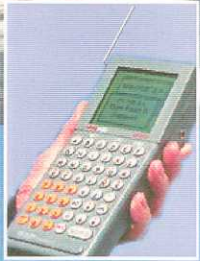
TP 13451E

Winnipeg International Airport

Ground Transportation Management System



Prepared for
Transportation Development Centre
Transport Canada

IBI
GROUP

December 1998

TP 13451E

WINNIPEG INTERNATIONAL AIRPORT GROUND TRANSPORTATION MANAGEMENT SYSTEM

By
IBI Group

DECEMBER 1998

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Un sommaire français se trouve avant la table des matières.

Transport Canada | Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No. TP 13451E	2. Project No. 8838	3. Recipient's Catalogue No.
4. Title and Subtitle Winnipeg International Airport Ground Transportation Management System		5. Publication Date December 1998 6. Performing Organization Document No.
7. Author(s) Derek Sims, Oliver Hesselborn, and Henry Ng		8. Transport Canada File No. ZCD1465-590-5
9. Performing Organization Name and Address IBI Group 230 Richmond Street West, 5th Floor Toronto, Ontario M5V 1V6		10. PWGSC File No. XSD-5-01664 11. PWGSC or Transport Canada Contract No. T8200-5-5545/001-XSD
12. Sponsoring Agency Name and Address Transportation Development Centre (TDC) 800 René Lévesque Blvd. West Suite 600 Montreal, Quebec H3B 1X9		13. Type of Publication and Period Covered Final 14. Project Officer Brian Marshall

15. Supplementary Notes (Funding programs, titles of related publications, etc.)

Co-sponsored by the Program of Energy Research and Development (PERD)

16. Abstract

This report covers the account information management enhancements that were developed to complement the basic commercial vehicle monitoring and control system originally developed by Transport Canada for Lester B. Pearson International Airport. This system is envisioned to be widely used as Canadian airports incorporate new strategies for ground transportation management.

This report focuses on the development of the account information management system and some typical applications. Such applications include automated dispatching and related operations for Commercial Vehicle Holding Areas and terminal curbs. The report establishes that the additional capabilities for account tracking are receiving increased recognition as essential elements of an efficient and effective Ground Transportation Management System. It reviews the integration efforts required to facilitate real-time commercial vehicle monitoring and control, as well as revenue management and cost recovery for the Winnipeg Airports Authority Inc.

17. Key Words Airport systems, commercial vehicle monitoring and control system, automatic vehicle identification, dedicated short range communication, taxi and limousine fleet management	18. Distribution Statement Limited number of copies available from the Transportation Development Centre E-mail: *tdccdt@tc.gc.ca*

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xii, 29	Shipping/ Handling

CDT/TDC 79-005
Rev. 96

Canada

Transports Canada / Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada TP 13451E	2. N° de l'étude 8838	3. N° de catalogue du destinataire
4. Titre et sous-titre Winnipeg International Airport Ground Transportation Management System		5. Date de la publication Décembre 1998 6. N° de document de l'organisme exécutant
7. Auteur(s) Derek Sims, Oliver Hesselborn, et Henry Ng		8. N° de dossier - Transports Canada ZCD1465-590-5
9. Nom et adresse de l'organisme exécutant IBI Group 230 Richmond Street West, 5th Floor Toronto, Ontario M5V 1V6		10. N° de dossier - TPSGC XSD-5-01664 11. N° de contrat - TPSGC ou Transports Canada T8200-5-5545/001-XSD
12. Nom et adresse de l'organisme parrain Centre de développement des transports (CDT) 800, boul. René-Lévesque Ouest Bureau 600 Montréal (Québec) H3B 1X9		13. Genre de publication et période visée Final 14. Agent de projet Brian Marshall

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

Projet coparrainé par le Programme de recherche et développement énergétiques (PRDE)

16. Résumé

Ce rapport présente le module de gestion de l'information sur les comptes élaboré en guise de complément au système de surveillance et de contrôle des véhicules commerciaux développé à l'origine par Transports Canada pour l'Aéroport international Lester B. Pearson. L'utilisation de ce système devrait se propager aux multiples aéroports canadiens à la recherche de nouvelles stratégies de gestion du transport terrestre.

Ce rapport porte plus précisément sur le développement du système de gestion de l'information sur les comptes et sur certaines applications types. Parmi ces applications, figurent l'affectation automatisée et d'autres opérations connexes visant les zones d'attente des véhicules commerciaux et les points d'embarquement à l'aéroport. Le rapport montre que les fonctions de suivi des comptes forment une composante de plus en plus essentielle d'un système efficace et efficient de gestion du transport terrestre. Il passe en revue les travaux d'intégration nécessaires pour faciliter la surveillance et le contrôle en temps réel des véhicules commerciaux, de même que la gestion des recettes et la récupération des coûts, pour l'Administration aéroportuaire de Winnipeg Inc.

17. Mots clés Systèmes aéroportuaires, système de surveillance et de contrôle des véhicules commerciaux, identification automatique des véhicules, communications dédiées à courte distance, gestion de parcs de taxis et de limousines	18. Diffusion Le Centre de développement des transports dispose d'un nombre limité d'exemplaires. Courriel : *tdccdt@tc.gc.ca*

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xii, 29	Port et manutention

Winnipeg International Airport
Ground Transportation Management System

EXECUTIVE SUMMARY

BACKGROUND

In 1993, Lester B. Pearson International Airport and Transport Canada's Transportation Development Centre (TDC) initiated an effort to develop a Ground Transportation Management System. The system enabled the automation of taxi and limousine monitoring and dispatching. A modular approach allowed the system to develop in an evolutionary way. By developing a Ground Transportation Management System (GTMS) that included only the most essential functions, the investment risks were minimized.

The Vehicle Monitoring and Control System operating at Lester B. Pearson International Airport rapidly became a successful showcase for Dedicated Short Range Communication (DSRC) technologies. This success has stimulated other airports to take a closer look at their operations and assess their own needs and problems in the context of what could be accomplished by implementing a similar system. Winnipeg International Airports was a logical candidate for applying the GTMS.

Winnipeg Airports Authority Inc. (WAAI), however, desired additional functions not found in the Pearson Airport implementation. New functions to facilitate per trip fees as well as potential future dwell time charges for commercial vehicles operating in and out of the airport, were developed and incorporated into the GTMS. With funding assistance from TDC, WAAI was able to enhance the GTMS software, an effort completed in 1997.

PROJECT GOAL AND OBJECTIVES

The goal of this project was to undertake the deployment of an innovative account information management system that enhances the GTMS developed for Pearson Airport. The objectives of the project were to:

- Implement an accurate and efficient system for revenue capture for landside commercial vehicles (i.e. taxis and limousines, as well as pre-arranged pick-up vehicles) accessing WAAI;
- Demonstrate real-time communication capabilities between vehicles and roadside infrastructure;
- Establish a foundation for future expansion to create a comprehensive system for interface with the full range of vehicles using the airport.

DESIGN OF THE GROUND TRANSPORTATION MANAGEMENT SYSTEM

An overview of the Ground Transportation Management System and the account information management enhancement in the context of landside operations at WAAI is provided in this report. The design implemented at WAAI included the following elements and subsystems at the Commercial Vehicle Holding Area (CVHA) and terminal curb-sides:

- Automated Vehicle Identification (AVI) or Dedicated Short Range Communications (DSRC) at entrances and exits of the CVHA and at the terminal curbs for identification and tracking purposes;
- Blank-Out Signs and Variable Message Signs at the CVHA for communication with commercial vehicle operators;
- Pay-at-Point Station at the CVHA to facilitate account transactions on-site for the commercial vehicle operators;
- Communication and computer subsystems.

These components and subsystems were designed by working closely with operations and business managers of the WAAI to ensure that the system:

- Supports the intended airport operations and business policies;
- Addresses specific system objectives;
- Delivers the anticipated system benefits;
- Provides flexibility for future evolution of the system.

To minimize some of the apparent risks, the enhancements to the GTMS were based on reliable, proven and commercially available technology to the largest extent possible. The report concludes by suggesting modifications to the operating system and discussing the potential for functional enhancements and extensions to the system.

Winnipeg International Airport
Ground Transportation Management System

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CONTEXTE

En 1993, l'Aéroport international Lester B. Pearson et le Centre de développement des transports (CDT) de Transports Canada lançaient un projet de développement d'un Système de gestion du transport terrestre (SGTT). Le système permettait l'automatisation de la surveillance et de l'affectation des taxis et des limousines. Constitué de modules, le système était évolutif. Comme le SGTT développé alors ne comportait que les fonctions essentielles, cela minimisait les risques d'investissement.

Le Système de surveillance et de contrôle des véhicules exploité à l'Aéroport international Lester B. Pearson est vite devenu une vitrine de démonstration des technologies de communications dédiées à courte distance (CDCD). Leur succès a amené d'autres aéroports à examiner de plus près leurs opérations et à évaluer leurs propres besoins et problèmes dans la perspective de ce que pouvait leur apporter un système semblable. L'Aéroport international de Winnipeg était un candidat naturel pour l'application d'un SGTT.

Mais l'Administration aéroportuaire de Winnipeg Inc. souhaitait que le système réalise d'autres fonctions, que n'assumait pas le système de l'aéroport Pearson. Ces nouvelles fonctions, qui devaient faciliter la perception d'un droit pour chaque course, et l'imposition éventuelle de frais de séjour pour les véhicules commerciaux, ont été incorporées au SGTT. Grâce à l'aide financière du CDT, l'AAWI a été en mesure de perfectionner le logiciel du SGTT, une tâche achevée en 1997.

BUT ET OBJECTIFS DU PROJET

Ce projet avait pour but de mettre en oeuvre un système novateur de gestion de l'information sur les comptes en guise de perfectionnement au SGTT développé pour l'Aéroport Pearson. Il avait pour objectifs de :

- mettre en oeuvre un système précis et efficient de saisie des recettes imputables aux véhicules commerciaux terrestres (taxis et limousines et bus-navettes) desservant l'AAWI;
- démontrer les capacités de communication en temps réel entre les véhicules et une infrastructure en bordure de chaussée;
- jeter les bases d'une expansion future qui permettra de créer un système complet d'interfaçage de toute la gamme des véhicules utilisant l'aéroport.

CONCEPTION DU SYSTÈME DE GESTION DU TRANSPORT TERRESTRE

Le rapport fait le survol du SGTT et de la fonction de gestion de l'information sur les comptes tels que mis en oeuvre pour les opérations terrestres à l'Aéroport de Winnipeg. Le système utilisé à Winnipeg comprend les éléments et sous-systèmes ci-après dans la zone d'attente des véhicules commerciaux (ZAVC) et aux points d'embarquement à l'aéroport :

- identification automatisée des véhicules (IAV) ou communications dédiées à courte distance (CDCD) aux entrées et aux sorties de la ZAVC et aux points d'embarquement à l'aéroport, à des fins d'identification et de suivi;

- panneaux escamotables et panneaux à message variable dans la ZAVC, pour communiquer avec les conducteurs de véhicules commerciaux;

- poste de perception dans la ZAVC, facilitant les transactions sur place sur les comptes des conducteurs de véhicules commerciaux;

- sous-système de communication et sous-système informatique.

Ces composants et sous-systèmes ont été conçus en étroite collaboration avec le directeur de l'exploitation et le directeur commercial de l'AAWI, de façon que le système :

- appuie les politiques d'exploitation et les politiques commerciales de l'aéroport;

- réalise les objectifs précis qui lui sont assignés;

- offre les avantages escomptés;

- soit évolutif.

Pour réduire au minimum les risques apparents, les améliorations apportées au SGTT se sont fondées le plus possible sur une technologie fiable, éprouvée et offerte dans le commerce. Le rapport se termine sur des suggestions de modification du système d'exploitation et une discussion de la possibilité de perfectionnements fonctionnels et d'extensions du système.

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LIST OF EXHIBITS

List of Acronyms

APTS	Advanced Public Transportation System
ATIS	Advanced Traveller Information System
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
AVI	Automatic Vehicle Identification
AVION	Advantage I-75/AVI-Ontario
BOS	Blank-Out Sign
CCTV	Closed Circuit Television
CES	CVHA Entrance Confirmation Subsystem or Curb Entrance Confirmation Subsystem
COTS	Commercially-off-the-shelf
CRCS	Close-Range Communication System
CVHA	Commercial Vehicle Holding Area
CVO	Commercial Vehicle Operations
DBC	Database Computer
DCC	Device Communications Computer
DSRC	Dedicated Short Range Communication
EDT	Electronic Data Transfer
ETTM	Electronic Toll and Traffic Management
FOT	Field Operational Test
GTAA	Greater Toronto Airport Authority
GTMS	Ground Transportation Management System
GUI	Graphical User Interface
HELP	Heavy vehicle Electronic License Plate
IEN	Information Exchange Network
ITI	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation System
LAN	Local Area Network
Massport	Massachusetts Port Authority
MCC	Master Control Computer
PAP	Pay-at-Point
PC	Personal Computer
RF	Radio Frequencies
SMC	System Maintenance Computer
SVS	Summoning Variable Signs
TC	Transport Canada
TCC	Terminal Curb Computer
TDC	Transportation Development Centre (of Transport Canada)
VIN	Vehicle Identification number
VMCS	Vehicle Monitoring and Control System
VMS	Variable Message Sign
VRC	Vehicle-to-Roadside Communication
WAA	Winnipeg Airports Administration
WAAI	Winnipeg Airports Administration Inc.
WAN	Wide Area Network
WIM	Weigh-in-Motion

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Winnipeg International Airport
Ground Transportation Management System

1.0 INTRODUCTION

1.1 OVERVIEW

Over the past five years, the application of Intelligent Transportation Systems (ITS) technologies to ground transportation management at airports has been gaining support from airport managers, planners and commercial vehicle operators. These "new" ITS technologies have been found to be low-cost alternatives to more traditional measures of solving landside transportation problems and management information needs at airports. Improvements brought about by these technologies are reshaping groundside operations at airports. A fundamental promise of ITS is to improve the operations of transportation facilities and services while making both more user-friendly.

1.2 BUILDING A GROUND TRANSPORTATION MANAGEMENT SYSTEM

A successful airport Ground Transportation Management System (GTMS) must accommodate both personal and commercial passenger trips. With annual air travel growth forecasts of 5.7 percent worldwide over the next twenty years, today's passenger volumes will more than double by year 2016 [1]. This places considerable pressure on groundside operations management to accommodate existing patrons and attract new ones. The following key landside transportation systems should be considered to better accomplish operational and business objectives:

- **Commercial Vehicle Control and Management System** – allowing for real-time automated dispatching of commercial vehicles from centralized holding areas to terminal curb-sides;

- **Terminal Shuttle Dispatch and Headway Management System** – allowing for real-time adjustments of shuttle bus schedules and interaction with roadway elements to increase schedule adherence and enhance system performance;

- **Parking Management and Information System** – allowing for dissemination of real-time information on parking availability and usage optimization of parking facilities as well as increased opportunities for coordination with Park-and-Fly facilities outside airport grounds;

- **Travel and Traffic Information System** – allowing for dissemination of real-time information on existing and potentially expected traveling, traffic and roadway conditions on major highways and arterials feeding the airport; and

- **Traffic Data and Count System –** allowing for better day-to-day ground transportation management and planning for the future through the use of the accumulated information contained in extensive databases.

Several layers may be added onto these individual landside transportation systems to include new and evolving functions. Account management information systems and floating car data management information systems are two of a myriad of potential layers that have been identified as desirable in many ground transportation management environments.

1.3 Ground Transportation Management Systems in North America

Canada's first fully automated airport GTMS for commercial vehicles was demonstrated at Lester B. Pearson International Airport, owned and operated by the Greater Toronto Airports Authority (GTAA). The system was designed to enable the automation of taxi and limousine dispatching. The GTMS at Lester B. International Airport has become a showcase of what the future of ITS technologies holds and it has prompted similar approaches for addressing ground transportation management issues in other airports in Canada as well as in the United States.

Massachusetts Port Authority's (Massport) Logan Airport in Boston, stands out as an early example of the desire to advance the integration of this type of system with other groundside transport systems. The GTMS at Boston Logan Airport will include improved flight arrival based dispatch, automated terminal curb management, contracted services monitoring and trip fee assignment. Other systems based on similar concepts are currently evolving in airport facilities across the U.S. However, at this time, most, if not all, of the more than two dozen GTM systems in North America provide only limited functionality.

1.4 Winnipeg International Airport's Ground Transportation Management System

Winnipeg International Airport, which is operated by Winnipeg Airports Authority Inc. (WAAI), is the first airport in Canada to build on the knowledge and experience gained through the implementation of the GTMS at Lester B. Pearson International Airport. Similarities in the design and functionality of the two systems reflect the importance of showcasing new and emerging technologies as a way of increasing "market awareness" and potential for "market penetration". The system also illustrates the benefits of starting with a proven architecture (i.e. Lester B. Pearson International Airport's VMCS). The additional functions incorporated in the WAAI GTMS include trip fee tracking and account management for revenue and cost recovery.

In order to build a truly comprehensive GTMS, integration with other airport landside systems is vital. As ITS technologies continue to create an evolutionary path towards an information-based transportation infrastructure, co-ordination efforts should be taken to ensure increased interoperability.

2.0 KEY ENABLING TECHNOLOGIES FOR GROUND TRANSPORTATION SYSTEMS

Today a wide variety of advanced computer, electronics, and communication technologies are available for ground transport system applications. These technologies are sometimes referred to as components of the Intelligent Transportation Infrastructure (ITI). These technologies offer the potential to substantially improve operations and management of the existing groundside transportation system. To meet this challenge and to bring the existing groundside transportation system to its full potential, these technologies need to be integrated in a strategic manner.

2.1 TECHNICAL APPROACH

The GTMS at WAAI is based on Dedicated Short Range Communication (DSRC) technology allowing for communication between moving vehicles and stationary roadside units. DSRC applications or Automatic Vehicle Identification (AVI) were historically referred to as Vehicle-to-Roadside Communication (VRC) systems, where vehicle movements were recognized through one-way communications. Recently, opportunities for innovative integration have been realized for readers, tags and the associated software. This progress has been driven and made possible by the introduction of two-way communication, easy data storage and retrieval from flexible databases, and increased data processing capabilities.

The concept behind DSRC systems can best be described as a two-step communication process:

1. Roadside antennae transmitting radio frequency signals to be received by in-vehicle transponders;

2. In-vehicle transponders transmitting a unique identification back to the roadside transceivers in response to the initial Radio Frequency (RF) signals.

2.2 UNIVERSAL CLOSE-RANGE COMMUNICATION SYSTEM CONCEPT

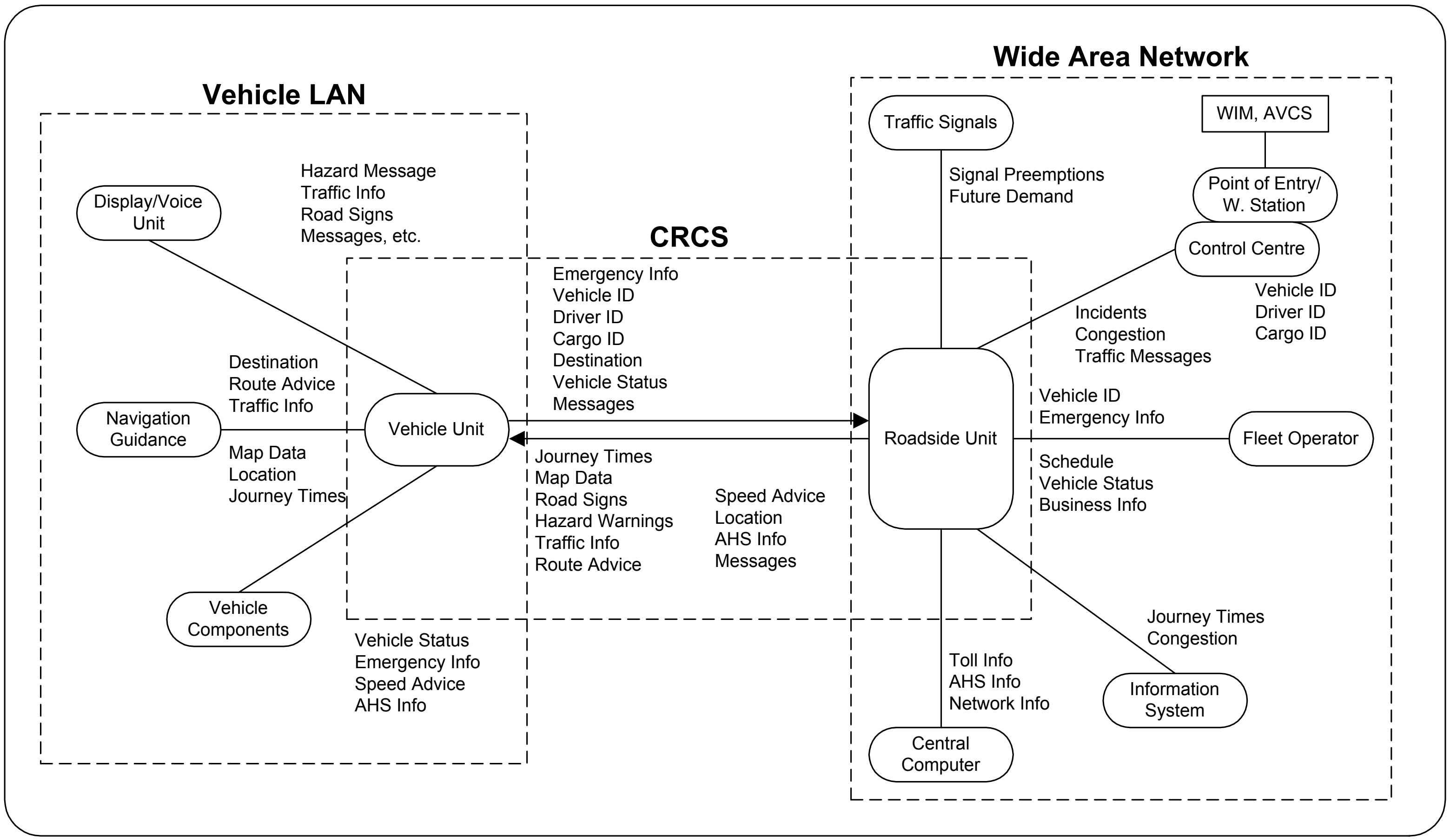
With advancements in computer software and hardware, today's in-vehicle transponders may in the future be connected via a serial port to a vehicle's on-board Local Area Network (LAN), while the roadside antennae and transceivers may be connected to a national Wide Area Network (WAN) through wired or non-wired transmission. This logical architecture, originally referred to as the Close-Range Communication System (CRCS) concept [2], is depicted in Exhibit 1. The exhibit illustrates the logical architecture of the CRCS concept (i.e. the potential data and information flows, for several transportation applications). Physical elements in the figure are separated by the vehicle LAN and the WAN and are presented only to introduce the idea of the physical placeholders that are expected to facilitate the exchange of voice, image or video data.

The fundamentals of the CRCS concept are discussed in greater detail in *Lester B. Pearson International Airport Vehicle Monitoring and Control System* [3]. The CRCS concept forms the basis of both the VMCS at Lester B. Pearson International Airport and the more advanced GTMS at Winnipeg International Airport. This concept is universal in the sense that any CRCS application builds on data and information exchange and sharing using suitable traffic message encoding and decoding techniques.

Several large-scale demonstration and implementation projects have proven the DSRC technologies successful. These projects range from commercial vehicle management systems, such as Heavy vehicle Electronic License Plate (HELP), Advantage I-75/AVI-Ontario (AVION), to various electronic toll collection systems such as EZ-Pass. Earlier systems, or first generation systems, focused primarily on the *read-only* (one-way communication) function. Future demonstration and implementation projects will focus on second generation systems brought about through the advancements in *read-and-write* (two-way communication) functionality. Some of the key initiatives of such projects are to investigate the interfacing capabilities with emerging in-vehicle technologies and the issues relating to interoperability of systems.

With modular software, flexible database structures and responsive multi-task capability computer systems, the original CRCS concept will continue to encourage the exploration of new layers to be added onto already established DSRC applications. Winnipeg's GTMS account management system is unique and represents only the beginning of what can be accomplished with today's two-way *read-write* capabilities when linking some of the CRCS applications depicted in Exhibit 1 to existing and emerging database structures over Information Exchange Networks (IEN).

Exhibit 1: Universal Close Range Communication System Concept



Source: Intelligent Vehicle Highway System - The Universal CRCS Concept, R.L. Sabounghi, 1991

3.0 Proof of Concept for Winnipeg International Airport's Ground Transportation Management System

The overall strength of using DSRC as the communications technology lies not only in the straightforwardness in applying the technology but also in the relatively low cost of equipment and operations. While tag prices vary widely within a range from $20 to $150 depending on the level of sophistication, infrastructure costs are typically absorbed by the agencies that own the system facilities or passed on to the end-users through transaction fees.

3.1 Functionality

The DSRC-based GTMS was implemented at WAAI to accomplish the following tasks:

- Recognize and process the movements of vehicles on airport grounds;
- Manage the queues at the holding area and terminal curbs;
- Maintain a performance level able to satisfy the demand of vehicles at the terminal curbs;
- Allow user control of the queues for both the holding area and the terminal curbs; and
- Allow supervision and status monitoring of all devices relevant to the system.

The GTMS at WAAI is based on the unique identification codes of the commercial vehicles operating in and out of the airport. Those unique identification codes are contained on the vehicle tags, or the transponders, which are attached to the vehicles. It is the reader, or the roadside controller, that acts as the intelligent agent capturing all the information contained in the tag and downloading it to a host computer through the DSRC communication backbone infrastructure. Traditionally, DSRC applications were only used in very select situations where other identification methods were considered too unreliable. Today DSRC has matured as a strategic technology providing a variety of delivery mechanisms enhancing almost any transportation system. With continued mass commercialization of DSRC technologies, these systems are slowly becoming a global reality.

The following types of transponders exist:

- **Type-I Transponder**

  Today Type-I transponders are considered part of older, legacy DSRC systems. Type-I transponders are fixed-code one-way (vehicle-to-road) communication devices. Reprogramming of the transponder can only be undertaken by the manufacturer.

- **Type-II Transponder**

  Type-II transponders came about as DSRC systems were penetrating new markets, especially as applications such as parking management were identified. Today Type-II transponders have become commonplace in the tag industry and many alterations have been made to the original Type-II transponder (see below). Type-II transponders are part fixed-code part variable-code two-way (vehicle-to-road-to-vehicle) communication devices. Reprogramming can be done during passage through the antennae detection zone.

* **Windshield Transponder**

  This Type-II transponder is the most common on the market. It is an interior-mounted transponder with no display or feedback to the driver. It affixes directly behind the rearview mirror on a vehicle's windshield. The transponder can be readily moved between vehicles as desired.

* **Roof-Mounted Transponder**

  This tag is a special class of Type-II transponder. It is an exterior-mounted transponder with no display or feedback to the driver. It mounts directly onto the roof of a vehicle that has characteristics making it unsuitable for the standard Type-II transponder use.

* **License Plate Transponder**

  This is an exterior-mounted transponder with no display or feedback to the driver. It mounts directly onto the license plate of a vehicle.

- **Type-II+ Transponder**

  Type-II+ transponders are part fixed-code part variable-code two-way communication devices. Reprogramming can be done during passage across reader antennae. They represent an update of the typical interior Type-II transponders and can support Liquid Crystal Displays for relevant messages such as travel time, fee/toll amount and account balance feedback. In spite of possibilities for decentralized accounting (through re-programming of the memory chip) typically account balance tracking is still conducted in a centralized computer system. Type-II+ transponders often allow for audio signals through an internal buzzer device in the transponder.

- **Type-III Transponder**

  Type-III transponders are part fixed-code part variable-code two-way communication devices. While re-programming is still done during passage across reader antennae it is done in a conceptually different way in comparison with the Type-II+ transponder. A Type-II+ transponder allows for re-programming to be done internally, i.e. in the transponder unit itself. A Type-III transponder is designed in a way that it can be integrated with external units or other in-car units. It is therefore expected that account balance tracking will be automated through the integration of smart card usage and other applications. It is expected that the Type-III transponder will generate additional benefits and potentially bring life to some of the DSRC applications incorporated in the conceptual discussion of CRCS (see Exhibit 1).

3.2 Outlook for Migration

What started as an electronic tag for simple vehicle identification purposes is today a system offering two-way communication capability, programmability and intelligence. With these mature capabilities and an overall increase in the interest for ITS, DSRC should be considered a key technology in any transportation system of the future. As implied by the CRCS concept, DSRC technologies belong to the Commercial

Vehicle Operations (CVO) cohort of ITS applications that are likely to migrate, both functionally and geographically, from stand-alone applications at single facilities to integrated applications at multiple facilities across North America. It is also expected that DSRC will become an enabling technology for other ITS applications in areas such as Advanced Traveler Information Systems (ATIS), Advanced Public Transportation Systems (APTS), Advanced Traffic Management Systems (ATMS) and Advanced Vehicle Control Systems (AVCS). Standards supporting a smooth migration for DSRC technology-based ITS applications are underway.

3.3 Ground Transportation Management System Needs

At the time of the project's inception in 1995, the need for improved ground transportation management at Winnipeg International Airport had been clearly identified as a critical factor behind the airport's competitiveness and economical sustainability in the future. The taxi and limousine fleets environment at Winnipeg International Airport were largely operated by a single company. It was important that a cost effective means be identified to equitably open the airport to service by any taxi company.

Other issues at Winnipeg International Airport were:

- Terminal curb capacity limitations; and
- High operating costs due to excessive staffing needs to supervise the holding and pick-up areas.

The limited terminal curb capacity was the reason WAAI instituted a remote holding area for commercial traffic. The CVHA permits WAAI to channel traffic flow at the terminal curbs, and to establish dedicated pick-up areas for most "for-hire" traffic as well as some general public traffic. All taxis and limousines are required to wait in the remote CVHA before picking up fare paying passengers at the terminal curbs. The dispatching of the taxis and limousines was administered by the contracted taxi company at the airport. The taxi company manually dispatched from inside the terminal. This approach was relatively costly and did not always consider or prioritize the satisfaction of customers. The manual dispatch system was labour intensive because a full-time staff commitment was needed. Other commercial vehicle types making passenger pick-ups such as pre-arranged vehicles and courtesy vehicles operated by hotels and rental car companies were given access to the airport grounds under a variety of payment arrangements. Accurately controlling and monitoring these commercial vehicle types, including the taxis and limousines, was difficult.

3.4 Ground Transportation Management System Opportunities

With an impending organizational transition of the airport to a local operating authority, collaborative steps were taken with Transport Canada to establish an airport-operated dispatch system. Given the airport's desire to change the long-standing arrangement with the dominant city taxi operator (to dispatch only its own vehicles from the CVHA in return for exclusive access at an annual flat fee) it was imperative that a more comprehensive and equitable per trip fee policy be adopted. Also it was important to work toward integration of dispatch and monitoring of all "for-hire" and other commercial vehicle types making passenger pick-ups at the terminal curbs. It was anticipated that the software developed for the GTMS at Lester B. Pearson would be applied and additional costs to modify the software and incorporate new functions would be sponsored by the Transportation Development Centre (TDC) of Transport Canada.

4.0 GROUND TRANSPORTATION MANAGEMENT SYSTEM DEVELOPMENT

4.1 PROJECT PURPOSE

The aim of the project was to undertake the deployment of an innovative information management system that would enhance passenger pick-up operations for commercial vehicles using core-enabling technologies. The scope of the GTMS was based on a previous preliminary design and costing study undertaken by IBI Group.

Specifically the project was to:

- Build the GTMS upon earlier work for Lester B. Pearson International Airport;
- Enhance the core software developed for Lester B. Pearson International Airport to demonstrate real-time account management using two-way communication capabilities between vehicles and roadside infrastructure; and
- Create a foundation for future functional and geographical enhancements.

The following benefits were deemed achievable by the GTMS:

- Increased customer satisfaction - Due to reliable and efficient delivery of taxi service at the curb.
- Improved curb management and enforcement - Terminal curb managers previously absorbed by the task of keeping up with passenger demand fluctuations now have more time available to help passengers and to ensure a controlled and pleasant environment. A pleasant terminal curb-side environment depends not only on the overall level of service but on reducing the level of congestion (which is heavily influenced by efficient enforcement policies and strategic pricing structures). Enforcement further secures dispatch equity and secures revenue streams to WAAI.
- Increased revenue – Through equitable and consistent collection of a per trip fee.
- Increased management information for airport use and for marketing to commercial fleet operators - As data on terminal curb-side usage is collected by the system, the administration at WAAI, including the curb managers and other on-site staff, are better able to make more informed decisions. This is particularly important when assessing future demand levels both in terms of commercial fleet volumes and actual passenger demand. Such information may possess value to commercial vehicle operators as well.

4.2 PROJECT AWARD

With the focus on customizing and extending GTMS software originally developed for Lester B. Pearson International Airport as well as on rapid and low-cost deployment, IBI Group was selected to design, develop and implement the GTMS at Winnipeg International Airport (WIA).

4.3 Overall Private-Public and Public-Public Partnership Environment for the Project

The transition to a local operating authority with full jurisdiction of the airport grounds did not preclude a continued role for Transport Canada as a driving force behind R&D for this project. However, further enhancements are more likely to grow from emerging market opportunities in the private sector and other airport authorities.

5.0 Research Assessment and Product Development

5.1 Context of Project

The planned improvement for WAAI required consideration of the existing commercial vehicle operations environment and policy. A significant issue in this project was the monitoring of remote entrance and exit areas of the CVHA and the terminal curbs since the infrastructure could not be cost effectively changed or reconfigured in different manner. The functional tasks assigned to the GTMS subsystems and field equipment such as Entrance Confirmation Signs (ECS), and Summoning Variable Signs (SVS) are outlined in Exhibit 2 and Exhibit 3 (and are in accordance to a vehicle's natural flow of progression through the system at the commercial vehicles' remote central holding area and terminal curb, respectively).

Exhibit 2: Affected Subsystems for Vehicle Progression Through the Commercial Vehicle Holding Area

Commercial Vehicle Holding Area Functions	Major Subsystem
Join Queue	AVI Subsystem
In-Queue Confirmation	VM Subsystem – Confirmation Sign
Short Trip Status	VMS Subsystem – Confirmation Sign
Position in Queue (when near head of queue)	VMS Subsystem – Dispatch SVS
Dispatch Notice	VMS Subsystem – Dispatch SVS
Exit Queue	AVI Subsystem

Exhibit 3: Affected Subsystems for Vehicle Progression Through the Terminal Curb Area

Terminal Curb Functions	Affected Subsystem
• Join Curb Inventory	AVI Subsystem
• Charge Access Fee Account	AVI Subsystem
• Compliance Confirmation	VMS Subsystem - Dispatch SVS
• Exit Curb Inventory	AVI Subsystem

In order for the subsystems presented above (see Exhibits 1 and 2) to run in a simultaneous fashion, the GTMS needed to allow not only for monitoring and control of the commercial vehicles operating in and out of the airport but also for Electronic Data Transfer (EDT) with respect to the electronic revenue transactions. In order to ensure proper administration of the EDT and compliance to the WAAI's policies the GTMS needed to incorporate an effective means for actual enforcement and regulation. The project was to create a solid foundation for future expansions to other Canadian airports.

5.2 Project Work Plan

After completing the system design in 1995, IBI Group was authorized to act as the system integrator of the GTMS implementation responsible for:

- Software development (to extend and customize the software developed for Lester B. Pearson International Airport);

- Procuring field equipment;
- Systems integration and commissioning; and
- Training, documentation and warranty.

The deployment of the GTMS involved the following three step procedure:

- **Step I: Selection of Enabling Technologies –** Assessment of the functional requirements of the GTMS with respect to the different subsystems in the context of equipment requirements, site characteristics and implementation issues.
- **Step II: Infrastructure Design and Software Development –** Development of an innovative operational concept where all subsystems are used in the most efficient manner and to their potential ensuring automatic and manual dispatching, field device monitoring, and fee collection. Infrastructure was built, equipment procured and software customized.
- **Step III: Integration and Testing of the System –** Integration of all system software and hardware with a central computer system test.

Whereas the field equipment devices could be implemented based on a staged approach, to slowly enhance the GTMS as the system matured, the software development had to address all envisioned capabilities before any integration efforts could be conducted and completed. The software components had to be developed to maintain or interact with the following entities:

- Transponder Accounts Module;
- Pay-at-Point (PAP) Module;
- Real-time Status Monitoring (AVI) Module;
- Dispatching and Vehicle Information (BOS, SVS and VMS) Modules; and
- Real-Time Database Reports Module.

5.3 Ground Transportation Management System

In developing the above components of the new software modules the following issues needed to be addressed:

- The software development had to be based on Transport Canada software originally developed for Lester B. Pearson International Airport;
- The system had to be developed under the Windows NT® operating system using an ORACLE® database; and
- The revenue department financial system would be a completely external system.

6.0 APPLICATION

The GTMS at WAAI provides the following main features for the management of airport taxi and limousine operations:

- Account information management;
- Ground transportation management.

6.1 ACCOUNT INFORMATION MANAGEMENT MODULE CAPABILITIES

The account information management system maintains transponder accounts that contain information on available and conducted curb trips of commercial vehicles equipped with transponders.

The following actions are performed:

- **Accounts Clearing/Account Transfers**
  - Set-up of transponder account; and
  - Management of transponder accounts through office banking and EDT.
- **Increment/Decrement Accounts**
  - Transponder accounts to be increased as a result of deposits at the Pay-At-Point (PAP) station; and
  - Transponder accounts to be decreased when vehicles enter fare-paying passenger pick-up areas (and other areas where transponders are detected).
- **Query Accounts**
  - Drivers to be alerted when their transponder accounts balances are getting low (while on airport grounds).
- **Account Reports**
  - Generate reports on current CVHA and terminal curb queue state (when applicable);
  - Generate reports on the current balance and history of transponder accounts; and
  - Generate reports on the history of transponder movements and other vital service statistics.

6.2 GROUND TRANSPORTATION MANAGEMENT SYSTEM CAPABILITIES

The GTMS provides the following capabilities:

- Tracking of commercial vehicle movements;
- Managing queues at the CVHA and terminal curbs;
- Vehicle dispatching;
- Maintaining performance levels for satisfying the demand of vehicles at terminal curbs.

The software employs a user-friendly Graphical User Interface (GUI) which allows the system users not only to monitor the GTMS but also to perform functions. The devices and the field equipment in the system are monitored to ensure their active and operational status. Furthermore, the operator can correct abnormalities (that may or may not exist due to non-functioning devices in the field). Control features include changing dispatch thresholds or terminal destinations, and engaging manual dispatching of vehicles.

6.3 Characteristics of the Ground Transportation Management System

The WAAI application includes AVI at entrances and exits of the CVHA and at the terminal curbs for identification and tracking, BOS and VMS at the CVHAs for communication with the commercial vehicle operators, PAP stations for commercial vehicle on-site transactions at the CVHA and additional pay display VMS at terminal curbs, and communication and computer subsystems. A plan highlighting equipment locations at the CVHA and the terminal is provided in Exhibit 4.

The GTMS at Winnipeg Airports Authority Inc. (WAAI) operates/tracks vehicles through the following five-step procedure:

- **Step I: Entering the CVHA**
  - Identify and register vehicles via transponder unit;
  - Once identified, a VMS confirms that the vehicle has been registered (into system queue);
  - Determination of qualification for "short trip" status (which permits queue pre-emption) based on elapsed time since entering vehicle left terminal curb, relative to a defined time threshold; and
  - Determination of transponder account status and potential "low balance alert" to drivers to PAP station.

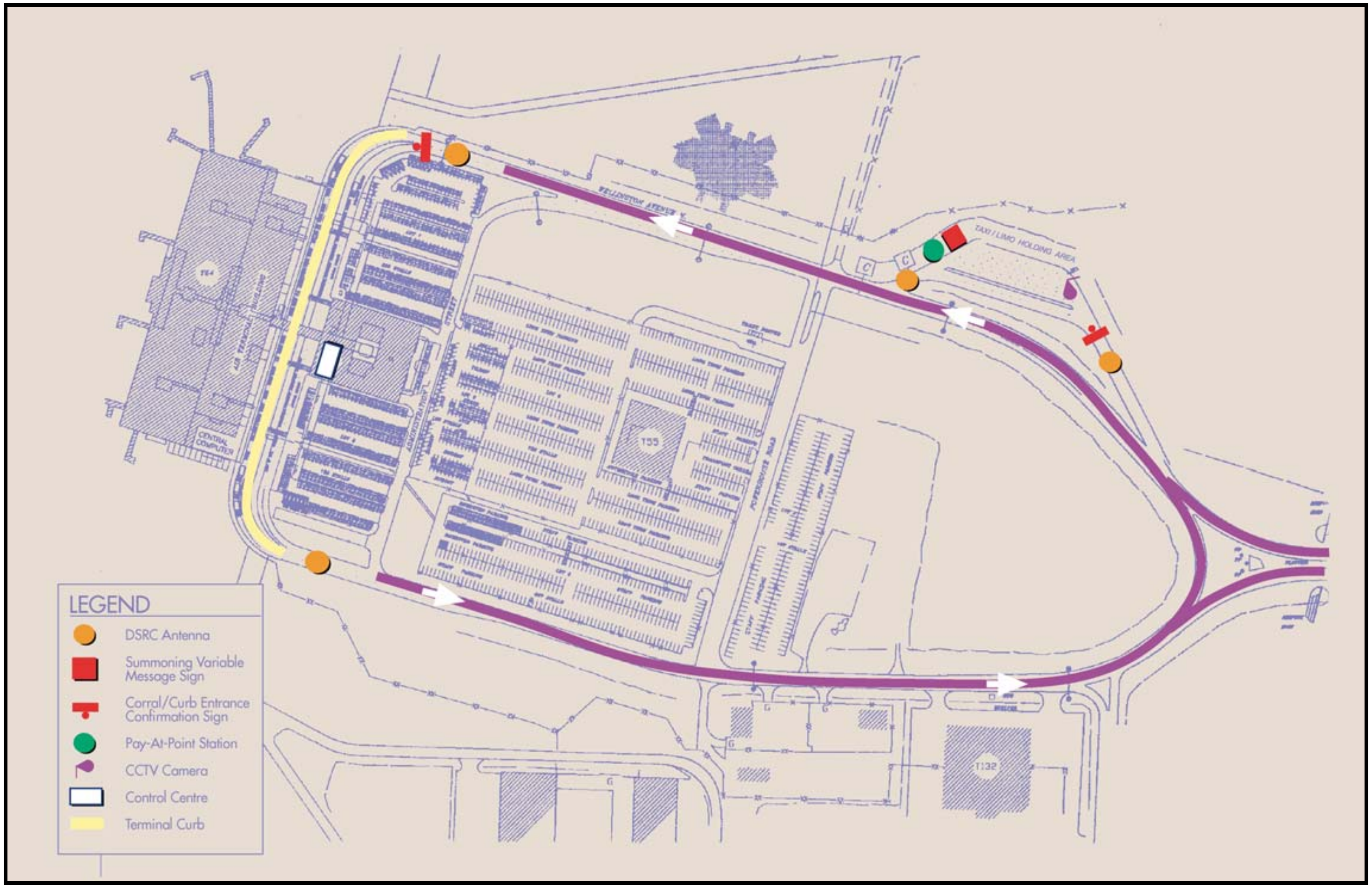
- **Step II: Information to Queued Vehicles**
  - Display of the top-5 queue lists for order in which vehicles will be summoned through SVS with a flagging symbol added when vehicles are summoned to exit.

- **Step III: Exiting the CVHA**
  - Display destination information via VMS; and
  - Provide authentication of transponder account transactions to drivers being summoned to exit via VMS.

- **Step IV: Summoning to a Terminal Curb**
  - Identify vehicles via the transponder unit upon arrival and departure to determine whether curb queue has increased or decreased; and
  - Tracking terminal curb queue lengths against target parameters to facilitate just-in-time dispatching of vehicles from the CVHA as required.

- **Step V: Pick-up at Terminal Curb**
  - Identify and register vehicles via transponder unit; and
  - Provide authentication of transponder account transactions to drivers being summoned to exit or violation messages at pay display VMS.

Exhibit 4: Winnipeg Airports Authority Inc. (WAAI) GTMS Layout Overview



6.4 VALUE ADDED THROUGH DEVELOPMENT AND DEPLOYMENT

The capabilities of Type-II transponders to perform multiple functions in a landside commercial vehicle operation environment at an airport including dispatching, monitoring and tracking were confirmed. The additional DSRC application for revenue collection functions was also proven.

This application is likely to spur future developments based on the modular approach taken to add functions. With these new functions, and additional growth in a fully operational system the case for Type-III transponders may soon become reality. For example, the transponder account balance could be increased through smart card interface in Step III. The integration of smart card technology is just one example of how the system could become more seamless for the end-user while optimizing the overall system performance.

6.5 GROUND TRANSPORTATION MANAGEMENT SYSTEM PROGRESSION

The functional layout of base system and interim system options for the CVHA and terminal curb pick-up area are shown in Exhibit 5 and Exhibit 6, respectively. The enhanced system option is depicted in Exhibit 7.

6.6 SUCCESS INDICATORS OF THE GROUND TRANSPORTATION MANAGEMENT SYSTEM

Passengers are enjoying a more pleasant curb-side experience with managed ground transportation through better service and less curb-side congestion. The taxi/limousine drivers experience less delay and stop-and-go conditions at both the CVHA and the terminal curb-sides since payments are truly seamless and there is no need for authentication of vehicles. The PAP station (see Exhibit 9), increases the drivers' convenience even more since it allows for transponder account balances to be increased while waiting to be summoned rather than at CVHA exit or through direct clearinghouse involvement. The environment for commercial vehicle drivers and operators is improved further through the incorporation of Closed Circuit Television (CCTV) units acting as a deterrent for confrontations between taxi/limousine drivers while giving the landside transportation operations staff responsible for dispatching an increased awareness. The addition of new hardware, such as the PAP station unit and CCTV units, were envisioned when the new software module was developed to enhance the operational base model at Lester B. Pearson International Airport.

The airport landside operations management are continuously improving their information base to facilitate more informed decision-making in both their daily management of commercial vehicles operations and their long-term planning efforts. Exhibit 8 shows the CVHA and the terminal curb-side pick-up area at WAAI. Exhibit 7 provides an illustration of some of the sample field equipment that the taxi/limousines interact with while operating on airport grounds. From the upper left corner to the lower right corner of the exhibit they are: DSRC antenna (A) entrance confirmation sign (B); SVS (C), PAP station (D), and transponder account authentication VMS at the curb entrance (E).

6.7 FUTURE ENHANCEMENTS

A change of operational procedures at the airport restricting taxi/limousine drivers from leaving their vehicles will bring additional structure to the terminal curb-side environment. This new policy is intended to minimize the potential for terminal curb-side price negotiation amongst drivers and between drivers and passengers. To facilitate this policy change, WAAI has outlined a need for additional information signage. These signs, if electronic, are envisioned to carry real-time information on vehicle choices (vehicle and operating company) and their fees or price structures. It is anticipated that WAAI's policy to minimize barriers for the disabled will require the incorporation of an audible analogue to the visual information.

Exhibit 5: Functional Layout of Base System Option

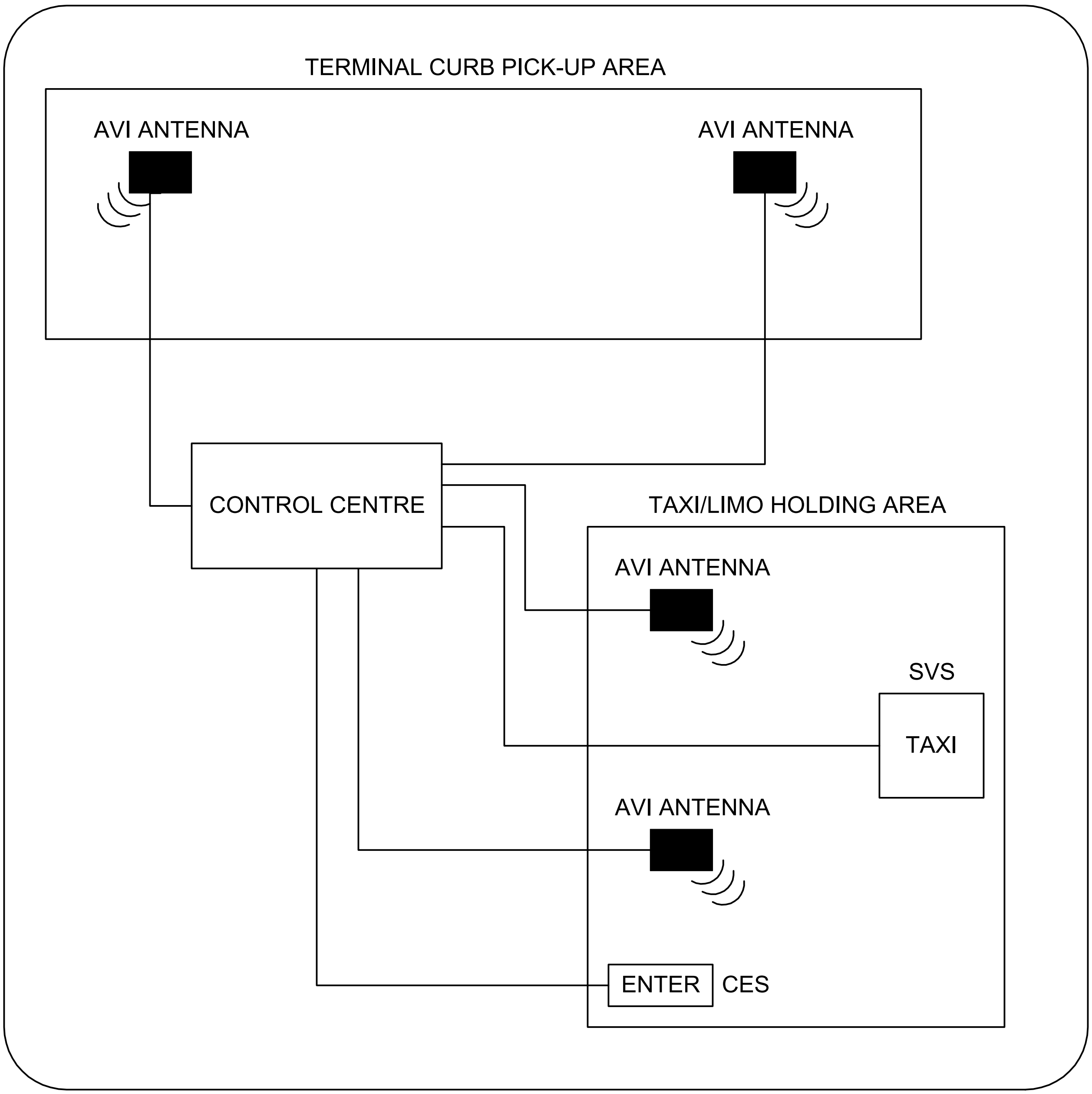


Exhibit 6: Functional Layout of Interim System Option

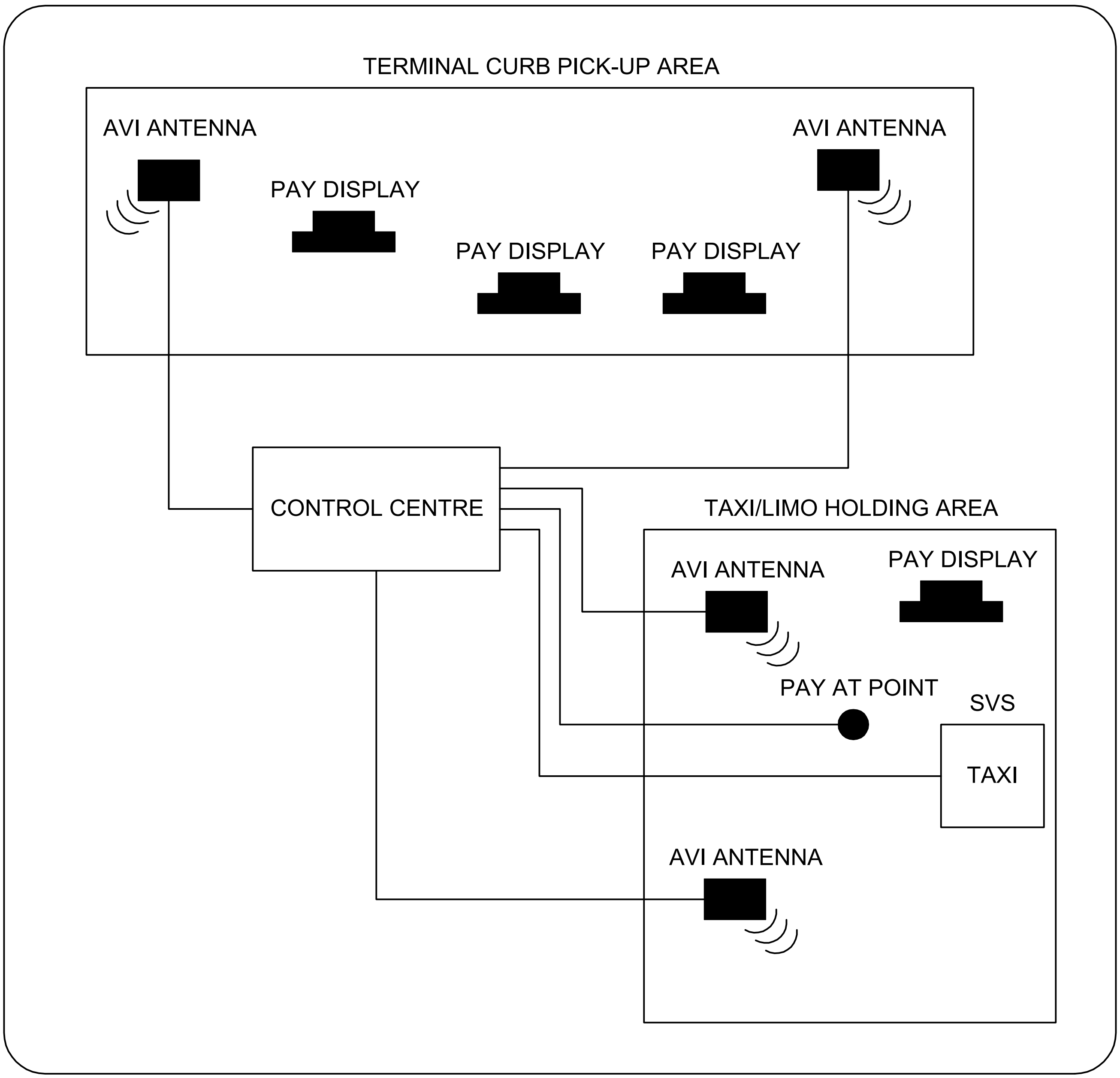


Exhibit 7: Functional Layout of Enhanced System Option

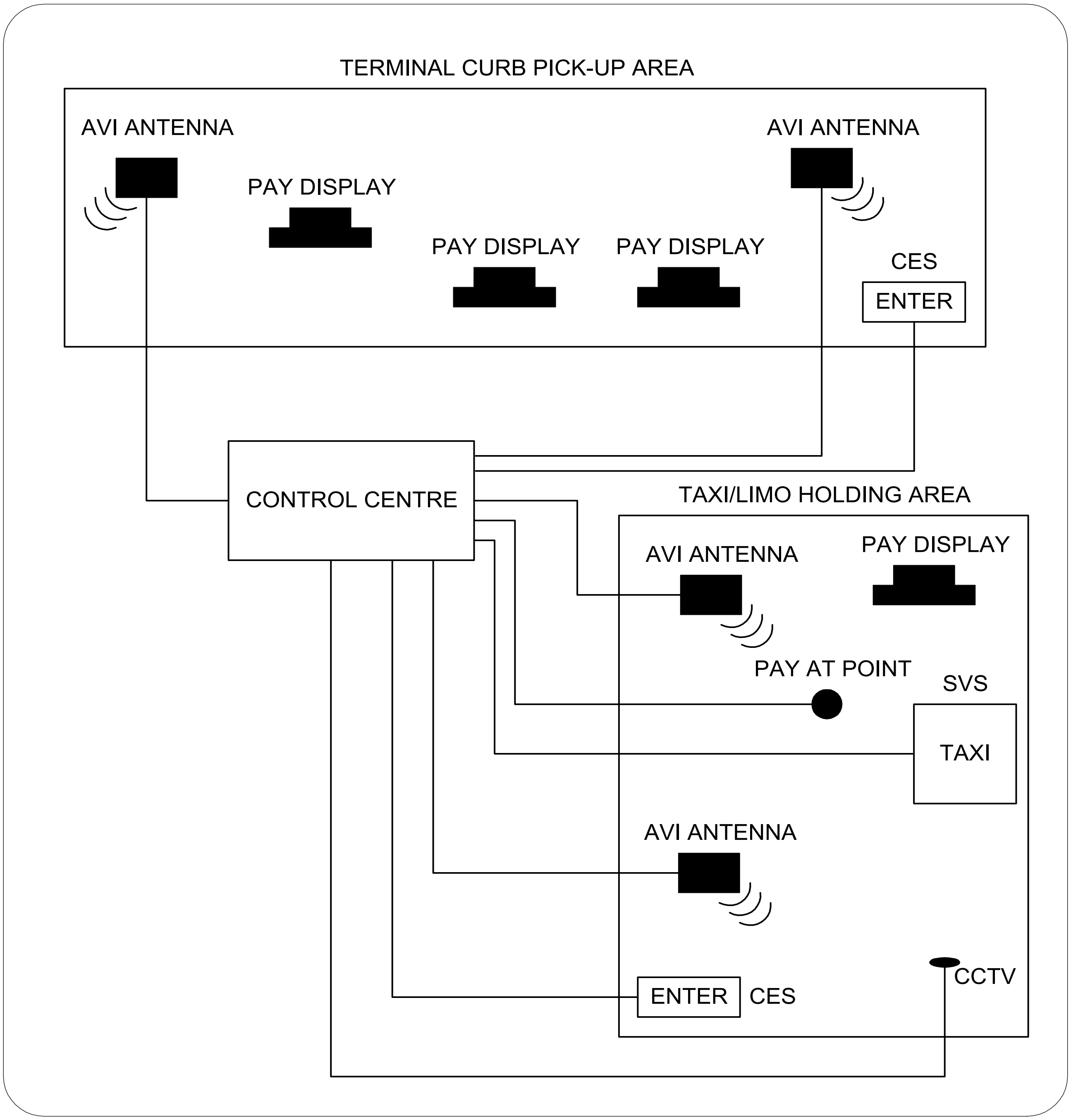


Exhibit 8: Commercial Vehicle Holding Area and Terminal Curb-side Pick-up Area

Commercial Vehicle Holding Area

Terminal Curbside Pick-up Area

Exhibit 9: Commercial Vehicle Holding Area Field Equipment

A

B

C

D

E

7.0 GROUND TRANSPORTATION MANAGEMENT SYSTEM AND SUBSYSTEM FUNCTIONS

The overall system design for the GTMS incorporates a series of electronic subsystems that are integrated in an overall system. The different subsystems represented in the GTMS include the signage, account management and voice communications subsystem.

The following are the types of information incorporated into and tracked by the GTMS:

- Valid Vehicle Identification Numbers (VIN);
- "Short trip" status threshold time;
- In-vehicle Equipment complement for each VIN;
- Terminal curb destination identifiers;
- Terminal curb destination identifiers associated with each terminal curb reader;
- License plate numbers associated with VINs for each fleet (pre-arranged vehicle operations only); and
- Registration information from pre-arranged vehicles.

Exhibit 10 illustrates the importance of data exchange and sharing in the system by summarizing the different data exchanges that occur through the communication interfaces between the GTMS and various field equipment units.

WAAI was responsible for supplying these initial "inputs" as well as for providing the resources to update this information on an ongoing basis. To facilitate these functions the software package was developed to run in a Windows NT® environment. The software is also flexible enough to assist the airport administration in archiving of database information as well as creating the reports and other needed "outputs" for administrative and planning purposes. Ease of future connections and interfaces of the GTMS at Winnipeg International Airport to other ITS or information management systems are ensured through the modular software and flexible database structures.

7.1 FUNCTIONALITY OF INSTALLED ROADSIDE COMPONENTS AND SUBSYSTEMS

Automatic Vehicle Identification Subsystem

In general, AVI equipment is used to track the location of the airport commercial vehicles. Each airport vehicle is equipped with a special AVI transponder identified by a unique Vehicle Identification Number (VIN). As an airport vehicle passes by an AVI antenna, its VIN is read by the reader/antenna and data is sent to the GTMS. This process enables the GTMS to track the overall vehicle movements within the airport through the AVI Subsystem. Each AVI antenna is connected to an AVI reader which constitute the AVI Subsystem Controller unit. The AVI readers send VIN data as they become available.

Exhibit 10: In-Vehicle - Field Equipment Interfaces

DATA FROM GTMS	FIELD EQUIPMENT	DATA TO GTMS
• Message for display on in-vehicle display	Vehicle Reader	• Vehicle identification (if Type-II) • Vehicle identification and Driver identification (if Type-III)
• Sign state selection • Sign message	Entrance/Exit Sign (BOS)	
• Sign message contents	Queue Sign (VMS)	
• Account balance	Pay-at-point station (PAP)	• Account balance
• Central database vehicle information • Payment required	Pre-arranged Vehicle Registration, Payment and Receipt Printing Machine (PTIE)	• Vehicle license number • Entered vehicle information • Transaction number • Passenger name • Payment received • Ticket identification

Taxi/Limousine CVHA Entrance Confirmation

The taxi/limousine CVHA Entrance Confirmation Signs (ECS) relay information to the commercial vehicle drivers entering the different CVHAs. This ECS displays a fixed message to the driver about his/her account status. Depending on the status of the account, one of three messages appears. "Enter" indicates that a transaction has occurred and is complete, "low" indicates that the account has passed below an acceptable threshold level while "exit" indicates that the system is either malfunctioning or the vehicle is not registered at the airport. The ECS is also available for other functions as well, such as to give an indication of a vehicle's short trip status (if any). Control of the CVHA ECS is through the ECS Controller unit, a microprocessor-based controller responsible for displaying the required messages in response to commands received from the central computer system.

Taxi/Limousine Summoning Signage

The Summoning Variable Sign (SVS) relays dynamic vehicle queue information to the commercial vehicle drivers through the use of a SVS mounted near the exit of the CVHA. The VMS displays the current top-5 dispatch queue. Due to the limitation of having only one VMS, the sign alternates between types of commercial vehicles awaiting dispatching to the terminal curb-side (taxis and limos). Control of the SVS is through a SVS Controller unit, a microprocessor-based controller responsible for displaying the required messages in response to commands received from the central computer system.

Taxi/Limousine Curb Entrance Confirmation

The taxi/limousine Curb Entrance Confirmation Signs (CES), as proposed in the enhanced implementation option, would be a sign similar to the CVHA discussed above. It would add capabilities for enforcement at the terminal curb-side if non-registered commercial vehicles attempt to pick-up fare paying passengers as well as for securing correct and equitable revenue collection by WAAI. Control of the CES is through a CES Controller unit, a microprocessor-based controller responsible for displaying the required messages in response to commands received from the central computer system.

Pay-at-Point Station Subsystem

The Pay-at-Point station subsystem (PAP) is the field unit of the account management system in the GTMS. The PAP station is placed after the entrance of the CVHA and is capable of the following:

- Receive coin deposit;
- Issue receipt with time stamp, amount received and new transponder account balance.

The PAP station provides an RS-232 serial link to the central computer for on-line communications. It incorporates a keypad for deposits to increase account balance, and for input on vehicle identification information as well. Proposed future upgrades call for integration of credit and debit cards.

CVHA Closed Circuit Television Monitoring Subsystem

The CVHA Closed Circuit Television Monitoring subsystem (CCTV), as seen in the enhanced implementation option, assists in the monitoring of ongoing activity in the CVHA, focussing on detection of inappropriate use of field equipment, especially vandalism, and confirmation of taxi and limousine inventories in the CVHA.

Functionality of Installed Central Computer Control System Components and Subsystems

Each of the above identified roadside components and subsystems are controlled and communicated through a centralized computer control system. The centralized computer control system is configured with the following components:

- Device Communications Computer (DCC);
- Master Control Computer (MCC); and
- Database Computer (DBC).

The Device Communications Computer (DCC)

The DCC is responsible for all communications to external system devices. The DCC provides the necessary protocols to communicate with each external device. In general the devices are interfaced through industry standard RS232 serial data interfaces. The DCC does, however, accommodate other industry standards as well. The DCC is a PC-based platform running Windows NT® operating system for co-operative real-time multi-tasking capabilities.

The Master Control Computer (MCC)

The MCC is responsible for monitoring and control of vehicle movements within the system. The main task is to maintain the vehicle queues at terminal curb-sides and CVHAs. The MCC is a PC-based platform running Windows NT® operating system for co-operative real-time multi-tasking capabilities.

The Database Computer (DBC)

The BDC contains the central database of the GTMS. The database is a client/server architecture and is accessible by all computers on the network. The DBC is a PC-based platform running Windows NT® operating system for co-operative real-time multi-tasking capabilities.

Additional computers in the GTMS, include:

- System Maintenance Computer (SMC); and
- Terminal Curb Computer (TCC).

The System Maintenance Computer (SMC)

The SMC provides a central facility to configure or re-configure applications of the GTMS. From the SMC, users may add/remove driver and vehicle information, add/remove external field devices, and obtain statistics on system performance and reliability. The SMC is a PC-based platform running Windows NT® operating system for co-operative real-time multi-tasking capabilities.

The Terminal Curb Computer (TCC)

The TCC is located at the terminal curb and provides a means to interact with the system through a GUI. From a TCC, users may summon vehicles, review vehicle queue information, and enter certain parameters and vehicle information data. The TCC is a PC-based platform running Windows NT® operating system for co-operative real-time multi-tasking capabilities.

7.2 DESIGN AND TECHNOLOGY SELECTION ISSUES

Important aspects in making the GTMS highly functional included the selection of technology to support the above described subsystems. For example, the LAN network employed is an industry standard 10-Base-T system capable of supporting TCP/IP, Ethernet and Novell Netware® traffic. This technology choice recognized the importance of communication and exchange of data between any computers on the GTMS network.

Additional considerations included an assessment of the different on-board vehicle units, i.e. Type-I, Type-II and Type-III (with smart card capabilities) transponders, applicable COTS software and specially developed (tailored/user-friendly) software and hardware, and the selection of the most appropriate communications media for interconnection of the central control computer system and the various devices and field equipment. The selection of centralized computer control system relates to the architectural and performance requirements of the GTMS. The use of PC (versus mainframe computer) allowed for the design of generic applications and user-friendliness at all levels. The Oracle® relational database management system facilitated easy integration with other airport information systems and long-term support and maintainability while the Windows NT® operational system enabled real-time traffic and some level of redundancy without reducing system performance in terms of required processing loads. Selecting an appropriate communications backbone required resolving issues such as use of leased or owned infrastructure, and the appropriate technology (i.e. twisted pair, coaxial cable, fibre optic cable, radio frequency, packet radio, cellular telephone, microwave or infrared).

8.0 FUTURE STEPS

Future enhancements must recognize that communication with on-board equipment of taxis and limousines is, in many cases, only possible if in-ground or embedded antennae are deployed. With appropriate visualizations of how Type-III transponders may continue to operate under different standards, system integrators and deployers alike should further address the need for open protocols and long-term system interoperability.

The GTMS software design and the flexible database structure provide an adaptable, expandable and modular product that supports future enhancements and integration with other systems. A comprehensive landside transportation operations system incorporates the following systems:

- Commercial Vehicle Control and Management System;
- Terminal Shuttle Dispatch and Headway Management System;
- Traffic Information and Count System; and
- Parking Control and Information System.

While such a comprehensive system may only be achievable in the longer term, short-term expansions could easily produce a full-fledged GTMS where new functional modules, or layers, would be added in a logical and strategic manner. With the insight gained through the implementation of the account management functions, the outlook for functional and geographical migration of the original CRCS using DSRC technology remains optimistic. Interesting possibilities exist for host-to-host computer integration that would allow the GTMS to disseminate the current and existing commercial vehicle operations conditions to other systems.

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