contact Center, as well as the multimedia management (e-mail, chat and collaboration web) supplying an universal queue for the distribution of contacts based on the skills of the agents.

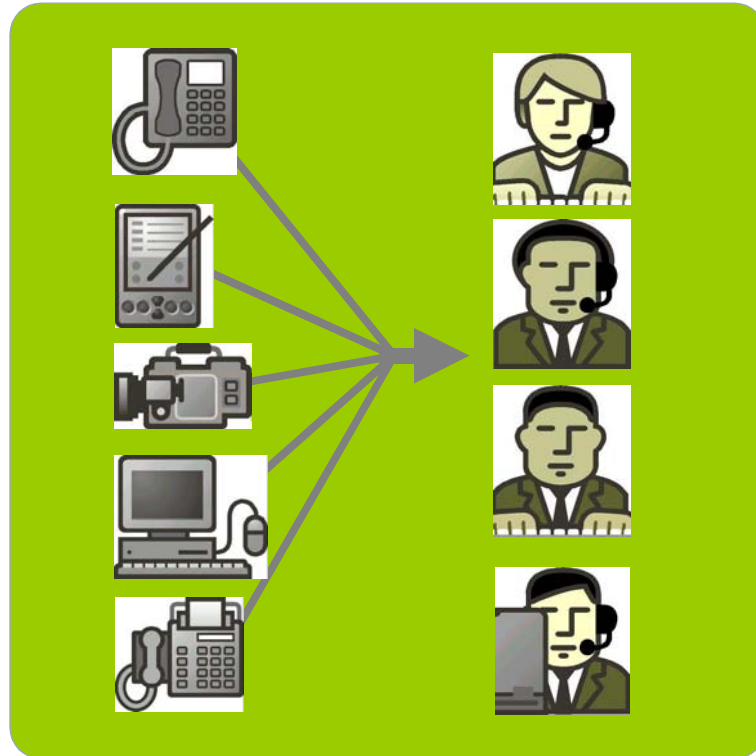
The outbound management, incorporates previsualized and progressive dialing and integrates all the administration and management of campaigns and scripts.

The outbound administration tool (Campaign Manager) allows:

- Campaign Creation
- To import contact data through the ODBC and plain text files
- Revision and modification of associated data of the calls and the scripts of the campaign
- To monitorize the progress of the outbound campaigns, allowing pause, restart and cancellation of these
- To implement the legal requirements of "not call" to certain contacts
- Complete Blending (universal agents inbound/outbound), not only of the telephone canal, as well as the multimedia channels (e-mail, chat and collaboration web)
- Automatic re-plannification and a manual of contacts



It also includes the contact management multimedia (e-mail, chat and collaboration web) managing the blending between canals through an universal queue with a routing based on the skills of the agents.



- Call Pilot for an unified message management (voice, fax and electronic mail) and supplying a self-service functionality with a reduced functionality (by DTMF tones).
- MPS 500: The advanced self service system of IVR (Interactive Voice Response) advanced incorporates management of complex services and advanced technology of voice, like ASR (voice recognition) and TTS (text to voice conversion). In a natural way it is integrated with the Nortel Contact Center suite.
- Contact Center Agent Desktop: Integrated agent tool for inbound, outbound and channels (telephone, e-mail, chat and web collaboration) with integrated menu and contextual representation in function of the type of contact and channel.
- It supports Citrix as well as advanced security systems (SSL, firewall), to be able to supply Web Services for integration.

Contact Details

File Action Help

Save Print Help Close
Script/Questions Disposition Code

Name: John Smith Skillset: MM_Sales

Contact view | Customer details | Customer history

Last Response

- 1st Response
- Initial Contact

Contact

Contact ID: **57**

Owner: Super Agent

Last Response

Details

From: Customer Care

To: sales@pc.com

Cc: orders@pc.com

Subject: Re: Account Query

Sent: 24/05/2003

Can you please help me with this problem I have on your web site? I have already sent an email to your help desk an hour ago. What I really want, is to setup a new account so I can purchase your goods online more easily. Thanks J.Smith

Agent notes on this contact.

Introduction

Hello Sir / Madam. My name is [your_name] and I'm calling from "Auto Reviews Ltd.". We want to know what your car is like to live with, and what the dealers are like - as long as your car is no older than 2000 and no newer than 2002/3. For taking part in the survey you could win free fuel for a year, worth up to £1500! There's no catch - just a few moments and you'll automatically go into the draw.

Car manufacturer?

Car model

Year?

Would you buy from the same manufacturer again? ☐ Yes ☐ No

Where do you get the car serviced?

Miles per year?

Any problems with the following?

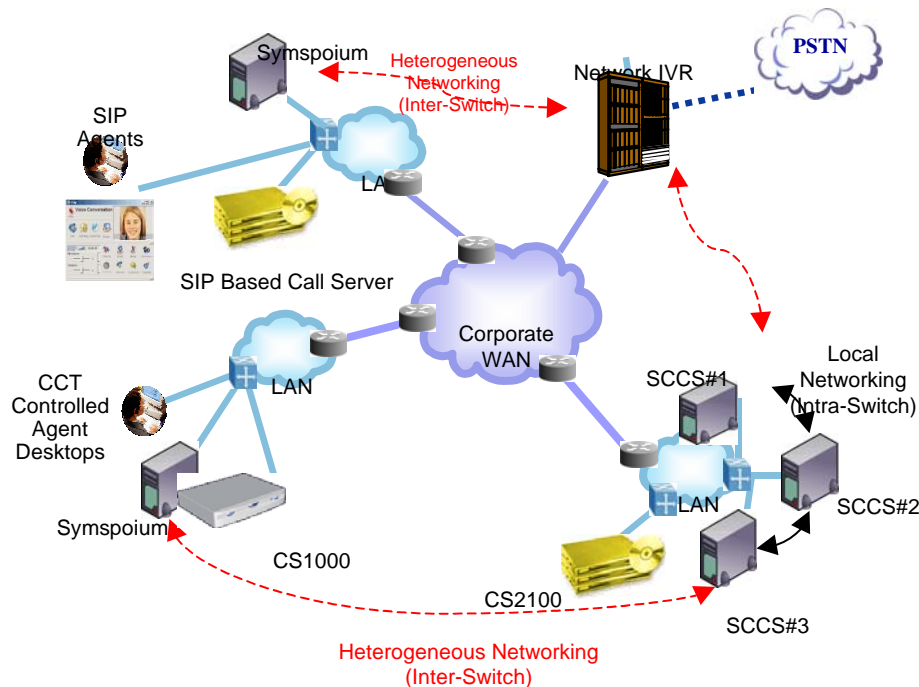
☐ Bodywork
☐ Engine
☐ GearBox

Call Notes:

Conclusion

Thank you Sir/Madam, We will be in touch by the end of the month to inform you if you have won....

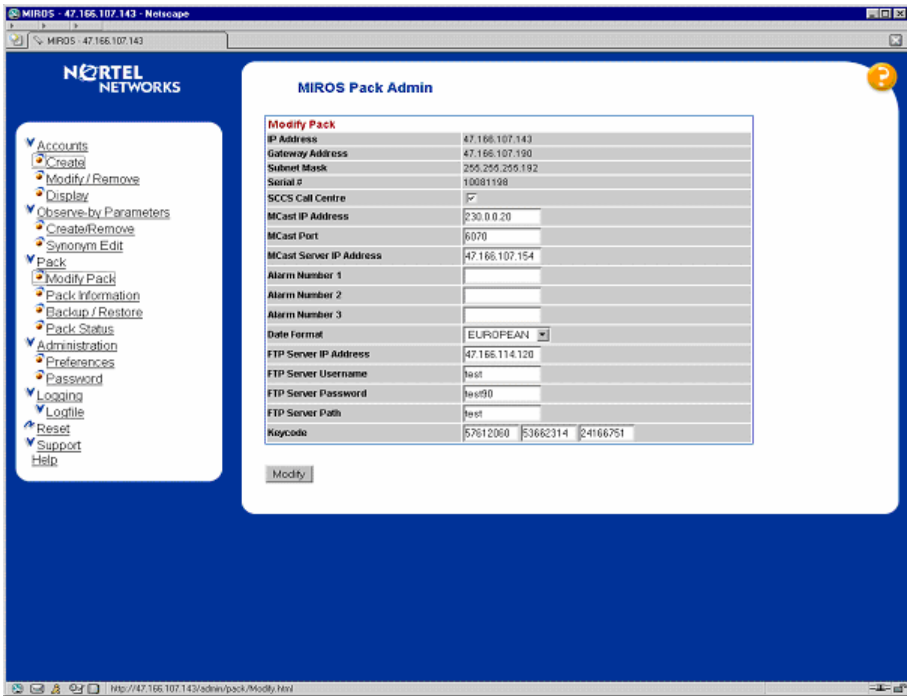
- Virtual Contact Center: the Nortel Contact Center service supplies in a natural way the integration and the management of multiple Contact Centers as it were only one. In this way it allows the distribution and balancing of contacts between various Contact Center, as well as the voice and data transfer between the different centers.



Besides, it allows geographical redundancy with an automatic reply of the database between the active center and the standby center.

Remote Agent Observe: permits to listen to the agents from every workplace allowing to control the persons who are outsourced by the Contact Center.

It provides a web administration system in which options of the supervisor can be defined like: name, password, recording options, monitoring in silence (only listening), monitoring not in silence (listening and talking).



It also permits the recording of stored calls and download them from an external FTP server, as well as reporting of the controlled calls.

MIROS - 47.166.107.136 - Microsoft Internet Explorer

Address: http://47.166.107.136

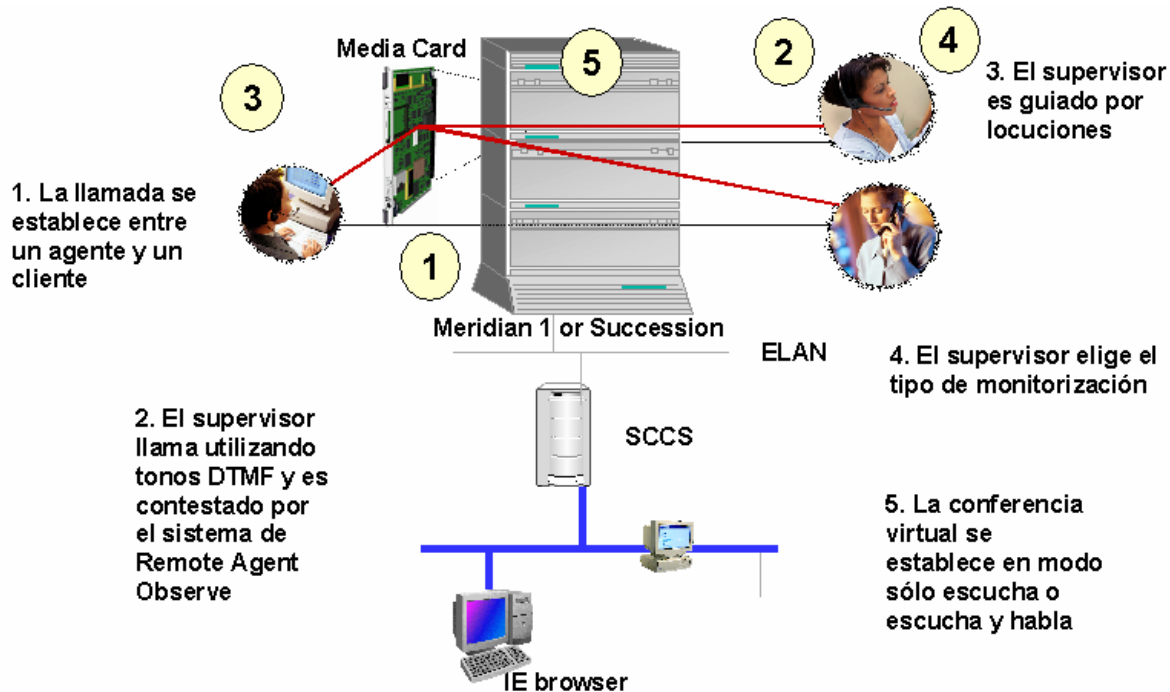
Observer Activity Details

***** MIROS Reporting Date: 12/08/03 *****

Ch	Time	Event	Observer	Duration	Message
00	14:55:27	Login	Shane_Hannon		User ID: 0.
00	14:56:13	Logout	Shane_Hannon		User ID: 0.
00	14:57:07	Login	Shane_Hannon		User ID: 0.
00	14:57:56	Observe	Shane_Hannon	23	AgentID: 1000 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. SkillsetID: 100008 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	14:58:53	Observe	Shane_Hannon	12	User ID: 0.
00	14:59:56	Logout	Shane_Hannon		User ID: 0.
00	14:59:16	Login	Shane_Hannon		User ID: 0.
00	14:59:25	Logout	Shane_Hannon		User ID: 0.
00	15:11:16	Login	Shane_Hannon		User ID: 0.
00	15:13:13	Observe	Shane_Hannon	30	SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:13:57	Observe	Shane_Hannon	30	SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:14:39	Observe	Shane_Hannon	29	SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:15:33	Observe	Shane_Hannon	29	SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:16:11	Observe	Shane_Hannon	29	SkillsetID: 0 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. AgentID: 1007 (OPN 2019). Call Not Recorded.
00	15:16:49	Observe	Shane_Hannon	29	AgentID: 1007 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. AgentID: 1007 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:17:47	Observe	Shane_Hannon	28	AgentID: 1007 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. AgentID: 1007 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:18:47	Observe	Shane_Hannon	29	AgentID: 1000 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'. AgentID: 1000 (OPN 2019). Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.
00	15:20:20	Observe	Shane_Hannon	31	Call Recording File: '00000000_12-08-2003_1'. Call Recording Location: 'record'.

Security is guaranteed by validation of the user and its password. Three following mistakes in the validation produce the blocking out of the user.

The following scheme represents the flow of a call in which a supervisor realizes a "remote agent observe"



Nortel Agent Greeting: this system permits each agent to pre-record one or various welcome messages that will be reproduced to the callers when the agent replies to the incoming calls.

Reach in detail

Each one of the components that forms a part of the complete solution selected will be detailed:

Contact Center IP

The system is constructed by the following Nortel components:

- Communication Server 1000S as the principal chassis with a signpost server for IP
- 2 dual primary card T1 = 96 simultaneous calls
- 1 dual primary card T1 to connect to the IVR system
- 2 Voice Media Cards with 32 DSP for the transfer TDM to IP
- MIRAN (card for announcements)
- 20 agent licenses of Contact Center 6.0 inbound
- 5 agent licenses Contact Center 6.0 inbound/outbound
- 48 IVR ports connection licenses
- CCT 6.0 to allow the integration CTI with external applications .
- CCMS 6.0 for the reporting (historical) and real time, as well as the distribution of the calls based on the skills.
- CCMA 6.0 web tool of administration of the CCMS for administrators and supervisors of the Contact Center.
- CCMM 6.0 for outbound management.
- Installation services, configuration and training of the central in the CPD of the client is included.
- Cables and Professional Services to implement the new system is not included, nor any work that does not have any relation with the platform, like airconditioning installations for the CPD for example.

Terminals

The following IP terminals are included

- 25 IP softphones 2050 with audio kit for USB: telephone software for the agents so that they only should be working with a terminal, the PC.



- The minimum requirements of the PC are as follows:
- Operating System: Windows XP, 2000 Professional, 98 y 98 SE
- Pentium Processor 200 MHz
- 128 MB RAM (for Windows 2000 or higher) and 64 MB RAM (for Windows 98)
- 55 MB free space on the Hard Disk (for all the languages)
- Video: 16 bit high-color with minimum resolution 800x600
- Ethernet network connection
- One free USB (powered) gate for the connection of the audio kit

Center Activity Management System:

These are systems that provide mechanisms for the center to visualize and efficiently control the activities of the ACD and their associated agent groups.

The ACD collects information on the status of agent groups, extensions, vectors, queued calls, agent status, etc..in real time.

These systems often come packaged with a database that permits the storage of information for periods of a few months to a few years depending on the detail of information required for storage and the capacity of the database itself.

Availability of standard as well as custom built reports. Both standard as well as custom built reports may be of two types: Reports that are generated in real time providing information that is occurring in real time and historical reports using data that was previously stored in order to fill some management necessity.

Interactive Voice Response Systems (IVR):

IVR definition

Systems that permit the automated management of large numbers of queries that a real agent would not add value to if he/she were to handle them himself. It could work as an alternative system that handles queries from clients during periods when agents are not working effectively extending this capability to offering services 24 hours a day, 7 days a week. These costs of such a system are recovered relatively quickly especially when compared to the cost of human resources who otherwise would be taking care of these calls. These systems are often used to complement services provided by human agents.

How does an IVR work?

Calls arrive to an IVR through the phone network or through an ACD. The system requests that the client selects an option from the menu at which the client introduces his personal identification number either using the phone pad or directly speaking to the system. The system captures the selected service as well the identification number and sets about validating and retrieving the requested information from its databases and finally providing the client the information requested. When a specific service cannot be fulfilled for one reason or the other, it is possible to transfer the call to an available agent in the center.

Integration between Phone and Information Systems (CTI)

CTI definition

Integration between phone and information systems (CTI, Computer Telephony Integration) by which, information associated to the contact and available in the phone / communication system (information such as caller number, dialled number, information retrieved during the call) is available to the information systems so that the call may be managed in a unified manner taking into account complete client data (both phone as well as IT data).

Typical CTI functionalities:

- Identification of Client Data through associated information of the call (ANI – Caller Number, DNIS – Dialed Number) so that the agent simultaneously receives the call as well as a window of the corresponding application popping up displaying client data (screen pop – up).
- Simultaneous Transfer of Voice and Data among agents that avoids requiring clients having to repeat information they previously gave to another agent.

- Access to telephone functionalities directly from the computer screen (telephone software) such as: dial, place on hold, disconnect, login – logout, etc..
- An improvement in ACD routing algorithms that permit the routing of calls according to client data such as profile, language, preferred treatment, client value, etc..(Call Routing).
- Monitoring of Phone Conversations with the objective to train or maintain quality levels.
- Inbound and Outbound activity balancing depending on demand, through the assignment of a mixture of inbound and outbound calls for agents (Call Blending).
- Integration with several contact centres (physically or geographically dispersed) so that they act as a single call centre (Virtual Call Center).
- Integrated statistics (including business data) in real time or historical data tracking of the evolution of all the components making up the contact center.

Commercial Transactional System functionality supported in the call center

Part of the transactional system functionality above mentioned must be fulfilled in the call-center. These processes are:

- Information request
- Claims
- Registry or change customer data
- Associate means of payment to customer
- Request bills
- Bills duplication
- TAG request
- Collection at the office (if the customer sends by fax or e-mail the bank receipt)

HARDWARE AND LICENSES FOR THE FIRST IMPLEMENTATION

Hardware and software components for the proposed technical architecture have been carefully chosen according to Soluziona's experience and knowledge with this type of systems. All the components have been tested separately and together to reach the highest quality and performance standards.

Nevertheless, **the proposed equipment has been chosen according to the current state-of-the-art technology available on the market.** This means that **it is very possible that in the moment of the technical solution deployment, the real hardware and software equipment deployed could not be the same than the proposed one,** since the technology available on the market could have changed dramatically. Likewise, **the economic estimation for the proposed equipment could present large deviations,** for the same reason.

The architecture has been designed according to the technical requirements of performance and availability expressed by TxDOT's documents. Servers and storage performance is suitable to run the system within the specified operational parameters, and redundancy and replication issues of the technical architecture has been designed in order to fulfil Disaster Recovery requirements. From now on, the entire solution will be discussed in detail according to these requirements.

Proposed configuration

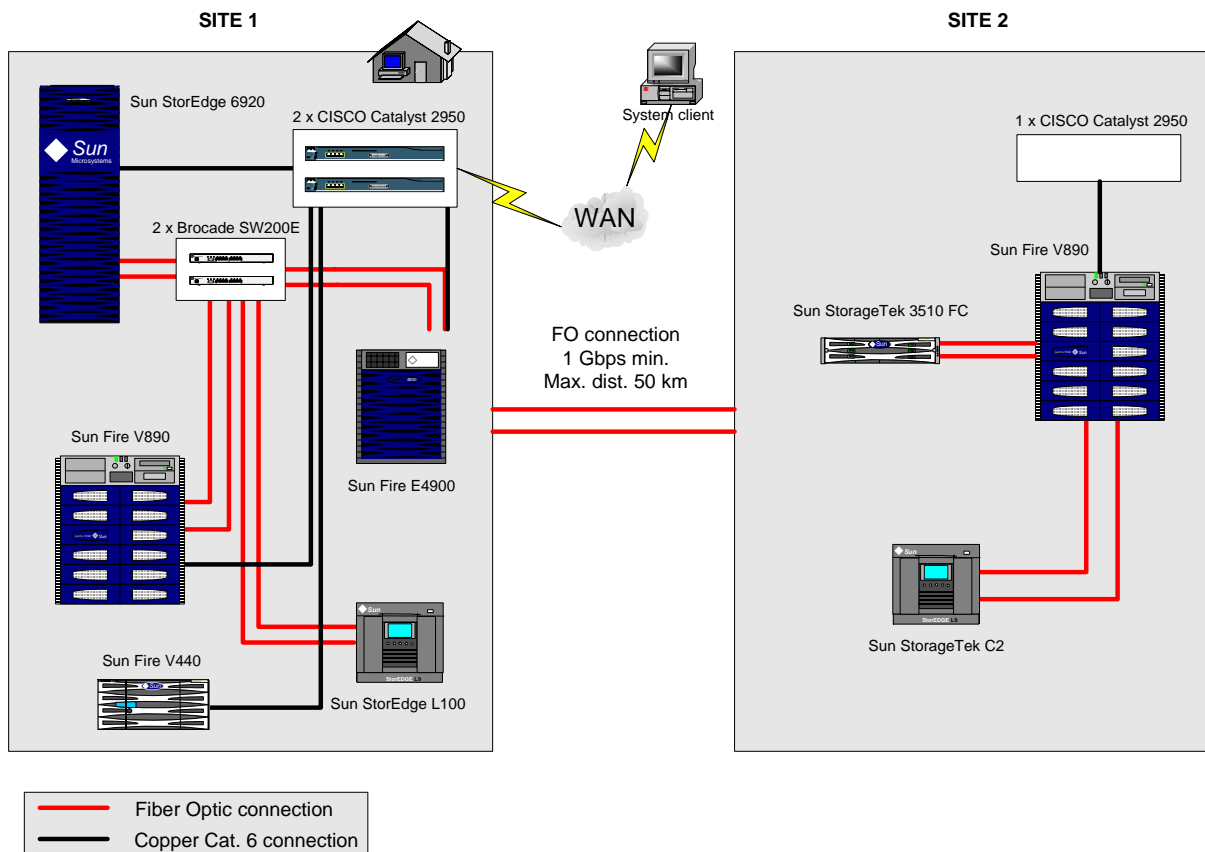
This proposed scenario considers a main site configuration and a second site with a very reduced hardware configuration, with an asynchronous copy of the production data. In case of a disaster occurrence in the main site, it will be possible to change manually the network configuration to allow clients to access this backup site.

Obviously, during this backup site operation time, the performance of the system will be heavily declined, but we have to keep in mind that this backup site is only running while the main site is reconstructed. Production data are backed up on both sites, because we cannot know *a priori* how much time is going to be up and running this backup site, and we must keep always an up to date copy of the production data.

This scenario provides full control of the disaster recovery situation to the system owner, but it is important to accept the performance deterioration inherent to this scenario.

Technical architecture diagram

For this system configuration, the proposed technical architecture could be the following:



As follows, the hardware needed for this proposed configuration is detailed:

Hardware

Physically, the equipment included in the present architecture will have the following hardware:

- 1 x Sun Fire E4900, with the following technical specifications, to run the main database and the main application server, including those images that are newest than 90 days:
 - o 8 UltraSPARC IV+ 1.35 GHz processors
 - o 32 Gb of RAM
 - o 2 internal 146 Gb HDDs
 - o FO connection to the SAN through two separated HBAs.
- 1 x Sun Fire V890, with the following technical specifications, to run the database and application that will store the images older than 90 days:
 - o 4 UltraSPARC IV+ 1.35 GHz processors
 - o 16 Gb of RAM
 - o 6 internal 146 Gb HDDs

- FO connection to the SAN through two separated HBAs.
- 1 x Sun Fire V890, for the second site with the following technical specifications:
 - 8 UltraSPARC IV+ 1.5 GHz processors
 - 64 Gb of RAM
 - 10 internal 146 Gb HDDs
 - FO connection to the SE3510 FC disk array through two dual HBAs.
- 1 x Sun StorageTek 6920 disk system. with 4 Tb of raw space. This array will be part of an SAN by means of two Brocade SW200E Fiber Channel switches. This equipment will be connected to the servers aforementioned.
- 1 x Sun Storage Tek 3510 FC with 12x300 Gb, for the second site
- 1 x Sun Fire V440 with the following technical specifications, to run the backup solution:
 - 2 UltraSPARC IIIi 1.593 GHz processors
 - 4 Gb of RAM
 - 4 internal 73 Gb HDDs
- 1 x Sun StorageTek C4, as backup tape library, with two LTO 3 SCSI drives, connected to the SAN through two separated HBAs.
- 1 x Sun StorageTek C2, as backup tape library for the second site.
- 1 x Sun Ultra 25 Workstation, to act as clusters console.
- 4 x CISCO Catalyst 2950SX with 24 Ethernet ports.

Software

- Oracle database and Oracle partitioning
- Data Protector
- Sun Java System Application Server Enterprise Edition 8.1
- Business Objects XI
- OCR software

The detailed description of the proposed hardware and software licenses is included as follows.

Main site production Servers

Sun Fire E4900

The Sun Fire E4900 server with the new UltraSPARC IV+ processors provides exceptional computing power and high reliability. Combine up to twelve 1.5 GHz UltraSPARC IV+ with 24 threads and memory capacity up to 96GB of memory per domain.

Sun Fire E4900 main features are:

- Increased performance: Sun's new UltraSPARC IV+ 64-bit Chip Multithreading (CMT) processor has significantly enhanced cores, 2-MB on-chip L2 cache, and a new 32-MB L3 cache using the latest 90nm process technology. It delivers up to 5 times higher performance than UltraSPARC III servers, and nearly double performance increase over previous generation UltraSPARC IV servers in the same footprint. The UltraSPARC IV+ system supports in-chassis upgrades for previous generation Sun Fire E2900 and V1280 servers, with no increase in power and cooling requirements.
- Exceptional scalability: The enhanced Sun Fire E4900 server continues Sun's tradition of reducing risk and enabling comfortably scale compute capacity. Member of the industry's most scalable server line from 1 to 144 threads it scales up to 12 processors, executing up to 24 simultaneous compute threads, and supports up to 96 GB of memory to provide maximum headroom for data-intensive applications.
- Preventive measures: The robust capabilities built into the various levels of the system, such as Predictive Self-Healing keep the system up and running. Automated diagnosis and recovery reduces need for human intervention. Error messages that are actionable and identify a clear cause can help eliminate delays in reacting to errors and can help minimize incorrect diagnoses. With better information about the dependencies throughout the software stack, systems can automatically recover services in the event of a fault.
- Dynamic Tracing: DTrace allows real time data collection and analysis of production systems, enabling customers to optimize application performance up to 300 percent.
- RAS Ready: RAS features include hot-pluggable disk drives; full hardware redundancy including redundant, hot-swappable power supplies; environmental monitoring and fault detection; Automatic System Recovery (ASR); automatic failover capability; and error correction and parity checking for improved data integrity.

The specifications for the unit included on this proposal are:

General

- Eight 1.5 GHz UltraSPARC IV+ processors
- Architecture Superscalar SPARC V9, ECC protected
- Cache per UltraSPARC IV+ processor
 - o Level 1: 64 KB data and 64 KB instruction per pipeline
 - o Level 2: 2 MB on-chip
 - o Level 3: 32 MB external
- 32 Gb DDRAM main memory
- Two 146 Gb 10k rpm Ultra3-SCSI internal hard disk drives.
- 2 integrated Gigabit Ethernet ports (66 MHz)
- 1 integrated Ultra3-SCSI port (66 MHz); 6 open 7 inch PCI slots (32/64 bit, one 66 MHz and five 33 MHz)
- System interconnect: 9.6-GB/sec. Sun Fireplane interconnect. System bus with redundant data, address and response crossbar interconnect.

- System bandwidth: 9.6-GB/sec. sustained bandwidth, 31.2-GB/sec. aggregate bandwidth.
- System controller: two per system.
- Redundant cooling fan trays

Environmental

- AC power: 200–240 VAC (47–63 Hz), 16 Amp. Three power cords.
- Operating: 5° C to 35° C (41° F to 95° F) 20% to 80% relative humidity, noncondensing.
- Nonoperating: -20° C to 60° C (-4° F to 140° F) 5% to 93% relative humidity, noncondensing.

Physical

- Height: 76.2 cm (30.0 in.)
- Width: 44.6 cm (17.6 in.).
- Depth: 72.4 cm (28.5 in.).
- Weight: 131.1 kg (289.0 lb.).

Sun Fire V890

The Sun Fire V890 server, powered by the new UltraSPARC IV+ processor and Solaris OS, provides enterprise-class features in a powerful, affordable platform. This server delivers up to 5 times the performance of UltraSPARC III servers, and nearly double the performance of UltraSPARC IV servers within the same footprint without additional power/cooling requirements. With up to eight UltraSPARC IV+ Chip Multithreading (CMT) processors executing 16 concurrent threads, up to 64 GB of memory, and nearly two terabytes of internal storage, the Sun Fire V890 server delivers extensive compute capacity with enterprise class throughput at a low-cost server price.

Sun Fire V890 main features are:

- Increased performance. Sun's new UltraSPARC IV+ 64-bit Chip Multithreading (CMT) processor has significantly enhanced cores, 2-MB on-chip L2 cache, and a new 32-MB L3 cache using the latest 90nm process technology. It delivers up to 5 times higher performance than UltraSPARC III servers, and nearly double performance increase over previous generation UltraSPARC IV servers in the same footprint.
- Dynamic Tracing. DTrace allows real time data collection and analysis of production systems, enabling customers to optimize application performance up to 300 percent.
- Preventive measures promote availability. The robust capabilities built into the various levels of the system, such as Predictive Self-Healing, keep the systems up and running. Automated diagnosis and recovery reduces need for human intervention. Error messages that are actionable and identify a clear cause can help eliminate delays in reacting to errors and can help minimize incorrect diagnoses.
- RAS-ready. RAS features include hot-pluggable disk drives; redundant, hot-swappable power supplies; environmental monitoring and fault detection; Automatic System Recovery (ASR); automatic failover capability; and error correction and parity checking for improved data integrity.

The specifications for the unit included on this proposal are:

General

- Four 1.35 GHz UltraSPARC IV+ processors
- Architecture Superscalar SPARC V9, ECC protected
- Cache per UltraSPARC IV+ processor

- Level 1: 64-KB data and 64-KB instruction per pipeline
- Level 2: 2 MB on-chip
- Level 3: 32 MB external
- 32 Gb DDRAM main memory
- Two 146 Gb 10k rpm FC-AL internal hard disk drives, FC-AL disk controller
- 1-Gb Ethernet and 10/100Base-T Ethernet
- Two EIA-232D or EIA-423 serial ports (DB25) via splitter cable
- Nine full-sized, hot-plug PCI slots compliant with PCI specification Revision 2.1 (2 @ 66 MHz, 64 bits wide, 3.3 volts; 7 @ 33 MHz, 64 bits wide, 5 volts)
- Two USB ports (compliant with USB Revision 1.0)
- Three redundant power supplies
- Redundant cooling fan trays

Electrical

- AC power 200-240 VAC, 47-63 Hz, 2078 VA
- Maximum AC input: 3200 W
- Maximum DC output: 2509 W

Physical

- Height 714 mm (28.1 in.) with casters
- Width 480 mm (18.9 in.)
- Depth 836 mm (32.9 in.)
- Weight 88.1 kg (194.0 lb.) (min.), 130.9 kg (288.0 lb.) (fully configured)

Key RAS Features

- Hot-pluggable disk drives and PCI cards
- N+1 power supply redundancy
- Hot-swappable power supplies
- Redundant, hot-swappable fan trays
- Environmental monitoring and fault protection
- Automatic System Recovery (ASR)
- Remote Lights Out Management capability
- Support for disk and network multipathing with automatic failover capability
- Dual-loop enabled FC-AL mass storage system
- Error correction and parity checking for improved data integrity

Second site production server

One **Sun Fire V890** server with 8 1.8 GHz USIV+ ways, 64 Gb RAM and 10 internal 146 Gb HDDs. The Sun Fire V890 server, powered by the new UltraSPARC IV+ processor and Solaris OS, provides enterprise-class features in a powerful, affordable platform. This server delivers up to 5 times the performance of UltraSPARC III servers, and nearly double the performance of UltraSPARC IV servers within the same footprint without additional

power/cooling requirements. With up to eight UltraSPARC IV+ Chip Multithreading (CMT) processors executing 16 concurrent threads, up to 64 GB of memory, and nearly two terabytes of internal storage, the Sun Fire V890 server delivers extensive compute capacity with enterprise class throughput at a low-cost server price.

Sun Fire V890 main features are:

- Increased performance. Sun's new UltraSPARC IV+ 64-bit Chip Multithreading (CMT) processor has significantly enhanced cores, 2-MB on-chip L2 cache, and a new 32-MB L3 cache using the latest 90nm process technology. It delivers up to 5 times higher performance than UltraSPARC III servers, and nearly double performance increase over previous generation UltraSPARC IV servers in the same footprint.
- Dynamic Tracing. DTrace allows real time data collection and analysis of production systems, enabling customers to optimize application performance up to 300 percent.
- Preventive measures promote availability. The robust capabilities built into the various levels of the system, such as Predictive Self-Healing, keep the systems up and running. Automated diagnosis and recovery reduces need for human intervention. Error messages that are actionable and identify a clear cause can help eliminate delays in reacting to errors and can help minimize incorrect diagnoses.
- RAS-ready. RAS features include hot-pluggable disk drives; redundant, hot-swappable power supplies; environmental monitoring and fault detection; Automatic System Recovery (ASR); automatic failover capability; and error correction and parity checking for improved data integrity.

The specifications for the unit included on this proposal are:

General

- Eight 1.8 GHz UltraSPARC IV+ processors
- Architecture Superscalar SPARC V9, ECC protected
- Cache per UltraSPARC IV+ processor
 - o Level 1: 64-KB data and 64-KB instruction per pipeline
 - o Level 2: 2 MB on-chip
 - o Level 3: 32 MB external
- 64 Gb DDRAM main memory
- Ten 146 Gb 10k rpm FC-AL internal hard disk drives, FC-AL disk controller
- 1-Gb Ethernet and 10/100Base-T Ethernet
- Two EIA-232D or EIA-423 serial ports (DB25) via splitter cable
- Nine full-sized, hot-plug PCI slots compliant with PCI specification Revision 2.1 (2 @ 66 MHz, 64 bits wide, 3.3 volts; 7 @ 33 MHz, 64 bits wide, 5 volts)
- Two USB ports (compliant with USB Revision 1.0)
- Three redundant power supplies
- Redundant cooling fan trays

Electrical

- AC power 200-240 VAC, 47-63 Hz, 2078 VA
- Maximum AC input: 3200 W
- Maximum DC output: 2509 W

Physical

- Height 714 mm (28.1 in.) with casters

- Width 480 mm (18.9 in.)
- Depth 836 mm (32.9 in.)
- Weight 88.1 kg (194.0 lb.) (min.), 130.9 kg (288.0 lb.) (fully configured)

Key RAS Features

- Hot-pluggable disk drives and PCI cards
- N+1 power supply redundancy
- Hot-swappable power supplies
- Redundant, hot-swappable fan trays
- Environmental monitoring and fault protection
- Automatic System Recovery (ASR)
- Remote Lights Out Management capability
- Support for disk and network multipathing with automatic failover capability
- Dual-loop enabled FC-AL mass storage system
- Error correction and parity checking for improved data integrity

Backup server

The high-performance, datacenter-class Sun Fire V440 server is an extremely flexible platform for delivering low-cost, horizontally-scalable services and solutions. With up to four 1.593-GHz UltraSPARC IIIi processors, up to 32 GB of memory, up to four 146-GB Ultra320 SCSI disks, six PCI slots, two Gigabit Ethernet ports, identity transfer feature, and remote server management capability, the rack-optimized 4U Sun Fire V440 server features an integrated architecture designed to meet a variety of different processing needs while reducing complexity and maximizing valuable data center floor space.

The Sun Fire V440 server features an exceptional memory capacity of 32 GB, dual Gigabit Ethernet ports, and four Ultra320 SCSI disks.

The specifications for the unit included on this proposal are:

General:

- Processor: Two 1.593-GHz UltraSPARC IIIi processors.
- Architecture: 64-bit, 4-way superscalar SPARC V9.
- Cache: 32 KB instruction, 64 KB data on chip
- Level 2 cache: 1 MB integrated cache.
- Main Memory: 4 GB of ECC memory.
- Network: Two 10/100/1000 Mbyte/sec Ethernet.
- Network Management: One 10 BaseT Ethernet.
- Serial management: One TIA/EIA-232-F (RJ45) Port.
- Serial: One TIA/EIA-232-F asynchronous (DB9) port.
- SCSI: One Ultra320 SCSI (LVD) port.
- USB: Four OHCI-compliant interfaces, each supporting dual speeds of 12 and 1.5 MBps.
- Expansion Capability: Six 64-bit, full-length, PCI 2.2-compliant expansion slots:

- Three 33-MHz or 66-MHz slots
- Three 33-MHz slots
- System Configuration Reader and Card (removable). Front accessible for transfer of system configuration information, including host ID.
- Four hot swap internal disk Ultra 160 SCSI disks, each with a capacity of 73 GB.
- Internal DVD. One Slimline DVD-ROM drive.

Electrical

- Power supply: One required, two for redundancy (hot swappable) with separate power cords
- Maximum AC power: 650 W (570 W typical)
- AC power: 90-264 V AC (47-63 Hz)
- Operating temperature: 5° C to 40° C (41° F to 104° F), 20% to 80% relative humidity, noncondensing, 27° C max wet bulb
- Nonoperating temperature: -40° C to 60° C (-40° F to 140° F), up to 93% relative humidity, noncondensing, 38° max wet bulb
- Altitude (operating): Up to 3000 m
- Altitude (nonoperating): Up to 12000 m
- Acoustic Noise: Less than 6.7 B sound power when operating and idle.

Dimensions and weight

- Height: 174 mm (6.85 in.).
- Width: 440 mm (17.3 in.).
- Depth: 635 mm (25 in.) (including bezel).
- Weight: 37 kg (82 lb.) fully configured with rackmount rails and cable management arm.

Main site External Storage

The Sun StorageTek 6920 System is a single-tiered storage solution boasting high value with cost-effective storage consolidation functionality as well as a complete set of business continuity and investment protection capabilities.

Sun StorageTek 6920 main features are:

- Consolidate application storage: Increase efficiency by supporting several applications in a single storage system. Enjoy the benefits of reduced complexity, centralized management, fewer software licenses and less maintenance while retaining the security and simplicity advantages of direct-attached storage.
- Couple with Solaris 10 Operating System for even more consolidation power: Use Sun's Solaris 10 Operating System (OS) with the Sun StorageTek 6920 system and achieve even more strength from the application to server to storage. Both Solaris 10 OS and Sun StorageTek 6920 systems enable flexible allocation of system resources and the capability to dedicate resources to specific applications. When using both Sun solutions together, the result is an end-to-end consolidation of IT infrastructure.
- Eliminate complexity: The Sun StorageTek 6920 system integrates and virtualizes a range of different storage arrays and operating systems concurrently. A variety of array types, including non-sun storage can be integrated and virtualized into a single, tiered-storage system.

- Protect and preserve investment: Preserve existing storage assets and add additional capabilities by using a unified suite of Sun data management and protection software – all without disrupting existing, in-place data.
- Sun StorageTek Pool Manager Software simplifies capacity management: Simplify capacity management by virtualizing and pooling storage resources, enabling quick and precise provisioning based on application workload. Simplifies administration, lowers risk and preserves existing storage investments with a consistent suite of software across both Sun and non-Sun storage.
- Sun StorageTek Data Snapshot minimizes data loss window: Reduce the window for data loss and improves time to recovery while supporting a broad range of users. Get rapid disk-based recovery and save on disk space. Flexible to handle unexpected growth when it's needed.
- Sun StorageTek Data Replicator Software protects against data loss: Increase business continuity by replicating volumes to protect against data loss from a system, building, site or even a regional outage. Copy installed storage from Sun, EMC or HP and protect existing storage investments while saving money.
- Sun StorageTek Data Mirror Software speeds copies: Leverage data by creating full copies of volumes and then splitting them off for use by other applications, such as backup or test. Rejoin the mirrored volumes rapidly when needed. Accelerates process of brining mirrored copies current and moves data quickly.

The specifications for the unit included on this proposal are:

General:

- Drives form factor: 3.5 in. drives (7 to 14 per enclosure).
- Supported drives: 36 GB, 15,000 rpm; 73 GB, 10,000 rpm; 73 GB, 15,000 rpm; 146 GB, 10,000 rpm.
- Raw capacity: 4 Tb.
- Total capacity: 65.4 Tb.

Host connectivity

- Maximum number of FC ports: 28 ports (with 4 SRC/SIO card combination).
- Maximum logical device support: 1024 volumes

Data Cache

- Data Cache: Scales from 2 GB to 28 GB

Electrical

- Input Power (per cabinet): 4200 W (maximum) Two dedicated 200 to 220 V AC, 30 A* circuit breakers.
- AC Power: 200 to 240 V AC at 50 to 60 Hz single phase.

Required clearances

- Front: 122 cm (48 in.).
- Rear: 92 cm (36 in.)

Second site External storage

One **Sun StorageTek 3510 FC** array with 12 300 Gb HDDs, attached directly to the proposed server by FO HBAs.

The specifications for the unit included on this proposal are:

Standard Interfaces

- Host interface: 2 Gb Fibre Channel
- Drives: 3.5 in. low profile
- Supported drives: Dual-ported active- active 2Gb Fibre Channel 73GB 15k rpm; 146GB 10k rpm, 146GB 15k rpm, 300GB 10k rpm
- Maximum number of host ports Dual RAID controllers: 8x2 Gb Fibre Channel host ports (no expansion); 6x2 Gb Fibre Channel with expansion trays
- Maximum cable length: 250 m

RAID Controller Card

- RAID configurations Expansion (no controller); single RAID controller; dual (mirrored) RAID controllers
- RAID levels 0, 1, 1+0, 3, 5, 3+0, and 5+0
- Max. LUNS Up to 1,024 per RAID array
- Max. LUN sizes and max. number of logical drives
- Firmware 4.11 and below: Max. 2TB LUN size; 8 logical drives max.
- Firmware 4.11 and above: Max. 16TB LUN size; 32 logical drives max.
- Max. local and/or global hot spares Up to 20 (RAID set and disk quantity dependent) per RAID array
- Cache size (read and write) 1GB per controller
- Cache battery backup Up to 72 hours
- Cache write policy Write Back—default; Write Through—user configurable
- Cache selectable block sizes 32K (random file transfer); 128K (sequential file transfer)
- Included Management software Sun StorEdge Configuration Service software; Sun StorEdge support Diagnostic Reporter software

Electrical Requirements

- Wattage 420W each (Dual Hot-Swap Redundant Power Supplies)
- AC Voltage 100 to 240 VAC, single phase
- AC Power requirement 90 to 132 VAC, 180 to 264 VAC (47 to 63 Hz)
- AC Current per input 100 to 240 VAC, 50 to 60 Hz, 5.0–7.1A
- DC Voltage –48 or –60 VDC, 18A
- DC Power requirement –36 to –75 VDC
- DC Current per input –48 or –60 VDC, 18A
- Environment
- Temperature
 - o Operating: 5°C to 40°C (41°F to 104°F)
 - o Nonoperating: –40°C to 65°C (–40°F to 149°F)
- Humidity (non-condensing)
 - o Operating: 10% to 90% relative to 38°C
 - o Nonoperating: 0% to 90% relative to 27°C
- Altitude

- Operating: –30m to 3048m(–100 to 10,000 ft.)
- Nonoperating: –30m to 12,192m(–100 to 40,000 ft.)
- Shock
 - Operating: 5.0 G, 11-ms, half-sine
 - Nonoperating: 15.0 G, 11-ms, half-sine
- Vibration
 - Operating: 0.2 G, 5–500 Hz, swept-sine
 - Nonoperating: 1.0 G, 5–500 Hz, swept-sine
- Noise *
 - Operating: LWAD = 6.6 bels
 - Nonoperating: LWAD = 6.6 bels

*LWAD (1 bel = 10 dB) Declared noise emissions in accordance with ISO 9296, measured at 23°C.

Main site Tape library

The Sun StorageTek C4 tape library provides reliable data storage with high availability, easy access, and comprehensive data protection for business-critical data. Available with the leading tape drive technologies, the Sun StorageTek C4 tape library offers among the highest rack density in its class and among the lowest cost per-gigabyte of storage. This highly scalable library can enhance the ability to respond to a business disruption, provide continued access to critical information, and rapidly recover from a disaster.

Sun StorageTek C4 main features are:

- Independent, internal robotics and power system. Modules operate independently, even when stacked. This tape library's internal robotics and power system will continue operating even if another module in the stack is down.
- Hot-swappable tape drives and optional redundant power supplies.
- Up to 15.2TB of native capacity fits within a compact 4U space.
- Multiple units can be stacked for up to 20 drives and 152TB of native capacity in a 40RU space.

The specifications for the unit included on this proposal are:

General

- Two LTO 3 SCSI drives, with maximum native throughput of 576 Gb/hr.
- Maximum of 38 LTO 3 cartridges (10 included with the unit).
- Ten LTO Universal Cleaning cartridges included.
- Host system Interface: Ultra 320 SCSI (LVD)
- Integrated Web-based management.

Dimensions and weight

- Height: 6.75 in. (17.1 cm)
- Width: 19 in. (48.2 cm)
- Depth: 31in. (78.7 cm)
- Rackspace required: 4U

- Weight: 87 lbs. (39 kg)

Electrical

- Input Voltage: 90 to 264 VAC
- Frequency: 47 to 63 Hz
- Consumption: 900W fully populated average
- Heat dissipation: 3070 BTU/hr fully populated average

Second site tape library

One **Sun StorageTek C2** Tape AutoLoader. This equipment should be used for recovery purposes, in case of some data corruption or similar issues.

The specifications for the unit included on this proposal are:

Performance

- Maximum native throughput LTO 3 – 288 GB/ hr
- Maximum native capacity LTO 3 – 6.4 TB
- Cartridge count 8 or 16 cartridges
- Availability
 - o MTBF 400,000 power-on hrs
 - o MTTR <30 min

Mechanical

- Height 3.41 in. (8.6 cm)
- Width 19 in. (48.3 cm)
- Depth 27.5 in. (69.9 cm)
- Weight 31 lbs. for typical configuration (14 kg)
- Rackspace required 2 U

Environmental

- Temperature Operating: +50°F to +95°F (+10°C to +35°C)
Non-operating: -40°F to +149°F (-40°C to +65°C)
- Humidity Operating: 20% to 80% non-condensing
Non-operating: 10% to 90% non-condensing
10%/hr without condensation

Power

- Input voltage 90–256VAC

UPS

APC Smart-UPS RT is a family of high-density, performance UPSs for voice and data networks and industrial applications. Capable of supporting up to 10kVA in a 6U rack/tower convertible form, users can support power hungry blade servers or heavily loaded equipment racks. This flexible form factor allows standardization across multiple applications. High power internal chargers allow virtually unlimited additional matching battery packs to

comply with aggressive runtime demands of business-critical systems. It is recommended for customers with harsh power environments looking for extremely tight voltage and frequency regulation, internal bypass, and input power factor correction typical of double conversion online topology.

The model selected for this proposal is **APC Smart-UPS RT 5000VA RM 230V**. Its technical specifications are:

Output

- Output Power Capacity: 3500 Watts / 5000 VA
- Max Configurable Power: 3500 Watts / 5000 VA
- Nominal Output Voltage: 230V
- Output Voltage Note: Configurable for 220 : 230 or 240 nominal output voltage
- Efficiency at Full Load: 92%
- Output Voltage Distortion: Less than 3%
- Output Frequency (sync to mains): 50/60 Hz +/- 3 Hz user adjustable +/- 0.1
- Crest Factor: 3:1
- Waveform Type: Sine wave
- Output Connections :
 - o (8) IEC 320 C13
 - o (2) IEC 320 C19
 - o (6) IEC Jumpers

Input

- Bypass: Internal Bypass (Automatic and Manual)
- Nominal Input Voltage: 230V
- Input Frequency: 50/60 Hz +/- 5 Hz (auto sensing)
- Input voltage range for main operations: 160 - 280V
- Input voltage adjustable range for mains operation: 100 - 280V
- Other Input Voltages: 220,240

Batteries and Runtime

- Battery Type: Maintenance-free sealed Lead-Acid battery with suspended electrolyte; leakproof
- Included Battery Modules: 2
- Typical recharge time: 2.50 hour(s)
- Typical Backup Time at Half Load: 15.4 minutes (1750 Watts)
- Typical Backup Time at Full Load: 5.0 minutes (3500 Watts)

Physical

- Maximum Height: 130.00 mm
- Maximum Width: 432.00 mm
- Maximum depth 660.00 mm
- Rack Height 3U
- Net Weight 54.55 Kg

LAN Switches

The Cisco Catalyst 2950-12 is a member of the Cisco Catalyst 2950 Series switches, and is a standalone, fixed-configuration, managed 10/100 switch providing user connectivity for small to mid-sized networks. This wire-speed switch comes with Standard Image (SI) software features and offers Cisco IOS functionality for basic data, video and voice services.

The key technologies of this switch are:

- **Superior redundancy for fault backup.**
- **Integrated Cisco IOS Software features for bandwidth optimization.**
- **Networkwide security features.**
- **Layer 2 QoS.**
- **Superior manageability.**
- **Cisco Cluster Management Suite.**
- **Support for CiscoWorks.**

The technical specifications of the switch included on this proposal are:

Performance

- 13.6-Gbps switching fabric.
- 1.8-Mpps wire-speed forwarding rate.
- 8 MB packet buffer memory architecture shared by all ports.
- 16 MB DRAM and 8 MB Flash memory.
- Configurable up to 8000 MAC addresses.

Connectors and cabling

- 10BASE-T ports: RJ-45 connectors, two-pair Category 3, 4, or 5 unshielded twisted-pair (UTP) cabling.
- 100BASE-TX ports: RJ-45 connectors; two-pair Category 5 UTP cabling.
- 1000BASE-SX ports: MT-RJ connectors, up to 1800 feet (550 meters) cable distance for 50/125 or up to 900 ft (275 m) cable distance for 62.5/125 micron multimode fiber-optic cabling.
- Management console port: 8-pin RJ-45 connector, RJ-45-to-DB9 adapter cable for PC connections; for terminal connections, use RJ-45-to-DB25 female data-terminal-equipment (DTE) adapter.

Electrical

- Power consumption: 30W (maximum), 102 BTUs per hour.
- AC input voltage: 100 to 127, 200 to 240 VAC (auto-ranging).
- AC input frequency: 47 to 63 Hz.
- DC input voltages for Cisco RPS 675 and Cisco RPS 300: +12V at 4.5A.

Environment

- Operating temperature: 32 to 113° F (0 to 45° C)
- Operating relative humidity: 10-85% (non-condensing)
- Operating altitude: Up to 10,000 ft (3000 m)
- Acoustic noise: 46 dBA.

Dimension and weight:

- Height (Rack Units): 1 U
- Width: 43.6 mm (1.72 in.).
- Depth: 444.5 mm (17.5 in.).
- Height: 241.8 mm (9.52 in.).
- Weight: 3.0 Kg (6.5 lb.).

Rack

In order to contain all the hardware included in this proposal, three Sun racks 900-38 are provided. Key technologies of this rack are:

- **Zero-RU Power Distribution System:** The power distribution system is integrated into the frame of the rack and does not occupy any rack units (RUs). The Sun Rack PDS provides redundant power supplies and a sequencing feature, which steps each racked product with power on the initial power-up.
- **Vertical cable management bracket:** When used with hook/loop straps, help protect the data cables and aids in the traceability and mobility of the cables, when necessary.
- **Anti-tip foot:** The anti-tip foot is located in the front of the Sun Rack cabinets and can be easily pulled out and balanced for the safe handling and servicing of racked products.

The technical specifications of the rack included on this proposal are:

Electrical

- Nominal Voltage: 200, 208, 220, 230, or 240VAC.
- Tolerance Voltage: 180 to 264VAC.
- Frequency Operating: 50 /60 Hz.
- Frequency Tolerance: 47 to 63 Hz.
- Input Current: 4x –16A.
- Operating Current: 32A (2x-16A) maximum.
- AC Power Plug: Domestic NEMA L6-20P International
- AC Power Receptacle: Domestic NEMA L6-20R International IEC 309 16A 3 Position

Dimensions and weight

- Available Rack Units (RUs): 38.
- Height: 188 cm (74 in.).
- Width: 59.7 cm (23.5 in.).
- Depth: 900 mm (35.4 in.).
- Empty rack: 163.3 kg (360 lbs.).

Oracle Database 9i

Oracle Database 9i Enterprise Edition offers industry-leading scalability and reliability in both clustered and single-system configurations. It provides the most-comprehensive features for OLTP and business intelligence and delivers the lowest total cost of ownership. Enterprise Edition includes:

- High-performance business intelligence services such as ETL, data warehousing, OLAP, and data mining.
- Comprehensive, open access to Web services through SQL, Java, XML, and standard Web interfaces.
- Continuous availability despite system failures, site failures, disasters, human errors, and planned maintenance.

Oracle Database Enterprise Edition delivers record-breaking performance and scalability on systems from small departmental servers running Windows or Linux to the largest UNIX servers and mainframes. Oracle is the only database with 17 independent security evaluations.

Data Protector

HP OpenView Storage Data Protector manages backup and recovery from both disks and tapes, delivering maximum data protection while providing continuous 24x7 business operations. The software is designed to simplify and to centralize backup and recovery operations by integrating a variety of techniques to eliminate backup windows. These range from on-line backup, open file backup, and instant recovery or zero-downtime backups. Its proven industry-leading instant recovery features and several other integrated disaster recovery alternatives meet the demands of the most complex enterprises so that they can recover critical data within minutes.

Data Protector simplifies the use of complex backup and recovery procedures with the fastest installation, automated routine tasks, and easy-to-use features, and it is the ideal solution to reduce IT costs and complexity while remaining reliable and scalable to grow. It provides broad compatibility of operating systems, applications, drives, libraries, and disk arrays.

It also provides tracking and management of offline storage media. Maximizing media operations staff productivity and increasing data availability by automating the tracking and management of removable storage media. With media operations, it is possible to manage the complete life cycle of removable storage media; shortening recovery time, reducing financial and business risks from lost data, and minimizing opportunities for human error.

Sun Java System Application Server Enterprise Edition 8.1

Sun Java System Application Server provides a Java 2 Platform, Enterprise Edition (J2EE platform) 1.4 compatible platform for developing and delivering server side Java applications and Web services.

As a key component of the Sun Java Enterprise System, the Java System Application Server provides the foundation for delivering enterprise-class application services and Web services. It offers a unique new modular architecture based on some of the industry's most proven, high-performance, and standards-compliant components — including proven implementations of the HTTP server infrastructure, Java Message Service (JMS) software, and rigorous support of the latest Java 2 Platform, Enterprise Edition (J2EE platform) and Web services specifications with J2EE 1.4 technology; Java 2 Platform, Standard Edition (J2SE) 1.5 technology; and the Java Web Services Developer Pack.

Business Objects

OCR

Disaster recovery

In this configuration the disaster recovery plan tasks are critical, so Soluziona suggests to provide these plan with all the procedures and to do real testing simulating a disaster in the main site.

Disaster Recovery Plan (DRP)

Disasters can be defined as disruptions that cause critical information resources to be inoperative for a period of time, adversely impacting business operations. Not all critical disruptions in service are classified as a disaster (e.g. systems malfunctions, accidental file deletions, viruses, etc.).

The system owner must develop a disaster recovery strategy to identify an alternate processing facility equipped to provide the continuation of information systems processing. The business continuity planning process can be divided into the following phases :

- Business Impact Analysis (BIA).
- Recovery Strategy.
- Development of a Business Continuity Plan (BCP) and Disaster Recovery Plan (DRP).
- Plan Testing and Maintenance.
- Business Impact Analysis (BIA)

The objective of this phase is to identify the events which could impact the continuity of business operations and their impact on the organisation. It is necessary to obtain an understanding of the key business processes and to identify the IT resources used to support those processes.

There are different approaches to perform a BIA and they could be based on the development of a questionnaire to circulate it to the key users, or on interviewing the key users to gather relevant information. The questions must be oriented to :

- Identify the business processes and assign their relative importance.
- Identify the critical information resources related to the critical business processes.
- Define the critical recovery time period for information resources in which business business processing must be resumed before suffering significant or unacceptable losses (Recovery Time Objective or RTO).
- Define the acceptable data loss in case of disruption (Recovery Point Objective or RPO).

As the last stage for the BIA, the system owner should perform a Risk Analysis based on the criticality and classification of operations and IT resources supporting them.

Recovery Strategy

The most effective action plan to build a recovery strategy should try to minimise the threat, the likelihood and the effect of a disaster occurrence. Threats and likelihood can be reduced by implementation of good physical and environmental security, while the effect can be minimised by implementing built-in resilience through alternative routing and redundancy.

Development of BCP and DRP

Based on the inputs received from the previous BIA and recovery strategy definition, a detailed disaster recovery plan should be developed. This plan should be documented in simple language, easily understandable by all involved personnel and copies of the plan must be maintained off-site. Some teams must be identified in the plan and created to perform specific tasks (incident response team, emergency action team, damage assessment team, offsite storage team, network recovery team, etc.).

The following information should be included in the formulation of the plan :

- A list of the staff involved, with contact information.
- The configuration of the alternative building's facilities.

During this stage, it is necessary to design the tests that will be performed, so that it is possible to identify training requirements for the involved staff. A training program will be defined from this duty.

Plan Testing and Maintenance

After the plan has been defined, scheduled and periodic tests should be performed during periods that don't affect normal operations. The test will simulate an actual disaster and accomplish the following tasks :

- Verify the completeness and precision of the Plan.
- Evaluate the performance of the personnel involved.
- Evaluate the coordination between the business continuity team and external suppliers.
- Measure the ability and capacity of the backup site, and evaluate the state and quantity of equipment relocated to the recovery site.
- Measure the overall performance of all the Plan activities in order to support the Corporation business continuity.

Through every phase of the test, detailed documentation of observations, problems and resolutions should be maintained. This documentation will be analysed to measure the success of the plan test against the stated objectives. After this analysis, the plan should be updated to reflect changing requirements or to correct design mistakes.

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Servers

There are three necessary racked servers:

- Web Server (VXML)/Java Application Server
- Server for CCMS, CCMA and CCTV
- Server for CCMM

The features proposed for these servers are:

- HP ProLiant DL380 G5 3.00GHz Server
- Dual Core Intel Xeon 5160 (3.00 Hz, 1333 FSB) processor
- HP 8GB Fully Buffered DIMM PC2-5300 2x4GB memory
- HP Smart array 642 controller
- HP slimline DVD+RW 8x drive
- Embedded NC373i multifunction gigabit network adapter
- HP PCI-X/PCI-E Non-hot plug riser card
- HP NC360T PCI Express Dual port gigabit server adapter (low profile)
- HP 1000-W Hot-plug power supply
- HP redundant hot-plug fans
- Integrated lights out 2 (iLO 2) standard management
- HP Care pack, install startup proliant DL380
- 3 years parts, labor and onsite service (3/3/3) standard warranty

PBX-Nortel (CS1000S)

Following all items are included regarding the hardware and software resources needed for this project.

Concept	Description	Units
NT5D12AH - Pack 1.544MBs/T1 Dual DTI or Dual PRI with ENET 48 channel (DDP)	Connection card for primaries T1	1

NTBK51AA - D-Channel DaughterBoard (EUROISDN/QSIG/MCDN)	Connection card for EUROISDN/QSIG/MCDN	1
NTRB21AC - T1 MultiPurpose Digital Interface (TMDI) Card	Card for Digital Interface T1	3
NTBK04AA - 1.5 Mbit DTI/PRI T-1 Cable	Cable for Mbit interconnection	3
NTAK20BD - Stratum 4 Clock Controller DaughterBoard Option 11	Clock for Daughter Board Control	1
NTHN18AB - Advanced Call Center /Premium Network Services-ACD Agent	Advanced services ACD	15
NTPY58DB - Voice Media Card - 32 ports	Card of 32 DSPs for conversion TDM to IP	2
NTPY61AB - Communication Server 1000S Base Platform (0 Line/ 0 Trunk)	Chassis principal CS1000S	1
NTHN96AA - MIRAN Small (Starter Package)	Card of announcements	1
NTHN12BA - ASTs	License for the extensions	5
NT5Y02CB - Nortel Mobile USB Headset Adapter with Monaural Headset and 2050 Softphone	Kit de audio USB for IP Softphone 2050	25
NTHN71DB - 8 Advanced Call Center Services IP Users	Package of 8 licenses for IP usage	4
NT6W20AA - CCM 6.0 Nodal Base System	Contact Center Manager server for "skill based routing", statistics and real time reports	1
NT6W21BA - CC Standard Voice Agent Increment 1-49	Licenses agent Contact Center inbound	25
NT6W20CA - CCMM 6.0 Nodal Base System	System base Contact Center Multimedia	1
NT6W20DA - CC 6.0 Outbound Nodal Base	Contact Center Multimedia for outbound	1
NT6W01BB - CCT 6.0 Nodal Base System for CCMM	Communication Control Toolkit	1
NT6W03EB - CCT 6.0 Contact Center Device for CCMM Agent - 1 Device	Licenses CCT	5
NT6W25BA - CC Standard Outbound Agent Increment 50-99	Licenses agent for Contact Center outbound	5

Installation, configuration and formation Nortel CS1000M	Installation and configuration of the system CS1000M, CCMS 6.0, CCMA 6.0, CCT 6.0 y CCMM 6.0	1

IVR-Nortel

Qty	Ref. #	Description
1	NTV780ABAA	MPS500 25 RU Cabinet 115VAC
1	NTV720ACAB	MPS Ethernet Switch 470, 1RU, 24 port, 115/230VAC
1	NTV781AAAC	MPS500 T1/E1 Enclosure (RJ48C), 115/230VAC
1	NTV782TBAA	MPS500 Telephony Media Server, Speech Processing Enabled, T1, includes onboard echo cancellation.
1	NTV783AAAA	MPS500 TMS, 12DSP Expansion Card MDM, (TMS slot 1 or 3)
1	NTV705AAAA	MPS DDS-4 DAT Tape Drive, cabinet mounted 115/230VAC. Use for data loads, backup and restore functionality for the AP's. Required for MPS systems utilizing Speech Recognition for securing media for utterance tuning. Optional for all MPS systems where additional backups are required.
1	NTV763AAAA	X335 and X336 UltraSCSI Interface option for NTV705AAAA, MPS DDS-4 DAT Tape Drive, cabinet mounted 115/230VAC.
1	NTV704BDAA	MPS 500 Customer Supplied USB modem or Virtual Private Network access. Confirms customer obligation to supply, install (not permitted to reside within the MPS cabinet), configure and support USB Pentium modem for Speech Server hardware or replace modem with Virtual Private Network (VPN) access to system." Any modem or VPN configuration/installation support time required from Nortel Support organizations will result in hourly billing above the originally quoted installation/service fee.
2	NTV801ABAA	MPS 500 Rel 3.0 AP, Base System Software License, Win2003 Std Server, per AP
2	NTV802CAAA	MPS Rel 3.0 N+1 AP Failover License. Must be equipped on every AP.
100	NTV804AAAA	License, Application Engine Runtime License, Media Processing Server Application Engine per port runtime license, Solaris or Windows 2000. Provides Application Engine per port runtime license.
100	NTV805ACAA	MPS, Periproducer 3.0 and VXML 2.0-Mar04 Interpreter Application Execution Environment Runtime License, per port, Solaris or Windows. Nortel MPS VoiceXML R2.0-Mar04 version Interpreter License (per port). License, PeriProducer, Media Processing Server PeriProducer 3.0 per port runtime license, Solaris or Windows. Enables a single system port to run the VXML 2.0 Execution Environment on the MPS release 3.0 or 2.1 Platform. VoiceXML is a W3C standard for creating web-server-based IVR applications, which are designed as VXML documents and then served using the HTTP protocol. This feature will interface to web servers to download and execute VXML documents that have been coded according to the

		<p>VXML 2.0 W3C recommended standard of March 2004. Package includes software & documentation and can be ordered for either new system shipments or field upgrades. Both speech and DTMF applications can be supported by Nortel's VoiceXML 2.0-Mar04 implementation. Nuance 8.0 & 8.5 ASR, OSR 2.0 & 3.0 ASR, Speechify 3.0 TTS, RealSpeak 3.5 & 4.0 TTS, and Nuance Vocalizer 3.0 TTS are the speech engines globally supported with the VoiceXML R2.0-Mar04 implementation. The Rhetorical TTS engine is also supported in EMEA region only. Nortel Networks Internet Audio Server is required in order to support the playback of internet audio files such as .wav, .mp3, & .au (i.e., beyond TTS) from web URLs, which is licensed separately. In order to support custom DTMF grammars (beyond defined VXML default DTMF grammars), one of the Nortel supported ASR engines is required, which are licensed separately from VXML (note that the same ASR licenses used for speech recognition in conjunction with VXML may also be used for DTMF grammar recognition). Note that some of the optional features of the W3C standard may not be supported (please refer to Nortel's VoiceXML 2.0-Mar04 documentation). MPS and Industry standard VoiceXML (VXML) sizing is application dependent. Nortel confirms support for execution of 120 concurrent VoiceXML ports per MPS application processor. Additional VXML ports may be supported if Nortel PSO provides the application development. Pilot and load tests must be performed with the final VXML application; and the results may require optimization of the VXML application code and/or purchase of additional MPS Application Processors and hardware. Contact CCE for specific implementations. Requirements include MPS release 2.1, Solaris 2.8 or Windows 2000 and MPS 3.0, Solaris 10, Speech recognition, TTS, and audio server engines require Nortel Speech Server hardware and software.</p>
5	NTV810TBAA	License, MPS500 T1 Span (24 ports), Media Processing Server. License enables one T1 span (24 ports) on a Telephony Media Server (TMS) with a maximum of 8 licenses per TMS.
100	NTV820AAAA	License, Speech Announcement Algorithm, PCM/ADPCM player, floating license within a TMS. Provides capability of playing a PCM (64KB) or ADPCM (32KB) MMF files. May require DSP expansion card, each DSP resource supports up to 30 player instances.
100	NTV826AAAA	License, DTMF/R1 fixed per port decoder license. May require DSP expansion card, each DSP resource supports up to 30 DTMF decoder instances.
2	NTV850ABBA	MPS Manager 3.0 Consolidation, Base Package per AP or Workstation (Windows 2003).
100	NTV850BBAA	MPS Manager 3.0 Consolidation, per port License, (Solaris 10 or Windows 2003)
1	NTV761AAAA	MPS Server/Speech Server, Keyboard/Video/Mouse Assembly, 115/230VAC, required for first Speech Server Cabinet per cluster. MPS supports four Speech Server cabinets, MPS500

		required on first Speech Server in MPS500 packaging.
3	NTV760ACBA	MPS Windows Server, Intel Dual (IBM X336), Windows 2003 Std Server, 2x3.6GHz, 1Gb mem, 73Gb, 115/230VAC (dual power)
3	NTV760ACDA	MPS Windows Server, Intel Dual (IBM X336), 1Gb memory extension to 2Gb
3	NTV760ACEA	MPS Windows Server, Intel Dual (IBM X336), Recovery Disk Drive
1	NTV761ACAA	MPS Windows Server, Keyboard/Video/Mouse Assembly, 115/230VAC with 16 port switch
2	NTV880BAAA	MPS, Speech Server Interface Enablement, Base Package per AP, Windows.
100	NTV880CAAA	MPS, Speech Server Interface Enablement, per port license, Solaris or Windows.
1	NTVU00AAAF	Speech Server, MPS Speech Interface, Base Software license, per Speech Server processor.
35	NTVU00AAAG	Speech Server, MPS Speech Interface, per Speech Server speech channel license.
35	NTVU01BDAA	License, software; Nuance 8.5 recognizer, TierA, Language 1, global (per port). Enables a single system port to run the Nuance recognizer with recognition vocabularies for broad yes/no (yes, yup, sure, ok, nope, etc.), natural numbers, simple alphanumeric strings, dates, times, currency, and up to (and including) 40 total Unique items in an application with one unique item per caller utterance. An alphanumeric grammar supports recognition of a continuous stream of mixed single alphabetic characters (from A to Z) and numeric digits (0 to 9). Nuance Tier A is configured with one license per concurrent incoming telephone port that will utilize the Nuance Tier A license. This License does not include any recognition grammars, or Nuance Verification, which must be licensed separately; nor does it include the cost for the development and tuning of the customizable grammar items. Solutions based on the Nuance Recognizer require at least one recognition grammar, and these grammars must be licensed, contracted for, or developed separately. It is not permitted to secure and release (e.g., do not GET and FREE within PeriProducer) the Nuance resource on a per utterance (recognition) basis within a call. During a call, an application may, for specific purposes, re-secure a Nuance resource (lvr-a) if call control must be transferred to an agent or a touch-tone application and then needs to return to the speech application. Must specify language. Supports Speech Server 6.0 with MPS 2.1 on Windows 2000 or MPS 3.0 on Windows 2003 or VPS/is release 5.4.2 (OSCAR 5.5 w/Windows 2000).
35	NTVU21AAAB	Language identifier, Nuance, (per port), UK English (8.0 & 8.5)

APPENDIX 5

Toll Collection System

1. INTRODUCTION

A fully integrated solution provides complete coverage of all TxDOT requirements through a contractual interface

This document provides a comprehensive description of the Raytheon TxDOT ORT technical solution specific to the SH121 solution and altered to accommodate the needs of Cintra Developments. It is structured in two principal sections with the first as an overview of the physical solution. The second Section delves into the components, their functions, design, hardware, capabilities, followed by aspects of installation, manufacture, and maintenance. Together, this document provides a complete picture and description of the proposed solution.

The specific differences between Raytheon's standard configuration for TxDOT and Cintra's design can be summarized in the following items:

- Full gantries instead of cantilevers have been priced for ramp sites. Although the final configuration is pending of a detailed review of each site, in order to determine where and if this is possible, we believe that a full gantry provides more stability and less vibration problems than cantilevers, and therefore more accuracy in detection and classification of vehicles.
- Generators will be provided at the mainline sites (one per direction) and at each ramp site.
- A paved maintenance pull-off area will be provided at each site, in order to ensure the best servicing possible to the gantries and adjacent area, for maintenance purposes.
- A network switch and a TIP are provided at each site. This ensures that any one site can work autonomously in the event of a cut anywhere in the network.
- A central system (Project Host) is provided, for bringing the data from the sites together and then serving these (transactions with images and/or DSRC IDs) to Cintra's Back Office System. Please notice that the rating is not performed anymore at the TIPs but rather at the Back Office.
- ETC antennas are provided in order to provide full DSRC coverage in the whole cross section, including the shoulder lanes.
- A solution will be provided (either a second camera or very large field camera) to ensure that the top of large vehicles is imaged in the event the rear has the plate mounted on the upper edge.
- Each of the sites will be ready to collect images (front and rear) from all vehicles, although this will be a parameter of the system that can be easily changed in the future. It will be a task of the Back Office to decide if these images shall be discarded or, on the contrary, included in the transactions to be forwarded to NTTA (or the Clearing House), according to certain business rules.

2. SYSTEM OVERVIEW AND DESCRIPTION

The ORT system offered by HTMS derives directly from fielded, proven operational ORT systems, as shown in **Figure 3.1.1-1**. The ORT system views the roadway as one continuous driveable road width, not a series of lanes. Because of this, critical processing decisions do not rely on the vehicle being in any particular position across the road width.



Figure 3.1.1-1. TxDOT ORT System Heritage. The TxDOT Open-Road Tolling system builds upon the success and experiences gained on other HTMS Open-Road Tolling systems.

Our sensor systems are highly accurate and reliable, and use no in-pavement components, reducing maintenance costs and all but eliminating road closures associated with maintenance action.

A top-level block diagram of the HTMS proposed ORT system is shown in **Figure 3.1.1-2**. The roadside suite of tolling equipment consists of several sensor and support subsystems, interfaced to the Integrated Roadside Unit (IRU). Although shown as “point-to-point” connections from the various subsystems to the RCU, the roadside ORT equipment employs a networked architecture. All subsystems are directly addressable devices on a Local Area Network.

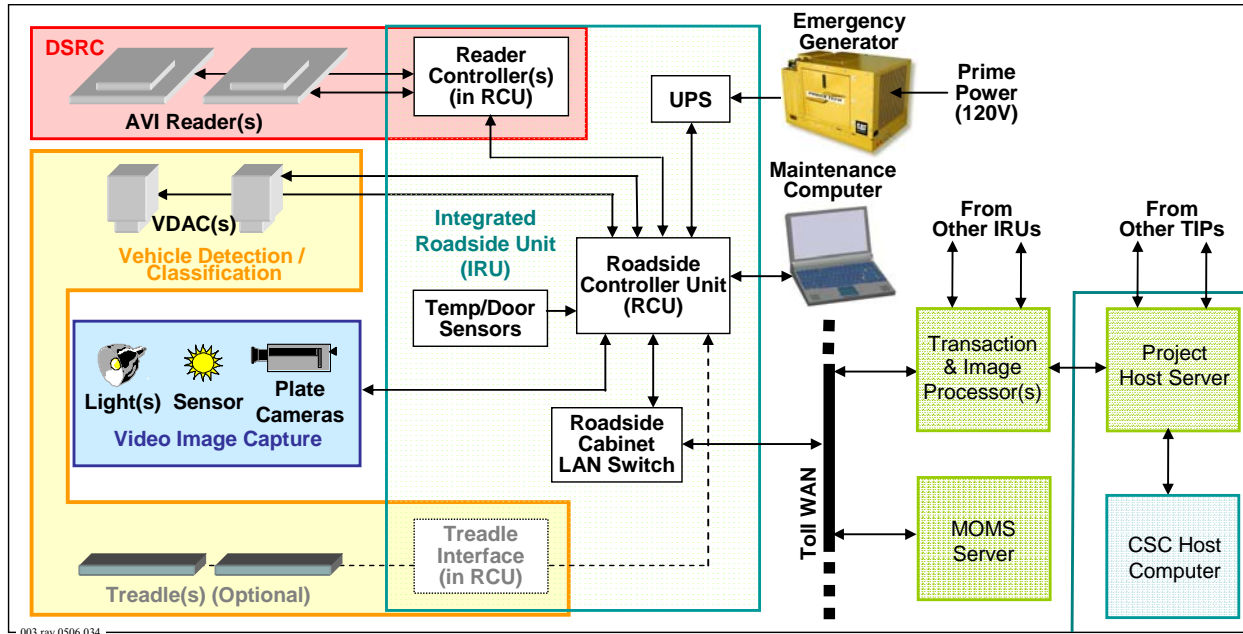


Figure 3.1.1-2. Top-Level Block Diagram. The highly modularized TxDOT Open-Road Tolling system provides all required functionality.

A key element of the ORT system is the AVI Reader subsystem, manufactured by TransCore. Raytheon has a reputation in the industry as a highly capable system integrator, as well as having the know-how to design any required system element not available from other suppliers. This core strength is illustrated in **Figure 3.1.1-3**. HTMS has successfully integrated several reader technologies into its tolling systems, and is currently completing integration of the TransCore Model 3110A reader at its Fullerton test site.

HTMS anticipates that the TransCore reader will support achieving of the specified performance levels. The antennas and RF modules are Gantry-mounted; a plug-in board in the RCU provides reader control.

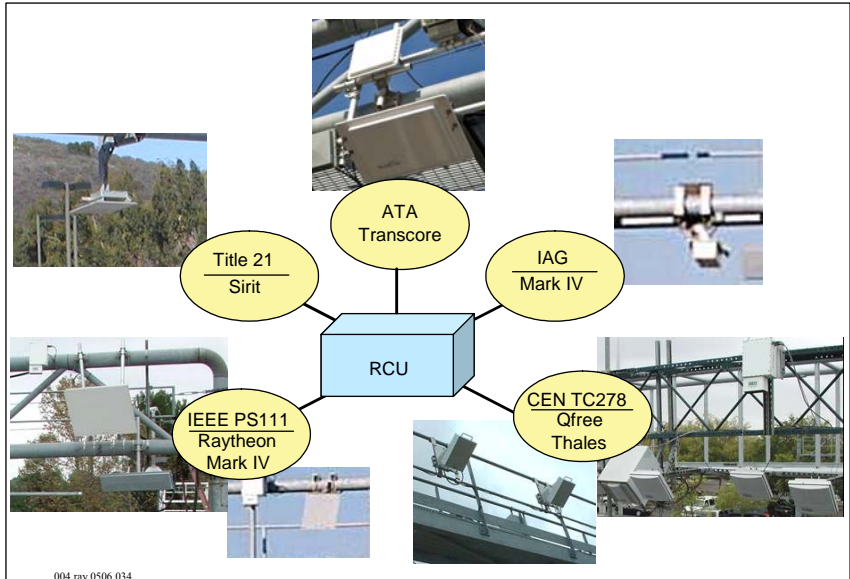


Figure 3.1.1-3. Multiple System Integration. Raytheon has integrated several DSRC technologies into their ORT product line.

Detection and Classification in our ORT system is performed by the Schwartz/OSI Laser Systems AutoSense II, a dual-beam laser radar unit. Raytheon worked closely with Schwartz to develop and refine critical processing algorithms in its first major (and highly successful) open-road tolling application on the Toronto 407 ETR system. This ground-breaking work produced an extremely capable vehicle detection and classification system which uses no in-road components, and provides classification accuracies that exceed those obtainable with in-road loops or treadles. The Toronto 407 ETR system has clearly demonstrated that shape-based classification fully supports a business model acceptable to the owner/operator, as well as to the financing banks. Provision of in-road axle-counting sensors, if they become necessary, or in specific applications, is easily accomplished, but the existing overhead sensors would be retained to maintain the necessary vehicle separation/camera triggering accuracy.

The Video Image Capture subsystem utilizes high-resolution cameras from Pulnix, with a wide-aspect 500 by 2000 pixel field of view, allowing fewer cameras to be employed to cover the width of the roadway. Coupled with these high performance cameras is a unique, patented light sensor system that measures reflected light from a target matching the reflectance and illumination geometry of the vehicle's license plate. The initial model of this light sensor was developed specifically for the Toronto 407 ETR tolling system. The light sensor directly controls the camera settings for optimum exposure under a wide variety of lighting conditions. Coupled with the very precise triggering control from the laser radar vehicle detector, the quality and consistency of the video images produced is unequalled for this image capture environment, producing over 98% readable images.

The light sensor design contains two targets, one oriented to match the rear license plate, and one oriented to match the front, to control both the front and rear image capture cameras from a single location. The Image Capture subsystem captures images of every passing vehicle. Post-capture processing then determines whether an image is saved or deleted.

The front image capture cameras produce full-color images during the daylight hours, and white-light LED illuminated images of reflective plates at night. The rear image cameras, with the vehicle illuminated by ceramic metal halide lamps, produces color images 24 hours per day, regardless of plate reflectivity.

The Roadside Controller Unit (RCU) is the control center for the Open Road Tolling system roadside equipment. It is a custom commercial grade rack-mounted computer system running the QNX RTOS. It combines the various sensor data into a complete transaction that accurately reflects events at the tolling point. The RCU also monitors all equipment status, and provides reports on the operational health of the ORT system. The RCU software modifications required for this program will be implemented using WATCOM ANSI C/C++ Compiler, Linker and Symbolic Debugger. Also employed is Premia Codewright Language Sensitive Editor.

Communications of transaction data to the Central System is via Wide Area Network serving the toll road project, and through the TIP and the Project Host Server (PHS), which are networked resources. The baseline approach for communication to the CSC is gigabit Ethernet over fiber.

The TIP subsystem collects the information required to identify each toll road user from the RCU and prepare final correlated results (one transaction for one vehicle). A TIP provides the capacity to service up to six RCUs depending on traffic levels and local direct non-routed access. This excess capacity serves as backup in the event of failure of one of the TIPs in a Road Segment whereby data from a site having a failed TIP is automatically routed to a pre-assigned alternate TIP. The TIP processes and stores all transaction data from one or more assigned RCUs. It contains Microsoft relational database capabilities capable of recalling any transaction stored over the required previous 30-day period. The TIP performs second-level correlation processing for those few cases where the RCU is unable to correlate all transponder reports to a vehicle detection/video image set. The TIP, having all of the data available is better able to resolve unusual correlation conditions, and complete an accurate correlation. The TIP is also capable of applying digital signatures on all transaction data forwarded to the PHS to prevent unauthorized/undetected modifications.

Data from the TIP is then “pushed” to the Central Host as it is received. The host (PHS) processes collects transaction data from the multiple TIPs in the Road Segment and provides a one year transaction and 30 day video storage service. From this point. Transactions are available to the Back Office System for image review plus business processing.

As a backup to the network, a customized laptop provides the ability to behave as a data transport service and integrates directly with any TIP and the PHS. In operation, and should a network warrant the manual transfer of data, this device can be attached to the roadside network, receive data from a TIP, provide download information to a TIP and then once connected to the central system perform the download and reconciliation of data with the PHS.

Overseeing all processing, from camera performance to power stability, including interfacing and interprocess queuing, the MOMs system is a SNMP-based monitoring and reporting tool. Combining customized applications using What’sUp and TrackIT (commercial applications), the MOMs system is capable of efficiently monitoring the complete performance and registering faults that are automatically and manually assigned to trouble tickets and dispatched. Through these tools we are able to quickly isolate problems and direct engineering and service crews while tracking all performance metrics.

In summary, the Raytheon approach provides a number of significant advantages to TxDOT, as itemized in **Table 3.1.1-I**.

Table 3.1.1-I. Features/Benefits of the Raytheon Approach

Raytheon ORT Program Feature	Benefit toTxDOT
<ul style="list-style-type: none"> Designed originally as an Open-Road System Mature, operationally proven in Toronto, Israel, Minnesota, and Chile Program led by a Systems Engineering House No in-pavement components Overhead Laser Detector/Classifier Laser detector for camera triggering Adheres to TxDOT’s interoperable interface from Host systems 100% Video capable, high performance, video image capture and processing system Open, bus-architected roadside system 	<ul style="list-style-type: none"> Fewer performance problems in the wide range of open-road traffic conditions Low risk for achieving required performance Better understanding of the issues when installing integrating, and testing complex electronic systems means fewer program problems for TxDOT. Lower road maintenance costs, no traffic disruption for Tolling Zone equipment maintenance Better performance in stop-and-go conditions; more reliable performance with lane straddling Higher percentage of readable license plate images and OCR success Minimizes CSC interfacing problems; more efficient interface Flexibility to consider other video-based tolling options (Daypass, or straight video tolling) can eliminate the traditional concept of a “violator” and increase customer base. Easy to configure for different road widths and configurations with minimal engineering costs; easily upgraded.

The various major elements are interconnected logically, as illustrated in **Figure 3.1.2-1**. A single Project Host Server (PHS) interfaces to the Back Office for each project and to several Transaction and Image Processors (TIPs), the number of which depends upon the size of the Road Segment. Each TIP in the Project Segment interfaces to Roadside Controller Units located in Integrated Roadside Units (IRUs). The TIP is physically located in one of these IRUs.

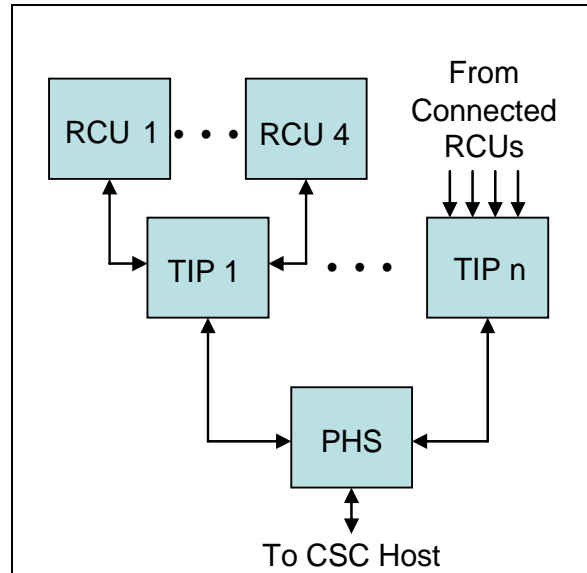


Figure 3.1.2-1. Logical Interconnection of All Major System Elements.

These major system elements are all networked resources, interconnected through the Wide Area Network (WAN), which will have a bandwidth of 1 Gb. A network switch will be provided at each site, thus forming a V-LAN that localizes traffic at the site, and connects each site to the fiber ring in two directions (please notice that the proposed communications network will be fiber optics based and will have not only logical redundancy, but also physical redundancy-fiber will be deployed at both sides of the motorway).

3. SYSTEM FUNCTIONAL DESCRIPTION

The Raytheon Tolling system fully complies with all TxDOT requirements, requires no new hardware development, and provides a high level of flexibility.

The Raytheon system utilizes proven installed hardware and software to meet or exceed all functionality required by TxDOT. A summary of this functionality is provided in **Table 3.1.2-I**.

The Raytheon system provides all of the functionality required to perform “mission critical” functions and specifically the following highlights:

- Read vehicle-mounted transponders and report transponder IDs to the Host System, including full coverage of the cross section at the toll sites (traffic lanes plus shoulders coverage)
- Identify non-equipped vehicles and capture video images of the front and rear of the vehicle suitable for extracting license plate numbers
- Capture images for all vehicles, including vehicle-mounted transponders when set to include 100% image coverage
- Capture images for vehicle-mounted transponders when a specific tag is located in a watch list, although the system will be initially configured to capture images of all vehicles, notwithstanding them carrying a tag or not, and notwithstanding the tag being in the list or not
- Capture images of the back of large box trucks having the possibility of a plate mounted on the upper portion of the box.
- Provide backup power systems capable of withstanding brown-outs and long term power loss
- Provide optimized redundancy through a configuration that utilizes prime and secondary processors in a tiered and distributed network
- Provide vehicle detection redundancy through the use of multiple sensors including the ability to perform well in degraded modes
- Provide continuous operational monitoring to ensure high system availability and immediate recognition of degraded performance
- Ensure rapid response to problems through automated and efficient trouble ticket, dispatch and inventory management features of MOMs
- Utilize relational database to support additional business rules and data-extract while performing automated unattended backups with “moment-in-time” recovery

Table 3.1.2-I. ORT System Functional Capabilities






Subsystem Element	Functionality
<div><div><ul style="list-style-type: none">AVI Reader (includes antennas, RF unit, reader control card)</div><div></div></div>	<ul style="list-style-type: none">Provide overlapping antenna pattern coverage to ensure that there are no “holes” in the communication zoneControl antenna pattern coverage to prevent reading of transponders not in the defined tolling zoneRead vehicle-mounted transpondersDiscriminate lane position to eliminate multiple reads from adjacent antennasReport transponder IDs and current hardware status to Roadside Controller Unit (RCU)
<div><div><ul style="list-style-type: none">Vehicle Detection and Classification (VDAC)</div><div></div></div>	<ul style="list-style-type: none">Detect the passage of each vehicleAccurately separate vehiclesMeasure the vehicle speedDetermine direction of travelProduce timing triggers for video image captureDetermine lane position of the vehicleReport vehicles pulling trailers as a single “vehicle”Measure the vehicle classification in one of 15 categories based upon the shape of the vehicle (height, length, width)Report vehicle classification in one of up to 11 tolling categoriesPerform all measurements from an over-the-lane sensor
<div><div><ul style="list-style-type: none">Video Image Capture</div><div> </div><div><ul style="list-style-type: none">Camera, Strobe Light, and Light Sensor</div></div>	<ul style="list-style-type: none">Capture color images of the rear of passing vehicles based on external triggeringCapture color images of the front of passing vehicles based on external triggeringProduce images with sufficient resolution for high-performance OCR processing (≥ 3 pixels per principal character stroke width)Capture readable images 24 hours per dayProvide active light level sensing in a realistic measurement environment.Provide automatic adjustment of camera settings by light sensor to obtain optimum exposureProvide continuous white-light illumination for nighttime rear image capture or license plate, and vehicle contextDoes not depend on license plate reflectivity to obtain a good imageProvide strobed LED illumination for nighttime front image capture

Table 3.1.2-I. ORT System Functional Capabilities


Subsystem Element	Functionality
<div><ul style="list-style-type: none">Roadside Controller Unit<div></div></div>	<ul style="list-style-type: none">Provide control of the AVI Reader subsystem<ul style="list-style-type: none">Receive Transponder IDs and status information from the ReaderMonitor and resolve multiple reads of a transponder to guarantee a single transaction report per transponderConfigure AVI reader operating modeAccept vehicle detection information from VDACS<ul style="list-style-type: none">Compare data from adjacent VDACS to “stitch” together reports to produce a continuous detection curtain across the full width of the roadwayDetermine direction of travel to enable proper camera trigger timingDetermine the position of the left and right edges of the vehicle from both front and rear gantry VDACSUtilize calculated lateral vehicle position to select the proper cameras for image captureGenerate camera triggers based on front or rear “end of vehicle” detection by the VDACSRecord time of vehicle detection to begin transponder-to-vehicle correlation processingAccept vehicle classification reportsControl supplementary illumination based upon light level information reported by light sensorCorrelate transponder read events to vehicle detection events to properly associate transponder ID, vehicle classification and video data with the proper vehicleObtain OCR service from TIP on downloaded video images<ul style="list-style-type: none">Process images to locate license plate sub-imageDetermine the principal license plate characters for Texas, Oklahoma, Arkansas, Louisiana, and New Mexico platesMake a Texas/not Texas jurisdiction decisionGenerate a character read confidence assessment and an overall license plate read confidence assessmentForward extracted license plate sub-image to RCUReport success or failure on each read attempt based on a settable threshold on read confidenceReport successfully read principal characters and the read confidence values for each plate readEvaluate sensor data against down-loaded Tag Status List to determine whether or not to save video images for the transaction, according to defined rulesFormulate complete transaction reports, save local copy, and prepare to transmit to the TIPProvide 90-day transaction data backup and 24-hour video data backup capabilityCommunicate with primary and redundant TIPs assigned to the IRU site (by IP address)<ul style="list-style-type: none">Transmit transaction reports as availableTransmit status data with each transactionReceive software updates over the WAN connectionReceive Time of Day data from the Host through the PHS-TIP interface
<div><ul style="list-style-type: none">Uninterruptable Power Supply (UPS)Uninterruptible Power Supply (UPS)</div>	<ul style="list-style-type: none">Monitor AC line input voltage levelRectify AC line input voltage to DCMonitor AC line input voltage levelRectify AC line input voltage to DCInvert this DC, or backup battery DC to clean AC powerReport status to the RCUReports status to MOMS (SNMP)

Table 3.1.2-I. ORT System Functional Capabilities




Subsystem Element	Functionality
	
<ul style="list-style-type: none">Emergency Generator 	<ul style="list-style-type: none">Monitor AC line input voltage levelAutomatically start generator and switch to emergency power if input power is interrupted for longer than one minuteAutomatically shut down generator and switch attached equipment back to line power when power is restoredReport status to the RCUReports status to MOMS (SNMP)Propane fueled for clean and utility independent backup powerOperate 1 mainline on 2 ramp IRUs for over 48 hours without refuelingProvides electrical use metering and stepdown transformers from utility power
<ul style="list-style-type: none">Transaction and Image Processor (TIP) 	<ul style="list-style-type: none">Receive transactions from the assigned IRUs (up to four)Receive Toll rate tables from the Host through the PHS-TIP interfaceDetermine proper toll charge based on tables downloaded from the CSC Host and detected vehicle classification, and append toll charge to the transaction dataReceive blacklist/whitelist data from the CSC Host through the PHS-TIP interfaceStore transactions for up to 30 daysProvide an SQL query interface with the Project Host Server (PHS)Send new transaction data to the PHS as they are received and processedProvide OCR processing of video images (option)Provide second-level data correlation based on OCR results and Transponder-Plate number association tables (option)Digitally "sign" all transaction reports (option)Provide 30-day transaction history for annual Audit TestingProvide Web interface

Table 3.1.2-I. ORT System Functional Capabilities



Subsystem Element	Functionality
<div><ul style="list-style-type: none">Maintenance Online Management System (MOMS)</div>	<ul style="list-style-type: none">Receive status data from TIPs, PHS, and roadside tolling equipmentMonitor/report equipment failuresGenerate repair requestsLog status/failure report dataLog repair dataMaintain spares inventory recordsLog component failure dataCalculate maintenance statistics (e.g. repair time, component/system MTBF, system availability, etc.)Track repair items returned to vendor
<div><ul style="list-style-type: none">Project Host Server</div>	<ul style="list-style-type: none">Receive date/time of day data from CSC HostReceive whitelist/blacklist data from CSC HostInput/maintain Toll Rate tables through provided GUI (option)Collect transaction and status/alarm data from all connected TIPsProvide data format and communications protocol transformation for the CSC Host interfaceSupport pass-through communications from the CSC Host to IRUs for the Tag Status FileServe as an NTP Stratum 1 server for distribution of date and time information to all connected tolling devices

Table 3.1.2-II. ORT System Performance Summary

Subsystem Element	Functionality
<div><ul style="list-style-type: none">AVI Reader (includes antennas, RF unit, reader logic card)Vehicle Detector and Classifier (VDAC)</div>	<ul style="list-style-type: none">≥99.99% probability of successful transponder read for properly mounted transpondersProbability of detection, 99.9%Classification accuracy of ≥99% (one of 11 categories)Speed measurement accuracy of ±10%End of vehicle detection resolution, 8.25 msVehicle lateral position resolution, ±4"
<div><ul style="list-style-type: none">Video Image Capture</div>	<ul style="list-style-type: none">Video Image Resolution of 500 x 2000 pixelsCamera Shutter speed of up to 1/2000 secondInstalled Horizontal Camera Field of View of 14 feet
<div><ul style="list-style-type: none">Supplemental Illumination</div>	<ul style="list-style-type: none">Rear image illumination by Ceramic Metal Halide lamps, 10-40 ft-candles at the license plateRear Lamp lifetime of 13,000 hoursFront image illumination by white light LED arraysFront image LED strobe speed of 500 microsecondsLED lamp lifetime of >10 million flashes
<div><ul style="list-style-type: none">(optional) OCR Processing</div>	<ul style="list-style-type: none">License plate read accuracy of 90%Error rate of 0.7%Processing rate of 1.5-2 images per secondReported character confidence of 0-100 plus overall read confidence of 0-100

3.1 Sequence of Operations

The Roadside Controller Unit (RCU) works together with the various sensors and subsystems to capture information on the passage of each vehicle enabling formation of accurate transactions.

The Raytheon Tolling system, refined over several Open Road Tolling (ORT) systems, has demonstrated its capability for processing a wide variety of vehicle travel conditions involving single and multiple vehicles. The sequence and timing of the various detection events is critical to accurately separating legitimate customers from violators, and recording the data necessary to document each transaction type. Accurate and repeatable measurement of vehicle position is critical to correlating transponder read data to the proper vehicle, and to capturing high quality video images of violators. Raytheon's processing approach is to collect all sensor data as the vehicle traverses the toll zone and process that data into transactions after all sensor data and license plate read results are available. Real-time data processing is limited to time-critical events, such as image capture.

Table 3.4.1-I illustrates the sequence of events for three cases of high interest for a vehicle traveling through the tolling zone. Case 1 describes the general sequence of operation where the vehicles are traveling in the proper direction and not on the shoulders. The vehicles may or may not be transponder-equipped, but the same general sequence of events applies. The figure shows a road with only one shoulder for illustrative purposes only.

Case 2 describes the sequence of operation for a driver traveling the wrong way on the road, which could in practice be either in a lane, or on the shoulder, with essentially the same results: a violation report. The only difference is that if the vehicle is in a traffic lane, there will be a transponder read if the vehicle is carrying one; on the shoulder there may be a transponder read.

Case 3 describes the sequence of operation for a vehicle traveling on the shoulder of the road, either right or left shoulder. Our solution to Cintra provides AVI coverage on the shoulder, such that the shoulder can be considered a real lane as in Case 1.

Not illustrated in the figure, but a case of interest is how the system responds in stop-and-go conditions. Although the performance requirements are relaxed for this condition, the system should still continue to generate valid transactions, and not violate transponder customers or produce unpredictable results. This case highlights one of the strong advantages of the overhead laser VDAC. If a vehicle stops under the detection zone, the VDAC continues to monitor the vehicle presence until the vehicle moves on, and the reader continues to monitor the presence of the transponder. The detection of the end of the vehicle (separation) and AVI correlation is as accurate in stop-and-go conditions as it is in free-flow conditions, which is not the case for loop-based systems.

As these transactions arrive at the TIP further consistency checking is performed and optionally OCR is used to read images and determine the plate characters. The completed transaction is then forwarded to the PHS, which forwards it on to the CSC.

Table 3.4.1-1. Sequence of Events for Vehicles Passing Through Tolling Point.

Case 1: General Sequence of Events	Case 2: Wrong-Way Driver	Case 3: Travel on the Shoulder
<p>Event 1. Detection of the front of the vehicle by the VDAC mounted on the first gantry, triggering the front-image camera(s) aligned with the vehicle lateral position. The VDAC measures the lateral position and width to within four inches, permitting accurate camera selection. The number of cameras triggered depends upon both the width of the vehicle and the lateral position of the vehicle relative to the camera fields of view. An interim Video1 transaction is generated and the data is held, pending completion of the passage of the vehicle through the tolling zone. As the vehicle clears the view of the VDAC, a classification report is generated and added to the Video1 interim transaction</p>	<p>Event 1. Detection of either the front of the vehicle by VDAC on gantry 2 or a transponder read (if the vehicle is carrying a transponder), depending on the mounting location of the transponder. If a transponder is detected, an interim AVI transaction is generated, and the transponder continues to be polled. The detection of the vehicle by the VDAC is actually two closely spaced events that allow the system to determine that the vehicle is traveling in the wrong direction. The VDAC generates two scanning laser beams, one vertically, and one at 10 degrees from vertical. In the normal direction of travel, the vehicle is detected first by the 10 degree beam, and second by the vertical (0 degree) beam. If the vehicle is traveling in the reverse direction, the order of these detections is reversed, cueing the system as to direction of travel.</p>	<p>Event 1. The vehicle is first detected by the shoulder VDAC on gantry 1, and the front image camera on the shoulder captures an image of the vehicle. An interim Video 1 transaction is generated and the data is held, pending completion of the passage of the vehicle through the tolling zone. NOTE: DSRC coverage is extended over the shoulder in the proposed solution to Cintra</p>
<p>Event2. The first read of the transponder ID (if present). Depending on the length of the vehicle, the VDAC on gantry 1 may or may not have detected the end of the vehicle and produced a classification report. At this point, if a transponder has been detected, an interim AVI transaction is generated, and transponder polling data is collected as the transponder passes through the communications zone</p>	<p>Event 2. The vehicle enters the 10 degree beam and triggers the proper camera(s) on Gantry 1. These cameras are normally used to capture rear images, but in this case, capture front license plate images.</p>	<p>Event 2. The vehicle clears the detection beams of the VDAC, and a classification report is generated. NOTE: DSRC coverage is extended over the shoulder in the proposed solution to Cintra</p>
<p>Event 3. The front of the vehicle is detected by the VDAC on the second gantry. This is a critical event, as it provides the primary timing data to determine if the interim AVI transaction should be associated with the just-detected vehicle, or if this is a non-transponder vehicle. The third, interim Video2 transaction is generated at this point. Lateral position of the vehicle, measured by the VDAC, is compared to the location of the transponder based on the measurements made by the reader system.</p>	<p>Event 3. Detection of the vehicle, as described above, by the VDAC on Gantry 1. No further actions occur at this time.</p>	<p>Event 3. Vehicle is detected by shoulder VDAC on gantry 2, and an interim Video 2 transaction is generated. The transponder in the vehicle (if present) may be detected. If it is, the transponder ID is included in the transaction report. NOTE: DSRC coverage is extended over the shoulder in the proposed solution to Cintra</p>
<p>Event 4. The VDAC detects the end of the vehicle, and triggers the rear-image camera(s) aligned with the vehicle lateral position, and a classification report is generated and added to the interim Video2 report.</p>	<p>Event 4. The vehicle clears the 10 degree beam and triggers the proper camera(s) on Gantry 2. These cameras are normally used to capture front images, but in this case, capture rear license plate images.</p>	<p>Event 4. The end of the vehicle is detected by the VDAC, and the rear image shoulder camera is triggered. NOTE: DSRC coverage is extended over the shoulder in the proposed solution to Cintra</p>

Case 1: General Sequence of Events	Case 2: Wrong-Way Driver	Case 3: Travel on the Shoulder
<p>Event 5. All data collection is complete and the decision to associated Video1, AVI and Video2 interim transactions is made, based upon time/space rules and OCR results from Video1 and Video2 interim transactions. A single transaction is generated for each vehicle, using the data from Video1, AVI and Video2 interim transactions. The Transaction is then sent to the assigned TIP.</p>	<p>Event 5. As the vehicle clears the tolling zone, the system has all of the data necessary to generate a violation report, with both front and rear images. If a transponder was read, the transponder ID information is included with the violation report, which is forwarded to the assigned TIP.</p>	<p>Event 5. After front and rear video images are correlated, and transaction processing is completed, it is forwarded to the TIP. NOTE: DSRC coverage is extended over the shoulder in the proposed solution to Cintra</p>

3.2 Implementation

Our solution is implemented on new-build and re-build roadway projects. We have integrated with a variety of "back office" systems. Our techniques, developed during past projects, ensure seamless installation on the roadway and trouble-free integration with the CSC.

Implementation of a toll collection system onto new or re-built roadways requires:

- an easy fit onto the roadway
- communications between sites
- integration with a back office
- ability to respond to regulatory changes.

Easy Fit. Our deployment methods decouple roadway construction activities from toll system installation activities, ensuring both activities can occur in parallel and the job can get finished faster.

Our system is designed to easily fit onto existing roadways with minimal disruption, no geometric redesign and little grading. It fits into any highway cross-section, including bridge structures and tunnels.

Because all tolling sensors are mounted on the gantries, we can perform the complete installation and test of a tolling site prior to placement of barriers, final pavement or lane striping. In some cases we can pre-install all equipment, cabling and connectors on the gantry span, lift the span onto its columns and complete the installation behind the barriers. This allows us to install tolling points on operational highways. We can even aim all devices using scopes and laser pointers, such that no one needs to go into the lane to place aiming targets; vehicles continue to freely flow during installation activities. Of course a closed road that permits work above and below simultaneously is far more efficient .

Flexible Communications. Each tolling point needs communications and electrical power. The tolling point has a Local Area Network switch and communicates with the back office via a Wide Area Network (WAN). The baseline WAN technology is Gigabit Ethernet over singlemode fiber optic cable. On the pilot projects, we have deployed a wireless IP network using 802.11a radios, so that dependencies on construction activities are removed from the installation schedule. Even when the permanent WAN utilizes Gigabit Ethernet over fiber, we can temporarily deploy the radios to provide communications during installation and test, further isolating the tolling installation from road construction dependencies.

Electrical power is easier to obtain than communications, but we also provide an implementation workaround for that. Our generator cabinet can run the site indefinitely, as long as a fuel supply is available. Large diesel tanks can be deployed to augment the internal tanks during installation and test activities, ensuring we can move forward even if electrical power will not be available for some time.

Assured Integration. To ensure successful integration with the back office we have included VE Systems on our team to provide the Project Host Server application. This removes integration risks between the project hosts and the CSC, so that TxDOT can be assured of smooth transaction flow for each project. VE Systems and Raytheon have already implemented a host server to roadside toll collection interface on the MnPass program and look forward to expanding that interface to provide all necessary data flows.

During integration and test activities, we use portable Transaction Image Processors (TIP), Project Host Servers (PHS) and CSC simulators to enable end-to-end testing of the tolling point during installation. These are also used during pre-deployment test activities to ensure installed equipment pass the acceptance tests.

During operation, our maintainers can use the portable TIPs as a "sneaker net," which enables transaction flow should network connections along the project be damaged. Likewise our maintainers can use the portable PHS to move transactions to the CSC should TxDOT's project to CSC communications link be damaged.

Regulatory Changes. We recognize the need to respond to regulatory changes and technology changes. For example, on Highway 407 we responded to a major change in license plate design by adjusting the license plate reading software and testing those adjustments prior to deployment.

Another regulatory change of interest to toll collectors is emergence of 5.9 GHz Dedicated Short Range Communications (DSRC), otherwise known as Wireless Applications for Vehicle Environments (WAVE). Soon these 5.9 GHz transponders will be mandated in all new vehicles and will provide means for secure, authenticated and universal revenue collection from vehicles for tolling and many other applications. Raytheon is leading the industry team developing the new DSRC standards. Raytheon looks forward to adding WAVE capabilities to tolling sites to allow simultaneous revenue generation from 5.9 GHz and ATA transponders.

With the advent of Homeland Defense issues, security and safety has become an issue that is aligned to take advantage of traffic information. HTMS is a division within the Homeland Defense organization and is developing synergies between these markets.

3.2 System Performance

The Raytheon ETC System provides accurate and timely processing of each vehicle passage at beyond the maximum expected traffic levels and vehicle arrival rates, as has been demonstrated in several operationally deployed systems.

The system proposed to TxDOT meets or exceeds all performance parameters defined in the System Performance Requirements of the Technical Provisions document, Table 4, as discussed in the following paragraphs.

Two key performance features provided by the Raytheon Open Road Tolling system are:

- The ability to capture and store all of the data required to construct transaction reports accurately reflect tolling related events associated with the vehicle passage
- A processing rate that exceeds the average daily data input rate. This is necessary to prevent the system from falling behind from day to day.

1. Vehicle Detection and Reporting, $\geq 99.8\%$ - Vehicle detection is performed by the VDAC, supplied by Schwartz Electro-Optics. This device was subjected to controlled testing by the Florida Department of Transportation in 1999, with a total of 28,268 vehicles. The results of these tests indicated a vehicle separation performance of 99.98 percent after non-VDAC errors were discounted. Vehicle detection performance was 100%. Field experience on the Toronto H407 and Israel CIH system shows performance levels of very near 100% over a wide range of weather conditions. The VDAC performance excels in stop-and-go conditions, where its performance is essentially unchanged from steady traffic flow conditions. Stop-and-go conditions are the weak performance point in loop-based systems, and where most of the errors occur in these systems.

2. ETC Read Accuracy Success Rate, 99.99% - The performance of the AVI system is controlled in large part by the only supplier of the eGo tag reader, TransCore. Initial integration testing with the Transcore reader and analysis of its link margins are consistent with TP requirements. The performance is also controlled in part by the RF antennas and their alignment. Raytheon is very experienced in the installation and alignment of this type and function of antennas on hundreds of Open Road Tolling sites, all of which have been successfully tested for performance at the same levels specified for the TxDOT system. If performance issues arise with this reader, Raytheon has the necessary technical expertise to work with the supplier to resolve any such issues.

3. ETC Read Accuracy, Incorrect Violation Image Capture of an AVI vehicle, $\leq 0.2\%$ - Testing on both the Toronto H407 system and the Israeli CIH system show best performance levels of correlation of 99.3 to 99.5%. This is considered an excellent rate of correlation of a transponder report to a specific vehicle. To meet the high performance level specified, the system will use internally generated transponder-to-license plate association tables stored in the TIP. Using these tables, uncorrelated transponder reports are compared against uncorrelated video images within a determined time window to find a license plate number that matches that

associated with the transponder ID. This association can be used in the secondary correlation processing in the TIP to reduce improper image capture (violation report) to the required level. If available, the license plate association data could be supplied instead in the Tag Status File from the CSC account database. Bear in mind that this situation is easily corrected at the CSC Host system, where all account information is available.

4. ETC Read Accuracy, Reporting of an AVI vehicle not in the tolling zone, $\leq 0.2\%$ - Raytheon expects to meet this performance level based upon experience in the MinDOT tolling system, where there are free travel lanes directly adjacent to the tolled lanes. Raytheon provided optimized-pattern antennas to address this issue and plans to use these, or similar antennas instead of Transcore supplied antennas to better control out of zone detections. No problems with improper detection have been experienced in this situation in the MinDOT system.

5. Peak ETC Transaction Processing, 2 per second for 15 seconds - Testing of Roadside Controller CPU performance has been conducted under conditions equivalent to maximum traffic flow rates of 2400 vehicles per hour, across a four-lane Open Road Tolling point. This is equivalent to 9600 vehicles per hour. Under these conditions, the Roadside Controller CPU experienced approximately 20% CPU loading. The specified rate of two transactions per second per lane translates to a total of six transactions per second for a three-lane road (21,600 vehicles per hour). This transaction rate would be expected to raise the CPU utilization to approximately 45%, a level still well within the capabilities of the CPU.

6. Peak Hour ETC Transaction Processing, 2400 per hour - Testing of operational Raytheon Open Road Tolling systems (H407, CIH, AVS) has shown that the roadside tolling equipment is capable of sustained processing rates of 2400 vehicles per hour per lane, across a four-lane roadway, (9600 transactions per hour), continuously, with only 20% CPU loading..

7. Image Capture of Human Readable Plate Image, $\geq 98\%$ - Operational experience on both the Toronto H407 and the Israeli CIH system has demonstrated performance levels in the capture of human readable images of greater than 99%.

8. Peak Image Sets Capture per lane, 2 per second - The Pulnix cameras that will be utilized in the TxDOT Open Road Tolling system are capable of capturing an image every 33 millisecond, or 30 images per second, well in excess of the requirement. On-board camera buffer memory of 80 MB will allow storage of approximately 80 images, pending downloading to the RCU versus a worst case buffering requirement in this situation of 10 images. However, the download rate of images to the RCU exceeds the capture rate, so there will typically be no backlog in the cameras.

9. Per Hour VES Transaction Processing Per Lane, 1,000 per hour - The Raytheon TxDOT Open Road Tolling system is designed to collect and store data, and then process. This architecture allows more flexibility in handling uneven loading throughout the day, and lessens the need for real-time processing. The system, as discussed in (5) and (6) above, is capable of keeping up with data capture (including image capture) at beyond the maximum theoretical traffic volume of 2400 vehicles per hour per lane. The VES cameras are interfaced to the RCU via a 100 BaseT Ethernet connection which is more than adequate to keep up in real time with the image capture, even assuming a 100% "violation" rate. Additionally, the cameras have 80 MB of on-board buffer memory to preserve images during short term peak demand periods. For a three-lane roadway, this translates to 7200 vehicles per hour, compared to a requirement of 3,000 (1,000 per hour per lane for three lanes).

10. Correct Vehicle Classification, $\geq 97\%$ - Testing with over 50,000 vehicles of mixed classification and over a wide range of weather conditions in the Florida DOT testing has demonstrated a performance level of 98.6% accuracy in classifying each vehicle into one of eleven categories. The final TxDOT structure of tolling categories, which is expected to result in less than the maximum eleven toll classifications measured by the VDAC, will result in a corresponding increase in the effective performance level compared to that cited above. The VDAC treats passenger vehicles pulling trailers as a single vehicle.

11. Reporting of One Vehicle as Two or More Vehicles, $\leq 0.5\%$ - The resolution of measurement of the start or end of a vehicle is approximately 8.25 milliseconds. A time gap wider than this will result in separate vehicle detection. At a vehicle speed of 60 mph, this corresponds to a vehicle separation of less than one foot. At any conceivable practical vehicle separation, there will be no problem with properly separating vehicles. Splitting a single vehicle into two or more vehicles requires a clear view of the road surface by the VDAC with a time period greater than 8.25 milliseconds. The only practical issue in this regard is with vehicles that are towing small, lightweight trailers with very narrow towbars. The lateral resolution of the VDAC is four inches, and this is the limiting factor in proper detection of the trailer towbar. With large truck/trailer rigs, this is not a problem, as the towbar is wider than four inches. For private vehicles towing lightweight trailers, towbar detection (and thus proper joining of the vehicle and trailer as one report) can be intermittent. Fortunately, this situation exists for only a very small volume of traffic, and Raytheon expects to meet the performance requirement.

12. OCR Success Rate, $\geq 90\%$ - Testing with 20,000 vehicles under live traffic conditions on the Raytheon Open Road Tolling system in Santiago, Chile, had demonstrated a performance level of 90% read rate with capture of vehicle rear images only. With an image of both the front and the rear of each vehicle being captured in the TxDOT system, and successful correlation of both images to a single transaction, two OCR measurements are attempted on each transaction, thus increasing the probability that a successful OCR is reported for the transaction, increasing the system performance level above the 90% level.

13. OCR Reporting Error Rate, $\leq 1\%$ - Testing on the Chile AVS Open Road Tolling system has demonstrated an error rate of 0.75% over a 20,000 vehicle sample.

14. Success Rate Of The Tolling Zone Transaction Records Being Correctly Presented In The Toll System Audit Reports, 99.99% - Transaction reports are archived for 30 days at the TIP to support the annual audit testing. Transaction data is digitally signed to prevent undetected tampering, and the TIP uses a high reliability, error correcting RAID-5 storage system which will all but guarantee 100% availability of valid data when the audit is conducted.

15. Success Rate For The Communications Protocol Used To Guarantee Message Delivery, 99.995% - The TCP/IP over Ethernet communications protocol used has built-in mechanisms to detect a failure to deliver, and to retry transmissions. This is supplemented with an application-layer message acknowledgement system in which all data is retained by the sender until a positive acknowledgement of receipt arrives from the intended receiver. This will guarantee that all messages sent are actually received.

The system automatically logs all transactions locally to hard disk, and generates transaction summary data, organized by transaction type, vehicle class, vehicle count, etc., allowing daily auditing of all transactions generated at the roadside. This data may be downloaded through the network connection, or locally using a maintenance laptop. Main data logging and backup is provided at the TIPs (30-day), and additional backup data logging (24-hour) is provided at the RCU. Transaction security is provided by digitally signing each transaction, using a process similar to a CRC checksum appended to a data message. This effectively prevents undetected tampering with the transaction data. This data signing includes the VES image data to prevent alterations of the video image.

Physical security is provided through fully enclosed steel cabinets with secure locking devices, and door open alarms.

The roadside equipment suite is a flexible modular design. It can be scaled up or down as appropriate to accommodate various road widths and lane counts. Additional cameras and VDACS can be added and interfaced to additional I/O cards in the Lane Controller, and software configuration tables are reset to allow the Lane Controller to recognize, and properly control the added hardware resources. Configuration tables are set through a connected laptop maintenance computer, or (more normally) prior to installation in the depot or manufacturer's facility, based on the lane configuration. Replacement Lane Controllers are also configured prior to installation.

Software updates to correct discovered problems, provide additional capability, or improve existing capability can be performed remotely through the network connection from the central maintenance location, or from any point with a workstation, internet access, and appropriate application software and passwords. As an example of the power of this capability, downloading new RCU software to the 193 sites on the H407 system can be accomplished from a remote location in less than 30 minutes.

By design, the ease of replacement of failed hardware elements is proportional to the difficulty of access to the failed element. Gantry mounted hardware elements, where access is more difficult, have mounting designs which support quick disconnect and dismount, and easy replacement, generally without the need for any re-alignment or adjustments. Where an element by itself is not designed for quick replacement, specialized mounting adapters are provided. Quick, no-alignment replacements minimize repair time and system down-time, thus reducing life-cycle costs. A good example of how Raytheon designs for low maintenance costs is the video camera enclosure. Raytheon has developed a (patent pending) custom enclosure which is precisely keyed to the aligned gantry mounting structure, allowing alignment-free replacement. Further, the enclosure is specially designed to reduce the build-up of airborne contaminants by 90% over standard commercial camera enclosures, thus significantly reducing preventative maintenance actions for lens cleaning. This has been verified in harsh winter conditions in Toronto on the H407 system.

3.3 Design for High Availability

Raytheon's Highway 407 ETC equipment has been in full operation since 1996. This system has grown to over 193 sites with a critical system availability of 99.99% as measured monthly from MOMS alarm data.

Much of the equipment deployed on Highway 407 (except for the DSRC) is nearly identical to the equipment proposed for this project. We are confident that our system will exceed TxDOT availability needs.

Raytheon has extensive experience in Reliability, Maintainability, and Availability (RMA) engineering. Our RMA teams regularly perform RMS analysis on all projects within Raytheon, many of which are mission critical (potential loss of life) systems requiring the highest levels of RMA.

Table 3.4.4-I presents the calculated functional availabilities for several tolling zone configurations.

Table 3.4.4-I. Functional Availability.

Functional Availability Group	Requirement (%)	Estimated Availability (%)		
		1 Lane	2 Lanes	3 Lanes
Group A: Performance Requirements- Vehicle detection, ETC tag read capability and transaction processing	≥99.96	99.982	99.972	99.964
Group B: Performance Requirements- Video image capture capability	≥99.50	99.997	99.997	99.997
Group C- Automatic Vehicle Classification (AVC) capability	≥98.00	99.999	99.999	99.999
Group D- OCR	≥96.00	99.999	99.999	99.999

Availability Determination. Operational Availability (Ao) is a ratio of “up time” to “total run time.” The total run time is the sum of the “up time” and “down time.” The average “up time” is defined as the Mean Time Between Failures (MTBF), while the average “down time” is the Mean Down Time (MDT).

MTBF is a measure of the Reliability of the system and MDT is a measure of the system’s Maintainability.

TxDOT Component Reliability. Raytheon considers the reliability of components as a key requirement for selection. Vendor reliability data is compared to field data by Raytheon RMA personnel to ensure the data is reasonable.

The majority of components to be used in the TxDOT ORT design have been used in many delivered systems. These systems have been subject to Raytheon’s standard Failure Reporting and Corrective Action System (FRACAS). FRACAS records key metrics for anomalies in deployed hardware for thousands of Raytheon systems worldwide. The anomalies are investigated and characterized for root cause. Those attributed to hardware failure contribute to that component’s observed MTBF. FRACAS is used to achieve better reliability estimates for components.

Mean Time Between Failures (MTBF). Table 3.4.4-II shows the Mean Time Between Failures (MTBF) for each Field Replaceable Unit (FRU) in a Tolling Zone. MTBF values are either actual values experienced in our operational ORT systems or values based on manufacturer’s MTBF data.

Table 3.4.4-II. Demonstrated FRU MTTR and MTBF.

Field Replaceable Unit (FRU)	MTTR (Minutes)	MTBF (Hours)
RCU	19	57,200
Light Sensor	21	65,600
Camera	22	26,000
Light Unit	20	500,000
VDAC	19	49,600
TIP	17	100,000
DSRC (*)	25	35,200
UPS	15	350,000

(*) Raytheon’s mounting and connector improvements to Antennas and RF modules allow an 8-minute R&R Time. The remaining time is for troubleshooting, Gantry access and repair verification.

System Redundancies. Numerous reliability enhancing features have been incorporated into our Tolling Zone, PHS, and MOMS architectures.

- Vehicle Detection Redundancy – Vehicle detection equipment is located on both the leading and trailing gantries. Both operate continuously and independently. In addition, overhead detection systems are much more reliable than their in-ground counterparts, and maintenance does not require roadwork or road closure
- Transaction and Image Processing Redundancy – In the event of a failure of a TIP, all transaction and image data is automatically redirected to a secondary TIP (located anywhere on the network) to continue transaction processing, OCR processing, and communications with the Project Host Server. This architecture allows virtually 100% functional availability of OCR capabilities (optionally provided)
- Video Processing Capability – In the event of a failure of a DSRC component, the system operates in 100% Video Transaction Mode to ensure full revenue collection. In addition, with the appropriate license plate to transponder ID customer information, the tolling zone controller can produce “implied” AVI transactions from the license number when a transponder is mis-read.

- Redundant Image Capture – Independent camera systems capture both front and rear images of detected vehicles providing multiple identification opportunities by performing independent OCRs on both front and rear license plates. This improves the reliability of the system, and false (error) OCR reads
- Project Host Servers - The PHS has a separate local disk, CPU with RAM, power supply, and network interface card. The PHS is configured with a RAID controller to provide mirrored databases. If necessary the configuration can be configured with a warm standby machine and utilize a Network Attached Storage (NAS) solution for data.
- MOMS Server – The MOMS Server consists of a dual node cluster architecture. Each MOMS node has a separate local disk, CPU with RAM, power supply, and network interface card (NIC). In the event of a node failure, the redundant node is completely and seamlessly switched by the Microsoft Server Operating System.

Built-In-Test. Devices in the Tolling Zone system are capable of performing built-in-tests (BIT) automatically and periodically. These tests include, but are not limited to, memory tests, disk tests, communications tests, database integrity checks and software integrity tests. The Tolling Zone System takes BIT tests one step further by automatically running key performance tests. These performance tests allow our system to sense when a device is degrading but not completely broken, resulting in detection of some problems before failure. When performance levels fall below defined acceptable limits, the system outputs a fault report indicating the particular performance degradation. A simple example of this technology is detecting low correlation accuracy rates.

Typically, DSRCs degrades in performance over time. When the AVI-Vehicle correlation rate performance falls below an expected minimum performance level, the RCU sends an alarm to the MOMS indicating this degradation, allowing replacement of equipment before the devices become non-operational. This capability supports achievement of superior availability .

When a fault is detected anywhere in the Tolling Zone system, the fault is sent to the MOMS system where maintenance personnel can be immediately dispatched to rectify the problem. In almost all cases, the Tolling Zone controller can fault isolate to the Field Replaceable Unit (FRU).

The MOMS provides alerts, cautions, and warnings based on failed BIT. Based on alarms that indicate when devices are “operational” versus “non-operational,” the MOMS can easily calculate the functional availability of tolling zones. The MOMS also provides an interface to the Roadside Controller Unit which provides remote, real time diagnostics for fault isolation.

Remote Diagnostics. The Roadside Controller Unit (RCU) is the primary device in which remote diagnostics are executed. All that is needed is a standard PC (laptop or desktop) and a standard telnet connection. This diagnostic software can either be run locally at the RCU or remotely across the network (including a Virtual Private Network). One of the most notable features of the Tolling Zone diagnostics capability is that all testing can be done with the system running “on-line,” and collecting tolls.

Local Diagnostics. Raytheon uses a signal termination panel for easy access to tolling zone equipment status and interconnections. This panel contains various LEDs showing the operational state of devices, blown fuse indicators, centralized connectivity points between the gantry equipment and IRU equipment, and access for a maintenance laptop connection for local service and diagnostics. Terminal strips provide a means for maintainers to measure key voltages without interrupting the circuit. Pluggable connectors allow maintainers to connect test devices for fault isolation.

Fault detection/isolation times vary from device to device. However, on average, most faults are automatically detected and isolated within five minutes of failure.

Rapid Removal and Replacement (R&R) R&R times are met through a design containing modular components with pre-aligned mounting adapters and a minimum set of electrical connections that provide the capability to efficiently replace failed equipment. The R&R times used in the availability analysis for TxDOT were validated in customer Maintainability demonstrations performed for both the AVS program and the Cross Israel Highway Program.

Logistics Delay. Every component in Raytheon’s system can be replaced without interrupting traffic flow, eliminating a major source of logistics delay. The gantry will be safe for the above ground maintenance personnel as well as the traffic passing below.

For the pilot programs, maintenance personnel will be located within short travel times to the gantry. Raytheon and our teammates have sites throughout Texas from which to base maintenance teams.

Best Value. The ultimate objective of the TxDOT toll road system is to ensure effective and efficient revenue collection for the state of Texas. After the Pilot Project, Raytheon can optimize the number of spares and maintenance personnel against the loss of toll receipts to optimize revenue and operational costs. In addition, MOMS allows us to reduce our maintenance costs by providing a flexible level of response based on the priority of the repair.

3.4 Environmental Issues

Raytheon's tolling system has been proven in the cold extremes of Canada, the desert extremes of Israel and the urban environment of Santiago, Chile.

Raytheon’s tolling systems operate in the environments shown in **Figure 3.4.5-1** and listed in Table 3 of the Technical Provisions (Section 4.1.5). In addition, we meet the wind and ice loading requirements of Texas Standard Plan WZ&IZ-96, as shown in Appendix B.



Figure 3.4.5-1. Extreme Environments. *The survivability of Raytheon’s roadside cabinet and gantry equipment has been proven in the harsh conditions of Canada and Israel.*

Our system operates in these extremes because we considered climatic compatibility from the start. For example:

- The IRU is air conditioned to control humidity and provide cool temperatures, which enhances system life and reliability (Refer to Section 3.4.4)
- The IRU can operate indefinitely as a ventilated enclosure. We provide an Emergency Ventilation System that activates if IRU temperatures exceed a set level
- Gantry-mounted items are designed for hot, sunny climates and cold, windy climates. Temperatures inside gantry-mounted items are limited to 130 F (55C) by sun shields, white paint and cooling fins
- Gantry-mounted items are sealed against moisture ingress
- Gantry-mounted items are heated to prevent accumulation of ice or condensation.

Another component of environmental suitability is the electromagnetic environment. Raytheon’s experience in all parts of the electromagnetic spectrum was applied to this design from the start. For example:

- We use a full on-line UPS that rectifies incoming power to DC and inverts clean AC power from the DC, isolating all input power noise from the system

- We double-shield all cables with a braid for lightning protection and an inner foil for Radio Frequency Interference (RFI) protection
- We ground both ends of shields to eliminate lightning-induced potentials across conductors inside the shields
- Wide area communications are via interference-immune fiber optics or carefully engineered wireless links that use narrow beam antennas and sight lines over the project right of way to eliminate outside interference.

These design features have allowed us to successfully operate tolling points directly below 500 KV power lines, within 50 meters of cell-phone towers, within 1000 meters of train yards and within 2000 meters of major airports. Our development and test site in Fullerton, California is collocated with military radars and communications systems, allowing us to test for compatibility with other systems using similar frequencies.

3.5` System Mechanical Design

Raytheon's mature tolling system design utilizes common mounting and cabling methods to interface between the equipment gantries, overhead sensors and the Integrated Roadside Unit.

The key to building a reliable tolling system is attention to the hardware design details: cabling, mounting, security, diagnostics and environment control. Technical Provisions Section 4.1.1 lists several general hardware requirements. Raytheon's system meets or exceeds these requirements, as detailed below.

Circuit Protection. The signal termination board and power distribution unit shown in **Figure 3.4.6-1** provide overcurrent protection.

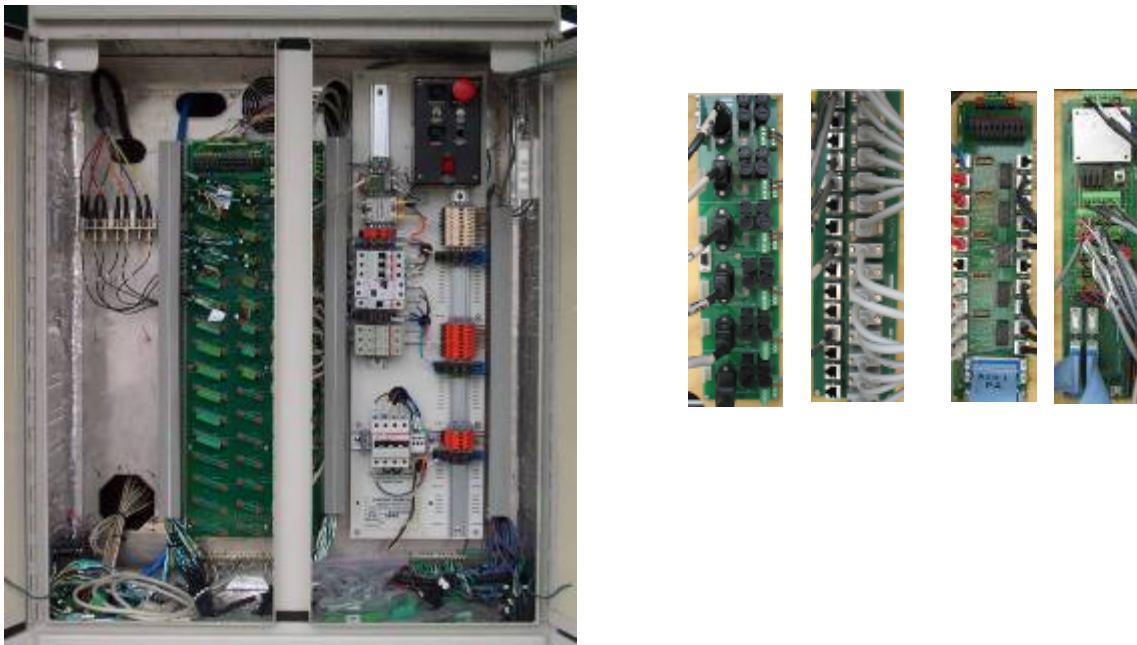


Figure 3.4.6-1 Signal Termination Board and Power Distribution Unit. All cables entering the IRU cabinet terminate in this compartment, which provides overcurrent protection and diagnostic indicators.

Each current-carrying cable is protected from overcurrent and overvoltage. Devices receiving 120 VAC are protected by circuit breakers or fuses. All fuses have a neon or LED indicator.

System Life. Our system uses substantially similar technology and equipment as have been used on Highway 407 since 1996, demonstrating a nine year life, to date. Changes in technologies and improvement to design made since 1996 improve the system life even further. We are confident that a 10 year system life will be exceeded.

New Equipment. All equipment is new.

Housings and Cabinets. Enclosures and cabinets provide physical protection, corrosion resistance and moisture management. All enclosures and cabinets are either painted stainless steel or aluminum, to resist corrosion. All gantry-mounted housings are sealed against moisture and include desiccants and/or heaters to keep the moisture that inevitably enters any space from condensing and affecting device operation. The IRU cabinet (**Figure 3.4.6-2**) is air conditioned and has a backup ventilation system in case of air conditioner failure.



Figure 3.4.6-2 Integrated Roadside Unit. *This small cabinet provides an environmentally-conditioned home for all tolling point cable termination, processing and communications equipment.*

Modular Design. Each FRU is aligned and ready to install without adjustment, by setting the IP address or other minimal configuration settings.

Accessibility. We achieve low MTTR times by making each item accessible and easily replaceable. We use captive hardware and twist-lock connections to ensure safe, fast replacement of gantry-mounted items.

Hardware. All mounting hardware is stainless steel or galvanized steel. Locking provisions are always provided in the form of lock nuts or washers. Raytheon's installation procedures require that each threaded item be tightened with a torque wrench to ensure nothing comes loose and hardware is not overstressed.

Fabrication. Raytheon's enclosure designs provide a neat, sealed exterior appearance, with smooth corners, and no protruding gaskets.

Environment. We use only corrosion resistant materials for all parts exposed to the weather. Paint is provided for cosmetic and temperature control purposes only.

Applicable Codes and Standards. Our products are either UL listed, CSA listed or built in accordance with the National Electric Code. We adhere to OSHA requirements for service access. The remaining codes listed in the Technical Provisions are followed as applicable.

Security. Enclosure doors are locked and have sensors to alert the MOMS when the doors are opened. Gantry-mounted equipment is continuously monitored, so that removal will alert the MOMS. Computers access is controlled by user name and passwords.



Figure 3.4.6-3 Camera Assembly. *The Raytheon Camera Assembly is designed for toll collection image capture. All other gantry-mounted equipment uses a similar mounting and cabling design with captive screws and environmental connectors.*

3.6 Maintenance and On-line Monitoring

Our MOMS integrates highly automated standards-based tools to provide rich functionality and accurate performance statistics supporting cost-effective maintenance.

To guarantee we meet our service level agreements, Raytheon has developed a robust MOMS solution that combines failure detection and reporting, inventory/spare parts control, and availability tracking. It features full help desk support, but is also easily accessible with a simple browser interface for service technicians. Based on industry standards for the management of hardware and software resources from a central location, our MOMS fully complies with the Simple Networking Management Protocol (SNMP) and provides a flexible, powerful, easy-to-use solution. **Figure 3.4.7-1** provides a pictorial overview of the features of the MOMS. MOMS data can be accessed remotely by TxDOT or other appropriately authorized users. This access can be controlled on a project-by-project basis.

Monitoring. The SNMP management model employs two basic entities: a Manager and an Agent. The Manager is the console through which the administrator performs management functions. Agents are the entities that interface to the actual device being managed. These objects are arranged in what is known as a virtual information database called a management information base (MIB). The MIB's collection of information is organized hierarchically, and in the case of the Raytheon Toll Zone Controller, our MIB includes all ancillary devices such the cameras, classifiers, readers, antennas and even the gantry lights.

Simple and extensible, SNMP allows us to easily add management functions to our existing products. The Raytheon MOMS solution is based on an off-the-shelf network monitor and the Intuit Track-It software, combined to provide a centralized monitoring tool.

The Raytheon SNMP Monitoring solution monitors MIB objects for threshold violations and faults so that alerts can be generated where necessary. Additionally, each trap that is captured through the MOMS will have its own type of monitoring profile automatically defined.

The monitoring profile dictates how SNMP traps should be processed before they arrive in the MOMS system, SNMP event messages can be restructured, event counts, alert thresholds, and alert severity can also be defined. This allows any maintenance service provider or operator to define two different levels functionality. One at the monitored component level and secondly at the MOMS level.

To support TxDOT (or a Regional Management Authority), we collaborate to identify the specific business rules or customization of those rules required. This ensures the MOMS system is tailored to the specific implementation and the tolling policy and business rules related to that implementation. This Business Rules Approach is beneficial for implementing best-practice business process flows that reduce errors and time to delivery and enable workforce optimization. In this way, we achieve optimal flexibility, and can adapt MOMS business rules and tolling policy to changing business realities.

For example, we can monitor a tolling zone for the percentage of video-only transactions, and if the level rises above a threshold send an alert to MOMS to notify the maintenance crews that a potential problem exists. After the trap is defined and the alert received at the MOMS, the system automatically generates and assigns a Work Order.

Help Desk and Work Orders. The Work Order is central to our MOM System and the Help Desk environment. Work Orders usually come in the form of problems, requests, questions, planned work, and unplanned work. Problems are typically interruptions in service caused by faulty hardware or software, or procedural errors. Requests are asking for help desk services such as ordering consumables, installing new equipment, logistics support and so on. Questions are queries about how to perform specific technical tasks. Planned work may include routine scheduled maintenance, while unplanned work may include installing firmware patches. All work orders have predefined parameters that include type, subtypes, classifications and priorities (I.e. type is hardware or software, subtype is the actual component, classification is whether scheduled or unscheduled or manually created, and the priority can be high, medium, or low). Further configuration allows definitions of default response times, notification times and Service Level Agreement (SLA) overrides. For example a fault from a camera component can be structured to generate a work order with a default response time of 10 minutes, requiring the technician to be notified immediately, and this work order will override normal hours of operation. Using this example, a technician can be automatically notified at 2:00 AM on Saturday if a camera goes non-operational regardless of other pre-set rules.

Notification is also configurable for each service technician. Profiles are used to determine when technicians will be notified and by what mechanism. The system can send e-mail, pager messages, and Short Message Service (SMS) messages to technicians when work orders are assigned, overdue or escalated; it sends e-mail to different end-users when work orders are completed; it can monitor an incoming mailbox, and can automatically create work orders from e-mail received from other end-users. This flexibility provides a robust work order system, though opening, investigation, solution and closure.

Inventory. Integrated into the Work Order is the Inventory module of the MOM System. All work orders are created against an Inventory component of the system. This can be a tolling zone or any component located at that tolling zone. Through this methodology we are able to track the life of any device, from installation, repair, upgrade through end-of-life. Inventory knowledge allows us to maintain a steady supply of all parts, including consumables such as filters, light bulbs, fuses and surge-suppressors.

The inventory also provides details such as vendor names, suppliers, and maintenance contract specifics. To safeguard SLAs, we keep informed about the following attributes of each asset:

- What it is
- Where it is at any point in time
- Where it has been

- When it was serviced
- When it was last serviced
- Warranty period
- Pricing
- Expected End Of Life
- How it is changing over time

Users can generate reports that list every asset, along with service tags and other details. The reports can be filtered to support maintenance activities, planning, and management reporting. The Inventory module provides an effective way to manage all inventory assets. It provides a clear picture of the toll collection system's distributed assets.

Purchasing. Tied to the inventory is the Purchasing module that allows us to keep complete control of the inventory system. If a service technician were to find a component no longer serviceable, he can open a purchase order. The purchase order will be routed for management approval, after which the vendor is notified, the new component is received and entered into inventory (or escalated because the order is overdue). From there it is assigned to the active spares list or is assigned to a tolling zone location. Reports showing the status of Purchase Orders allow for easy follow-ups to ensure that materials continue to flow and do not jeopardize system availability.

Library Services. Completing the MOM System is a Library feature to the system. The Library module is a repository for resources, such as specialized hardware, software, equipment, books, and training materials. The Library module organizes the process of distributing information and leverages our experience and knowledge. It organizes that knowledge in such way to allow users to get the right answers the first time, every time. This encourages knowledge sharing and re-use and enables less experienced staff to use complex knowledge (of senior staff).

With the Library module, remote service technicians can easily look-up procedures for quick on-site help or research a component service manual. The Library also can follow resources so they are available for reserve, check out, and or use at an appointed time. When a user checks out an item, it is distinguished from similar assets. Specialized tools or other assets can be properly tracked. For example, the Library may include several maintenance laptops of the same model type from the same manufacturer that are used by a rotating staff. The Library shows who has what asset, how long they have had it, and when it will be returned.

Reporting. The MOMS allows the user to choose from dozens of predefined reports or to develop customized reports as required. The predefined reports are populated by the database and formatted using a Crystal Reports 9.0 interface. Through the reporting module, users can view and print reports or report sections. Additionally, from any of the previously discussed modules, users can access relevant, predefined reports that cover every piece of information required.

Summary. MOMS provides extensive monitoring and diagnostic capabilities, including displaying system and component status, alerting operations staff to significant events, providing diagnostic aids, and supporting analysis of maintenance trends. The configurable, scalable design supports efficient system expansion and evolution of tolling policy and business rules. The MOMS can be configured to monitor a single tolling location or can be scaled to monitor numerous geographically diverse tolling zone locations. Similar configurations are successfully deployed in Canada, Israel and select portions are now in use in Minnesota.

3.7 Site Design Approach

The tolling site design meets or exceeds all roadside safety requirements, minimizes impact on the roadway, adapts to any road geometry and provides a suitable platform for the Electronic Toll Collection devices and processors.

A tolling site includes gantries, barriers, foundations, equipment cabinets, buried conduits, backup power, signage and maintenance access. Appendix B provides detailed drawings of these site elements.

Standard Gantries. Raytheon's tolling system includes two gantries that span any roadway design and support the toll collection devices. The gantry design uses the Texas standard sign support with maintenance walkways. A similar gantry is shown in **Figure 3.4.8-1**.

The gantries accommodate roadway design features such as flexible or rigid pavement, grades, crowns, super elevations, horizontal curves, and vertical curves. In all circumstances, the gantry designs comply with highway design standards, and ensure full and safe access to maintenance crews to every element hanging from the gantries.

Barriers. Gantry columns are roadside hazards which must be protected by an approved barrier. Barriers are installed wherever warranted by roadside safety design standards. We work with the road builder to position tolling points along the roadway such that gantry columns are protected by barriers warranted for other reasons. Texas standard Metal Beam Guard Rail (MBGR) is proposed, with non-deflecting barriers used where roadway geometries dictate.

Foundations. All gantry foundations are designed in accordance with applicable structural standards. Wind, seismic, and other natural forces are considered in the gantry foundation design. Cast In Drilled Hole (CIDH) caissons minimize the foundation area and provide excellent overturning resistance in any soil type. The roadside cabinet foundations are designed in accordance with all applicable standards.

Housings and Other Buildings. The Integrated Roadside Unit (IRU) serves as a shelter for the tolling zone processors. Generator Cabinets are provided to power one mainline or two tolled ramp sites. These cabinets minimize space requirements and visual impact. They are placed between the gantries, in space naturally protected by the gantry barriers. These small cabinets eliminate the need for space-consuming buildings (pill boxes).

Conduit. All tolling sites utilize standard buried rigid steel or PVC conduit. The conduits are compliant with all requirements of the district in which the conduit is used. Because we place the cabinets between the toll gantries, conduit runs are minimized.

Power Distribution and Power Systems. An 8 kilowatt power drop is provided for each Generator Cabinet (GC). When power is available from roadway lighting or signal panels, we connect to those, subject to coordination and approval of the road builder. Our GC includes electrical power meters to record the amount of power utilized. When new power drops are necessary, we bury a conduit to the nearest utility line and obtain a power drop from the utility company. The GC includes full network monitoring and control, automatic start/transfer controls and fuel storage, including fuel leak detection, safety shutdown and fire suppression. GFI circuits and proper grounding is done to ensure a safe working environment. All power cable terminations are made in accordance with the latest electrical standards.



Figure 3.4.8-1 Standard Gantry. The standard Truss structure simply and adequately supports tolling zone equipment.

Pavement Requirements and Modifications. We fit onto any pavement type and marking scheme. No equipment is mounted in the pavement. No modifications to pavement are needed. Because our system monitors shoulder traffic with the same precision as lane traffic, it is not necessary to prevent driving on shoulders in the tolling zone. Likewise, because we monitor reverse traffic flow as well as normal traffic flow, we can even allow passing in the tolling zone

Service Vehicle and Equipment Access. Integrated walkways are provided to access gantry-mounted equipment. Walkways are constructed as elevated work platforms or include fall restraint systems in accordance with OSHA fall-prevention standards. The walkway allows for maintenance above live traffic, thus eliminating the need for lane closures and their associated impact on traffic flow and safety.

Access to the walkway is through the maintenance area incorporated into the toll site design. Typically, the maintenance access area is approached through a vehicle pull-off area downstream of the protective barriers, or when available, via the frontage roads.

3.10 Computer Systems

Raytheon's Tolling system is a 4th generation system that is highly reliable, easily expandable, contains proven hardware and software, and utilizes state-of-the-art computer systems for superior performance.

Computer Systems. Raytheon Tolling System computers are the Roadside Controller Unit (RCU), the Transaction and Image Processor (TIP), Project Host Server (PHS), and the Maintenance On-Line Management System (MOMS). **Table 3.6-I** shows general specifications for each. The RCU and TIP are located inside the IRU cabinets at the roadside and the PHS is located at the CSC.

Roadside Controller Unit (RCU). The RCU operates with QNX4 which is a commercial real-time operating system. QNX is also a POSIX compliant system and the RCU application software conforms to this specification. POSIX compliance facilitates software portability. The RCU application is proprietary and was developed by

Raytheon. The RCU is at the heart of the roadside systems and is responsible for communicating and controlling all devices at the roadside.

When communications paths are operating, all transaction data is pushed in real-time to the TIP via Ethernet utilizing TCP/IP. Any image data associated with a transaction is transferred in raw image format via File Transfer Protocol (FTP). In the event of a communication loss between the RCU and the TIP, the RCU automatically redirect all transaction data/image data to an alternate, preconfigured TIP.

Table 3.6-I. Major Computer Components Specifications

Specification	RCU	TIP	PHS	MOMS
Maker	Raytheon	Dell	Dell	HP
Model	512	PowerEdge 2850	PowerEdge 2850	DL385 (Dual Nodes)
CPU Speed	1.3 GHz	Dual Xeon 3 GHz	Xeon 3 GHz	Per Node: 2.4 GHz
Memory	128 MB	2 GB	2 GB	Per Node: 2 GB
Disk Capacities	120 GB	Raid 1,5 6 – 300 GB disks (1.8 Terrabytes)	Raid 1 2 – 146 GB disks (mirrored disks) External NAS (TBD)	Per Node: 146 GB Common: Raid 5 5 – 146 GB disks
Operating System	QNX	Microsoft Server 2003 Standard edition	Red Hat Linux	Microsoft Server 2003 Enterprise edition
COTS	N/A	IIS Microsoft Message Queue SQL Server 2000	IIS DB2	IIS Microsoft Message Queue SQL Server 2000
Application Language	C	C Sharp	TBD	COTS
Transaction Data Capacity	7 days or 500,000 transactions 100,000,000 Tag List	90 days or 6,000,000 transactions/RCU	6 months transaction data 5 year summary data	N/A
Video Image Storage Capacity	7 days or 125,000 image sets	30 days or 500,000 image sets/RCU	30 days	N/A
Alarm Capacity	200,000 alarms	N/A	N/A	1 year or 520,000 alarms/ RCU
Networking	10/100 Base T	10/100/1K NIC PCI Express	10/100/1K NIC PCI Express	Per Node: 10/100/1K NIC
Licenses Provided	QNX License RCU License	Windows 2003 Server License Microsoft SQL Server 2000 License TIP Application License	Linux License DB2 License PHS Application License	Windows 2003 Server License Microsoft SQL Server 2000 License What's Up License Track It License

If an alternate TIP is not available, the RCU spools transaction data to its local disk. The RCU utilizes a flat file system for the storage of transaction data and automatically “unspools” transaction data when communications are restored. The RCU contains disk capacities to store 7 days of data. With redundant TIP capabilities, this is more than adequate storage.

Transaction and Image Processor (TIP). The TIP operates with Windows Server 2003 Standard Edition which is a commercial operating system. The TIP application is proprietary and was developed by Raytheon. The TIP is capable of connecting to up to 4 RCUs. The TIP is capable of storing all transaction data in a Microsoft SQL Server relational database for 90 days. Video Image data is stored as lossless jpeg images in a normal windows file directory structure for 30 days. The TIP utilizes a RAID 1,5 architecture for the most efficient handling of transaction data. The RAID 1 disk stores all transaction log data. This is the data repository just prior to storing it in the SQL database (on the RAID 5 disk). The RAID 1 disk provides data mirroring in the event of file corruption. The RAID 5 architecture provides data integrity such that any single disk error will not cause any lost of data. Furthermore, RAID 5 allows for hot swappable disks and automatic regeneration of disk data.

The TIP also performs OCR at a rate of 2 OCRs per second. The OCR engine is a software only function and is proprietary.

The TIP also provides a Web interface to allow real-time viewing of transaction/image data. In addition, the TIP has the capability to send all transaction/image data to an additional secondary path. Thus, if a second string of central system equipment is available, this allows a new version of central system software to be tested with a live data stream (simultaneously with the normal path of data).

Project Host Server (PHS). The PHS connects all TIPs for a given project to the CSC. The hardware architecture is similar to the TIP. However, this system is composed of two separate and identical computers, one active and one in hot standby mode. In the event of a failure of the active computer, the hot standby will seamlessly cut over and assume control to the CSC. This system runs under the Red Hat Linux OS and utilizes DB2 for all database services.

To minimize the movement and storage of image data, the Network Attached Storage (NAS) device is connected to the dual PHS units for common access.

The PHS can be located at the CSC or at any location desirable by TxDOT. Configuration can be a Tower or rack mount as desired.

Maintenance On-Line Management System (MOMS). The MOMS hardware provides two reliability enhancing features: 1) A RAID 5 hot swappable disk architecture for all database storage. This ensures a high data integrity and prevents against loss of data with any single disk failure, and 2) A dual-node Microsoft cluster configuration. This feature encompasses two hardware nodes, each with their own CPU, memory, local disk, power supplies, and NIC. In addition, a common RAID 5 storage architecture is utilized for database storage. In the event of any node failure, the redundant node automatically takes control in a completely seamless fashion. These combined features are necessary, as the MOMS availability must be virtually 100%, so that alarms detected throughout the system can be rapidly reported.

From a software perspective, MOMS is primarily composed of two COTS software packages: 1) “What’s Up,” a highly configurable package which allows SNMP connectivity to all devices throughout the ORT system. As these alarms are received, this information is stored in an SQL database. In addition, this COTS package provides an email server. For each alarm received, the program can be configured to send an email message with all desired alarm data. 2) The software package “Track It,” that is capable of receiving these email messages, automatically generating trouble tickets, dispatching maintenance personnel, and providing full inventory management.

Backup Capabilities. Primary backup capabilities for all transaction and image data reside in the TIP. In previous systems, at the customer's request, the TIP performed incremental backups of transaction data to a predefined central system location. It is important to note here that the TxDOT TIP utilizes a RAID 5 architecture for the database and image storage. This architecture uses an array of striped and mirrored disks which are hot swappable. In the rare event of a disk loss, a disk can be swapped in minutes and all data loss is automatically recovered when the new disk is automatically rebuilt by the operating system. Using this architecture, the usefulness of off-site backups is diminished.

The MOMS is capable of backing up its database to an external DVD R/W device. This allows indefinite backup of all MOMS data (alarms, inventory, etc.).

Finally, the PHS has multiple forms of backup. For all transaction and toll rate data, the SQL database is continually mirrored onto the redundant, hot standby PHS server disk. In addition, transaction data and image data on the NAS device can be backed up to an external DVD array on a daily basis to archive data for as long as desired.

User Interfaces. As mentioned in previous sections, all maintenance to the Tolling Zone equipment is done through the RCU. This interface is done via Ethernet and can be done locally at the site or remotely from any location in the world (assuming proper VPN access controls). The maintenance software is located completely in the RCU. As a result, the maintenance computer needs only the standard telnet application or equivalent.

The MOMS automatically obtains operational status and event information for all critical ETC hardware and software components. It continuously monitors and displays the health of critical equipment, enabling the operator to know immediately when a failure occurs, allowing rapid dispatch of maintenance personnel. This minimizes any outages, maximizing revenue collection.

Our MOMS allows multiple operators from multiple locations to view status and events from entire system in user-friendly and comprehensive displays. Views can be tailored to accommodate specialized maintenance roles.

Auditing of all transaction data can be accomplished via the Web Service connected to the TIP or through the PHS. The user can specify the data/time range of interest in creating an auditing report.

Lastly, the PHS provides a Graphical User Interface (GUI) to support the building and maintenance of the desired toll rate tables and generation of audit reports for a given project. This interface will be customized to meet TxDOT's business rules for toll collection.

Connectivity/transfer methods. From a physical perspective, all connections between the RCU, TIP, PHS, MOMS and CSC are accomplished via Ethernet. The TIP/PHS/MOMS contain 10/100/1000 NICs that support a multitude of protocols including internet protocol (IP). At the next highest layer, the TIP utilizes the standard Microsoft Message Queues which creates a very simplistic, standard COTS approach to retrieving/sending data. All transaction data and image data is sent to the PHS in this fashion. Finally, all transaction data and image data is sent to the CSC in files via FTP as specified in the PHS to CSC ICD. All alarm/status data is sent to the MOMS via SNMP.

3.11 Communications System

Raytheon interconnects the tolling zones using IP communications across a Gigabit Ethernet backbone, with supplementary IP communication methods used where fiber optic cables are not available or feasible.

Each tolling point includes a Cisco 2800 Series Router (**Figure 3.7-1**) to provide a Local Area Network (LAN) for tolling equipment. Ramp tolling points are usually placed in pairs and are interconnected using

100-Base-F media converters and multimode fiber cables run in conduit between the two ramp locations to form one LAN across two tolling points. Precise configuration of the network is a design task that includes analysis of the physical plant, structure or topology of the physical plant, and desired redundancy using multi path, redundant path and rings



Figure 3.7-1. Cisco 2800 Series Router and switch ports. *The Cisco Catalyst 2800 Series Router combines high-level security along side easily manageable configuration tools to allow superior reliability and flexibility.*

Each LAN is interconnected across the project by singlemode fiber optic Gigabit Ethernet links or alternative methods where fiber is not present, as shown in **Figure 3.7-2**.

Alternative communications methods are used where suitable and cost-effective. Projects that require no more than 25 Mbps WAN throughputs are excellent candidates for 802.11a wireless Ethernet connectivity. Likewise, isolated sites over a kilometer from the fiber run are excellent candidates for wireless or the emerging Broadband over Powerline (BPL) connectivity. Full Gigabit Ethernet throughput can be achieved using standard microwave network radios. All non-fiber communications use multiple security protocols (authentication and encryption) to secure the data flow.

Raytheon successfully utilizes Cisco products throughout our business units. We use 802.11a connectivity for maintenance purposes on that project and for developmental work underway at our Fullerton facility.