Measuring Border Delay and Crossing Times at the U.S./Mexico Border

Task 3 Report
Final Design Document

Prepared by

Battelle
The Business of Innovation

and

Texas Transportation Institute

Prepared for
U.S. Department of Transportation
Federal Highway Administration

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November 21, 2008
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BORDER CROSSING TIME MEASUREMENT PROJECT DETAILED DESIGN

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Border Crossing Time Measurement Project
Detailed Design

Introduction

This document provides the detailed design for the field subsystem of a commercial-off-the-shelf (COTS) passive Radio Frequency Identification (RFID) technology designed to acquire data via a unique identifier (i.e., RFID tag) from equipped vehicles as they pass known points in the border crossing complex entering the United States at the Bridge of the Americas (BOTA) Port of Entry, El Paso, Texas. This detailed design is based on the conceptual design described in the Task 1 Preliminary Design Document, reviewed with FHWA on June 16, 2008 and accepted with minor changes. With several detection stations identified, tag data can be time stamped and transmitted to a central location for processing into travel times between reader sites and ultimately through the border crossing complex.

The preliminary design organized the time measurement system into three subsystems: Field Subsystem, Central Subsystem, and User Subsystem. The main body of this document addresses the detailed hardware design of the Field Subsystem. Appendix A contains the Select Equipment Specifications for the Field Subsystem. References to BOTA and to the Texas Departments of Transportation and Public Safety (TxDOT and DPS, respectively) appear in this document for the sake of reference, although the Field Subsystem design is intended to be representative to the extent possible for the needs of any international border crossing implementing a comparable RFID system.

Design detail for the Central Subsystem can be found in Appendix B at the end of this document. The design description of the Central Subsystem was derived from the Preliminary Design Document developed in Task 1. The final design of the Central Subsystem for this project will be dictated by the site-specific deployment and the stakeholder requirements for the User Subsystem. For example, the attribute structure of tables and the relationship between tables are strictly dictated by stakeholder requirements and number of RFID readers, that will vary at each port of entry where this type of system may be deployed.

Like the Central Subsystem, a design description for the User Subsystem was developed in the preliminary design document. This general description can be found in Appendix C at the end of this document. Because the User Subsystem will vary considerably from site to site, the final design of the User Subsystem for this specific project, which includes the software design, will be developed separately in subsequent tasks.

Field Subsystem – RFID Station

The border crossing time is measured by means of stations located along the path the vehicle takes through the different border authorities’ facilities. The measurement point will be called an RFID Station and will read passing RFID tags on equipped vehicles. The tag data will be both stored locally and forwarded in real time to a central collection point. Exhibit 1 is a detailed design defining individual parts required to deliver the conceptual design.
Each field site will be solar powered to reduce overall system installation and operation costs and to accelerate deployment time. Hardwired electrical power is not available at most of the optimal RFID stations at BOTA.

The field component can be organized into four groupings:

- Equipment on passing vehicles,
- Equipment mounted on a cantilevered pole,
- Equipment mounted in a control cabinet and,
- Equipment mounted in a ground level vault.

Vehicle ‘equipment’ is simply the RFID windshield tags, which at BOTA will be handled by the Texas Department of Transportation (TxDOT), Texas Department of Public Safety (DPS) and others. The tag protocol has been defined by those parties to be the Transcore eGoPlus protocol. The RFID equipment must be able to read and recover data using this protocol.

The equipment mounted on the pole is essentially the RFID reading equipment. A multiprotocol Transcore Encompass 2210 reader is selected. The reader was chosen for the following reasons:
- Supports the eGo protocol, the common American Trucking Association (ATA) protocol, and others,
- Small physical footprint,
- Simple control protocol,
- Supports external antenna(s) for multi-lane use,
- Common equipment with TxDOT / DPS onsite installations, and
- Compact, outdoor-ready product design.

The reader sites will require reading tags in multiple lanes. The Transcore 2210 reader supports an external antenna or multiple antennas with the use of an RF power splitter. Transcore recommends the use of their model AA3153 panel antenna to produce a wider tag reading footprint in the lane. The design does not require identifying a specific lane of travel for each tag read, thus overlapping antenna coverage is very beneficial. Overlapping coverage eliminates reduced sensitivity zones near the edge of a single antenna footprint (e.g. near a lane center stripe).

High frequency RF signals can easily lose a significant percentage of their power in coaxial cables. High quality coaxial transmission line with low loss at 900MHz must be selected and cable runs kept to a minimum. Transcore recommends coaxial cable RF loss to be no more that 1dB for optimal performance and no more than 3dB for adequate performance. The Transcore 2210 reader will be installed as close as possible to the external antennas to limit the RF coax length. The reader will be installed near the upright support pole to limit its exposure to passing traffic and possible damage due to shifted truck loads. For multiple lane locations, an RF power splitter will be installed directly adjacent to the tag reader to split the RF into individual coaxial cables connected to the individual panel antennas. A single lane deployment will not require the RF power splitter. The control cable for the reader includes power, communication, and contact closure wires bundled into a single cable. The cable will be routed through the supporting pole / structure and will terminate in the control cabinet.

Three 115 watt solar photovoltaic modules (PV modules or solar panels) will be installed on the upright portion of the cantilever pole in such a manner as to not shade each other. Each solar panel can generate up to 7.5 amps. Power cable sizing should be sufficient for the current needs and maintain reasonable voltage drop (energy loss).

The majority of the site equipment is installed in a secure metal outdoor cabinet (NEMA 3R enclosure or better). This equipment includes all the power conditioning, data recording, and communication hardware. The control cabinet will operate from a 12vDC main power source with all cabinet equipment operating directly on 12vDC. The Transcore 2210 reader requires a minimum of 18 v DC and the programmable relay requires 24vDC to operate. A 12vDC to 24vDC converter is included to power both. Thus, the solar panels will power both the RFID reader and the control cabinet associated with it.

The 2210 reader consumes the vast majority of the power used by the entire site. At a minimum the 2210 reader should be turned off during times when tag reads are not expected, in order to conserve energy and to lower the solar panel and battery needs. These times would correspond to time periods when the border facility is closed (i.e. at night). The programmable relay will be
used to manage the power to the 2210 reader. The relay will enable power to the 2210 one hour before the roadway will experience traffic and remain on until one hour after the roadway (bridge crossing) closes.

Communication from the field station to the central data collection point (the El Paso TTI office) will be provided by the ConnectPort WAN product. The device uses a cellular data link with an area commercial service provider to extend Internet access to a field station. One serial port on the ConnectPort WAN will be used to connect to the data logger and the 2210 reader. The serial port will be configured to send all data frames to a receptor at the TTI El Paso office. Other configurations can be implemented to send data to multiple locations for backup or parallel processing if required.

A common problem with continuously operating cellular modems is that, on occasion, they drop the connection with the cellular provider. Although the cellular router product has built in software-based recovery measures, an external watchdog solution has proven to be beneficial. The iBoot product will cycle the power on the cellular router when a loss of network access is detected. The iBoot product will periodically interrogate at least one network server (either at the TTI office or somewhere on the Internet) using the wireless network to ensure a functional data path. The iBoot product will cycle the power on the wireless network interface (ConnectPort WAN) to attempt to reinstitute the connection. This action will happen in the background during regular operations and will catch data disruptions quickly.

The data logger product will time stamp and store a copy of all tag reads as the equipped vehicles pass the RFID antenna. The logger provides a local (i.e. in the field) backup system in case communication is lost long-term and provides the means to add a time and date to the tag read data which is not provided by the 2210 reader. Each tag read creates a 37 character (byte) record and the logger has a 2 gigabyte storage area yielding a capacity for over 50 million stored tag reads.

Energy from the solar panels is stored by a bank of eight 12vDC solar service batteries. As per local TxDOT practice, the batteries will be housed in a ground level, sealed and secure vault. Two vaults will be utilized with each housing four batteries. Conduit will be provided between the vaults and the cantilever upright pole. Properly sized power cable will run from the vaults up to the control cabinet and terminate at the Morningstar charge controller.
A typical RFID installation is shown in Exhibit 2 below.

**Exhibit 2: Typical Design of RFID Detection Station**
*(Street Level – Front View)*

![Exhibit 2: Typical Design of RFID Detection Station](image)

The design utilizes the standard overhead mounting of antenna(s) for detecting RFID tags on vehicles passing beneath. Prior research (TxDOT – Southwest Research Institute) has shown that a mounting height of 18 feet above pavement is ideal with a maximum useable distance of 20 feet above pavement. This design recommends 18 feet, which is similar to the height of the CBP and DPS readers. A semi trailer height will be under 14 feet, as no over-sized trailers are allowed at BOTA.

The antennas will be supported by an overhead fixture, typically a pole with a cantilever arm although this exact arrangement is not required. The requirement is that the antenna be securely installed approximately 18 feet above pavement in the middle of the travel lane. Existing bridge structure may also be used assuming there are proper supports for the antenna, coax, reader, and reader control cable.
A single reader and multiple (if required) antennas will be used per site. An RF power splitter will be used to combine multiple (up to 3) antennas to one reader. All lanes at the detection point will be covered by an antenna.

Transcore recommends the use of their panel antenna for a wider coverage zone. This antenna is included in the field design and mounts as shown in Exhibit 3 below.

**Exhibit 3: Antenna Mounting Design**  
(Street Level – Side View)

The panel antenna mounts nearly horizontal to the roadway with a 15 degree tilt upward into the direction of vehicle travel. Again, high quality RF coax is used to connect the panel antenna to the RFID reader or power splitter.

The solar power system is comprised of three groups of items. The photovoltaic modules convert the sun’s rays into electrical current and will be mounted on the pole upright near the top. The modules need to be installed such that the adjacent panel does not shade or minimally shades the other modules. The modules connect to the input side of a charge controller. The charge controller manages the energy draw from the solar panels as well as limits any reverse current during dark periods. A battery bank is used to store energy from the solar panels and to
provide power to the charge controller load when there is insufficient sunlight to pull the needed power from the PV modules. The battery bank is designed to provide power for the site during an extended period of heavy cloud cover. The load side of the charge controller supplies power to all the electrical equipment at the station. Additionally, the controller will turn off power if the battery bank becomes depleted and limits the depth to which the batteries can be discharged (since prolonged deep discharging of batteries reduces their useful lifespan). Exhibit 4 illustrates the solar design layout.

**Exhibit 4: Solar Design Layout**

Exhibit 5 is a representative equipment list for a complete RFID station. The design assumes two travel lanes and thus two panel antennas and a power splitter.
A power budget was developed for the specified equipment to be used in the solar energy design. Exhibit 6 shows the energy needs of the station as well as the generation and storage capability.

**Exhibit 6: Solar Energy Power Budget**

<table>
<thead>
<tr>
<th>Solar Budget Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Consumption (W*hr/day)</strong></td>
</tr>
<tr>
<td>650</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| **Generation (W*hr/day)** | **Panels** | **Wattage** | **Avg hrs sun** | **Derate** | **Excess (W*hr/day)** |
| 1552.5 | 3 | 115 | 5 | 90% | 902.5 |

| **Storage (W*hr)** | **Battery Cap** | **Voltage** | **Quan** | **Cycle Depth** | **Reserve (days)** |
| 6451.2 | 96 | 12 | 8 | 70% | 9.9 |

It is clear from the consumption data that the RFID reader is the major user of energy and needs to only operate during the active hours of the border crossing operations. The panels generate approximately 140% more energy than is required to operate the station. The excess energy is stored in a battery bank that is designed to provide approximately 10 days of autonomous operation from a full charge.
The solar equipment required to meet the energy budget described in Exhibit 6 is listed below in Exhibit 7.

**Exhibit 7: Detection Station Solar Equipment List**

<table>
<thead>
<tr>
<th>Item</th>
<th>Model</th>
<th>Vendor</th>
<th>Quan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Panel</td>
<td>3115 BP Solar module 115 watt 12Vdc</td>
<td>SW Photovoltaic</td>
<td>3</td>
</tr>
<tr>
<td>Charge Controller</td>
<td>Morningstar ProStar 30M</td>
<td>SW Photovoltaic</td>
<td>1</td>
</tr>
<tr>
<td>Solar Batteries</td>
<td>MK8G31 Gel battery 96AH with cable kit</td>
<td>SW Photovoltaic</td>
<td>8</td>
</tr>
<tr>
<td>Battery Cabinet</td>
<td>In ground vault per quote</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>misc solar install parts</td>
<td>brackets, mounts, shipping, etc</td>
<td>SW Photovoltaic</td>
<td>1</td>
</tr>
</tbody>
</table>
Appendix A:
Select Equipment Specifications
(Field Subsystem)
Encompass™ 2 Reader
Model 2210

TransCore’s Encompass™ 2 Reader Model 2210 is an integrated 915 MHz radio frequency identification (RFID) reader designed to be used with high-performance external antennas. The unit includes a radio frequency (RF) module, digital signal processor (DSP), power supply, I/O ports, serial communications interface, and an external antenna connector. The reader is ideal for high-speed tolling and electronic vehicle registration applications where 64-bit 1D tag read mode allows tags to be read at highway speeds. The reader is also suitable for parking, security access, and eCommerce applications with a requirement to read TransCore’s eGo® tags and/or TransCore’s American Trucking Associations (ATA)-compliant tags.

The Encompass 2 Model 2210 can be configured to read TransCore eGo tags, as well as other tags, which are compliant with ANSI INCITS 295-001, International Organization for Standardization (ISO) 18000-6B or ATA standards. It reads the 64-bit tag ID or 128 bits of specially programmed data and can read tags formatted to a wide range of industry-standard formats, including Wiegand format. Custom Wiegand 26-bit to 50-bit (inclusive) formats can be developed to match identification card formats used by existing security systems.

The Encompass 2 Model 2210, configured with an external antenna, transmits an RF signal that is reflected back from an RF tag. The Encompass 2 Model 2210 then decodes the tag data carried by the reflected signal. The system transmits this data to a local host computer for processing.

The Encompass 2 Model 2210 is compatible with TransCore’s AmTech®-brand toll antennas and uses a similar interface as TransCore’s SmartPass® readers.

PRODUCT PROFILE
Encompass™ 2 Reader Model 2210

**COMMUNICATIONS**

- **Frequency Range**: 902 to 928 MHz capable, 912.5 to 919.5 MHz, FCC-authorized in United States
- **RF Control**: By sensor input or host command
- **Read Performance**: Read performance varies depending on tag, reader, and antenna configuration and environment. See Figure 1.
- **Communications Interface**: RS-232 with Wiegand or RS-422 with Wiegand-compatible host interface

**POWER REQUIREMENTS**

- **Input Power**: 10 to 20V AC, 47 to 63 Hz, or 10 to 28V DC
- **Output Power**: 2 W maximum to 200 mW minimum, selectable in 1 dB steps

**LICENSING**

- **Equipment License**: The user is required to obtain a Part 50 site license from the FCC to operate the unit in the United States. Access the FCC Web site at www.fcc.gov/Forms/Form001/001.html for more information.
- **FCC ID**: PHX999999999 (See product label for actual ID number)
- **Users in all countries should check with the appropriate local authorities for licensing requirements.**

**DOCUMENTATION**

- **For product information call**: 1.800.923.4824 or 972.733.6600 (outside the U.S.) Fax 972.733.6485
- **www.transcore.com**

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**SPECIFICATIONS**

**COMPLIANCE**

- **RF Interference**: Units have been tested and are verified to Part 15 of the FCC rules for a Class A digital device.
- **Safety**: The Encompass 2 Model 2210 complies with the requirements of Underwriters Laboratories UL-1990, Standard for Safety of Information Technology Equipment.

**HARDWARE FEATURES**

- **Antenna Interface**: RF coax, Type N female connector
- **Antenna Interface**: RS-232 with Wiegand or RS-422 with Wiegand-compatible host interface

**ENVIRONMENTAL**

- **Operating Air Temperature**: -40°F to +131°F (-40°C to +55°C)
- **Humidity**: 100% condensing
- **Vibration**: 0.5 g rms, 10 to 500 Hz

**OPTIONS**

- **Power/Communications Cable Accessory Kit**: Cable accessories allow flexibility in installing the Encompass 2 Model 2210. Include the part number when ordering.
- **Part number 58-1620-901**: Connector with 5 ft (1.5 m) cable
- **Part number 58-1620-002**: Connector with 20 ft (6.1 m) cable

**Wall Mount Bracket**: A wall mount bracket is used to install the Encompass 2 Model 2210 on a flat surface. Include the part number 94-1620-001 when ordering.

**Transformer**: A Class C transformer (part number 76-1620-005) is available to allow 110V AC to 18V AC conversion. Include the part number when ordering. A Class C (part number 76-1620-006), 220V AC to 18V AC transformer is available by special request.

**TRAINING**

- **Installation, operation, and maintenance training for TransCore authorized dealers is available through TransCore. For details, call (972) 733-6010.**

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**Figure 1 Example Coverage Area**

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**Final Design Document**

A-2

November 21, 2008
The AA3153 Toll Antenna broadcasts and receives radio frequency signals in the 902 to 928 MHz radio frequency band. It is specifically designed for toll lane applications, with virtually no side or back lobes, which helps confine antenna coverage to a single lane width. The AA3153 Toll Antenna is ideally suited to applications requiring a low profile antenna.

A weatherproof enclosure provides favorable electrical characteristics, resistance to ultraviolet radiation, and maximum corrosion resistance. The AA3153 Toll Antenna includes a sturdy aluminum backplate with mounting hardware, a multi-patch array, and matching network.
# AA3153 Toll Antenna

## Specifications

<table>
<thead>
<tr>
<th><strong>Communications</strong></th>
<th></th>
</tr>
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<tbody>
<tr>
<td>Frequency Range</td>
<td>902 to 928 MHz</td>
</tr>
<tr>
<td><strong>Gain</strong></td>
<td>10.5 dBi</td>
</tr>
<tr>
<td><strong>Polarization</strong></td>
<td>Linear — horizontal</td>
</tr>
<tr>
<td><strong>Cross Polarization</strong></td>
<td>&lt; -45 dB</td>
</tr>
<tr>
<td><strong>Side Lobe</strong></td>
<td>≤ -25 dB</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.9:1</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 ohms nominal</td>
</tr>
</tbody>
</table>

| **Half-Power Beam Width** | 50° E-plane and 60° H-plane |

<table>
<thead>
<tr>
<th><strong>Hardware Features</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Connector</strong></td>
<td>N-type socket</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Physical</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dimensions</strong></td>
<td>Size: 24 x 24 x 2.5 in (61 x 61 x 6.4 cm)</td>
</tr>
<tr>
<td></td>
<td>Weight: 18 lb (8.2 kg)</td>
</tr>
<tr>
<td><strong>Mounting Location</strong></td>
<td>15 to 20 ft (4.6 to 6 m) above lane</td>
</tr>
<tr>
<td><strong>Mounting Method</strong></td>
<td>To support pipe with a maximum outer diameter of 3.0 in (7.6 cm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Environmental</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature</strong></td>
<td>-40°F to +167°F (-40°C to +75°C)</td>
</tr>
<tr>
<td><strong>Humidity</strong></td>
<td>100% condensing</td>
</tr>
<tr>
<td><strong>Vibration Tolerance</strong></td>
<td>0.5 g rms, 10 to 500 Hz</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Options</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Check Tag</strong></td>
<td>The AA 3153 Toll Antenna may be ordered without an internal check tag or with the A15720 external check tag installed.</td>
</tr>
</tbody>
</table>

---

For product information call: 1.800.923.4824 or 972.733.6600 (outside the U.S.) fax 972.733.6486

www.transcore.com

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3-Way 900 MHz Signal Splitter N-Female Connector

Features for this Signal Splitters product

- Used to split 900MHz RF signals
- 800-1000 MHz frequency range
- Industrial grade cast aluminum construction
- DC power will pass to all ports
- Available with N-Female connectors

HyperGain® 900 MHz Signal Splitters / Signal Combiners are used for connecting more than one antenna to a single radio. They feature weather-proof construction and can be installed indoors or outdoors. This 3-way splitter can be used with amplified systems since they will pass DC power to all ports. Mast or pole mounting is possible using the optional mast mounting kit.

Note:
To ensure proper operation, any open splitter ports should be terminated with a high quality 50 Ohm terminator. We recommend the Hyperlink ANM-TERM1 0-6 GHz 50 Ohm N-Male Terminator.

Guaranteed Quality
These products are designed and manufactured by HyperLink Technologies in the U.S.A. and are backed by Hyperlink's Limited Warranty.

Details for this Signal Splitters product

HyperLink Item # SC903N
Manufacturer Hyperlink

Applications for this Signal Splitters product

- Compatible with 900 MHz ISM band and 900 MHz cellular applications
- Connect more than one antenna to a single radio

Specifications

<table>
<thead>
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<th>Type</th>
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<tr>
<td>Frequency</td>
<td>915 MHz ±50 MHz</td>
</tr>
<tr>
<td>Insertion Loss*</td>
<td>&lt;0.5 dBi</td>
</tr>
<tr>
<td>Impedance</td>
<td>50 Ohms</td>
</tr>
<tr>
<td>VSWR</td>
<td>&lt;1.5 : 1 Typical</td>
</tr>
<tr>
<td>Power Rating</td>
<td>25 Watts</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>-40°C to +85°C</td>
</tr>
<tr>
<td>Dimensions (L x D x H)</td>
<td>4.6 x 2.6 x 1.7 (inches)</td>
</tr>
<tr>
<td>Weight</td>
<td>0.65 lbs. (.29 kg)</td>
</tr>
<tr>
<td>Reverse Port Isolation</td>
<td>No</td>
</tr>
<tr>
<td>RoHS Compliant</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Acumen Instruments Corporation’s DataBridge SDR-CF is another way Acumen Instruments makes it easy to add data storage to any device or system.

The SDR-CF is a compact, rugged device that captures data from any device equipped with a serial port and stores it in a PC-compatible file on a CompactFlash card.

No programming required.
The SDR-CF is a hardware solution that is ready to deploy. Unlike embedded computers, no programming is required, and you don’t need to install special application software. Configuration can be changed using any computer’s serial port. Because the SDR-CF records data to PC-compatible files, your files appear on a standard drive letter and can be read with any common CompactFlash card reader.

If you already use a computer or laptop for data collection, the SDR-CF is a convenient drop-in replacement.

Low power consumption.
The SDR-CF consumes less than 1 Watt, offering significant power savings over PC’s, laptops, and embedded PC’s, so batteries last 10 to 100 times longer and no heat is generated. The SDR-CF operates from a 7-30 VDC power supply, simplifying system integration.

DataBridge™ SDR-CF
Serial Data Recorder

- Low-power
- Low-cost
- Small footprint
- Zero development time
- Records PC-compatible files

The flexibility you need.
At Acumen, we know every application has unique requirements. For devices that require it, the SDR-CF can send commands to the attached device on initialization, shutdown, or at specific intervals. You also control when files are opened and closed, how files are named, and date/time stamping.

Using the SDR-CF’s configuration port, you can connect to a computer to control and monitor your recording, download files, change recording settings, or communicate with your device using serial pass-through mode.

Industry-standard storage technology.
The SDR-CF gives you access to industry-standard CompactFlash solid-state storage media. You benefit from competitive pricing as well as assured compatibility with your PC.

Options for OEMs.
A board-only version of the SDR-CF, the SDR-OEM-CF, is available for integration with your product. Other OEM features include a remote panel interface connection. Customizations and quantity discounts are also available.

See it for yourself.
The DataBridge SDR-CF starter kit includes everything needed to get started. See our web site or contact Acumen Instruments Corporation for details.
DataBridge™ SDR-CF
Serial Data Recorder

**Specifications**

**Data rates**
2400 bps to 230.4 kbps

**Handshaking modes**
RTS/CTS (hardware handshaking)

**File format**
PC-compatible (DOS FAT16 file system)

**Storage device compatibility**
Devices conforming to the CompactFlash specification

**Electrical interface**
ATA/ATAPI (True IDE Mode)

**Storage capacity**
Limited only by storage device and FAT16 file system

**Power requirements**
7-30 VDC unregulated (under 1 W)

**Operating Temperature**
-40° to +85° Celsius (industrial temperature range)

**Physical Characteristics**

**Dimensions**
4.825” L x 3.375” W x 1.250” H
(12.2 cm x 8.57 cm x 3.12 cm)

**Weight**
8.5 oz (241 grams) without CF card

**Enclosure**
 Extruded aluminum

**Serial connectors**
DB9 male (DTE data port)
DB9 female (DCE configuration port)

**Drive connectors**
Type I/II CompactFlash connector with ejector

**Media Options**

**Solid-state media**
CompactFlash media - 8 MB to 2 GB
(limited only by FAT16 file system)

**Notable Features**

**Serial download protocols**
YModem batch, ASCII text

**Power-up modes**
Resume recording w/new filename, append to file

**Real-time clock functions**
Scheduled file closings every 1 second to 194 days
Optional date/time stamping of recorded data

**Output messages**
8 256-byte strings
1 second to 194 day output interval
(messages can also be sent at initialization or shutdown)

**Device control**
Serial passthrough mode
(converts between baud rates if needed)

---

Acumen Instruments Corporation • 2525 N. Loop Drive Suite 2200 • Ames, IA 50010
Voice: 515-286-5360 • Fax: 515-286-3504 • www.acumeninstruments.com

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### SG2 Programmable Relay Specifications

#### Power Supply Input
- Transformer input ranges compatible by terminal: 14-25 VDC
- DC power consumption: 100 mA
- AC power consumption: 150 mA

#### Environmental/General
- Operating temperature: 0°C to 55°C
- Storage temperature: -25°C to 70°C
- Operating altitude: 2000 m
- Maximum temperature: 100°C
- Humidity: 40% to 90% non-condensing
- Height: 220 mm
- Width: 150 mm
- Depth: 220 mm
- Weight: 2.5 kg

#### Discrete Inputs
- Input type: transistor
- Minimum load: 100 mA
- Maximum load: 40 mA

#### Analog Inputs
- Voltage range: 0 to 10 V
- Accuracy: ±0.02%

#### Relay Outputs
- Contact rating: 14-25 VDC
- Contact type: 1 N.O. 5 A

#### Transistor Output
- Voltage range: 14-25 VDC
- Current range: 0.1 A

#### Timers
- Counters
- Real-time clock
- Analog compares

---

**B&B Electronics Manufacturing Company**

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---

Overview

The ConnectPort WAN family of upgradeable 3G cellular routers provides secure high speed wireless connectivity to remote sites and devices. The routers can be used for primary wireless broadband network connectivity to equipment at remote locations, as well as for a backup to existing landline communications. They are ideal for use where wired networks (e.g., leased line/frame relay, ISDN, DSL) are not feasible, or where alternative network connections are required.

Flexible design ensures easy upgradeability via supported PCI Express modules or cards. With an upgradeable wireless network platform, customers are able to quickly migrate to future 3G platforms and beyond. The routers also include Ethernet, serial, USB and sensor ports to connect peripheral devices and TCP/IP network devices, as well as optional Wi-Fi and GPS.

Instant deployment, flexibility to move the connection, and elimination of wiring costs and problems caused by wire breaks make the ConnectPort WAN family ideal for utilities, industrial automation, retail/POS, financial (ATMs), traffic, medical, video surveillance and other applications. Integrated IPsec VPN client/server models are also available for secure connection requirements.

Each router includes Digi Connectware Manager software for easy setup, configuration, reporting and monitoring of large installations. Users can proactively monitor for problem devices and make simple firmware or configuration upgrades to thousands of devices with only a few clicks. With the Digi SureLink feature, users can keep a connection alive via device or server initiated settings. The ConnectPort WAN family also supports the easy-to-use Python environment, giving users a powerful software tool to develop custom applications to run on the router.

Please contact us at 1-800-437-7251 or 952-912-3444 for additional information or to discuss your specific application requirements.
## Features Comparison

<table>
<thead>
<tr>
<th></th>
<th>Special Features</th>
<th>EV-DO</th>
<th>HSDPA</th>
<th>Type of Card/Module Support</th>
<th>Python</th>
<th>Cellular Router (No Modules)</th>
<th>Ports</th>
<th>VPN</th>
</tr>
</thead>
<tbody>
<tr>
<td>ConnectPort WAN VPN</td>
<td></td>
<td>X</td>
<td>X</td>
<td>PC Card, PCI Express Module</td>
<td>X</td>
<td>X</td>
<td>4 Ethernet, 2 USB, 2 RS-232 Serial</td>
<td>X</td>
</tr>
<tr>
<td>ConnectPort WAN Wi</td>
<td></td>
<td>X</td>
<td>X</td>
<td>PCI Express Module</td>
<td>X</td>
<td>X</td>
<td>1 Ethernet, 2 USB, 1 Sensor, 1 RS-232 Serial</td>
<td>X</td>
</tr>
<tr>
<td>(Ad-Hoc Mode)</td>
<td>Wi-Fi, Sensor</td>
<td>Port</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ConnectPort WAN GPS</td>
<td>GPS, Sensor</td>
<td>Port</td>
<td></td>
<td>PCI Express Module</td>
<td>X</td>
<td>X</td>
<td>1 Ethernet, 2 USB, 1 Sensor, 1 RS-232 Serial</td>
<td>X</td>
</tr>
<tr>
<td>ConnectPort WAN Express</td>
<td></td>
<td>X</td>
<td>X</td>
<td>PC Express Card</td>
<td>X</td>
<td>X</td>
<td>4 Ethernet, 2 USB, 2 RS-232 Serial</td>
<td>X</td>
</tr>
</tbody>
</table>

### ConnectPort WAN VPN
- 3G high speed upgradeable Wireless WAN cellular router with integrated IPsec VPN client/server for true end-to-end data protection.

### ConnectPort WAN GPS
- 3G high speed upgradeable cellular router with GPS capability.
- Provides secure wireless connectivity to remote sites and devices.
- Allows efficient tracking of mobile workforce location.

### ConnectPort WAN Express
- 3G high speed upgradeable Wireless WAN cellular router with integrated IPsec VPN client/server for true end-to-end data protection.
- Support for new PC Express Card enclosed for security and durability (PC Express Card antenna ported to standard SMA connector on outside of enclosure).

### ConnectPort WAN Wi (Ad Hoc)
- 3G high speed upgradeable cellular router with support for Wi-Fi (802.11b/g) technologies.
- Provides secure high speed wireless connectivity to remote sites and devices.
- Operates in Wi-Fi ad hoc (or peer-to-peer) mode to provide local networking as well as the ability to act as an Internet gateway for multiple devices.
Features/Specifications

**Features**
- Network protocols: UDP/ICMP/CHT/FTP
- Status LEDs: Ethernet, power on, cellular link/activity, signal strength (4 bars)
- Device-based Intel/Port COM port redirector and RFC2217
- Security - SSL, SSH/v2, IPS 197 (serial port)
- Python scripting, custom development environment

**Router/Network Features**
- NAT
- NAT (NAT traversal) VPN tunneling
- Port forwarding
- Access control lists (IP filtering)
- IP pass-through
- Virtual Router Redundancy Protocol (VRRP) per RFC 3268

**VPN Features**
- PSK with IKEv2/AES
- IPsec pass-through, GRE

**Management**
- HTTP/HTTPS, CLI or Telnet
- Optional secure enterprise management via Digi Connect Manager

**Interfaces**
- **Serial**
  - 2 RS-232 DB-9M serial ports (Connect Port/WAN VGA/Express)
  - 1 RS-232 DB-9 serial port (Connect Port/WAN VGA/LP, ConnectPort WAN G50)
  - Throughput up to 230 Kbps
  - Full signal support for RS232, XON, XOFF, RTS, CTS, DTR, DSR, and DCD
  - Hardware and software flow control

- **USB**
  - 2 USB Type A connectors
  - See www.digi.com for a list of supported USB devices

- **Ethernet**
  - 4 RJ-45 switch ports (ConnectPort/WAN VGA/Express)
  - 1 RJ-45 switch port (ConnectPort/WAN VGA/LP, ConnectPort/WAN G50)
  - Standard: IEEE 802.3
  - Physical Layer: 10/100Base-T
  - Data rate: 10/100 Mbps (auto-sensing)
  - Mode: full or half duplex (auto-sensing)

- **Cellular**
  - Upgradable interfaces
  - PC Card

**Interfaces (continued)**
- 16/32 bit Type 2 PCMCIA Card Slot
- Sierra Wireless Aircard
  - UMTS/HSDPA/HSUPA/PCMCIA Card
  - 881 - North American Carriers
  - 880 - European Carriers
  - 875 - Worldwide Carriers
  - 860 - North American Carriers
  - 850 - European Carriers

- PCI Express Module
  - Sierra Wireless 5725 Rev A EV-DO - Sprint Version
  - Standard: 800/1900 MHz with RX Diversity
  - Sierra Wireless 8775 1.6 HSDPA
  - UM3/HSDPA 850/1900/2100 MHz, GSM/GPRS/EDGE
  - 850/900/1800/1900 MHz

- PCI Express Card
  - Option GT Express 7.2 HSDPA
  - Sierra Wireless AC801E/AC841E HSUPA
  - Option GT Express HSUPA
  - 1 or 2 external 50 ohm female SMA connectors (see model # for antenna count)

- **Wi-Fi**
  - Standard: IEEE 802.11b/g
  - Frequency: 2.4 GHz
  - Data rate: Up to 54 Mbps with automatic rate fallback
  - Transmit power: 15 dBm ± 2 dBm
  - Receiver sensitivity: -71 dBm @ 54 Mbps, -81 dBm @ 11 Mbps, -85 dBm @ 6 Mbps, -93 dBm @ 1 Mbps

- **WLAN Security**
  - WEP: 64/128 bit encryption (RC4)
  - WPA-PSK, WPA2-PSK (802.1X)
  - 128/192/256-bit encryption
  - Enterprise model (802.1X):
    - LEAP (WEP only), PEAP, TLS, TLS
    - EAP/MSCHAPv2, EAP-TLS, EAP-TTLS
  - Pre-shared key mode (PSK)

- **Antenna**
  - 1 external 50 ohm male SMA connector

- **GPS**
  - 2.5 m CE efficiency
  - Supports AIME protocol
  - 148 dBm acquisition sensitivity
  - 36 sec acquisition time on cold start
  - 4 Hz min update rate
  - Asterisc: 1 external 50 ohm male SMA connector

**Dimensions**
- Width: 4.11 in (10.4 cm)
- Length: 3.30 in (8.3 cm)
- Weight: 1.60 lbs (0.7 kg)

**Power Requirements**
- Power input: 9-30VDC
- 120VAC power supply for o°C to +60°C (28°F to +140°F) with locking barrel connector included
- Surge protection: 115 V, Max: 115 V
- Surge protection (with included power supply): 4.4 kW max (ETT per EN61000-4-4, 2.2 kW surge per EN61000-4-5)

**Environmental**
- Operating temperature: -30°C to +60°C (-22°F to +140°F)
- Relative humidity: 10% to 95% (non-condensing)
- Ethernet isolation: 1500VAC min per EN61000-4-2
- Serial port protection (ESD):
  - +15kV ESD latch and +15kV contact discharge per EN61000-4-2
Final Design Document

A-12

November 21, 2008
Crashed systems are a fact of life. Minimize downtime with these automatic and remote controlled reboot units. Just point your web browser to the iBoot and you are one click away from eliminating service calls that take valuable time and money.

Remote power control is just a click away with these IP addressed, Web controlled power switches. From anywhere on the network, even your wireless PDA, you can securely access iBoot and control power.

Point your browser to iBoot’s IP address, enter valid credentials and your one click away from power ON, OFF or a timed Reboot. It’s that simple.

iBoot can also be used to automatically detect failures and perform a timed reboot or other power control function. The unique Auto-Ping feature allows iBoot to monitor any device on the network and take automatic action whenever the device is down.

iBoot is available as either a single outlet device, ideal for kiosks and other small footprint systems, or as a rack mountable power strip, capable of handling multiple devices from a single sign-on.

<table>
<thead>
<tr>
<th>Use iBoot for</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reboot</td>
<td>Remote reboot of any device, routers, servers, kiosks, etc. The device to be rebooted need not be network attached.</td>
</tr>
<tr>
<td>Security</td>
<td>Secure sensitive devices by keeping them powered off when not in use. This prevents hackers from detecting them at all times.</td>
</tr>
<tr>
<td>Energy Savings</td>
<td>Power down equipment when not needed for power savings and to save on wear and tear.</td>
</tr>
<tr>
<td>Notification</td>
<td>Power up alert devices like sirens, lamps, messages.</td>
</tr>
<tr>
<td>Control</td>
<td>Power up environmental system like heaters, coolers, pumps, etc.</td>
</tr>
</tbody>
</table>

Critical Acclaim for iBoot

**Network World Fusion**

“Cool Tool”

May 10, 2006

“Gratifying Gadget”

May 21, 2006

The Dataprobe iBoot is a small investment that has greatly improved the reliability and uptime of our wireless Internet network.

Steve McIlvain, Unosphere Online

After finding your iBoot online and then installing it into our equipment we have not had to go out to this unit again. I have not only made it a policy in our office that any new installation MUST have an iBoot installed in it but I also notified the other 10 tech departments I work with and have told them they will need to do the same.

Your iBoot will save lives! Charles Paikul LACROC

We are a subscription-based business, so our customers expect service around the clock. Dataprobe’s iBoot devices allow us to deliver on our promise to those subscribers. Matt BenDaniel SLOUCH
**iBoot**

**Single Outlet Power Switch**

iBoot is a network attached, IP addressed, web controlled power switch. Anyone with a web browser can access iBoot to perform power on, off or cycle (timed power shutdown Reboot, or power up). iBoot is dual password protected and uses IP filtering for security.

iBoot uses international standard IEC320 power connections and is auto sensing for worldwide use. Line cord and Output Cord are included for North America. iBoot handles circuits up to 12 Amps (10 Amps at 230VAC).

iBoot-DC supports 5-48VDC, 2 Amps and uses simple screw terminals for power in and out.

The unique Auto-Ping feature allows iBoot to monitor any IP device on the network and take automatic action whenever the device is down. With Auto-Ping, you can monitor your broadband connection by pinging an address across the network. Reboot automatically when service is not available.

The new Heartbeat Detect feature allows iBoot to monitor any server or PC running either the free Heartbeat Generator Program, or heartbeats integrated into your custom software. Dataprobe can provide developer support to make integration easy.

---

**Features**

<table>
<thead>
<tr>
<th>Access from any Network point</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No field trips required for Reboot. Save time and money by eliminating service calls and reducing downtime to a minimum.</td>
</tr>
</tbody>
</table>

**Web Control**

No special software required. Works with any form capable browser. Easy Web Administration for all configuration.

**Dual Password & IP Filtering for Security**

Deploy iBoot securely throughout your organization. User and Admin Passwords. IP Filtering keeps out unwanted visitors.

**IP Addressed, 10/100Base-T**


**Automatic Reboot Operation**

Auto-Ping and Heartbeat Detector. Automatic Operation for crashed devices. Auto-Ping pings device while heartbeat listens for periodic message. Complete control over frequency and timers. Developer Assistance and software tools are free.

**Direct TCP and Software Control**

Directly Control iBoot directly from your software application for the highest degree of power control integration. Simple protocol is freely available. Use iBoot control program to call power control from any network management system.

**Built in Hub**

Reduce cabling and simplify installation. One cable from your network closet serves the iBoot and server, kiosk, etc. Auto-sensing uplink/downlink eliminates the need for expensive crossover cables.

**110/220 VAC Operation**

Auto ranging power input. Deploy iBoot anywhere in the world. iBoot uses IEC320 Connectors and includes line and extension cords for North America.

**Current Capacity for your needs**

12 Amps at 110 VAC, 10 Amps at 220 VAC. 2 Amps at 5-48 VDC. Current for most Servers, Routers, Kiosks, etc.
iBoot Specifications

**iBoot**

**Physical:**
- Height: 2.25 in (8 cm)
- Width: 4.50 in (11.5 cm)
- Depth: 6.00 in (15.25 cm)
- Weight: 1.25 lbs (0.5 Kg)

**Environmental:**
- Temperature Operating: 0 to 40°C
- Storage: -10 to 85°C
- Relative Humidity: 0 to 95% Non-Condensing

**AC Version**
- Power: 105-240 VAC
- Power Input: IEC 320-C13 Plug
- Power Out: IEC 320-C14
- Power Switching: Up to 12 Amps at 105-125 VAC, 10 Amps at 210-240 V
- Supplied with: Line cord for NEMA 5-15 outlet, extension cord for NEMA 5-15 plug, Cat 5 Cable

**DC Version**
- Power: 5 – 48VDC
- Connectors: 3 Position screw terminal (Pos. Nog, Earth)
- Power Switching: up to 2 Amps
- Supplied with: Cat 5 Cable, Compliance: FCC Part 15 B, CE Marked

**iBootBar**

**Physical:**
- Height: 1U 1.75 in (4.5 cm)
- Width: 19.0 in (48.25 cm)
- Depth: 6.00 in (15.25 cm)
- Weight: 7 lbs (3.25 Kg)

**Environmental:**
- Temperature Operating: 0 to 40°C
- Storage: -10 to 85°C
- Relative Humidity: 0 to 95% Non-Condensing

**Table**

<table>
<thead>
<tr>
<th>Input Required</th>
<th>Model</th>
<th>Input</th>
<th>Output</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IBB-N15</td>
<td>N15</td>
<td>8 x N15</td>
<td>I, S, L</td>
</tr>
<tr>
<td></td>
<td>IBB-N15-M</td>
<td>N15</td>
<td>8 x N15</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-N20</td>
<td>N20</td>
<td>8 x N15</td>
<td>I, S, L</td>
</tr>
<tr>
<td></td>
<td>IBB-N20-M</td>
<td>N20</td>
<td>8 x N15</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-2N15</td>
<td>2 x N15</td>
<td>8 x N15</td>
<td>I, S, L</td>
</tr>
<tr>
<td></td>
<td>IBB-2N15-M</td>
<td>2 x N15</td>
<td>8 x N15</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-2N20</td>
<td>2 x N20</td>
<td>8 x N15</td>
<td>I, S, L</td>
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<tr>
<td></td>
<td>IBB-2N20-M</td>
<td>2 x N20</td>
<td>8 x N15</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-C10</td>
<td>C10</td>
<td>8 x C10</td>
<td>I, S, L</td>
</tr>
<tr>
<td></td>
<td>IBB-C10-M</td>
<td>C10</td>
<td>8 x C10</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-C14</td>
<td>C14</td>
<td>8 x C13</td>
<td>I, S, L</td>
</tr>
<tr>
<td></td>
<td>IBB-C14-M</td>
<td>C14</td>
<td>8 x C13</td>
<td>I, S, L, M</td>
</tr>
<tr>
<td></td>
<td>IBB-2C10</td>
<td>2 x C14</td>
<td>8 x C13</td>
<td>I, S, L</td>
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<tr>
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<td>IBB-2C10-M</td>
<td>2 x C14</td>
<td>8 x C13</td>
<td>I, S, L, M</td>
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<td>IBB-C20-M</td>
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<td>8 x C13</td>
<td>I, S, L</td>
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<tr>
<td></td>
<td>IBB-2C20-M</td>
<td>2 x C20</td>
<td>8 x C13</td>
<td>I, S, L, M</td>
</tr>
</tbody>
</table>

**Key:**
- Input: N15 NEMA 5-15 Linecord 115VAC 15 Amps combined total switched
- N20 NEMA 5-20 Linecord 115VAC 20 Amps combined total switched
- C14 IEC320 C14 Receptacle 100-240VAC 10 Amps total 240VAC Max
- C20 IEC320 C20 Receptacle 100-240VAC 20 Amps total 240VAC Max
- Outlet: N15 NEMA 5-15 Receptacle 115VAC 12 Amps Max
- C13 IEC 320 C13 Receptacle 100-240VAC 10 Amps Max
- Control: 10/100 Ethernet, Web, Telnet, SNMP
- Port Assignable for Web and Telnet, SSL on web control
- S Serial Port: 1200-115,200 BPS. Command Line Interface
- D Dual Link ports for expansion. Cascadable to 15 additional units
- Internal Modem, V.92 and below. Approved in 50 Countries
- M Supports data and DTMF tone control (with voice response)
Model: 485LDRC9

Industrial DIN Rail Mounted
Optically Isolated RS-232 to RS-422/485
Converter with Surge Suppression

Introduction
The DIN Rail mountable Model 485LDRC9 optically isolates and converts unbalanced, full or half-duplex RS-232 signals to optically isolated, balanced, full or half-duplex RS-422 or RS-485 signals at baud rates up to 115.2 kbps. This unit also surge suppresses the RS-422/485 lines. Features Send Data Control circuitry so no software control of handshake lines is required in RS-485 mode.

LEDs
3 LEDs indicate RS-485 Transmit Data, RS-485 Receive Data, and Power.

Description
The 485LDRC9 has screw down terminal blocks on the RS-232 side and the RS-422/RS-485 side. The RS-232 side also has a DB9 female connector. Transmit (TD), Receive (RD) and Ground are supported on the RS-232 side. The unit is powered by a supply voltage of 10 to 30VDC on the RS-232 side, useful where 24VDC is commonly found. Transmit Data A (+), Transmit Data B (+), Receive Data A (-), Receive Data B (+), and Ground are supported on the RS-422/RS-485 side. Communication features on the 485LDRC9 are dip-switch selectable on the unit.

RS-485 Mode with Send Data Control
Send Data Control recognizes the first bit of data from the RS-232 side, enables the transmitter and disables the receiver. After the last bit of data is sent from the RS-232 side, the timeout waits one character length, then enables the transmitter and disables the receiver. The timeout can be selected with dipswitches or by changing the value of R11 (see Table 2). If the system requires the line to be "turned around" faster, i.e. the slave device starts responding before the transmitter of the 485LDRC9 is disabled, R11 can be changed to meet the specific baud rate. Termination resistance can be selected with Switch 5 for high baud rates and long cable distances. See B&B Electronics’ RS-422/485 Application Note available on the web site or by mail. Factory setting: 9600 baud.

Table 1. Typical Communication Setups

<table>
<thead>
<tr>
<th>Switch 1 TX Enable</th>
<th>Switch 2 RX Enable</th>
<th>Switch 3 2/4 Wire</th>
<th>Switch 4 2/4 Wire</th>
</tr>
</thead>
<tbody>
<tr>
<td>On</td>
<td>On</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>RS-485 2-Wire Mode (half duplex)</td>
<td>On</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>RS-485 4-Wire Mode (full duplex)</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>RS-422 Mode (full duplex)</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
</tbody>
</table>

Table 2. Baud Rate Selection

<table>
<thead>
<tr>
<th>Switch 5</th>
<th>Switch 7</th>
<th>Switch 8</th>
<th>R11</th>
<th>Time (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200</td>
<td>Off</td>
<td>Off</td>
<td>On</td>
<td>Not Used</td>
</tr>
<tr>
<td>2400</td>
<td>Off</td>
<td>Off</td>
<td>On</td>
<td>Not Used</td>
</tr>
<tr>
<td>4800</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Not Used</td>
</tr>
<tr>
<td>9600</td>
<td>On</td>
<td>Off</td>
<td>Off</td>
<td>Not Used</td>
</tr>
<tr>
<td>19200</td>
<td>On</td>
<td>Off</td>
<td>Off</td>
<td>Not Used</td>
</tr>
<tr>
<td>38400</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>57kΩ</td>
</tr>
<tr>
<td>57600</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>57kΩ</td>
</tr>
<tr>
<td>115200</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>8.2kΩ</td>
</tr>
</tbody>
</table>

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TYPICAL RS-422/485 4 WIRE

Terminal Block Configuration

RS-232
(D) TD (input)
(A) RD (output)
(B) SIG, GND
(F) +10 to 30VDC
(C) PWR, GND

RS-422/485
TDA (G) Tx inverted or ( ) (output)
ROA (K) Rx inverted or ( ) (input)
TDB (H) Tx non-inverted or ( ) (input)
RDB (L) Rx non-inverted or ( ) (input)
ISO, GND (M) Isolated RS-422/485 Signal Ground/Common

Switch Setting (Up = ON)
1 - Tx Enable (On for 485 mode, off for 422 mode.)
2 - Rx Enable (On for 2-wire 485 mode, off for 4-wire 485 and 422 mode.)
3 - 2/4 Wire (On for 2-wire/half duplex, off for 4-wire full duplex.)
4 - 2/4 Wire (On for 2-wire, off for 4-wire.)
5 - Termination Resistors (On for termination, off for no termination.)
6 - 9600 Baud (On for 9600, off for others. See Table 2 for additional baud rates.)
7 - 4800 Baud (On for 4800, off for others. See Table 2 for additional baud rates.)
8 - 2400 Baud (On for 2400, off for others. See Table 2 for additional baud rates.)

TYPICAL TWO-WIRE RS-485 SETUP

DB9 Female Configuration

RS-232 (DCE)
Pin 2 RD (output)
Pin 3 TD (input)

Figure 1

Integrate – Expand – Simplify

B&B ELECTRONICS

Removing Converter from DIN Rail

A flat-blade screwdriver will be needed when removing the 485LDRG9 from a 35mm DIN rail.

1. Place a flat-blade screwdriver blade in disengagement clip on the converter enclosure (See Figure 1)
2. Gently pry on screwdriver handle.
3. Rock enclosure toward you to release it from the DIN rail.

Specifications

- Dimensions: 4.2 x 3.1 x 1.0 in (10.7 x 7.8 x 2.5 cm)
- Temperature Range: -40 to +70 °C (-40 to +170°F)
- Humidity Range: 0 to 95% non-condensing
- Supply Voltage: +10 to 30 VDC @ 100mA
- Data Rates: 1200 to 115.2 kbps
- 2400 to 115.2 kbps switch selectable
- Connectors: Screw down terminal blocks for RS-232 and RS-422/485 sides
- LED's: Transmit Data, Receive Data and Power
- Isolation: 2200VAC optical isolation of data signals and ground
- Surge Suppression: 7.5kV bi-directional avalanche breakdown device
- 500W peak power dissipation
- Clamping time: < 1 picosecond (theoretical)
Appendix B:
Central Subsystem Design
The objective of the Central Subsystem is to facilitate stakeholder access to data originating from the field subsystem - by filtering, aggregating, converting and storing the data in a structured database. The Central Subsystem is also an implementation of business processes involved with determining, relaying and archiving crossing time data.

The Central Subsystem can be implemented in several commercial off-the-shelf database environments, such as Oracle, Microsoft SQL Server, MySQL etc. However, the design shown below will be the same in spite of the database environment chosen for the implementation.

The Central Subsystem shown in Figure B-1 receives all inbound tag reads from the field RFID stations. The tag reads will be formulated into a data record containing the originating station, time stamp, and tag ID. Tag records will be routed to a Raw Tag Archive and introduced to a process utilizing a database to manage the real-time calculations for the project.

![Figure B-1. Central Subsystem Concept](image)

The database will contain a Real-time Tag table to hold tag records for vehicles currently within the confines of the border crossing and a Trip Time table which holds individual travel times between the entrance and exit stations.

The process begins by determining the location from which an inbound tag originated. If the tag is from the entrance reader station, the tag record is added to the Real-time Tag table within the
database and no further action is taken. If the tag is from the exit location, the Real-time Tag

table is queried for all other tag records containing that tag ID. These records will indicate the
tag’s entrance (and possibly passage if additional RFID stations are deployed) through the border

area. The tag’s exit time on the U.S. side and entrance time on the Mexican side is compared

and a single trip travel time is calculated and added to a Trip Time table within the database.
The same measurement technique will be applied to multiple segments if one or more additional
tag reader is added between the initial and final readers. The records returned as part of the
database query are then removed from the Real-time Tag table thus cleaning up the table as

vehicles exit the system.

An external process will be periodically executed to completely clean old tag records which

remain in the Real-time tag table. Records could get ‘lost’ if a vehicle remains within any of the

inspection facilities for an extended period (e.g., more than a day). Data processing algorithms

will allow a check to be placed on tag matches that return unrealistic numbers (both high and

low), so that suspicious data can be tagged or eliminated to avoid skewing of crossing time

measurements.

Single trip travel time records will be archived in another database. The archive can be opened

for remote user access by project partners via an Internet interface which would support queries

to return individual trip times and border crossing times. The information may be useful for

future regional planning purposes.

The Trip Time table will be periodically queried to return all the single trip records for a time

interval, for instance 30 minutes or 60 minutes. A border crossing time can be calculated as well

as a measure of the variance (reliability) in the crossing time. This information will be packaged

using the standard Internet information syndication scheme Real Simple Syndication (RSS).

RSS is a common internet format for publishing frequently updating content such as news

headlines. A web host will serve the RSS formatted border crossing time information and

support access to the Trip Time Archive.
Appendix C:
User Subsystem Design
The objective of the User Subsystem is to disseminate the information collected and stored in the Central Subsystem to anyone interested in accessing northbound border crossing times. The User Subsystem design is shown in Figure C1 below.

![Figure C-1. User Subsystem Concept](image)

All users of the border crossing information will access the shareable data (RSS border crossing information and Trip Time Archive) via the Internet. Real-time border crossing times will be distributed as an RSS feed which can be added to area transportation information providers’ web pages. The RSS feed is designed to deliver raw, basic information. Each user who chooses to add the content to their site must define the graphical method for the data display. In general, the RSS provides only the data while the users (data consumers) must design and provide the display of the data. This project may choose to develop a simple display which utilizes the RSS feed as an example application for other web developers.

The Trip Time Archive will support an Internet interface. The interface should provide a group of tools to perform simple database queries and to display the results for users.

### C.1. Relationships with the El Paso Regional ITS Architecture

#### C.1.1. Background

The El Paso region’s ITS architecture (referred hereafter as “the ITS architecture”) is a framework defining the technical, institutional, and commercial features of the region’s future ITS system in an outline and graphical format (1). The ITS architecture identifies regional stakeholder agencies, their needs and requirements for systems and subsystems to operate and manage current and future transportation needs. The El Paso region being one of the busiest international ports of entry also faces a tremendous challenge to provide commercial and non-commercial border crossing information, including border crossing times and delay, to its stakeholders not only in U.S. but also in Mexico. In subsequent sections, key concepts in the ITS architecture that are related to the project are discussed. The operational concept provided in the ITS architecture should either serve as a starting point for a more detailed definition, or possibly provide all the needed information for the project.
The identification of stakeholders and their roles and responsibilities (including inter-agency cooperation) can come from the operational concept developed as part of the ITS architecture. The ITS architecture also identifies transportation services as market packages that are important to the region. The requirements of systems are defined at several different levels, ranging from general subsystem descriptions through somewhat more specific equipment package descriptions. While attempting to understand the relationship between the project and the El Paso region’s ITS architecture, it will reveal that the ITS architecture is inadequate in terms of defining framework for much broader border crossing information needs of the region. However, the ITS architecture does identify U.S. Customs and Border Protection as an important stakeholder agency to produce border crossing related information.

This chapter uses two important terminologies – border crossing information and border crossing time and delay. It is important to note that border crossing time and delay is the subset of the border crossing information, which also consists of information such as number of inspection lanes open, closure of bridges, volume of entering traffic etc.

C.1.2. Identification of Stakeholders for the Project

The most important attribute of a successful project is a clear statement of requirements that meet the stakeholder needs, which requires identification of stakeholders in the region that benefit from the project. Also, an important step in designing a concept of operations for a project is to make sure that all relevant stakeholders are impacted by the proposed system. The list of stakeholders identified in the El Paso region’s ITS architecture lacks agencies, especially in Mexico that directly benefit from border crossing information. Hence, Border Information Flow Architecture (2) developed by the Federal Highway Administration in 2006 was referred to identify much broader list of stakeholders in U.S. and Mexico that need border crossing time and delay information at international ports of entry. Stakeholders in both U.S. and Mexico along with their roles and responsibilities are provided in Table C-1.
Table C-1. Stakeholders in U.S. and Mexico Benefiting from Border Crossing Times and Delay Information

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Description of Roles and Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. and Mexican Bridge Operations Agency</strong></td>
<td>These agencies are responsible for operation of a bridge (or bridges) at the U.S.-Mexico border. Examples of this are the Zaragoza Bridge between El Paso and Ciudad Juarez. This stakeholder could be a private operating company, a public sector agency, or a public-private partnership.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Freight Shippers</strong></td>
<td>These agencies engage in the shipment of freight by multiple means, including road-going trucks as well as using other modes such as heavy rail, air, sea etc.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Local Media</strong></td>
<td>Media outlets in a local area include TV and Radio stations, cable operators, print media etc. provide current border crossing time information and other major delays at the border.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Private Sector Probe Information Providers</strong></td>
<td>Private sector operators can generate probe information from commercial vehicle fleets, cell phones, or from general traveler information system</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Toll Authorities</strong></td>
<td>Government agencies (could include public-private arrangements) responsible for the administration, operation and upkeep of bridges, tunnels, turnpikes, and other fee-based roadways. Includes setting tolls, managing their collection using manual and automatic methods, and managing the roadway. Also operate a clearinghouse of information to share tolling data between Toll Authorities.</td>
</tr>
<tr>
<td><strong>U.S. Bureau of Transportation Statistics</strong></td>
<td>Agency of U.S. government charged with data gathering, analysis and distribution of transportation data.</td>
</tr>
<tr>
<td><strong>U.S. Customs and Border Protection</strong></td>
<td>U.S. Customs and Border Protection (CBP) is a part of the Department of Homeland Security (DHS) and is responsible for managing the nation's borders and ports-of-entry, preventing the passage of individuals or goods from entering the United States unlawfully.</td>
</tr>
<tr>
<td><strong>U.S. General Services Administration</strong></td>
<td>The U.S. General Services Administration (GSA) secures the buildings, products, services, technology, and other workplace essentials federal agencies need. This includes planning and constructing, and perhaps operating, infrastructure at border crossings.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Municipal Government</strong></td>
<td>City/Municipal government agencies within the U.S. that operate and maintain their own transportation systems.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Regional Transportation Planning Organization</strong></td>
<td>Metropolitan Planning Organizations (MPOs) serve a region as a support agency for local governments in developing and administering transportation program activities.</td>
</tr>
</tbody>
</table>

*Source: Adopted from Border Information Flow Architecture (2006)*
### C.1.3. Stakeholders Needs for the Border Crossing Times and Delay Information

#### C.1.3.1. Advanced Traveler Information and Archived Data

The specific area of interest for this project is to measure border delay and crossing times for freight traffic inbound to the U.S. from Mexico and provide the information in near real-time to freight operators and also archive the data, which can then be accessed by regional transportation agencies. Although northbound freight traffic volume data are gathered by both CBP and the City of El Paso, Texas, there is currently no systematic approach in place for measuring border delays and crossing times. CBP obtains crossing time estimates by surveying drivers on how long it took them to cross together with unaided visual observations of how long the queue is. Being able to accurately and automatically determine average crossing times will result in better immediate information with which stakeholders can take steps to help improve transportation flow or to conduct more effective routing of assets for higher logistics efficiencies.

Stakeholder needs for border crossing times and delay information related to ITS services can be categorized into advanced traveler information and archived data. Advanced traveler information and particularly pre-trip information is mostly used by freight operators, freight shippers, and carriers to plan a trip from origin to destination. During the trip, border crossing times and delay information is used by this specific category of stakeholders to modify pre-determined route to adjust to current travel conditions and determine optimal route that would reduce travel time between origin and destination. The border crossing time and delay information produced in real time is archived and aggregated into variety of temporal and spatial granularity and also converted to develop border crossing performance measures. Archived data is then used by agencies, such as CBP and GSA to plan future infrastructure improvements and manage resources to efficiently operate border crossings. Tables C-2 and C-3 lists stakeholder data needs for pre-trip and archived commercial border crossing information.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Data Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>U.S. and Mexican Freight Shippers, Private Commercial Carriers</strong></td>
<td>To use commercial border crossing times and delay information along with other pertinent information, such as incidents, bridge closures, current roadway condition etc. for pre-trip decision making.</td>
</tr>
<tr>
<td><strong>U.S. and Mexican Local Media</strong></td>
<td>To relay commercial border crossing times and delay information along with other pertinent information, such as bridge closures, current roadway conditions, incident locations to public as well as freight operators.</td>
</tr>
<tr>
<td><strong>U.S. Customs and Border Protection</strong></td>
<td>To use current border crossing times of commercial vehicles and number of inspection lanes open to manage resources at inspection booths.</td>
</tr>
</tbody>
</table>
Table C-3. Stakeholder’s Archived Commercial Border Crossing Times Data Needs

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Data Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. and Mexican Bridge Operations Agency</td>
<td>To use border crossing volume trend data to manage, operate, and plan bridge improvement.</td>
</tr>
<tr>
<td>U.S. and Mexican Freight Shippers, Private Commercial Carriers</td>
<td>To monitor trends in border crossing times of commercial vehicles and other economic indicators for supply chain management.</td>
</tr>
<tr>
<td>U.S. Bureau of Transportation Statistics</td>
<td>To publish performance indicators of international border crossings, mostly average crossing times.</td>
</tr>
<tr>
<td>U.S. Customs and Border Protection</td>
<td>To use trends in border crossing times and volume of commercial, passenger vehicles and pedestrians to plan improvements at the inspection facility.</td>
</tr>
<tr>
<td>U.S. General Services Administration</td>
<td>To use trends in border crossing times and volume of commercial, passenger vehicles and pedestrians to manage and plan expansion of inspection facility at the border.</td>
</tr>
<tr>
<td>U.S. and Mexican Municipal Government</td>
<td>To use border crossing trends data and other socio economic indicators to estimate short and long-term socio economic impact of border delays. In some regions plan and operate bridge infrastructure.</td>
</tr>
<tr>
<td>U.S. and Mexican Regional or Metropolitan Transportation Planning Organizations</td>
<td>To use border crossing trends data and other socio economic indicators to develop short and long-range transportation plan for the border region.</td>
</tr>
</tbody>
</table>

C.1.3.2. Centralized Archived Data and Single Portal for Border Crossing Time Information

Currently, the only mechanism to obtain historic border crossing time and delay data is to request CBP and other U.S. government agencies that share data with the CBP. BTS is one such agency which provides, on its website, highly aggregated annual average daytime border crossing delay information of commercial vehicles. However, border crossing time is highly aggregated based on annual daily average of entire region rather than individual border crossing. Agencies, such as metropolitan planning organizations, analyze the impact of border crossing trends data on socio economic trends and vice versa to plan infrastructure improvements to achieve short and long-term mobility needs of the region. However, highly aggregated data may not be useful for planning organizations and freight shippers to understand hourly and daily border crossing trends at individual border crossings.

In addition to previously mentioned data needs, stakeholders also need efficient methods to access and retrieve the data. For example, freight shippers and operators have to access CBP’s website to obtain current crossing time and delay at border crossings. In addition to the fact that the border crossing delays provided by CBP is unreliable, there are several alternative methods whereby the information can be pushed to freight operators before leaving the point of origin and while en-route to destination. This provides operators capabilities to choose between border crossings to reduce the overall trip time. Freight operators not only use border crossing
information, but also information regarding highway and arterial traffic conditions, such as major incidents and lane closures, which could severely impact the overall travel time between origin and destination. From an operator’s perspective, the most efficient method of accessing all multi-modal advanced traveler information is through one single source rather than multiple sources or agency websites.

Center for International Intelligent Transportation Research (CIITR) at the Texas Transportation Institute (TTI) has developed a data warehouse with capabilities to not only archive multi-modal transportation data, but also provide access to users and stakeholders of the real time traffic conditions data in the region. CIITR is also developing mechanism to push real-time traffic conditions (including border crossing information) data to stakeholders using latest communication and mobile technologies. Using CIITR’s website, transportation data stored in multitude of temporal and spatial granularity can be accessed through a web-based user interface.

One of the objectives of this project is to integrate the RFID system with CIITR’s regional data warehouse, whereby the current commercial border crossing times data will be pushed to the data warehouse in real-time. Several automated processes inside the data warehouse will filter and aggregate the data, which will be relayed as pre-trip traveler information and archived in variety of temporal and spatial granularity. The other benefit of integrating the RFID system with the data warehouse is that the archived border crossing information will be accessible to stakeholders along with archived traffic conditions data, weather information, and socio-economic indicators. Stakeholders will significantly benefit by having access to a single or centralized repository of archived border crossing times and delay information as well as other transportation performance measures.

C.1.3.3. Border Crossing Performance Measures

The focus on the border transportation system has identified the possibility of collecting travel time related data to support a set of performance measures and ultimately a performance management process for evaluating and improving border crossings for freight as well as passenger movement. A set of travel time related performance measures has to be identified for both freight and passenger movement, which would be a basis for establishing common indices to compare performances of border crossings throughout the U.S.-Mexico region. Such performance measures can be applied to: compare border crossing performance nationally, take into account local operation of crossings, derive from a system to provide travel time information to travelers and shippers, apply archived travel time data and travel time reliability information, consider causal data that explains the differences in travel time, and should reflect changes in operating practices and infrastructure at individual crossings.

The basic element of border crossing performance measurement system is the travel time of roadway segments while entering, crossing, and exiting individual border crossings. From agency perspective, this data represents the performance of the border crossing system. From public and freight operator perspectives, this travel time is a part of the overall door to door trip time between origin and destination. RFID system being developed in this project is crucial to measure travel time of segments entering and exiting border crossings, which is a basic parameter to develop border crossing performance measures, which are as following:
• Travel Time – For individual segments of the trip as well as the trip as a whole.

• Target Travel Time – The targets could be the travel time at low-volume traffic flows or during rapid processing time.

• Border Crossing Index – A ratio of the travel time in the peak period to travel time during low volume conditions. For example, a BCI of 1.20 would indicate that a trip that takes 20 minutes in the off-peak period will take 24 minutes in the peak period (20 percent longer).

• Border Planning Index – The total travel time that should be planned for a border crossing (near-worst case travel time) to a travel time in light traffic conditions. A Border Planning Index of 1.60 means that a driver should plan for 32 minutes to make a trip that requires 20 minutes in light traffic (20 minutes x 1.60 = 32 minutes).

• Buffer Index (BI) – A measure of trip reliability that expresses the amount of extra “buffer” time needed to be “on time” for 95 percent of the trips (e.g., a late shipment on one day per month).

C.1.4. **El Paso Region Market Packages**

ITS market packages describe technologies that are bundled together to address the needs of stakeholders in the region. El Paso’s regional ITS architecture has identified transportation services that are important to the El Paso region. In the ITS architecture, market packages were reviewed and prioritized based on the relevance of the services provided to El Paso. The ITS architecture provides two market packages that are relevant to border crossing information and to this project. These market packages are related to providing advanced information to stakeholders (Broadcast Traveler Information) and archiving border crossing information (ITS Data Warehouse). In the ITS architecture, Broadcast traveler information market package represents CBP’s website providing border crossing information for public use through the website and to other regional stakeholders, as shown in the Figure C-2.
ITS data warehouse market package represents regional metropolitan planning organizations as implementing agencies for archiving transportation data. The architecture’s ITS data warehouse market package represents El Paso Metropolitan Planning Organization Data System collecting and providing archived data from CBP and other agencies as well as providing archived data to other Metropolitan Planning Organizations (MPO) in U.S. and Mexico, as illustrated in Figure C-3. However, the ITS architecture only provides an interface for El Paso MPO to store volume of travelers from CBP, but not border crossing times or delay information. Also, the list of ITS Data Marts does not include a data mart specifically for border crossing information.
C.1.5. El Paso Region Equipment Packages

Equipment Packages group similar processes of a particular subsystem together into an “implementable” package. The grouping also takes into account the user services and the need to accommodate various levels of functionality. Since equipment packages are both the most detailed elements of the physical architecture view and tied to specific market packages, they provide the common link between the interface-oriented architecture definition and the deployment-oriented market packages. Functions to be provided by system in the ITS architecture are defined at several levels, ranging from general subsystem descriptions to somewhat more specific equipment package. The ITS architecture consists of sub systems and equipment packages related to or applicable to much broader border crossing information. These subsystems and equipment packages are listed in Table C-4. Not all equipment packages listed in Table C-4 are applicable to the project. Table C-5 provides specific equipment packages that are directly applicable to the project. On-board Trip Monitoring equipment package is not part of the El Paso’s regional ITS architecture and has been adopted from the current version of the national ITS architecture (3).
### Table C-4. Description of Equipment Packages Related to or Applicable to Border Crossing Information

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Equipment Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archived Data Management Subsystem</td>
<td>ITS Data Repository</td>
<td>Collects and maintains data and data catalogs from one or more data sources. May include quality checks, error notification, and archive coordination.</td>
</tr>
<tr>
<td></td>
<td>On-Line Analysis and Mining</td>
<td>Provides advanced data analysis and mining features to support discovery of information, patterns, and correlations in large archives.</td>
</tr>
<tr>
<td></td>
<td>Traffic and Roadside Data Archival</td>
<td>Collects and archives traffic and environmental information directly from the roadside for use in off-line planning, research, and analysis.</td>
</tr>
<tr>
<td>Commercial Vehicle Administration</td>
<td>CV Information Exchange</td>
<td>Supports the exchange of safety and credentials data among jurisdiction. The package also supports the exchange of safety and credentials data between agencies within a single jurisdiction.</td>
</tr>
<tr>
<td></td>
<td>On-board Cargo Monitoring</td>
<td>Provides the Commercial Vehicle Subsystem the capability to monitor both interstate and intrastate cargo safety such that enforcement and HAZMAT response teams can be provided with timely and accurate information.</td>
</tr>
<tr>
<td></td>
<td>On-board CV Electronic Data</td>
<td>Provides the Commercial Vehicle Subsystem the capability for two-way data exchange between the vehicle and the roadside facility with the transmission of information such as status of driver, vehicle, and carrier IDs and cargo information.</td>
</tr>
<tr>
<td></td>
<td>On-board Trip Monitoring (Not part of the El Paso Region’s ITS Architecture, but is part of the National ITS Architecture)</td>
<td>Provides capabilities to support fleet management with automatic vehicle location and automated mileage and fuel reporting and auditing. In addition, this equipment is used to monitor the planned route and notify the Fleet and Freight Management Subsystem of any deviations.</td>
</tr>
<tr>
<td>Information Service Provider Basic</td>
<td>Basic Information Broadcast</td>
<td>Provides capabilities to collect, process, store, bill, and disseminate traveler information including traveler, transit, traffic, and parking information.</td>
</tr>
<tr>
<td></td>
<td>Infrastructure Provided Route Selection</td>
<td>Provides a capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, returning the calculated plans to the users.</td>
</tr>
<tr>
<td></td>
<td>Interactive Infrastructure Information</td>
<td>Augments the Basic Information Broadcast Equipment package by providing the capabilities for interactive traveler information.</td>
</tr>
<tr>
<td></td>
<td>ISP Data Collection</td>
<td>Collects and stores traveler information that is collected in the course of operation of the ISP subsystem. This data can be used directly by operations personnel or it can be made available to other data users and archives in the region.</td>
</tr>
</tbody>
</table>

Table C-5. Description of Equipment Packages Related to or Applicable to the Project

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Equipment Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archived Data Management Subsystem</td>
<td>ITS Data Repository</td>
<td>RFID system along with CIITR’s data warehouse can collect and maintain data and data catalogs from one or more ITS data sources. Also includes quality checks, error notification, and archive coordination.</td>
</tr>
<tr>
<td></td>
<td>On-Line Analysis and Mining</td>
<td>CIITR’s data warehouse has capabilities to provide advanced data analysis and mining features to support discovery of information, patterns, and correlations between parameters in large archives. Border crossing time data collected by the RFID system in this project will be archived within the data warehouse and mechanisms will be developed to “mine” hidden relationships between border crossing and other transportation performance measures and socio-economic indicators.</td>
</tr>
<tr>
<td></td>
<td>Traffic and Roadside Data Archival</td>
<td>Through a separate project, data warehouse is collecting and traffic and weather information for use in off-line planning, research, and analysis.</td>
</tr>
<tr>
<td>Commercial Vehicle Administration</td>
<td>CV Information Exchange</td>
<td>Not provided by the project.</td>
</tr>
<tr>
<td>Commercial Vehicle Subsystem</td>
<td>On-board Cargo Monitoring</td>
<td>Not provided by the project.</td>
</tr>
<tr>
<td></td>
<td>On-board CV Electronic Data</td>
<td>Not provided by the project.</td>
</tr>
<tr>
<td></td>
<td>On-board Trip Monitoring</td>
<td>Border crossing time collected by the RFID system can be an integral part of monitoring vehicle fleet.</td>
</tr>
<tr>
<td>Information Service Provider Basic</td>
<td>Basic Information Broadcast</td>
<td>The data warehouse has capabilities to collect, process, store, and disseminate traveler information including traveler, border crossing, traffic, weather, incidents information. This project will develop mechanisms to collect border crossing time information to disseminate current conditions to travelers through CIITR’s data warehouse website.</td>
</tr>
<tr>
<td></td>
<td>Infrastructure Provided Route Selection</td>
<td>Through a separate project, capabilities are being developed by CIITR for which border crossing time collected by the RFID system in this project is vital.</td>
</tr>
<tr>
<td></td>
<td>Interactive Infrastructure Information</td>
<td>Through a separate project, capabilities are being developed by CIITR for which border crossing time collected by the RFID system in this project is vital.</td>
</tr>
<tr>
<td></td>
<td>ISP Data Collection</td>
<td>The data warehouse collects and stores border crossing information in addition to other real-time transportation data, which can be made available to stakeholders as well as other agency archives.</td>
</tr>
</tbody>
</table>

C.1.6. Applicable Standards for the Project

ITS Standards are fundamental to the establishment of an open ITS environment, the goal originally envisioned by the U.S. Department of Transportation (USDOT). Standards facilitate deployment of interoperable systems at local, regional, and national levels without impeding innovation as technology advances and new approaches evolve (3). Standards can maximize ITS investments by allowing sharing data between devices and fields, across different applications, and among agencies located in different jurisdictions. ITS standards listed in the El Paso regional ITS architecture that are applicable to the project are as following:

- NTCIP 1201 – Global Object Definitions
- NTCIP 1206 – Object Definitions for Data Collection and Monitoring (DCM) Devices
- NTCIP 1209 – Object Definitions for Transportation Sensor Systems (TSS)
- SAE J2354 – Message Set for Advanced Traveler Information System (ATIS)

In addition, the following technology standards or specifications apply to the area of RFID and Internet formatting:

- ISO/IEC 18000-6: http://www.hightechaid.com/standards/18000.htm is the UHF (860-960 MHz) industry standard developed for the type of passive RFID system planned for the BOTA implementation.
- Really Simple Syndication (RSS) Specifications
- Extended Markup Language (XML): http://www.w3.org/TR/xml11/.

C.1.7. Reference