INTERNATIONAL BORDER ELECTRONIC CLEARANCE

IBEX

Evaluation Report

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1 EXECUTIVE SUMMARY

The International Border Electronic Crossing (IBEX) system implemented in this operational test was intended to demonstrate the integration of electronic information systems and technologies aimed at facilitating the safe, efficient movement of goods between the United States and Mexican North American trading partners.

A system consisting of dedicated short-range communications (DSRC) equipment, an RF local area network (LAN), and signaling devices was installed and operated in the US import and export compounds at the Otay Mesa, California border crossing site. This system was designed to provide an interface between vehicle traversing the border, and US information systems such as the US Treasury's North American Trade Automation Prototype (NATAP) system. Operating in a manner consistent with weigh station bypass systems currently in operation throughout the US, information stored on a transponder placed inside the vehicle is retrieved for use in processing vehicles through the port. In addition, on-vehicle equipment, in the form of a central processor called a data processing interface unit (DPIU) that collected and stored information regarding vehicle location and brake system operation, was installed on a small number of vehicles.

The IBEX DSRC system became operational in the fall of 1996, and has been processing vehicles participating in the NATAP program since then. The on-vehicle systems have undergone developmental testing.

The evaluation of the IBEX system focused on four major areas of interest: documentation of the level of system and component technical performance; assessment of the user acceptance of the technologies and services provided; estimation of the potential impacts to the trade community; and documentation of the institutional and technical lessons learned. Data regarding these evaluation goals were collected through a combination of electronically data recorded by the IBEX and NATAP systems, interviews with test participants, and observation of system developer testing. The test user population consisted of a small, non-random selection of border crossing stakeholders that included shippers, carriers, customs brokers, and public officials. While this sample cannot be considered significant from a statistical standpoint, the feedback received can be considered to be a reasonable representation of the views of participants in the maquiladora business model operating between the San Diego–Tijuana commercial region.

System Technical Performance

While accurate statistical data regarding the technical performance of the IBEX system are not available, a number of conclusions regarding functionality can be made. As anticipated, the layout of an international border compound, and the operations within it, present a challenge in implementing current DSRC systems in a border environment. The large number of trucks operating in close proximity, often looping the inside of the compound going to and from secondary inspection facilities, place a premium on appropriate reader and antennae placement and tuning. In the import compound, the placement of the advance reader, and the tuning of one of the exit readers, resulted in both missed and extraneous transponder reads. The link between the DSRC system and the NATAP system, referred to as the TRAFIC hub, demonstrated that it was capable of providing communications between transponder-equipped vehicles and the Treasury prototype. However, review of system logs from both systems indicated a success rate of around 60%. Thus, while the technical feasibility of the concept was validated, success rates in excess of 90% would likely be required for the system to be of value to users.

The on-vehicle systems originally anticipated to be available during the test were never fully implemented. The system developer did conduct some development testing of the brake monitoring system, from which results were sparse. While additional testing and analysis is needed, the concept behind these sensors has some merit. The vehicle itinerary verification and electronic cargo seal devices were not available during the test period, and were therefore not evaluated.

User Acceptance

Overall, carrier participants indicated that they liked the simplicity of the transponders. They also indicated that they saw a great deal of potential for enhancement of their operations using the technologies provided at the border and on their trucks. A common interviewee comment was that the provided technologies were capable and adequate to perform the intended purpose, but the processes surrounding the technology required further refinement. Participants generally agreed that the cost of technology is continually declining, and they do not believe that transponders and data entry devices will constitute a significant investment. Considering the perceived potential return in time savings and enhanced productivity, some initial investment was considered acceptable provided the process was not required to be duplicated on paper. The perception that the reengineering of the existing paper-based processing is of primary importance was echoed in the responses from participating customs brokers. The primary shipper concern was the degree to which the NATAP program and other automated data exchange programs could be integrated with their existing processes and systems. It should be noted that the commercial participants in this test take part in the maquiladora business model, and as such, represent highly integrated, cross-functional organizations consisting of companies operating under long-term relationships. Therefore, the feelings expressed by these respondents may not necessarily reflect those of other operating models.

Potential Impacts

Test partiipants were asked to indicate what reduction in border crossing times that they perceived was achieved in using the services and technologies provided by the IBEX program in conjunction with NATAP. All respondents indicated that currently any time savings that may have occurred is tempered by the pre-processing time investment, and the preparation of all of the normal paper documentation that is still required in this phase of the NATAP test. Only when the NATAP test is moved to the next phase where paper documentation is not required do the respondents believe that they will be able to quantify any reduction in time required to move goods across the border. In general, participants interviewed believe that as congestion at the border increases that participation in automated pre-clearance programs will make the difference in the efficiency and competitiveness of their operations. One participant stated that benefits from the current process indicated that participation in the automated border crossing programs early will allow him to make business decisions based on the future character of the border rather than the current situation, once again, maintaining competitiveness in the market.

Lessons Learned

The institutional environment within which international goods movement must take place is highly complex. This complexity has had two major impacts. The first is the travel delay stemming from the difficulty associated with processing goods, vehicles and drivers through the port in a timely manner. The second is the genesis of thriving commercial enterprises that prosper by capitalizing on the secondary effects of inefficient processing and increasing demand. As such, the implementation of systems such as IBEX and NATAP represent positive change from a border operations perspective, and potentially negative change from the perspective of the aforementioned commercial interests. Understandably, there is considerable skepticism regarding the near term success of such systems, especially as long as participation remains voluntary. This skepticism is, however, tempered by those companies who see themselves as forward-thinking, and are confident they can offer participation as a competitive advantage for clients.

Highly-integrated trade chains, as described earlier, continually focus considerable energy and resources maximizing the efficiency and effectiveness of operations. As a result, they are often reluctant to adopt externally developed systems without positive proof of their ability to provide an acceptable return on investment. The lack of such evidence often does not justify the risk associated with the adoption of the technology. Given the relative percentage of operations that fit this description operating through the Otay Mesa port, and the importance of these operations to the successful implementation of a border crossing system, additional effort must be expended to develop the necessary justification for participation.

From a technical standpoint, much was learned regarding the installation and operation of a DSRC system in a border compound environment. In addition to the conclusions offered earlier, significant insight was gained on a number of technical issues. The RF LAN used during the test functioned quite well, in spite of initial concerns regarding reliability and potential interference. While concerns regarding data security have not been fully addressed, this type of network continues to offer the necessary connectivity in instances where port disruption due to construction must be minimized. The Type III transponders used for the test functioned reasonably well. The transponder power source is one important discriminator in overall performance within a DSRC rich environment where extended exposure to instruments is likely. More specifically, in battery powered transponders, battery life was dramatically reduced with the extended reader exposure experienced by transponders remaining in one of the compounds over longer periods of time. However, the performance of transponders that were hardwired to the truck electrical system was also subject to the quality and correctness of the installation.

2 IBEX OPERATIONAL TEST DESCRIPTION

2.1 PURPOSE OF THE OPERATIONAL TEST

The Intelligent Transportation Systems (ITS) National Program Plan defines operational tests as bridging the gap between research and development activities, and full-scale deployment of proven technologies. Furthermore, it states that the emphasis in operational tests is on integrated systems and services. Operational tests are conducted under real world conditions in the transportation domain. Although many of the technologies are being transferred from the defense industry, the application in the transportation community still needs to be explored. Therefore, the evaluation of these operational tests is critical to provide information on viability of technologies and systems as potential ITS applications.

The purpose of the IBEX operational test is to demonstrate the integration of electronic information systems, RF technologies, and on-vehicle monitoring and information systems to promote safety and support the international border clearance process for commercial vehicles for both government and private industry stakeholders. The test was primarily conducted at both the import and export compounds of the Otay Mesa international border crossing between the United States and Mexico.

2.2 OPERATIONAL TEST PARTNERSHIP

This field operational test (FOT) of Intelligent Transportation Systems technology was funded by the Federal Highway Administration (FHWA) via a contract with the Federal Transit Administration (FTA). The IBEX program was a joint effort being conducted by the Southern California Partnership. Exhibit 2-1 lists the principal partners and illustrates areas of involvement to which they originally agreed. If a partner was no longer active in the test during the period of the evaluation, this is indicated in the role description. There were no steering committee meetings or activities during the period of the evaluation.

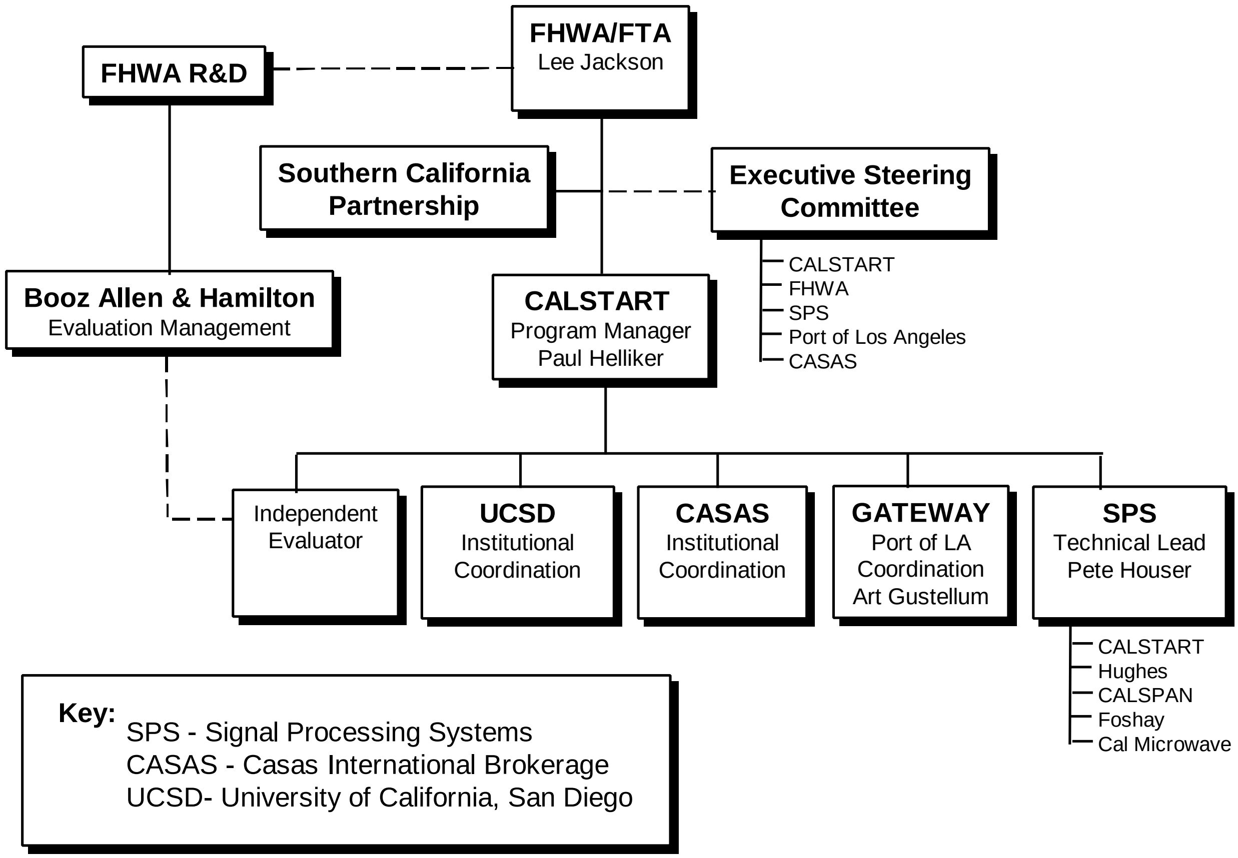
EXHIBIT 2-1
Partners and Roles

Organization	Role
CALSTART	Prime contractor and program manager
Signal Processing Systems	Technical lead and principal developer
Port of Los Angeles	Technical support and program funding (inactive)
Casas International Brokerage	U.S. customs broker and border trucking consultant
Agencia Aduanal Obregon	Mexican customs broker (inactive)
American President Lines	Shipping Coordination and vehicles (inactive)
Hughes	Roadside to vehicle communications
CALSPAN	On-vehicle sensors
UCSD Dialogue	Institutional coordination (inactive)
HELP Inc.	Coordination with PrePass, I-75, and other ITS programs (inactive)
FHWA	Evaluation

2.3 PROJECT ORGANIZATION

The IBEX Field Operational Test (FOT) was comprised of a combination of public and private organizations. Five of the project partners each designated a representative individual to serve as a member of the Executive Steering Committee. Program management was provided by CALSTART, and FHWA served as the evaluation manager, supported by Booz·Allen & Hamilton. Signal Processing Systems (SPS) served as the technical lead and was the principal developer of the IBEX technologies and services. These and other partners and their respective roles are depicted in Exhibit 2-2.

EXHIBIT 2-2
Project Organization



2.4 OPERATIONAL TEST GOALS AND OBJECTIVES

The primary goal of the IBEX Operational Test was to facilitate the safe movement of commercial vehicles, drivers, and cargo across the United States-Mexico International Border by providing automated electronic clearance decision support and demonstrating on-vehicle safety and security monitoring systems. The objectives developed to support this goal were as follows:

- Provide technical support for the North American Trade Automation Prototype (NATAP) demonstration
- Demonstrate on-vehicle brake monitoring system
- Demonstrate electronic cargo seal
- Demonstrate on-vehicle electronic log

2.5 RELATION TO NATIONAL GOALS AND OBJECTIVES

The IBEX operational test directly addressed the national goals of enhancing the efficiency and the level of customer service provided by the nation's transportation system by implementing systems and services aimed at increasing the throughput, and hence, reducing the time required to travel through international border crossings. It was anticipated that the improved level of service at the border would result in cost and operational benefits to the agencies and trade community constituents that conduct international business. Finally, providing a means for carriers to more proactively and efficiently ensure the safety of their fleets was projected to enhance the safety of international commercial vehicle traffic.

This evaluation was designed to address the ability of the IBEX technologies and services to advance these national goals and objectives.

2.6 IBEX OPERATIONAL TEST BACKGROUND

The International Border Electronic Crossing field operational test has evolved tremendously from the original concept proposed in the fall of 1995. The objectives of the original test were to demonstrate the use of technology to produce a non-stop international border crossing for commercial vehicles from the Port of Los Angeles to maquiladoras in the Tijuana vicinity of northern Baja California, Mexico. Additionally, On-vehicle safety monitoring devices were to be developed and installed on participant vehicles to demonstrate automated monitoring of steering column and brake system adjustment, and an integrated GPS for vehicle route or itinerary verification.

During the initial phases of the project, the U.S. Department of Treasury began the process of implementing the North American Trade Automation Prototype demonstration. The U. S. Department of Transportation, Federal Highway Administration was responsible for the installation of electronic communications equipment at select border crossing sites for the purposes of this demonstration. The Otay Mesa, CA site was among the first to be selected to be outfitted with dedicated short range communication (DSRC) equipment to support NATAP. The IBEX project was essentially overcome in the process of meeting the NATAP communications requirements. Technical specifications for the NATAP system were not available which made the implementation of the DSRC system challenging for the system developers, Signal Processing Systems (SPS), that were charged with this task. An initial start date for the NATAP demonstration at Otay Mesa was set for September 9, 1996. SPS had all equipment installed by this date.

There were originally fourteen companies approved by U.S. Customs and USDOT to participate in the NATAP demonstration. Of the original fourteen companies, only four have been issued transponders and transponder data entry devices and have had drivers cleared for participation. SPS recruited and prepared one manufacturer, Sony Corporation, and one of Sony's carriers, Transportistas Fronterizo de Tijuana (TFT), for participation in the demonstration. Other recruited carriers and manufacturers chose not to actively participate during this initial few months of the demonstration. SPS provided Sony's carrier, TFT, with transponders for three trucks and software for a notebook computer such that the transponders could be programmed with appropriate trip / load numbers. SPS or their contracted agent, Tradeflow Technologies, also spent considerable time studying Sony's business processes, training personnel and generally preparing Sony for successful participation in the test. Trucks began to cross the border using the DSRC system and transponders in October 1996. Sony shipped NATAP processed shipments consistently for the following six months. In April 1997, Sony discontinued regular NATAP shipments.

Early in the IBEX planning phases, other carriers and shippers were being recruited for participation in the Port of Los Angeles to Tijuana portion of the operational test. At least one formal meeting was held to provide information to potential participants whose operations included the Port of Los Angles. There were other informal meetings in an attempt to encourage participation. There were few respondents and none chose to participate in the test. There were other meetings held with Port of Los Angeles personnel, a large shipping company, and cross-border trucking company representatives to further encourage participation. None, however, chose to participate. Reasons for lack of participation are examined in the Institutional Issues section of this document.

Two other manufacturers/carriers sent NATAP shipments through the Otay Mesa Port of Entry: Amex de Mexico and Orbis Industries. Amex de Mexico sent NATAP shipments on a consistent basis for the latter eight months of 1997 and as of the writing of this document continues to send shipments regularly. Toward mid 1997, Orbis began sending a small number of shipments on a fairly regular basis. Amex de Mexico is a Mexican based organization that has worked through Mexican authorities and directly through the U.S. Treasury International Trade Data System (ITDS) project office to become a participant in the NATAP demonstration. Orbis Industries, on the other hand, is both an IBEX participant and a NATAP participant, and has acquired information and transponder equipment through Signal Processing Systems.

The IBEX operational test was originally scheduled for a period of six months beginning in September 1996 and ending in April 1997. Continued limited operation of the DSRC equipment installed at Customs compounds occurred through December 1997. Lack of resources for maintenance and operations has discontinued most of this activity as of the writing of this document.

On-vehicle systems actually developed and tested during the test evaluation period included only a brake monitoring system. Test activities related to these components began in late November 1997 and ended in March 1998. Other proposed on-vehicle systems were not tested as originally planned.

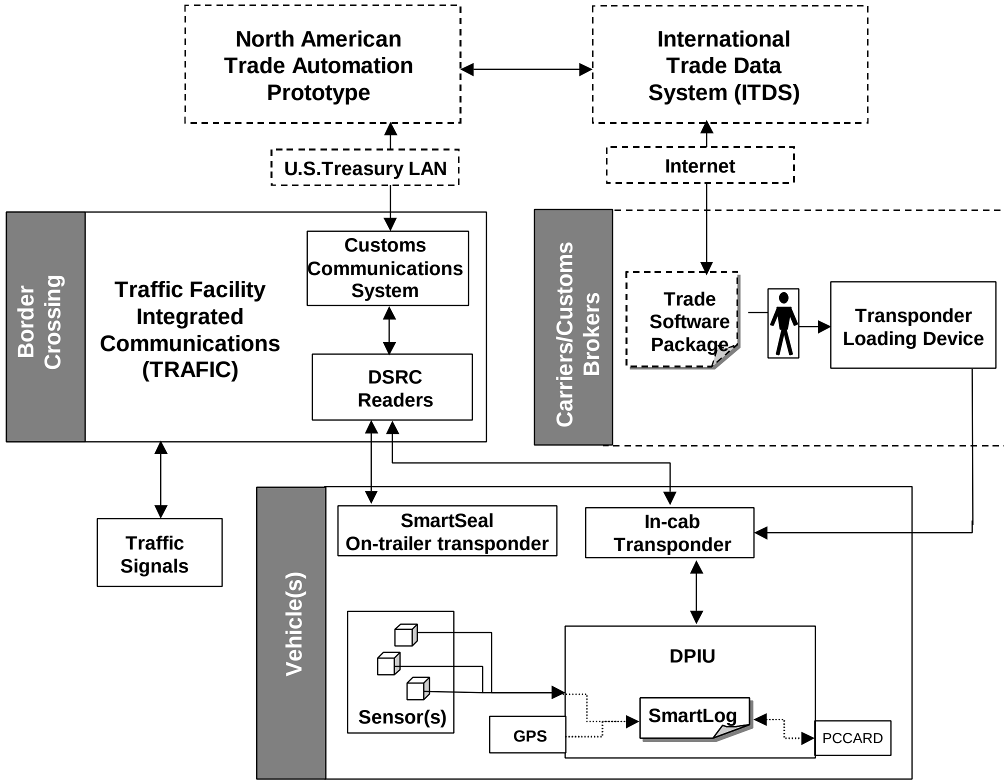
3 IBEX SYSTEM DESCRIPTIONS

The IBEX Operational Test provided the trade community and regulatory agencies with services and technologies that demonstrated electronic solutions to current border crossing and commercial vehicle safety processes. Each stakeholder in the border clearance process will require data to be collected or information to be exchanged in a way that is unique to their portion of the process. Thus the IBEX services and technologies offered are varied and tailored to the data collection and information exchange environment of the stakeholder being served. In this test, the three primary environments for which technologies were developed were the international border crossing facilities, the shipper or carrier or customs broker facilities, and the commercial vehicles. These environments provided the physical infrastructure that housed the demonstrated technologies.

3.1 SYSTEM OVERVIEW

There were two distinct operational tests conducted during the period of the evaluation. The purpose of one test was to demonstrate a DSRC equipment and communications infrastructure developed and installed at the Otay Mesa International Border Crossing in support of the North American Trade Automation Prototype (NATAP) Project. The purpose of the other test was to demonstrate an on-vehicle electronic brake monitoring system concept. Other on-vehicle equipment and capabilities that were originally planned for this test were not demonstrated. It was originally intended that these systems would communicate through an on-vehicle electronic log called a SmartLog. The system as it was originally envisioned is depicted in Exhibit 3-1. However, even though both systems were part of the overall IBEX program, the tests were unrelated and conducted separately and distinctly. So, two separate system descriptions follow in this section: one for the DSRC equipment and supporting devices (to support the NATAP project), and the other for the On-Vehicle brake monitoring system.

EXHIBIT 3-1
IBEX DSRC System As Originally Planned



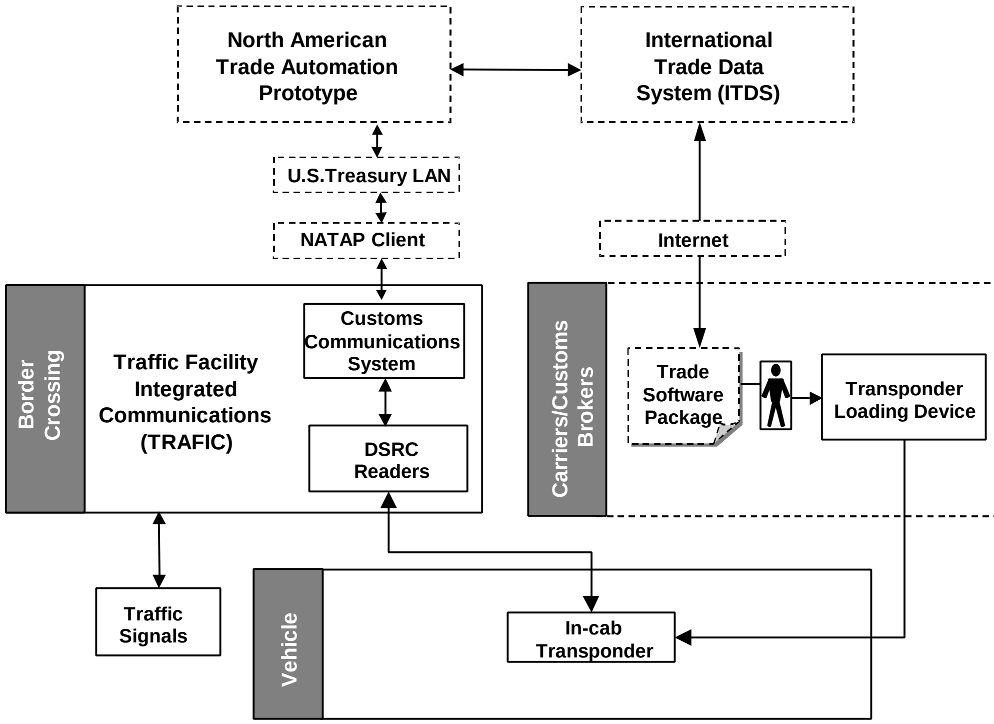
3.1.1 IBEX DSRC equipment and supporting devices

The IBEX DSRC equipment and supporting devices consisted of three primary components and their respective interfaces.

- Traffic Facility Integrated Communications subsystem (TRAFIC)
- On-Vehicle DSRC Equipment
- Carriers and Customs Brokers Equipment

The provided technologies consisted of both hardware and software components. A general overview of the system and its components they actually existed during the period of this evaluation is depicted in Exhibit 3-2.

EXHIBIT 3-2
IBEX DSRC System As Evaluated



3.1.1.1 Traffic Facility Integrated Communications (TRAFIC)

The purpose of the TRAFIC subsystem was to provide the capability to read the transponders on approaching vehicles, pass the received information to external information and decision systems (such as the International Trade Data System (ITDS)), control the Customs inspector interface and relay the inspector actions to the external system (ITDS), and finally to control the traffic signal in response to messages from the external system (ITDS) or the inspector action.

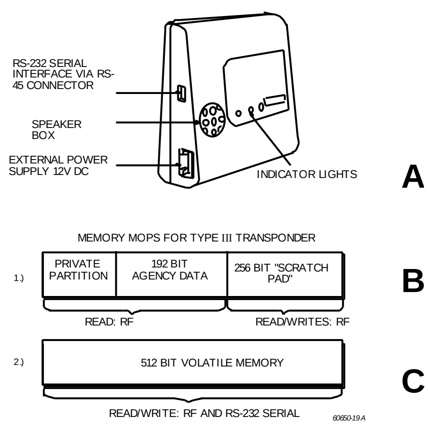
The TRAFIC component consisted of Hughes Dedicated Short Range Communications (DSRC) Readers with associated antennas, an RF LAN system, and other components. The TRAFIC component maintained two interfaces: one with ITDS, and the other with the transponder via the DSRC reader.

The readers used were Hughes model VRC 200 or 200C . This model reader can support up to four antennas. These were chosen because they were (at the time) the same reader that was used at California Pre-pass weigh station by-pass program locations and at the International border crossing at Nogales, Arizona for the EPIC program. Two types of antennae were installed at the compounds. The first was a Sinclair di-pole omni-directional antenna used as an advance read antenna. The second was a Scala yagi high-directional antenna and was installed at locations where decision and exit reads occur. Communications between the antennae and readers was via cable. RF Modems were used to transmit data from the readers to the computer (one in each compound) installed in the office and docks building located at the center of each compound. The computers are represented by the box labeled Customs Communication System located in Exhibit 3-2 above. Traffic lights were installed at each of the entry and exit gate lanes that are equipped with DSRC equipment. They provided signaling to vehicle drivers, and indicated clearance status.

3.1.1.2 On-Vehicle DSRC Equipment

The On-vehicle DSRC equipment consisted of a Hughes Type III transponder. The purpose of the transponder was to provide a DSRC information exchange media that stored information and provided that information upon demand to DSRC readers at regulatory agency decision points. The transponder stored or provided information specific to the vehicle on which it was installed, in addition to other required information such as driver, carrier, and cargo data. The transponders used in the IBEX test were American Society of Testing and Materials (ASTM) Draft 6 compliant devices. This generation of transponders has a non-volatile memory area of 256 bits, which can be used for long term data storage, and can be manipulated via RF DSRC roadside equipment. There is a volatile 512 bit transport memory area that stays active while there is power applied to the transponder. Exhibit 3-3 illustrates the transponder and the available memory areas.

EXHIBIT 3-3
Transponder and Memory Area



The transponder is mounted on the interior of the windshield of the commercial vehicle and power is supplied externally by the vehicle electrical system. It is also possible to use a portable external battery to power the transponder independently of the vehicle, although this is not was not the intent of the transponder design. The transponder is capable of providing both audible and visual signals to the driver. The audible signal is in the form of a tone or buzzer, and the visual signals are provided by a red or green LED indicator light integral to the transponder.

3.1.1.3 Carrier and Customs Broker Equipment

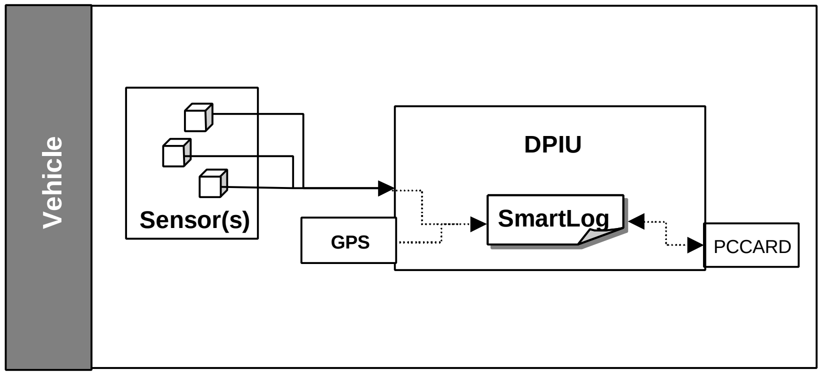
The Carriers and Brokers equipment was often in the hands of the shipper or manufacturer depending on how transportation operations were managed by the test participant. This equipment consisted of a transponder data entry device and a NATAP furnished Trade Software Package (TSP). The Transponder data entry device was either a handheld data entry device or a laptop computer with data entry software. The transponder data entry devices provided a means whereby the test participant was able to transfer information obtained from the TSP to the transponder. The transfer of this data was a manual process, requiring information to be physically entered into the data entry device and then transmitted via cable and an RS232 data connection to the transponder. Sometimes transponders were brought to the data entry device (a laptop or desktop computer) and sometimes that device was taken to the transponder mounted in the vehicle. The TSP was a U.S. Treasury supplied software package, which provides a PC running Windows NT or Windows 95 with the capability to interface with the U.S. Treasury International Trade Data System (ITDS).

3.1.2 On-vehicle Brake Monitoring System

The on-vehicle brake monitoring system consisted of several components integrated for the purpose of monitoring the function and condition of the pneumatic braking system on Class 8 trucks. The SmartLog was small box mounted in the cab of the truck that contained a Data Processing Interface Unit (a 80386 Co-processor), a PCMCIA card slot, an RS232 data port, and a GPS receiver. The SmartLog performed the automated data collection for the overall brake monitoring system tested by the system developer. The SmartLog stored the vehicle mounted sensor data using an industry standard PCMCIA card, or PC card. The PC card slot was built into the SmartLog box. The SmartLog also contained a built-in GPS receiver for collecting vehicle position data that was used to calculate speed and heading of the vehicle. The function of the SmartLog was entirely dependent on PC card application installed. It was somewhat analogous to a 386 computer with no operating system installed. The operating system program was contained on the PC card and the DPIU functions according to the instructions contained therein. The program used for this test was one that gathered and logged information from brake monitoring sensors and ancillary equipment installed on the vehicle. The DPIU had five bi-directional communications ports. The five ports had the ability to support items such as cellular modems, DSRC transponders, and RS-232 peripherals. None of these items were tested with the brake monitoring system.

A diagram of the brake monitoring system concept is shown in Exhibit 3-4 below.

EXHIBIT 3-4 On-vehicle Brake Monitoring System



3.2 SYSTEM DOCUMENTATION

The following documents were referenced:

International Border Electronic Clearance (IBEX) System Summary & Program Plan, Signal Processing Systems, October 1996.

System Specification for International Border Electronic Crossing (IBEX), Signal Processing Systems, September 1996.

4 IBEX EVALUATION DESCRIPTION

4.1 EVALUATION OVERVIEW

This section summarizes evaluation test activities as actually performed for each of the IBEX technologies or services evaluated. The IBEX FOT served two major purposes: First, to install and support a DSRC system in support of NATAP, and second to test the use of On-vehicle safety monitoring equipment. The NATAP DSRC Installation and Support section includes the methods used to evaluate the installation and support of the DSRC equipment at the Otay Mesa Commercial Vehicle Customs Compound. The On-vehicle Safety Equipment section describes the methods used to evaluate the On-vehicle brake monitoring system installed as part of the original IBEX project.

4.1.1 NATAP DSRC Installation and Support

Three categories of components were developed, installed, and supported by the IBEX program in support of NATAP:

1) TRAFIC hub computer hardware & software,
2) DSRC hardware and ancillary equipment installed at the customs compound, and
3) DSRC devices (i.e. transponders and transponder loading devices) installed on or used in conjunction with the commercial vehicles participating in the NATAP tests.

Each of these components was tested or evaluated by the system developer, the IBEX evaluator, and the NATAP evaluator in varying capacities. Data collected by any of the three aforementioned teams was shared with the others in order to economize data collection efforts where practical. Data collected by the system developer during routine operations provided information regarding the performance of the TRAFIC hub computer and the DSRC and other equipment installed at the customs compound. Performance of each of the individual hardware or software components was not tested, but the entire component package or integrated system was evaluated to document its ability to provide a solution for the requirements of the NATAP test. Individual hardware or software component performance or capability is only noted where ever it had an impact on the ability of the system to perform as expected.

4.1.1.1 TRAFIC Hub Computer Hardware & Software

Data regarding the performance of the TRAFIC hub computer hardware and software was collected in two ways:

1)Automated data collection, and
2)Interviews.

Automated data was collected in log files by the TRAFIC software, and by a remote NATAP server. Files were retrieved by the system developer from the TRAFIC computers at both the import and export Customs compounds and were provided to the evaluator in ASCII text format. The files provided encompass recorded activities between January 15, 1997 and August 8, 1997 for the US import compound, and between March 14, 1997 and August 8, 1997 for the US export compound. Gaps in the automated logs exist due to an operating system software change at the export compound that caused all archived data to be lost, as reported by the system developer. Data logs were only archived after the data starting dates listed above. Data for periods prior to and after the period of the supplied data were requested but not provided or available.

Additional perceptions regarding the hub performance were collected during interviews with the system developer, local Customs NATAP system administrators, and the NATAP evaluator.

4.1.1.2 DSRC Hardware & Ancillary Equipment

The installation of various DSRC data collection devices, signaling equipment, and data relay equipment at the Customs compound provides information to the TRAFIC hub computer. Data regarding the performance of this equipment has been collected in four ways:

1) Automated data collection,
2) Interviews,
3) Observation, and
4) Coordinated NATAP interoperability testing.

Automated data was collected in log files by the TRAFIC hub software. Performance perception data was collected during interviews with the system developer, local Customs NATAP system administrators, industry participants, and the NATAP evaluator. Additionally, observations of system operation were made by both the NATAP evaluator and the IBEX evaluator both remotely and during transponder interoperability testing. While transponder interoperability testing was not in the scope of this evaluation, system performance observations were made and recorded during these tests conducted by the NATAP evaluation team.

4.1.1.3 Transponders and Transponder Loading Devices

Transponders and transponder loading devices were considered to be tested for technical functionality and reliability by the vendors providing this equipment. Qualitative data and performance observations were collected in three ways:

1) Interviews,
2) Observation,
3) NATAP Interoperability testing.

Data on perceived functionality, reliability, usefulness, and user acceptance for both transponders and transponder loading devices was collected through the participant interview process. Data regarding the perceived acceptability of the support provided for this equipment was also collected through the interview process. Observations regarding the performance of the transponders was collected and recorded during NATAP transponder interoperability testing. As with the other DSRC components, transponder interoperability was not in the scope of this evaluation. However, useful observations were made during the conduct of the interoperability tests by the NATAP and IBEX evaluators.

4.1.2 On-vehicle safety equipment

4.1.2.1 SmartLog/DPIU

The SmartLog was evaluated as part of the overall brake monitoring system and will be discussed in those sections. Only reports from system developer testing are available to gauge the performance of this unit. A diagram of the relationship of the SmartLog to the other components within the brake monitoring system is shown previously in Exhibit 3-5.

4.1.2.2 Brake Monitoring System

All tests of this system were conducted by the system developer with data provided to the evaluator after the fact. The system developer tests included collection of GPS data, shoe temperature, and slack adjuster pushrod travel.

Data collected from the system was converted from an ASCII file containing encoded information regarding the speed of the vehicle in Kilometers per Hour, the temperature of the thermocouple data used to indicate brake shoe temperature, and slack adjuster pushrod switch settings.

4.1.2.3 GPS Log

This equipment was not tested independently of the Smartlog which was tested as part of the overall brake monitoring system. Therefore any related testing or performance information will be covered in the sections discussing the brake monitoring system.

4.1.2.4 Cargo Seal

This equipment was not available for testing and data was not provided or available during the evaluation period.

4.2 DETAILED TEST SUMMARIES (BY GOAL, OBJECTIVE, AND MEASURE)

The following section summarizes planned and actual evaluation measures used (by goal objective), and changes or deviations from the original evaluation plan measures. Tables are broken out by evaluation goal with objectives and measures included under each goal heading. The key located in the heading row of each table describes the symbols used to denote how each planned measure and collection method was actually used in measurement and data collection activities. If a data collection method was not used, an × replaces that check mark that indicated a planned activity. If a measure was performed but the planned data collection method was modified, or the measure deviated in some way from the original intent, it is denoted with a ▲. If a method was added that was not originally included during the evaluation planning phase, it is denoted with a ✚. If a measure was simply not performed, for any reason, the entire row of text and any associated data collection method symbology, is gray. Following each table is a description of evaluation and test plan changes and deviations for the goal, objectives, and measures discussed in the previous table.

4.2.1 Goal 1 – Document the technical performance of IBEX technologies at the component level.

Goal 1 – Document the technical performance of IBEX technologies at the component level. **Objectives & Measures** **Key**: ✓ Tested as planned; × Not tested; ▲ Tested differently than planned; ✚ Additional / Alternate test used		**Data Collection Methods**							
		User Logs	**User Surveys**	**User Interviews**	**Observation**	**System Developer Test Data**	**Research**	**Electronic Data**	**NATAP Data**
1.1. Document the functionality of on-board monitoring systems' sensors/outputs.									
1.1.1	Indications that brake monitoring system reflected brake system anomalies correctly based on data from observed system developer testing.	×			×	✓	✓	▲	
1.1.2	Observed functionality of cargo seals based on inspection of cargo seal integrity upon arrival of vehicle at destination.				×	×		×	
1.1.3	Observed reliability of the SmartLog / DPIU to successfully capture and record vehicle position information for a traveled route.				×	×	×	×	
1.2. Document the ability of the IBEX DSRC and RF LAN systems to function in the RF laden border-crossing environment.									
1.2.1	Reliability of the TRAFIC system, based on TRAFIC system automated activity logs and expressed in terms of mean time between failures.	✚		✚			×	▲	
1.2.2	Reliability of the DSRC and RF LAN components based on TRAFIC system automated activity logs and expressed in terms of mean time between failures.	✚		✚			×	▲	
1.2.3	Observed system availability based on TRAFIC system automated activity logs.	✚		✚			×	▲	
1.2.4	Observed DSRC or RF LAN component availability based on TRAFIC system automated activity logs.	✚		✚			×	▲	
1.2.5	Point estimate of frequency of successful DSRC transmissions as compared to historical contractor data (i.e. Is data consistent with tests already performed.)						×	×	
1.2.6	Instances and duration of scheduled and unscheduled maintenance or repair, with duration based on time of notification to time of completion.			✚		✚	×	×	▲
1.3. Document the ability of the IBEX DSRC and RF LAN systems to effectively support NATAP processes.									
1.3.1	Reliability of the TRAFIC system in support of NATAP, based on TRAFIC system automated activity logs and expressed in terms of mean time between failures.			✚			✓	▲	
1.3.2	Reliability of DSRC or RF LAN components in support of NATAP, based on TRAFIC system automated activity logs and expressed in terms of mean time between failures.			✚	✚		✓	▲	▲
1.3.3	Observed system availability to support NATAP, based on TRAFIC system automated activity logs.			✚	✚		✓	▲	▲
1.3.4	Observed DSRC or RF LAN component availability to support NATAP, based on TRAFIC system automated activity logs s.			✚			✓	▲	▲
1.3.5	Point estimate of frequency of successful transmissions of red / green indicators from the U.S. Treasury LAN to the signals and transponders, based on TRAFIC system automated activity logs							▲	▲
1.4 Document the functionality of the transponder loading device to transponder interface.									
1.4.1	Observed functionality of transponder loading device and transponder interface hardware or software based on observation of user's operation of the equipment.	×	×	✓	✓			×	

Goal 1 - Evaluation and Test Plan Changes and Deviations

User logs and user surveys were not used as a data collection method throughout this evaluation for the following reasons: 1)Extremely low number of test participants or users of the services and technologies provided by the IBEX FOT, 2)Desire by participants to provide information through the interview process rather than through a survey instrument or activity / observation log, and 3) to minimize the possibility of lost information due to surveys not returned or not completed.

The system developer provided a small sample of collected data and a system description regarding the On-vehicle brake monitoring system (Measure 1.1.1, 3.1.1). Neither the users of this system nor the evaluators were provided with a means of accessing or evaluating data collected by the system without interpretation software and assistance by the system developer. Any measures that call for documentation of user perceptions, evaluator observations, or analysis and assessment of electronically collected data, were eliminated for the following reasons: 1)the users lack of access to interpreted data, 2)the lack of opportunity to observe the system or its function as installed on the vehicles, and 3) the completely insufficient data provided by the system developer.

A working model of the cargo seal was never made available to the evaluator for testing during the period of this evaluation (Measure 1.1.2). The system developer reported that some bench testing of a prototype had occurred but no test data was available. All evaluation observations, data collection and analysis, or research related to the functionality of the cargo seal was eliminated from the performed activities.

Data regarding the functionality of the GPS unit used as a component of the SmartLog was not evaluated (Measure 1.1.3). This component is an off the shelf Geographic positioning system unit that has been tested independently for its technical performance and functionality. Documentation of the performance of the SmartLog as a component of the On-vehicle brake monitoring system include observations regarding speed and direction of travel data that are derived from the data provided by the GPS. Thus, indirect references to its performance as part of the SmartLog unit are suggested.

The changes to measures regarding the TRAFIC system (Measures 1.2.1 through 1.2.4) can be characterized as follows:

Reliability and availability assessments are based on user interviews, daily logs kept by Customs personnel, and some trend information provided by the automated activity logs. A request was made for any available system trouble reports that may have been archived by the system developer but none were provided (thus the elimination of Measure 1.2.6). TRAFIC hub automated activity logs were incomplete in their ability to provide a continuous stream of information regarding the performance of the TRAFIC hub. It must be noted that the system developer indicated that they never intended for the TRAFIC hub logs to be used for evaluation purposes. They indicated that this data was primarily intended as a realtime debug tool for the TRAFIC hub software and its communication with DSRC devices installed at the Customs compound. These same remarks apply to assessments of the ability of the TRAFIC hub and installed DSRC components to support NATAP processes (Measures 1.3.1 through 1.3.5.)

The data collection regarding the function of the handheld transponder data entry device and the system developer's data entry software occurred primarily during interviews with NATAP participants and also during participation and observation in a transponder interoperability test that was conducted separately from this IBEX evaluation (Measure 1.4.1).

4.2.2 Goal 2 – Determine User Acceptance of IBEX Services and Technologies.

Goal 2 – Determine User Acceptance of IBEX Services and Technologies. **Objectives & Measures** **Key**: ✓ Tested as planned × Not tested ▲ Tested differently than planned ✚Additional / Alternate test used		**Data Collection Methods**							
		User Logs	**User Surveys**	**User Interviews**	**Observation**	**System Developer Test Data**	**Research**	**Electronic Data**	**NATAP Data**
2.1. Evaluate the carrier users' acceptance of the IBEX services and technologies.									
2.1.1	Ease of use of the IBEX services and technologies based on carrier user responses.		×	✓					
2.1.2	Acceptability of time required to use IBEX services and technologies based on carrier user responses.		×	✓					
2.1.3	Perceived component ruggedness based on carrier user responses.		×	✓					
2.1.4	Carrier user willingness to pay for IBEX services and technologies based on user responses.		×	✓					
2.1.5	Carrier user acceptance of observed reliability based on user responses.		×	✓					
2.1.6	Carrier user acceptance of observed accuracy based on user responses.		×	×					
2.1.7	Carrier user acceptance of installation procedures or services provided based on user responses.		×	✓					
2.1.8	Acceptability of maintenance required or provided based on user responses.		×	✓					
2.1.9	Carrier user acceptance of training provided based on user responses.		×	✓					
2.1.10	Carrier user acceptance of manuals and support documents provided based on user responses.		×	✓					
2.1.11	Perceived usefulness of information provided by on-board sensors based on carrier user responses.		×	×					
2.1.12	Perceived usefulness of information provided by electronic cargo seals based on carrier user responses.		×	×					
2.1.13	Perceived usefulness of itinerary verification functions and information provided based on carrier user responses.		×	×					
2.2. Evaluate the customs broker users' acceptance of the IBEX services and technologies.									
2.2.1	Ease of use of the IBEX services and technologies based on customs broker user responses.		×	✓					
2.2.2	Acceptability of time required to use IBEX services and technologies based on customs broker user responses.		×	×					
2.2.3	Perceived component ruggedness based on customs broker user responses.		×	✓					
2.2.4	Customs broker user willingness to pay for IBEX services and technologies based on user responses.		×	✓					
2.2.5	Customs broker user acceptance of observed reliability based on user responses.		×	×					
2.2.6	Customs broker user acceptance of observed accuracy based on user responses.		×	×					
2.2.7	Customs broker user satisfaction with installation procedures or services provided based on user responses.		×	×					
2.2.8	Acceptability of maintenance required or provided based on user responses.		×	×					

Goal 2 – Determine User Acceptance of IBEX Services and Technologies.

Objectives & Measures

Key: ✓ Tested as planned × Not tested
▲ Tested differently than planned ✚ Additional / Alternate test used

	Objectives & Measures	Data Collection Methods: User Logs	User Surveys	User Interviews	Observation	System Developer Test Data	Research	Electronic Data	NATAP Data
2.2.9	Acceptability of training provided based on user responses.		×	×					
2.2.10	Acceptability of manuals and support documentation provided based on user responses.		×	×					
2.2.11	Perceived usefulness of information provided by on-board sensors based on customs broker user responses.		×	×					
2.2.12	Perceived usefulness of information provided by electronic cargo seals based on customs broker user responses		×	×					
2.2.13	Perceived usefulness of itinerary verification functions based on customs broker user responses		×	×					
2.3.	**Evaluate the shipper users' acceptance of the IBEX services and technologies.**								
2.3.1	Ease of use of the IBEX services and technologies based on shipper user responses		×	✓					
2.3.2	Acceptability of time required to use IBEX services and technologies based on shipper user responses		×	✓					
2.3.3	Perceived component ruggedness based on shipper user responses		×	✓					
2.3.4	Shipper user willingness to pay for IBEX services and technologies based on user responses		×	✓					
2.3.5	Shipper user acceptance of observed reliability based on user responses		×	✓					
2.3.6	Shipper user acceptance of observed accuracy based on user responses		×	✓					
2.3.7	Shipper user satisfaction with installation procedures or services provided based on user responses.		×	✓					
2.3.8	Acceptability of maintenance required or provided based on user responses.		×	✓ ✓					
2.3.9	Acceptability of training provided based on user responses.		×	✓					
2.3.10	Acceptability of manuals and support documentation provided. Based on user responses		×	✓					
2.3.11	Perceived usefulness of information provided by electronic cargo seals based on shipper user responses.		×	✓					
2.3.12	Perceived usefulness of itinerary verification functions based on shipper user responses.		×	✓					
2.4.	**Evaluate receiver users' acceptance of the IBEX services and technologies.**								
2.4.1	Ease of use of the IBEX services and technologies based on receiver user responses		×	×					
2.4.2	Acceptability of time required to use IBEX services and technologies based on receiver user responses		×	×					
2.4.3	Perceived component ruggedness based on receiver user responses		×	×					
2.4.4	Receiver user willingness to pay for IBEX services and technologies based on user responses		×	×					
2.4.5	Receiver user acceptance of observed reliability based on user responses		×	×					
2.4.6	Receiver user acceptance of observed accuracy based on user responses		×	×					
2.4.7	Receiver user satisfaction with installation procedures or services provided based on user responses.		×	×					
2.4.8	Acceptability of maintenance required or provided based on user responses.		×	×					
2.4.9	Acceptability of training provided based on user responses.		×	×					
2.4.10	Acceptability of manuals and support documentation provided based on user responses.		×	×					

Goal 2 – Determine User Acceptance of IBEX Services and Technologies.

Objectives & Measures

Key: ✓ Tested as planned ✕ Not tested
▲ Tested differently than planned ✚Additional / Alternate test used

		Data Collection Methods							
		User Logs	User Surveys	User Interviews	Observation	System Developer Test Data	Research	Electronic Data	NATAP Data
2.4.11	Perceived usefulness of information provided by electronic cargo seals based on receiver user responses.		✕	✕					
2.4.12	Perceived usefulness of itinerary verification functions based on receiver user responses.		✕	✕					
2.5.	**Evaluate the regulatory agency users' acceptance of the IBEX services and technologies.**								
2.5.1	Ease of use of the IBEX services and technologies based on regulatory agency user responses		✕						
2.5.2	Acceptability of time required to use IBEX services and technologies based on regulatory agency user responses		✕						
2.5.3	Perceived component ruggedness based on regulatory agency user responses		✕						
2.5.4	Regulatory agency user willingness to pay for IBEX services and technologies based on user responses		✕						
2.5.5	Regulatory agency user acceptance of observed reliability based on user responses		✕						
2.5.6	Regulatory agency user acceptance of observed accuracy based on user responses		✕						
2.5.7	Regulatory agency user satisfaction with installation procedures or services provided based on user responses.		✕						
2.5.8	Acceptability of maintenance required or provided, based on user responses.		✕						
2.5.9	Acceptability of training provided, based on user responses.		✕						
2.5.10	Acceptability of manuals and support documentation provided, based on user responses.		✕						
2.5.11	Perceived usefulness of information provided by on-board sensors based on regulatory agency user responses.		✕						
2.5.12	Perceived usefulness of information provided by electronic cargo seals based on regulatory agency user responses.		✕						✕
2.5.13	Perceived usefulness of itinerary verification functions based on regulatory agency user responses.		✕						

Goal 2 - Evaluation and Test Plan Changes and Deviations

User perceptions of the acceptability, usefulness, reliability, satisfaction with, and adequacy of IBEX services and technologies was collected almost exclusively through interviews (Measures 2.1.1 through 2.5.13). This set of measures was developed in anticipation of a larger number of participants when it was developed. Due to the small number of participants in each category the data provided through the interview cannot be considered to represent the entire potential participant population. Instead the data must be viewed as an indicator of possible attitudes that may be reflected in each participant category.

In the case of measures 2.5.1 through 2.5.3 the evaluator had the opportunity to observe the participants using and interacting with the equipment or systems which provided useful attitudinal information.

4.2.3 Goal 3 – Evaluate the potential impacts of the IBEX services and technologies to transportation processes and interfaces with the trade community for international movement of commerce.

Goal 3 – Evaluate the potential impacts of the IBEX services and technologies to transportation processes and interfaces with the trade community for international movement of commerce. **Objectives & Measures** **Key**: ✓ Tested as planned × Not tested ▲ Tested differently than planned ✚Additional / Alternate test used		Data Collection Methods: User Logs	User Surveys	User Interviews	Observation	System Developer Test Data	Research	Electronic Data	NATAP Data
3.1.	**Evaluate the potential impact of the IBEX services and technologies on the time required for commercial movement of goods across an international border.**								
3.1.1	Difference in elapsed travel time for test vehicles, from time of arrival at the international border crossing compound to time of departure from that compound, prior to and after IBEX system implementation. (The above measure will be dependent on the availability of control group data prior to IBEX system implementation).		×						
3.2.	**Estimate the potential impacts the implementation of the IBEX services and technologies on carrier business processes and interfaces with the customs broker, shipper, receiver, and the Port of Los Angeles.**								
3.2.1	Estimated reallocation of brake system maintenance and repair expenses after system implementation, based on comparison to historical data.		×	×			×		
3.2.2	Indications that the use of electronic cargo seals will positively impact cargo insurance premiums based on insurance representative response.		×						
3.2.3	Indications that the electronic cargo seals will facilitate prompt reconciliation of cargo shortage disputes, based on carrier, shipper, and receiver responses.		×						
3.2.4	Estimated potential increase in carrier productivity / efficiency based on comparison of duration of border crossing transactions before and after system implementation.		×						
3.2.5	Indications the system provides benefit with respect to mileage recording for commercial vehicle administrative purposes based on user responses.		×	×					
3.2.6	Indication that cargo security and itinerary verification services are of value to carrier customers based on shipper, receiver, customs broker responses.		×						
3.2.7	Documentation of potential impacts as perceived by the carrier to their business processes.		×						

Goal 3 - Evaluation and Test Plan Changes and Deviations

Participants in the brake monitoring system test did not have an opportunity to assess any impacts, or compare procedures for maintaining and repairing their brake systems based on data provided by the brake monitoring system (Measure 3.2.1). Nor did participants have the opportunity to retrieve GPS data for itinerary verification during this test (Measure 3.2.5). As explained in detail in section 4.2.1, participants in the these tests were not provided with a means of accessing or evaluating data collected by the system without interpretation software and assistance by the system developer. This data was retrieved solely by the system developer. Therefore these two measures were eliminated from Objective 3.2.

4.2.4 Goal 4 – Document the transportation institutional issues and lessons learned.

Goal 4 – Document the transportation institutional issues and lessons learned. Objectives & Measures **Key**: ✓ Tested as planned; × Not tested; ▲ Tested differently than planned; ✚ Additional / Alternate test used		User Logs	User Surveys	User Interviews	Observation	System Developer Test Data	Research	Electronic Data	NATAP Data
4.1. Document the institutional issues encountered in executing the system demonstration and the potential impacts on the eventual commercialization of the service.									
4.1.1	Documentation of trade community views regarding organizational, regulatory and policy, legal, liability issues on the IBEX system and the automated border crossing processes.		×	✓			✓		
4.1.2	Documentation of regulatory agency views regarding organizational, regulatory and policy, legal, liability issues on the IBEX system and the automated border crossing processes.		×	✓			✓		
4.2. Document lessons learned and technical approaches to electronic border crossing.									
4.2.1	Documentation of technical and non-technical lessons learned, and technical approaches to electronic border crossing.		×	✓			▲		

Goal 4 - Evaluation and Test Plan Changes and Deviations

User logs were not found to be suitable for retrieving institutional issues and lessons learned types of information from those participating in, developing, or impacted by the services and technologies being evaluated.

It was not possible to document most of the technical approaches and many of the technical lessons learned during the course of this evaluation. The system developer considered much of this information to be company proprietary. As such, it was not made available to the evaluator. Some research external to the system developer revealed some very useful information, but not to the extent that it would provide any blueprint level information that would aid in a more effective or efficient installation or application of the developed systems at future sites.

4.3 REFERENCES

International Border Electronic Clearance (IBEX) *Evaluation Plan*, April 1997.

International Border Electronic Clearance (IBEX) *Evaluation Test Plan Briefing*, July 1997.

International Border Electronic Crossing (IBEX) *System Summary & Program Plan*, Signal Processing Systems, October 1996.

System Specification for International Border Electronic Crossing (IBEX), Signal Processing Systems, September 1996. [This document was informally updated for the purposes of this evaluation by SPS representatives in June 1997]

North American Trade Automation Prototype (NATAP*) Interoperability Test Final Report*, January 1998.

Tri-lateral Evaluation Interview Guide (NATAP), 1997.

5 OVERALL EVALUATION RESULTS & FINDINGS (BY GOALS AND OBJECTIVES)

The focus of this portion of the evaluation was twofold. The primary purpose was to document the ability of the IBEX system components to function properly under the conditions that existed within the context of the operational test. Additionally, it allowed for the establishment of a frame of reference for the assessment of user responses regarding the utility and acceptance of the systems and services under evaluation. A combination of system developer-provided technical data, records from the TRAFIC hub, and user responses obtained during interviews was used to address the objectives identified for each goal.

5.1 DOCUMENT THE TECHNICAL PERFORMANCE OF IBEX TECHNOLOGIES AT THE COMPONENT LEVEL.

5.1.1 Document the functionality of on-board monitoring systems' sensors/outputs.

The brake monitoring system functionality was originally to be documented using data provided by the system developer. The intent was to gather evidence that the brake monitoring system could correctly identify brake system anomalies.

Brake system sensors, maxi-cans, cabling, and a SmartLog were installed on three test participant tractors. The tractors were separated into two categories: shorthaul and longhaul. The system was designed to record two brake system characteristics that are thought to be indicative of the ability of the brakes to operate effectively. The first is brake chamber pushrod travel, which is an indicator of the level of adjustment of the brakes. The Commercial Vehicle Safety Alliance (CVSA) criteria for brake adjustment specifies that any brake actuator with a stroke in excess of two inches is cause for the issuance an out-of-service (OOS) order. The IBEX system employed prototype brake cylinders that incorporated two magnetic position switches, one to indicate a dragging brake (less than .15" of shoe clearance when brakes are not applied), and a second to indicate travel in excess of 1.9 inches. The second brake characteristic to be measured was brake shoe temperature, which can also be an indicator of brake adjustment. To accomplish this, the system developer bonded a thermocouple to the back side of the leading brake shoe on each drive axle of the tractor. The basic operating principle was that substantial differences in the operating temperatures of brakes at opposite ends of the same axle would indicate that one brake was providing a disproportionate share of the braking on that axle. The existence of this condition would indicate that one of the brakes was either out of adjustment or contaminated.

While the principles by which these components were chosen have merit, a lack of sufficient data prevents any conclusions from being made regarding the functionality of the systems as installed. The shorthaul tractors were typically drayage operators working within a short radius (<25 miles) of the international border crossing at Otay Mesa. The tractors frequently picked up and dropped trailers as part of their daily operations. The longhaul tractor pulled loads between the border area south of San Diego and Los Angeles (<150 Miles each way). It was not clear whether this driver was dropping and picking up trailers or pulling the same trailer over the duration of the test. In reality, the longhaul carrier still represented a regional or semi-local carrier. The route between Los Angeles and the San Diego region does not have significant downgrades that would have exercised the brake system more thoroughly. Additionally, both the short and longhaul had any worn brake components replaced including shoes during system installation and prior to collection of test data. This created a situation where there was little wear on the components, thus providing little opportunity for the system to report inconsistencies or anomalies in brake components. To date, the data provided by the system developer has been limited to some sample plots showing traces of brake temperatures, temperature differentials, vehicle speed, and switch 1 position for six unidentified, short-duration test runs. The sample data traces appear to demonstrate the system was able to monitor and record vehicle operating conditions, however, conclusions regarding the accuracy or usefulness of the information could not be drawn from them. Requests for more comprehensive data sets have not been granted.

From an operational standpoint, once again, little information was available for review by the evaluator. While thermocouple temperature measurement devices are useful and accurate under controlled conditions, achieving long-term reliability and accuracy in the often severe operating environment of over-the-road freight tractors could prove challenging. In addition, the introduction of electronics in the vicinity of the vehicle brakes is likely to complicate brake system maintenance. Further evaluation of the technology is required for more conclusive statements to be made.

The functionality of the electronic cargo seals was to be observed by electronically and visually inspecting the seals of several randomly selected vehicles upon arrival at their destinations. Because none of the test vehicles were equipped with electronic cargo seals during the test time frame, the functionality of these devices could not be documented.

The basic concept behind itinerary verification is the ability to monitor the path of a given shipment from origin to destination. The underlying principle is that shipments that adhere to approved routes and schedules are less likely to have opportunity to take on unauthorized cargo or contraband. Hence, this system concept offered a means by which those stakeholders legally liable for the content of shipments crossing borders could potentially reduce the risk of contaminated shipments.

While the on-vehicle system was equipped with a GPS system, data regarding the ability of the system to provide itinerary verification was not available. However, any number of commercially available fleet management systems offer the ability to track individual shipments in real time. This data should be easily incorporated with software designed to alert consignees when predetermined route adherence criteria are violated.

Findings and observations regarding the on-vehicle systems are provided below.

Data Drop-outs

Observed occasional data drop outs for GPS component in sample data. Graphical representations of data collected by the system developer indicated that periodic data drop outs occurred with the GPS unit installed in the SmartLog. The drop-outs observed by the evaluator on the data samples provided represent seconds rather than minutes and for normal operation could be smoothed through interpolation. However, if a significant braking event were to take place, seconds of drop-out could mean the difference between the capture of important data and an entirely missed period of data.

Thermocouple design

Thermocouple design was reported by the system developer to be subject to moisture damage. The system developer reported one significant event in which a thermocouple was rendered non-functional due to moisture build-up within the housing of the unit. The unit was dismantled, dried, reassembled and sealed, after which it seemed to return to normal operation. It can not be concluded whether this was a unique event or whether the thermocouple used is subject to moisture damage by design.

Sensor Cabling

Cabling is designed for constant movement and long wear. The system developer chose a TBD type cabling for communication between axle and wheel mounted components with frame mounted components. This type of cabling is designed for the continuous motion that occurs between elements of the tractor chassis and is an appropriate solution for this application. Cabling on cab to frame and frame to axle applications would otherwise represent an area subject to high risk of failure.

Thermocouple Installation

Sensor functionality is dependent on special installation techniques. The sensors/thermocouples installed on the inside of the shoe required cleaning and grinding of the surface of the shoe backing in order for the sensor to function properly. The sensor could not be simply affixed to the shoe backing with epoxy due to its insulating properties. Therefore, the proper function of the thermocouples is highly dependent on proper installation.

Brake Monitoring System Data Presentation

Current system developer testing does not include tailoring of data for use by test participants. The sensor data collected by the SmartLog was not formatted for use by test participants in performing any evaluation of their own equipment condition. The system developer designed a software program to interpret the hexadecimal data provided by the SmartLog and present it in a graphical format. However, the formatted data in the current stage of testing would need significant further refinement to be useful to the test participants.

System Maturity

Additional testing and further development and maturity of system would be required to complete evaluation of these components. The system developer indicated during interviews that the brake monitoring system would continue to be tested and modified as funding was made available. However, the brevity of the first test, coupled with the provision of only sample data by the system developer, rendered an evaluation of the functionality of the brake monitoring system impossible at this time.

5.1.2 Document the ability of the IBEX DSRC and RF LAN systems to function in the RF laden border-crossing environment.

Dedicated short-range communications systems have traditionally been used in two applications–electronic toll collection, and weigh station bypass systems. In each of these applications, rarely is more than one antenna/reader combination required to operate in such a way as to provide sequential transponder reads in a confined area, as is the case in an international border crossing compound. In addition, the use of RF local area network (LAN) hardware introduced additional opportunity for RF interference to hamper system performance. As such, the Otay installation (and other border system installations) represents a unique set of technical challenges.

The sources of information for documenting the functionality of these systems was data gathered from system user logs and interviews, and the TRAFIC system automated activity logs. Findings and observations regarding this functionality are provided below.

While the opportunity existed for interference to be present due to the many systems within the compound, the most common technical problems stemmed from the multiple DSRC antennae operating in close proximity. This problem was characterized by the difficulty experienced tuning the antennae to provide reader footprints of a size and profile appropriate for the operational characteristics of the import and export compounds, while ensuring a level of performance adequate for the implementation of the border system. The ramifications of this issue were most commonly manifested in missed or extraneous transponder reads.

Because the DSRC technologies implemented represent an adaptation of commercially available off-the-shelf products, the evaluator will defer detailed RF capability testing to that already performed by the component vendors. However, it must be noted that the specific application of the DSRC equipment in this FOT was also subject to various uncontrolled elements. So, for testing purposes, some observed and documented behaviors of the equipment are not attributable to one specific cause, or cannot be ascertained due to the possibility of multiple reasons for the event or behavior. Documentation of the abilities of the DSRC equipment used in this FOT are reported terms of general observations and by equipment type in the paragraphs that follow.

Test Lane/Gate Control

The lack of a dedicated and isolated NATAP entry lane provided the opportunity for NATAP participant trucks to enter the import compound in a non-DSRC equipped lane. Thus, in cases where an exit read was recorded without a corresponding Advance or Decision read, it was not possible to ascertain whether the Advance or Decision read was missed or improperly recorded by the antennae or reader, or whether the truck simply traveled in the wrong lane through the entry gate. The import compound lane configuration shown in Exhibit 5-1 below illustrates the configuration of the lanes into the import compound. For the export compound, shown in Exhibit 5-2, there are two entry gates with a single entry lane. The gates are separated by a complex of buildings. The export compound North Entrance gate is the one DSRC equipped. Therefore, as long as a test participant entered through the proper gate, there was no problem with the driver choosing an incorrect lane. However, there was still the possibility of the driver entering through the non-DSRC equipped gate, which would result in a missed Advance and Decision read for the export compound. The exit gates at the import compound were both equipped with DSRC equipment thus eliminating the possibility of a missed exit read due to improper lane choice. In the export compound, only one exit lane is equipped with DSRC equipment, and thus the possibility of an improper lane choice arises again.

Antennae Footprints

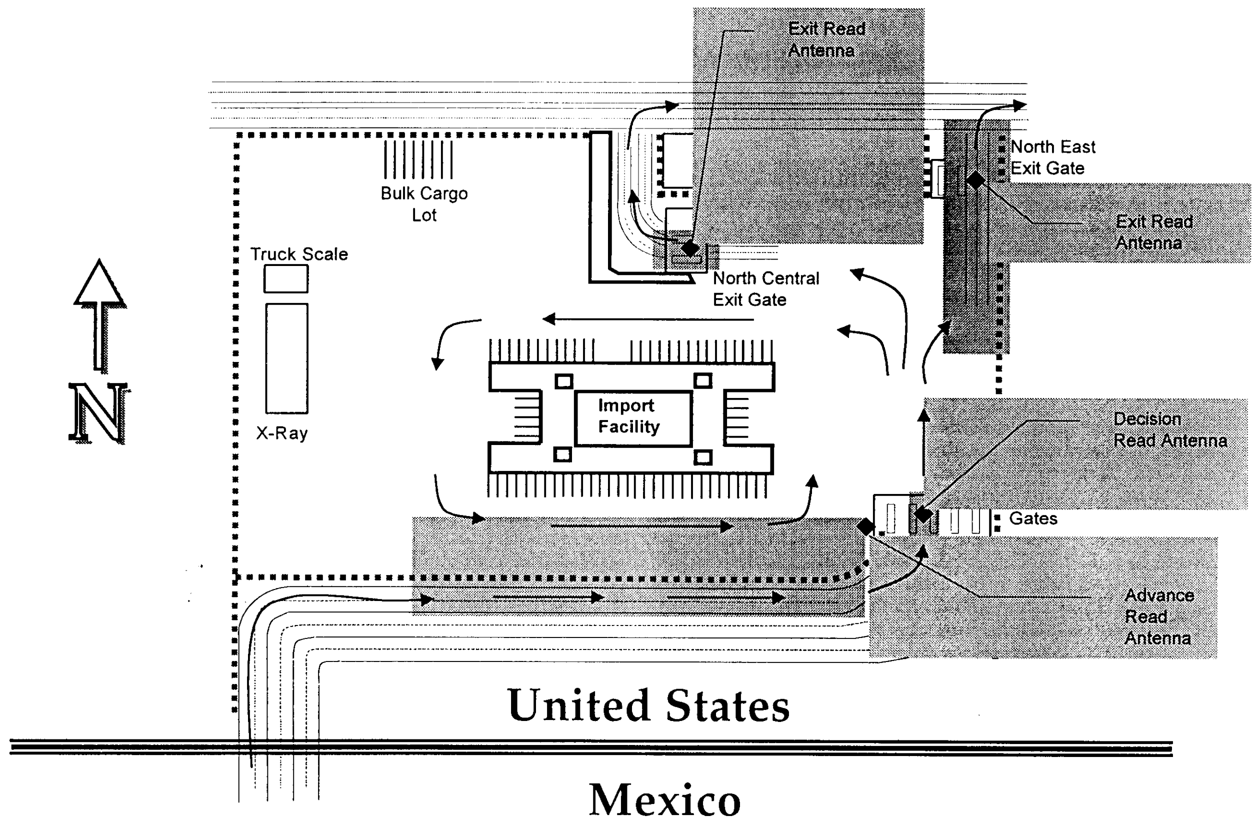
During the first few months of testing readers and antennae were undergoing adjustment, fine tuning, and modification, thus rendering the antennae footprints (read zones of the antennae) to be larger or smaller depending on both environmental factors and the most recent adjustments that had taken place.

Depending on the path traveled by a transponder equipped truck, once inside the import compound, early or extraneous transponder reads were observed to be recorded by the North East Exit antenna and the Advance read antenna. These extraneous reads occurred if the truck traveled through a read zone while driving inside the compound to conduct business prior to exiting. If the truck passed too close to the reader at the North East Exit prior to exiting at the North Central Exit, both reads would be recorded. If the truck "looped" the building and inspection docks located in the center of the compound and passed too close to the fence on the south side of the compound, the transponder would be detected by the Advance antenna an extraneous Advance read would be recorded. Truck travel paths are depicted in the diagram of the import compound in Exhibit 5-1.

While Advance reads often occurred inside the compound, the chain link metal fencing surrounding the compound was reported by the system developer to cause significant interference to the Advance antenna read zone. This condition resulted in missed Advance reads. When a truck approached the entry gate at the import compound it was on the opposite side of the chain link fence from the Advance read antenna. If an Advance read was not recorded, the TRAFIC hub software "manufactured" a simulated Advance read to send to the NATAP system. According to the system developer, the NATAP system cannot process a Decision (primary) read without first receiving and recording the Advance read. The manufactured Advance read is indicated in the TRAFIC hub activity logs by approximately a five second difference in the Advance and Decision read times.

The system developer also reported that humidity and moisture can also affect the read zones of the antennas, thus the occasional fluctuation in the footprint area. This is especially evident in the performance of the North East Exit antenna and the periodic change in size of that read zone which has detected transponders at more than 75 feet from the exit booth where the antenna is mounted.

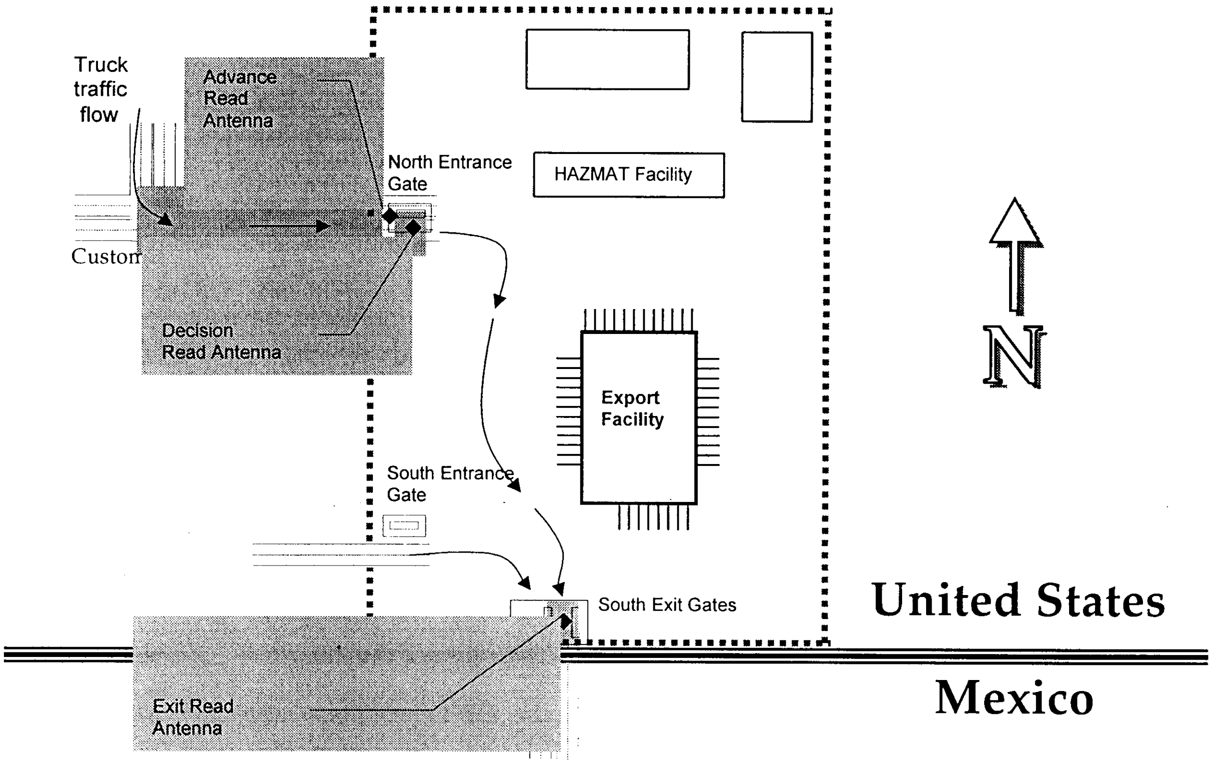
Exhibit 5-1 Otay Mesa Commercial Vehicle Import Customs Compound



The export compound advance read antenna also has a large read zone that extended well into a "t" intersection where trucks made a left turn to get to the North Entrance gate or a right turn to get to other manufacturing, warehouse, or brokerage facilities. This read zone is depicted in the diagram of the export compound in Exhibit 5-2. One test participant had facilities that required their transponder equipped trucks to make a right turn at this intersection. The result was that the truck's transponder would be read and often a trip/load number would be recorded that may have been recorded previously during an import event or even a previous export event. This duplicate read is due in part to the large Advance antenna read zone and in part to the fact that a programmed transponder remains programmed with the last information entered until it is overwritten.

A timing mechanism was put in place by the system developer to attempt to avoid duplicate reads. In other words, if a transponder was read by a reader at a specific location, it should not be read again at that location for a specified period of time (at last report this period was one hour.) However, if the truck's stay in the compound exceeded the one hour time period, as observed in the TRAFIC hub logs, or if the Advance read was manufactured by the system, a second or extraneous Advance read could be and often was recorded. In at least one instance, as reported by the system developer, the antenna footprint for the North East Exit gate was adjusted such that it extended slightly into the roadway adjacent to the north side of the compound. During this time, at least one extraneous read was recorded from a NATAP transponder equipped truck passing by the North East Exit gate while on the roadway outside the compound. This was corrected by a readjustment of the direction of the antenna read zone.

Exhibit 5-2 Otay Mesa Commercial Vehicle Export Customs Compound



Instances of significant DSRC component malfunctions or failures during FOT period.

Major component failures were conveyed to the evaluator by the system developer, NATAP system administrators at the Otay Mesa compound, and by the NATAP evaluators primarily during interviews. Other information regarding significant equipment failures, repairs, or maintenance were relayed by the system developer in several email reports provided to stakeholders during the official and unofficial period of operation of the test. Throughout the test, equipment malfunctions and failures were reported primarily via phone by the Customs agents monitoring the system at the border. Significant events of this nature are summarized in the paragraphs that follow.

The following bulleted list represents significant incidents or conditions impacting the performance of the computer or DSRC equipment installed by SPS at either the Cargo West(Export) or Cargo East(Import) compounds:

- Late 1996 – Rainwater accumulated in the housing of he exit reader at Cargo West causing a failure. A hole was drilled at the bottom of the housing to let any water accumulation drain resolving the problem.
- Late 1996 – RF Modem produced by California Microwave did not function well due to its subjectivity to RF interference. The vendor has been changed to Black Box, which performs reliably as reported by the system developer.

- April 1997 – A GSA contractor replaced ceiling tiles in the computer server room at Cargo West. Debris from the removal of the old ceiling fell into the vents of the computer monitor causing an electrical short and ultimate failure. The monitor was replaced.
- June 19, 1997 – Circuit Breaker at the east exit gate for NATAP traffic signal was turned off causing signal not to function. The circuit breaker panel is available to GSA contractors and serves all the electrical equipment at the east exit gate. DSRC and other NATAP related electrical equipment is not separated or isolated in any way from the rest of the electrical equipment serving the booth.
- July 3, 1997 – A toggle switch on a reader controller box was turned off causing the reader at the primary export gate not to respond. Problem was resolved by turning the toggle switch back on.
- August 11-12, 1997 – Both ITDS and SPS computers received software upgrades to accommodate new firewall restrictions. Customs agents report that since the software upgrade communication between the two systems has been troublesome.
- August 22, 1997 – Advance and Decision reader did not appear to be receiving or retrieving information on this date when system functions were checked by the local Customs NATAP Administrator. The NATAP Administrator shut down all systems, restarted them, and rebooted all computers in an attempt to correct the problem. This was reported to have corrected the problem.

Other on going conditions:

- TRW Network Services causes periodic Customs LAN outages causing both TRAFIC and ITDS systems not to function properly during the early months of the FOT. The outage simply disconnected communications between the systems. The systems would require rebooting after such events. Communication between the two computers is no longer via the U.S. Treasury LAN.
- Throughout the test, the primary ITDS computer has needed to be rebooted periodically ("daily" prior to Jan. 97) to restore the connection between ITDS and SPS equipment. The SPS equipment now polls the ITDS computer on a regular basis to maintain the connection without the need for rebooting.
- When a truck approaches the entry gate at the import compound and an Advance transponder read is not recorded, the TRAFIC hub software "manufactures" a simulated Advance read to send to the NATAP system. According to the system developer, the NATAP system cannot process a Decision (primary) location read without first receiving and recording the Advance read. The simulated read is indicated in the TRAFIC hub activity logs by approximately a five second difference in the Advance and Decision read times. This condition has existed throughout the test and evaluation periods
- Duplicate or extraneous trip/load numbers have been reported by NATAP administrators periodically throughout the life of the test and have had been produced by various conditions at various locations. This activity is also discussed in this section under *Antennae Footprints*. The most common of the conditions that apparently are causing duplicate reads are as follows:
  - At Cargo East (Import), the advance reader footprint is situated along the fence line that divides the entry lanes (specifically entry lane 1) from the interior of the compound, thus producing an occasional duplicate read when the same

transponder equipped truck comes too close to the fence while "inside" the compound. Trip / load numbers may not be reported to ITDS if read a second time within sixty minutes of the initial advance and decision reads. However, trucks often remain in the compound for a variety of reasons well beyond the sixty-minute window, thus producing the opportunity for duplicate reads under the above described condition.

- Another condition that allows a trip / load number to remain active is when a truck that is re-entering Mexico does not go through Cargo West (export) and / or does not use the dedicated / designated NATAP lanes. Upon return to the U.S. this trip load number may be read repeatedly.
- At Cargo East (Import), the primary decision reader footprint is large and can often pick up a transponder in both lanes 1 and 2. Again, an active trip / load number may be read, even if the truck driver thinks that he is clear of the readers.
- At Cargo West (Export), there is an intersection directly in the line of site of the advance reader. This is the intersection of Customhouse Plaza and Siempre Viva, which is a turn off for trucks entering the Custom's broker's facilities prior to entry into Cargo West. The reader has been tuned such that the footprint should fall short of the intersection; however, it will occasionally pick up a transponder from a truck in the intersection that is turning the opposite direction (west) on Customhouse Plaza. This also produces occasional duplicate reads.

Transponder performance

During interoperability testing performed by the NATAP evaluation team in December 1997, some noteworthy observations were made regarding the performance of transponders in the "RF laden" environment of the customs compounds. Multiple types of transponders were transported in and around the import and export compounds for a period of several hours. Each of the transponders, while not exposed to other DSRC equipment for the entire period of the test, were exposed to readers and antennae for up to four or five hours of cumulative time. Toward the end of the test, battery operated transponders began to fail to be read properly by the antennae on the compound. The primary explanation for this behavior was the discharged condition of the batteries. When shielded from the DSRC equipment for a few hours or recharged the batteries would once again regain enough charge to interface properly with the antennae. It would not be unlikely for a transponder equipped truck in a secondary inspection to spend up to a few hours inside the compound in the vicinity of the installed DSRC equipment. Thus, battery operated transponders would need to be equipped with a battery able to withstand a longer duration exposure to an RF rich environment.

On two occasions, transponders were thought to be responsible for improper or missed reads at both the import and export compounds as observed by the NATAP administrator at the Customs compounds.

Reader reliability and functionality

Customs personnel have reported that the rebooting of the reader at the entry gate has been required on a consistent basis in order for the equipment to function properly. Reader software was upgraded during the summer of 1997 to accommodate a Mark IV transponder. A

NATAP and an IBEX software upgrade were also installed Summer 1997 and have been reported by Customs personnel to have caused some instabilities.

Prototype vs. Permanent System Design and Installation

Because the IBEX project was originally supposed to be a prototype demonstration lasting six months, the system developer did not design or install their DSRC equipment as they said they would have for a permanent installation. There are many places in the installation where electronics, switches, and wiring are exposed and are subject to accidental or deliberate tampering by personnel in or near the booth. The system developer has solutions that have been applied at subsequent border crossing DSRC installations. The system developer reports that upgrades to the Otay Mesa installation would make the equipment more resistant to tampering and could provide for more consistent performance of the DSRC components.

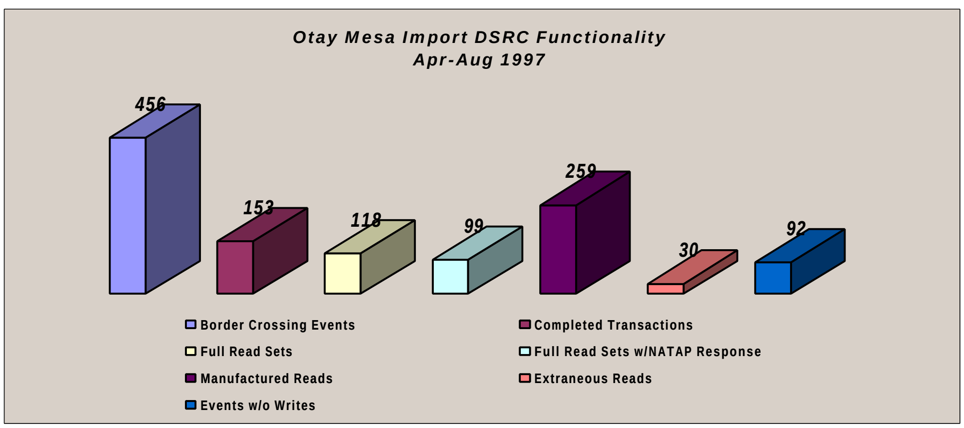
5.1.3 Document the ability of the IBEX DSRC and RF LAN systems to effectively support NATAP processes.

The primary function of the DSRC and LAN systems during the operational test was to capture and relay information between the transponders installed in crossing vehicles, and the NATAP system. As such, the ability of the DSRC and LAN systems to support the NATAP processes would be characterized in terms of the reliability with which this information was captured and passed between the systems, and the availability of the system for use. In order to gain insight into these performance indices, three different sources of information were used: Electronic data from TRAFIC and NATAP system logs, user interviews, and system observation.

Both the IBEX TRAFIC system and the NATAP system were capable of maintaining an electronic record of border crossing events. Combined, these logs contain information regarding the date and time for each transponder read and each write decision. The analysis consisted primarily of a detailed comparative review of these logs to document instances of successful and unsuccessful system interoperability.

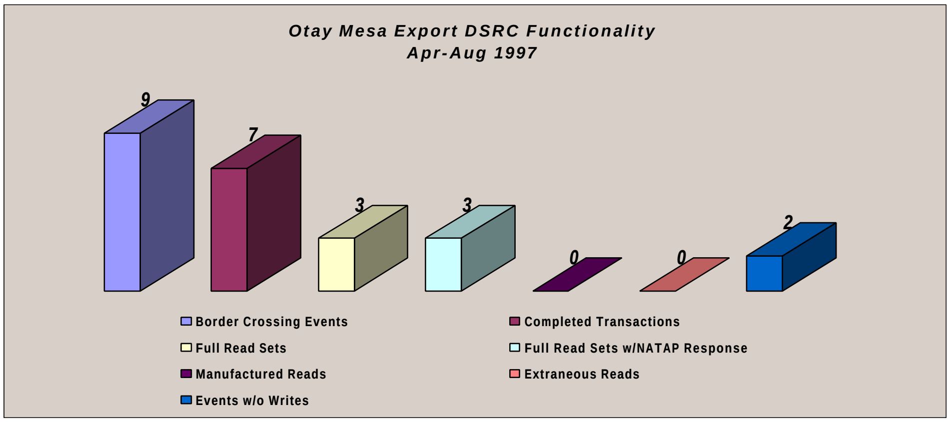
For the period between April 1 and August 8, 1997, the TRAFIC log indicated a total of 456 import border crossing events. For the purposes of this evaluation, a border crossing event is defined as the passing of a transponder equipped vehicle through one of the border compounds (US Import or US Export). Of these events, 153 border crossing transactions were completed. A complete border crossing transaction consisted of the submittal of a NATAP trip load number, read from a transponder, to the NATAP system from the decision and exit reader locations, and the receipt and subsequent broadcast of a red or green status indicator by the TRAFIC system at those locations. The presence of a valid advance read was omitted as a criterion for the classification of an event as complete for the simple reason that, due to the inability of the advance reader to reliably read transponders on trucks approaching the compound, many of the advance reads listed in the TRAFIC log were actually added after a decision read was made. Close examination of the log revealed that 259 of the advance reads were indicated as having been made 5 seconds prior to the corresponding decision read. Discussions with the system developer revealed that the NATAP system required an advance read to function properly, so the TRAFIC system software was modified to "manufacture" an advance read whenever a true advance read was not available. A total of 118 full sets of reads–advance (real), decision, and exit–were recorded during the period of analysis, 99 of which included a red or green response from NATAP. As described earlier, depending on the path a transponder-equipped vehicle took through the compound, and the tuning of the antennae within the compound, extraneous advance and exit reads were not uncommon. A total of 30 such reads were recorded by the TRAFIC log between April 1 and August 8. Finally, a total of 92 crossing events were recorded for which no red or green indicators were received from the NATAP system. There are two possible explanations for this. First, once a trip load number is programmed into transponder memory, it must either be removed, or overwritten with another number. It was not uncommon for a given transponder-equipped vehicle to pass through the compound several times after the trip for which the number was assigned, so many of these events did not require a decision from NATAP. In addition, 112 of these supplemental crossing events consisted only of exit reads and writes, indicating the vehicle probably entered the compound through a primary inspection lane that was not equipped with a reader, and proceeded through the compound to one of the exits, where the transponder was read. Second, on occasion, trucks participating the Mexican NATAP system test passed through the compound. These transponders were programmed with trip load numbers that were not recognized by the NATAP system. The functionality of the Import DSRC and LAN is graphically depicted in Exhibit 5-3.

Exhibit 5-3 Otay Mesa Import DSRC Functionality



The export system saw decidedly less activity over the duration of the test. For the period between April 1 and August 8, 1997, the TRAFIC and NATAP logs contained corresponding transaction information only for events between July 3rd and July 14th. A total of 9 border crossing events occurred during this time span. A total of 7 transactions included a response from NATAP, of which 3 had complete sets of transponder reads. The functionality of the Export DSRC and LAN is graphically depicted in Exhibit 5-4.

Exhibit 5-4 Otay Mesa Export DSRC Functionality



The resulting data set provides insight in to the overall ability of the DSRC and LAN to support the NATAP processes. While numerical analysis is problematic, due primarily to the uncertainty associated with the status of missing reads, some simple mathematical analysis is useful. Using the import data set, subtracting the number of exit only reads and events without writes from the total number of crossing events (both likely to be non-NATAP events) leaves 252 possible NATAP events. Since writes were generated for 153 events, it can be postulated that the success rate of the DSRC system was somewhere on the order of 61% (153/252). As was alluded to earlier, this number is, at best, an estimate of the ability of the systems to support NATAP. Examination of the log data would also seem to indicate that the success rate, which was very low early in the analysis period, appeared to improve somewhat near the end of the period. This suggests that hardware and software adjustments made over the course of the period were having an effect. In any event, this data illustrates that the use of this form of DSRC does provide a technically viable approach to vehicle screening at international borders. However, the success rate demonstrated is not likely to be acceptable for the application. Provided technical difficulties such as antenna tuning and system reliability are resolved, it would appear possible that a system of this configuration might eventually produce success rates on par with weigh station bypass systems, which currently enjoy rates in excess of 90%. Because the data from the export compound is so sparse, any mathematical analysis must be considered insignificant.

At this time, it is important to note that both the TRAFIC and NATAP logs contained gaps in data that suggest that one or both of the log files are less than complete. Both show discontinuities in the progression of assigned trip load numbers. While this data provided the opportunity to gain significant insight into the interoperability of the two systems, it fell short of being sufficient to make a full assessment. In order to fully and accurately characterize the ability of the IBEX system to support the NATAP processes, a comprehensive data set is required. This data set would contain information regarding each attempted crossing event, including results, in a level of detail sufficient to identify individual system reads and writes in both directions. While the TRAFIC and NATAP logs provide much information, neither offers the data needed to ascertain whether the DSRC system missed any transponder equipped trucks altogether.

Other perceptions observations made by Customs personnel, the NATAP evaluators, IBEX evaluator, and test participants are included in the paragraphs that follow.

Slow ITDS response time

The system developer and the NATAP administrators reported that the ITDS system was very slow to respond during the early stages of the FOT. The response time has improved but continues to be intermittently slow. When the response time was more than a couple of minutes, the agents at the booth would sometimes instruct a truck to proceed to a secondary inspection or an exit gate thus producing an out of sequence read and response.

Signage at the compounds

None of the DSRC instrumented lanes at either the import or export compounds at Otay Mesa was equipped with a sign to direct test participants to the proper lane. There was an extremely small number of participants in the test and each driver was instructed individually regarding which gates and lanes to use at each of the compounds. However, the installation of signs was requested by U.S. Treasury and FHWA at the Sixth International Border Crossing Planning and Deployment Committee meeting in 1997. According to the minutes of this meeting the system developer agreed to sign installation as an action item. Later during interviews with the evaluator, the system developer reported that the cost of labor and materials for sign installation at the border was prohibitive.

5.1.4 Document the functionality of the transponder loading device to transponder interface.

Two approaches for loading NATAP trip load numbers onto transponders were examined during the operational test. The first simply involved the entry of pertinent information into a software program designed to run on a standard desktop or laptop computer. The second involved the use of a device designed specifically for this purpose. Test participants were given the opportunity to use either device. The findings are provided below.

Computer software for transponder data entry

The computer software developed by Signal Processing Systems for loading data into transponder memory provided a solution that could be used on either a laptop or desktop computer. The software was a simple set of commands that sent a string of characters to for storage into the transponder. In observations of use of the software by the system developer, and two of the test participants, the interface worked reliably and quickly. Test participants did not report any difficulty with the software related to its functionality, reliability, or accuracy.

Handheld transponder data entry device

The Oyster +8 handheld data entry device functioned correctly and quickly in all demonstrations and observations of use by the evaluator. One major shortfall of the device is as follows. When a trip load number is entered into the device for transmission to transponder memory, that trip load number is stored in the handheld device memory. One of the reported functions of the device is to verify the data entered into the transponder. However, when the device is asked to provide this verification, what is displayed is the last number that was transmitted from the device, rather than what is actually stored in the memory of the transponder. Therefore the verification process does not truly serve the purpose of verifying that the transponder memory has actually stored the transmitted data correctly. It does serve to verify that the individual that entered that data into the device keyed that data correctly. Whether or not this function was intended to verify actual data in the transponder memory is not clear. Observation and testing of the device and its use was performed by the evaluator during coordinated transponder interoperability testing performed by the NATAP evaluation team.

5.2 DETERMINE USER ACCEPTANCE OF THE IBEX SERVICES AND TECHNOLOGIES

5.2.1 Evaluate the carrier users' acceptance of the IBEX services and technologies.

All of the NATAP test participants interviewed during the period of this evaluation were either private carriers or manufacturers that managed the activity of a single carrier for the purposes of this test. The following responses are often representative of the shipper, manufacturer, or customs broker which may have been one in the same with the carrier. When carrier user responses are representative of other such entities, the responses will be referred to in the report sections covering those interviewed.

During the interview process, it was incumbent upon the evaluator to remind the interviewees of the distinction between the evaluation of the NATAP system and services and the evaluation of the DSRC technologies and services provided by IBEX. From the users' perspective there was not a clear distinction between the equipment and services provided under each program.

Overall, participants indicated that they liked the simplicity of the transponders. They also indicated that they saw a great deal of potential for enhancement of their operations using the technologies provided at the border and on their trucks. A common comment from interviewed participants was that the provided technologies were capable and adequate to perform the intended purpose, but they believed that the processes surrounding the technology required further refinement.

Test participants for the brake monitoring system did not actively use the system nor were they involved in the collection or use of data from the system. Currently, the system did not provide an on-vehicle interface that would relay system status information to the user. There was some minor involvement required in the placement and installation of the system on the vehicle that the participant provided. However, given this general lack of involvement, the carriers were not interviewed regarding acceptance of any aspects of the brake monitoring system.

The paragraphs that follow describe user acceptance concerns or issues that arose during the interview process.

Inconsistency of technical literacy

During the interview process both the evaluator and some test participants noted that there is a great deal of inconsistency in technical literacy among current and potential test participants. One test participant noted that there would be a continual segregation of technically advanced and technically illiterate companies. Those companies that have the resources and willingness to embrace technology are more likely to accept it as an enhancement of their operating procedures and interface with government and other industry members.

Training

Test participants interviewed for this evaluation differed tremendously in the overall acceptance and satisfaction with training provided. One test participant was provided with extensive assistance during the period of their participation in the FOT. As mentioned previously, test participants did not discriminate between the NATAP and DSRC portions of their participation. Where one agency responsibility ended and the other began was of no consequence to the participant. Therefore the evaluator often received a large number of comments related to elements of the NATAP test, such as the Trade Software Package, or training or information related to NATAP participation. One test participant expressed a desire for more training and personal interaction during the early stages of their participation. Ultimately, this U.S. test participant relied on the Mexican contractors Integradora de Servicios Operativos (ISOSA) and Technitrade to assist them by installing software, troubleshooting problems for them, and providing training to their personnel.

Transponders

Test participants were generally satisfied with the transponders provided. There were two trouble areas that could be easily corrected. First, drivers complained that the green LED light was difficult to see in bright sunlight. Occasionally, participants reported that no LED light was observed when passing through the decision antenna read zone. It is not clear if the driver missed the light or whether the transponder light was not prompted to light or whether there was a simple malfunction of the transponder. The second problem relates to how the transponder was powered. This test chose to use a Hughes type III transponder that was powered by the vehicle power supply in which it was mounted. This posed the following problem as reported during interviews by test participants and by the system developer. The transponder memory was volatile and would be erased if the power supply to the transponder was removed. (i.e. if not hardwired to the truck electrical supply or wired into an ignition dependent hot wire, the transponder would lose power and thus lose the contents of the volatile memory.) One original intent, as reported during interviews with NATAP administrators, was to provide for a transponder that would be permanently mounted into one vehicle, and provide a security mechanism in that if removed from the vehicle, the programmed information would be removed. If an individual desired to tamper with the transponder or its programming, the simple removal of power would not prohibit such tampering.

Transponder Loading Devices and Software

Most of the test participants assigned an individual from their organization with a degree of computer literacy that would permit them to run the DOS based data entry application provided by the system developer very little additional training. In the case of one test participant, an individual employed by the system developer provided this service for a period of time and this person ultimately trained participant personnel in the use of the software. All participants interviewed described the use of the software as “simple.”

Test participants interviewed also reported that even though the handheld device was more convenient, that cost of the dedicated device would probably preclude the purchase of such a device. A laptop or palmtop computer running the system developers software would be a more reasonable solution given that a computer is a multipurpose piece of equipment that represents a more versatile investment for the user. Test participants indicated that the simplicity of the devices and the operation to be performed on them warranted a much simpler, less expensive solution than the handheld device used for this test.

Some test participants, who used the data entry software and did not have a laptop computer, loaded the application onto a desktop computer. To improve data entry convenience, they would then connect their transponders to a small external battery for power. This enabled them to remove the transponder from the truck in order to walk it to the computer in an office to enter data (i.e. program in a new trip/load number.) Prior to obtaining a laptop computer or handheld device, one test participant ran over one hundred feet of cable from a desktop computer through a building and out a window in order to provide a method for loading data into the transponders mounted in their trucks.

Traffic signal light usefulness

During the early conceptual planning stages of the NATAP project, traffic signals placed at the entry and exit gates to the US import and export compounds were intended to be used to indicate to commercial motor vehicle drivers that they may proceed through a gate without stopping. However, in practical application at the Otay Mesa border compounds, the truck is always required to stop at the gate in order for the customs agent to visually identify the driver and briefly look at the vehicle. The agent must also periodically wait for a response on the NATAP terminal installed in the inspection booth, therefore also requiring the truck to wait before proceeding into or through the compound. Also during the evaluation interview process, vehicle drivers indicated that they depend on the green or red LED signal on the transponder for an indication whether or not they are cleared to proceed via the NATAP system rather than the traffic signal light.

Willingness to pay for services and technologies provided

Participants interviewed generally agreed that the cost of technology is continually declining and that they do not believe that transponders or transponder data entry devices should be a significant investment. In order to be a test participant, other investments were required that no participant had quantified sufficiently to provide estimates of cost for purposes of this evaluation. However, some of the following items that required additional expense in order to participate in the test were noted during interviews: Internet access charges and sign-up fees with an internet service provider, upgrades to current desktop computer systems to bring them up to a speed that was acceptable to the user (>133Mhz pentium), laptop computer, additional cabling, high speed modem, hours for personnel dedicated to administering the NATAP program in addition to current paper processing. Considering the potential return in time savings and enhanced productivity, some initial investment was considered acceptable provided that the process was not required to be duplicated on paper. The current duplicative processes were not considered acceptable. The other cost participants currently did not accept was that of the dedicated handheld data entry device. Participants perceived this device to be too specialized for the simple task that it was required to perform, thus not justifying its cost. This is discussed in more detail in the *Transponder loading device and software* section above.

5.2.2 Evaluate the customs broker users' acceptance of the IBEX services and technologies.

Four custom's brokers were contacted and asked to provide input for this evaluation. Two of the four brokers contacted responded and provided information regarding the overall NATAP program and the acceptance of the technologies provided by the IBEX program. The two brokers that responded, worked as part of an organization that handled all aspects of their transportation operations. In other words, the brokers were in-house brokers that provided service for the company they were associated with or that employed them. One company responded to the interview questions as the broker, carrier, shipper (or manufacturer), and receiver. The other company responded as both broker and carrier. Therefore, carrier responses regarding the transponders, transponder data entry device and software, and training are also representative of the broker's responses.

From the broker perspective the acceptability of the technologies was not particularly an issue. During interviews there was general agreement that the technology is mature enough to be a known quantity. They indicated that the processes that the technologies are supposed to expedite must be further simplified or reengineered in order to make the most effective use of the electronic and RF components used in the test.

As would be expected, some frustration was indicated when they encountered situations where a remote system such as ITDS or a local system such as the TRAFIC hub computer was inoperable or slow to respond. Both indicated that this was attributable to the fact that the system was still in prototype or test condition.

Finally, as indicated in the carrier responses, the brokers noted that the duplicative nature of the NATAP processes overshadowed some of the potential benefits provided by the automated systems and technologies provided.

5.2.3 Evaluate the shipper users' acceptance of the IBEX services and technologies.

Four shippers were interviewed for the purposes of this evaluation. One shipper (which was also a manufacturer and receiver) participated in the FOT for about six months from October 1996 through April 1997, and was the first full participant in the FOT. During this period of time, the system developer assisted this shipper with test preparation, transponder and transponder data entry software installation, business process mapping and integration, and actual test conduct. A great deal of effort was expended by the system developer and its contractors in assuring that this early participant would be able to successfully integrate the services and technologies provided by the NATAP project and the IBEX FOT into their transportation operations. The other shipper was not a participant in the FOT. However, they were well informed regarding the NATAP program and had been approached by the system developer to be an IBEX FOT participant. During interviews they provided some useful insights into the border community that are covered in the institutional issues section of this document. Other information regarding reasons for non-participation is also covered in that section.

Shippers were primarily concerned with how well that the NATAP program and other similar automated data exchange programs integrated with their current processes. They indicated that they had a fairly high degree of confidence in the capability of the technology to handle the data entry and information exchange tasks required. However, the processes that were being automated needed further refinement in order to make the most effective use of the technology provided. The participating shipper indicated that one agency, U.S. Department of Commerce, had been left out of the data exchange loop in the NATAP program. They explained that there was a lengthy paper process that was associated with this agency and that should be automated in parallel with the custom's processes in order to truly automate the reporting operation.

Another concern raised by the participating shipper was the change in their normal transportation operations in order to accommodate the test. The shipper's operation normally used two or three different carriers to move goods between their plants in the northern San Diego region and the southeastern Tijuana region. For the purposes of the test, a single carrier was used to move single commodity shipments between the plants. The single carrier may have been used to maintain some control over the early test shipments and possibly due in part to the driver and carrier security clearance and program application processes. Whatever the reason, these were the only trucks equipped with transponders, and were therefor used bi-directionally for shipments between the plants. Another operating accommodation made by the shipper was to ship only single commodity loads in order to cut down on the data entry time required for NATAP processing, keeping in mind that preparation of the paper documentation was also required during this prototype phase of NATAP. The shipper suggested that elimination of the duplicative paper process, and ability of the TSP to interface with or handle large legacy system data files would be two of the most important steps in promoting the enrollment and participation in border crossing automation and technology programs.

Other shipper concerns and user acceptance issues revealed during the interview process regarding technical literacy, training, transponders, transponder loading devices, and willingness to pay for the technologies provided, are reflected in the respective paragraphs in the Carrier user acceptance section.

5.2.4 Evaluate the regulatory agency users' acceptance of the IBEX services and technologies.

U.S. Customs was the primary regulatory agency associated with this FOT. Three Customs agents at the Otay Mesa compound were involved in the administration of the NATAP program at the border. For the first two agents, monitoring and administration of the NATAP program was collateral duty. A third person with supervisory status was assigned as a full time NATAP administrator in June 1997.

The NATAP administrators kept weekly and eventually daily activity records of NATAP associated events. The events included records of: truck crossings; interface with test participants; NATAP related border compound tours; visits by either NATAP or IBEX system developers, government agency representatives, or evaluators; and reports of trouble with either NATAP or IBEX computer equipment, or the DSRC equipment. These reports were examined by the evaluator in order to verify times, dates, and facts regarding significant DSRC related events.

Most information regarding user acceptance was conveyed during the interview process with the NATAP administrators. The primary areas of concern as indicated during the interviews are described in the following paragraphs.

Customs sees potential in technology installation

Custom's agents indicated that they see a great deal of potential in the technology installation at the compound. They agreed that the overall system was another step toward a paperless border crossing process for commercial vehicles. Early in the program there was some concern that the automated systems would usurp agent authority, but this perception has been replaced by an understanding of the installed technology as an aid to decision making rather than a final word on border clearance status.

Temporary nature of installation causes problems

The NATAP administrators understood that the DSRC installation was temporary and not intended as a permanent solution. However, the temporary nature of the installation still posed problems periodically (see section 5.1) that would interfere with processing of NATAP shipments. They indicated that as long as the known problems with the installation were resolved at some point in the near future, that the interim difficulties would be tolerated.

Service (in terms of troubleshooting and response to problems) intermittently acceptable

During the early months of the FOT, when there were problems with equipment, computer or DSRC, Customs personnel indicated that the response time by the system developer in responding to the problem was acceptable. Customs described the system developer representative as knowledgeable, friendly, and helpful. However, after the initial six months of the test, Customs reports that the response times became more and more inconsistent and were intermittently acceptable. Many times, Customs knew that there was a problem somewhere in the system, but discovery of that problem was not always immediate. Problem resolution time was a function of three things: time problem was discovered, time it was reported, and response time. Neither the system developer nor Customs personnel used a formal trouble reporting system until late in 1997. Prior to that, a verbal trouble report in the form of a phone call was the normal procedure. Even after a trouble report form and procedure was proposed by the system developer, neither the form nor the procedure were used consistently. Times for problem discovery, reporting, response, or resolution were inconsistently recorded, if at all. Therefore, only perceptive information regarding acceptability of trouble report response times and related services provided by the system developer have been suggested here.

SPS TRAFIC hub computer user interface liked by NATAP administrator (ease of use).

The system developer created a software application that monitored DSRC equipment activity for real-time debugging of the DSRC equipment and the TRAFIC hub computer. The application was an MS Windows based user interface that provided separate windows that monitored each of the DSRC equipped gate locations. As DSRC activity took place, a text indication of that activity scrolled across the appropriate window. The Customs personnel praised this interface and were grateful for the activity record that it provided. They indicated that it is their only insight into the activity that was taking place between the TRAFIC hub computer and ITDS. They indicated a desire for a similar interface on the NATAP computer. One agent compared a program with no user interface to a jet without windows: the navigation equipment may get you where you want to go, but it is human nature to want to see the scenery.

Traffic signal light usefulness

The agents staffing the inspection booth indicated that they would like to see a signal to be sure that the decision transmission occurred, however, the traffic signal is positioned to the agent's back, and therefore the light is often missed. This is an issue for the agents staffing the exit booths because these booths are not equipped with Thus, the usefulness of the traffic signal as it is currently configured for the Customs agent is questionable.

5.3 EVALUATE THE POTENTIAL IMPACTS OF THE IBEX SERVICES AND TECHNOLOGIES TO THE TRANSPORTATION PROCESSES AND INTERFACES WITH THE TRADE COMMUNITY FOR INTERNATIONAL MOVEMENT OF COMMERCE.

5.3.1 Evaluate the potential impact of the IBEX services and technologies on the time required for commercial movement of goods across an international border

Test participants were asked to indicate what reduction in border crossing times that they perceived was achieved in using the services and technologies provided by the IBEX program in conjunction with NATAP. All respondents indicated that currently any time savings that may have occurred is tempered by the pre-processing time investment, and the preparation of all of the normal paper documentation that is still required in this phase of the NATAP test. Only when the NATAP test is moved to the next phase where paper documentation is not required do the respondents believe that they will be able to quantify any reduction in time required to move goods across the border. In general, participants interviewed believe that as congestion at the border increases that participation in automated pre-clearance programs will make the difference in the efficiency and competitiveness of their operations. One participant stated that benefits from the current process indicated that participation in the automated border crossing programs early will allow him to make business decisions based on the future character of the border rather than the current situation, once again, maintaining competitiveness in the market. While dual processing makes any comparative analysis of crossing times between NATAP-equipped and non-NATAP-equipped largely meaningless within the context of this evaluation, some light can be shed on the baseline conditions. Data regarding this baseline are offered below.

Average truck compound crossing times

An analysis of Non-U.S. NATAP transponder equipped trucks crossing the Otay Mesa import compound for the period January through March 1997 revealed the following compound traversal time information:

Mean Elapsed Time	0:44:23	Minutes
Median Elapsed Time	0:35:25	Minutes

These times do not represent seasonal fluctuations in traffic at the compound. In addition, the data from which these figures were calculated represent various times of the day, and only weekdays (i.e. no Saturday or Sunday). However, the trucks represent a segment of the carrier population that is already using automated systems and transponder technology which means that they are probably working within a trade chain that is likely to be more compliant with border regulatory agency requirements than other carriers.

In any event, these figures make it readily apparent that , in order to have any hope of dealing effectively with the traffic increases expected when the full effect of the NAFTA provisions become reality, systems such as IBEX will need to be fully functional, reliable, and worthy of the trust of the Customs agents.

5.3.2 Estimate the potential impacts the implementation of the IBEX services and technologies on carrier business processes and interfaces with the customs broker, shipper, receiver, and the Port of Los Angeles.

A number of factors contribute to making a valid estimate of the potential impacts of the system impossible. These include, but are not limited to, such issues as the dual processing required of participants, which included the continued use of existing Customs processes, the limited success of the DSRC / NATAP interface, and the limited duration of the evaluation period. However, significant insight has been gained on a number of fronts. As mentioned earlier, the technical feasibility of the system concept was successfully demonstrated. With continued development at the component and system levels, it is likely that a system meeting the performance criteria of the various participants can be successfully implemented.

With that said, it can be postulated that systems such as that deployed under IBEX continue to have significant potential to impact cross-border goods movement. While the data presented here may not offer conclusive proof that the originally envisioned impacts will be realized, neither do they serve to dispel them.

User perceptions regarding likely impacts are quite useful in understanding this issue, and are described in section 5.2.

5.4 DOCUMENT TRANSPORTATION INSTITUTIONAL ISSUES AND LESSONS LEARNED.

5.4.1 Document the institutional issues encountered in executing the system demonstration and the potential impacts on the eventual commercialization of the service.

Institutional Issues related to non-stop shipments from the Port of Los Angeles

Interviews with organizations from the initial recruitment efforts at the Port of Los Angeles have provided some insights into the reasons for non-participation in this part of the operational test. The following bulleted list summarizes some of the common points that were made by those interviewed.

- Smaller carriers and owner-operators fear of equipment seizures if allowed to go into Mexico. Lack of familiarity with current laws and regulations governing foreign carriers in Mexico, with the knowledge that equipment may be permanently impounded for certain violations seems to be the basis for this reluctance to allow trailers, containers, and especially tractors, across the border.
- Cost of licensing and insurance for equipment that will travel in Mexico. At the time of the recruitment efforts, the cost of licensing and insuring equipment for travel in Mexico as a foreign carrier was considered to be a barrier to cross border operations.
- Reluctance of Japanese and Korean customers to be the first, or even second in testing a new process or technology. Many of the companies that represent the shipper or carrier customer base are Japanese or Korean owned. As a general rule, these companies prefer to let new concepts be tested by others before participating in or committing resources to them.
- According to the Port of Los Angeles based companies interviewed, most if their customers are satisfied with the current process. Time savings at the international border crossing is not a pressing issue with them. Their primary concerns are with a higher priority and smoother seaport operation.
- Many shippers and their customers still do not have a clear understanding about what NATAP is and how automating current processes would be of benefit given some of the costs. Most of the carriers and manufacturers participate in and are satisfied with the line release program and are not sure why a similar program is being proposed.
- Manufacturer's production cycles are accommodated by the current process. The carrier provides the warehousing and delivers product on JIT cycles as requested by the manufacturer or consignee. Therefore, speeding the border crossing process has the potential to increase the manufacturers warehousing requirements.
- NATAP implementation delays have also posed perception problems among shippers and carriers. Early in the recruitment phase, shippers report that there was a great deal more enthusiasm for the program, however delays in the project dampened some enthusiasm and reflected doubt about the overall organization of the project.

International Border Business and Political Institutional Issues

The following paragraphs in this section are based on interview comments from manufacturers, shippers, customs brokers, and carriers operating in the international border environment. Most interviewees are part of or in some way dependent upon the Maquiladoras in the San Diego-Tijuana region for some or all of their revenue.

The maquiladora industry is highly integrated, primarily according to the country that owns or manages the twin plant operation. When vendors are selected, services are rendered, or contracts are awarded, plant management will likely choose an associate business entity, or an entity that is owned in or affiliated with the country where the firm is based. For instance, a Korean owned twin plant operation in San Diego and Tijuana, ships containers from the Port of Long Beach to Tijuana several times per week. The shipping line that brings the product is a

Korean owned, Mediterranean flagged fleet. The trucking company that hauls the containers from the seaport to the drayage yards at Otay Mesa is an affiliate of the Korean owned, U.S. Custom's broker that handles all the documentation for the twin plant operation. All parties involved in the current process must agree when any part of the process is changed. The risk inherent in a particular process change is shared by the entire chain of manufacturers, shippers, suppliers, and service organizations–hence, there was reluctance to immediately embrace new technology or new processes that might impair the effectiveness of the current methods of doing business. This scenario does not represent all chains of trading partners, but does represent a significant number of them.

The perception that the cost of making any changes to current transportation processes would outweigh any near term benefit was a recurring theme throughout the interview process. Most of industry likes the idea of automating processes, but are unwilling to give up any niche portions of their business that benefit from the processes as they currently exist. Usually this is expressed in terms of cost versus benefit, although that is not what the concern really is if taken in the purest sense of the term. For instance, one carrier is concerned that the cost of registering, insuring, and equipping drivers and trucks for operations in Mexico will not be worth the risks involved in sending the equipment and personnel across an international border. However, because the carrier also has a stake in the current border processes (Customs brokerage and storage / drayage yards) the concern must also be viewed from the perspective of this carrier's business interests. If the percentage of revenue that could be attributed to this portion of the business is significant, the carrier would certainly be interested in maintaining the status quo.

Technology vendors and system developers are also concerned about their continuing efforts to provide services to the border trade community without some realization of on-going benefit and continued business opportunity.

Another carrier and driver concern is the power and influence of labor unions and trucking associations on either side of the border. Both have lobbied to keep the border closed to foreign carriers until certain criteria are met. In most cases, the safety records of foreign-based carriers seem to be the primary concern for U.S. based carriers. For Mexican based carriers, the concern is primarily increased competition in an already competitive and economically disadvantaged business environment.

5.4.2 Document lessons learned and technical approaches to electronic border crossing.

The system developer considered their technical approaches to providing a DSRC infrastructure solution at the international border crossings to be company proprietary. Therefore, this information was not made available to the IBEX evaluator for publication in a report. However, a number of technical and operational lessons were learned over the course of testing as observed by the system users and the evaluator. These lessons are described in detail in previous sections of this report, and are offered in summary format in section 6.

6 LESSONS LEARNED

6.1 DSRC INSTALLATION AT CUSTOMS COMPOIND

Antenna Footprints

Two primary issues arose regarding antenna read zones or footprints during the operation of the DSRC equipment at the Otay Mesa Commercial Vehicle International Border Crossing. The size and direction of the read zones is a correctable condition that poses some problems at both compounds. Subsequent DSRC installations at other border crossings have corrected some difficulties posed by the condition as it exists at the Otay Mesa compounds. The specific footprints of each antenna / reader combination must be carefully controlled so as to preclude missed and extraneous reads. The system developer indicated that one solution that would assist in resolving this issue would be to instrument all adjacent lanes with antennas, which would permit the easier implementation of a lane discrimination scheme. In this way, the reader would be able to determine in which lane a vehicle is located. This is a site specific concern that will have to be dealt with in each installation.

RF Modems vs. Cable applications

During the interview process, the system developer indicated that the preferred solution for inter-component communications is a cable solution, such as fiber-optics cable. The RF Modem to inter-component DSRC communications solution, as applied at an established facility such as Otay Mesa, was practical in that it was the least disruptive to port operations . This was due to brief installation time requirements and required virtually no demolition and construction, as would have been required by a cable solution. The reliability of the RF modem solution compared with the cable solution was not evaluated for this report. The performance of the RF modem,, in conjunction with other components was perceived as acceptable by the users of the DSRC equipment. The primary concern regarding the use of the RF modem in this application was security and the ability of the signal to be protected from tampering or interference. As evidenced by the consistent signal transmission between remote DSRC components and the TRAFIC hub, the rate of failure attributable to an RF modem failure was insignificant for the data made available for this evaluation.

Traffic signal light usefulness

During the early conceptual planning stages of the NATAP project, traffic signals placed at the entry and exit gates to the US import and export compounds were intended to be used to indicate to commercial motor vehicle drivers that they may proceed through a gate without stopping. However, in practical application at the Otay Mesa border compounds, the truck is always required to stop at the gate in order for the customs agent to visually identify the driver and briefly look at the vehicle. The agent must also periodically wait for a response on the NATAP terminal installed in the inspection booth. Also during the evaluation interview process, vehicle drivers and customs agents indicated that drivers depend on the green or red LED signal on the transponder for an indication whether or not they are cleared to proceed via the NATAP system. The agents staffing the inspection booth indicated that they would like to see the signal to be sure that the decision transmission occurred, however, the traffic signal is positioned to the agent's back, and therefor the light is often missed. Thus, the usefulness of the traffic signal as it is currently configured for either the driver or the Customs agent is questionable.

Computer hardware maintenance and security

A budget, plan, and guidelines for routine maintenance of the computers, RF, and other DSRC equipment installed at the compounds was not provided for after the initial IBEX test period was formally ended. The DSRC system and supporting equipment, as it was originally designed by the system developer, was intended to perform as a prototype system for a short period of time and then be upgraded to a more robust and maintainable system at a later time. The NATAP test was extended for an additional six months, and thus a fully functioning and maintainable DSRC system was required at the border crossings to support the test. Due to the unanticipated extension of the test, and the very temporary nature of the DSRC installation, performance of the system and the system developer's ability to continue to maintain that system were somewhat deteriorated. The temporary nature of the installation also posed an additional difficulty in that it was not designed to inhibit or resist tampering. Thus, the insecure nature of the installation lent itself to occasional crashes due unauthorized modification of equipment settings or switches, and periodic damage, either intentional or unintentional.

Integration with local area networks

The early interface of the IBEX computer systems with the US Treasury LAN at the custom's compounds was an area of concern for those administering Treasury's network. The concern was alleviated by the installation of a remote server and local NATAP client that also performed as a firewall for interfacing systems, such as the IBEX TRAFIC hub. TRW network outages periodically caused drop-outs in the exchange of data and information between the Custom's system and the TRAFIC hub.

Customs compound geometry and equipment configuration

As described in section 5.1, chain link metal fencing is reported to interfere with antenna performance. The position of antennae and their respective read zones in conjunction with metal fencing needs to be considered prior to installation. The proximity of the antennae to one another in a close proximity situation has a detrimental effect on overall performance. The large read zones of the antennae have been managed better in subsequent border crossing installations. Mounting of antennae on existing infrastructure is not always the best solution for optimum performance. Separate supports that place the instruments at locations that provide for optimal performance should be considered prior to installation.

6.2 TRANSPONDERS AND TRANSPONDER LOADING DEVICE

Transponder functionality

Power supplies to transponders vary between users. Some users hardwired the transponder to the trucks ignition and others to a battery direct hot lead in the vehicle. Those that chose the ignition-powered installation were faced with erasure of the transponder memory each time that the truck was turned off. Some participants also chose to equip the transponders with a small portable auxiliary battery in order to be able to remove the transponder from the truck for programming. Battery powered transponders are available, however the battery life in these transponders negatively affects performance during extended exposure to DSRC antennae.

Drivers also complain that LEDs can be difficult to see in bright sunlight through the windshield. This characteristic was also observed by the evaluator during demonstrations and observations of operations. The green LED is particularly troublesome on all transponders tested by the evaluator.

Transponder interoperability

Interoperability of transponders was not in the scope of this evaluation but some useful observations related to the transponder functionality and that of other DSRC components were made during interoperability testing with the NATAP evaluation team.

Acceptability of Transponder loading devices and software

The price of the Oyster +8 TLD is not proportional to its intended functionality. Users report that they would like a simpler, less expensive device. A fault found with the Oyster +8 TLD is that when the device confirms a loaded TL Number, it is actually confirming a number within it's own memory rather than a number read from the transponder memory. Software provided by the system developer as an interim solution for loading data onto transponders is simple but cryptic according to users. The DOS based software is a cost-effective solution, but is not convenient for high volume use.

6.3 ON-VEHICLE EQUIPMENT (BRAKE MONITORING SYSTEM, DPIU/SMARTLOG, GPS)

Limited data was made available by the system developer. The system developer also indicated that further development and testing would be required to refine the system for commercial use. Test participants had very little interaction with the devices installed on their trucks and therefor were not suitable participants for interview or survey regarding these devices. Discussions were held with insurance industry representatives and law enforcement to determine their acceptance of the concept.

Insurance industry representatives indicated that only after long term testing of such equipment and proof of its contribution to a reduction in accident rates would such devices be considered in a premium discount program. Improvements in safety cannot be proven attributable to a single device. The insurance industry recognizes that fleets with a regular preventative maintenance program have better overall safety records. Therefore, a on-vehicle monitoring equipment that contributes to such a program would be encouraged, however, under the current insurance underwriting system would probably not be a factor in rating a carrier.

The law enforcement representatives indicated that at this time an electronic monitoring system would not be an acceptable substitute for a physical or visual inspection of tractor or trailer brake system components. The only electronic monitoring device currently accepted by the state is an on-vehicle electronic hours of service log. There are specific rules and regulations governing the use of such logs in Title 13 of the California Code of Regulations, which reflects a similar set of regulations in the Federal Motor Carrier Safety Regulations.

6.4 CARGO SEAL

This device, although reported to be under development, was not completed to such a degree as to permit any testing or evaluation activity. Discussions were held with insurance industry representatives and law enforcement to determine user acceptance of the concept.

Insurance industry representatives indicated that they did not foresee a way to evaluate the potential reduction in risk associated with a device of this type. There are many security devices currently on the market, none of which the insurance industry considers to be effective enough, at this time, to warrant carrier rate adjustments based on reduced risk.

7 RECOMMENDATIONS

The following recommendations are organized into five categories: Technology, Operational, Institutional Issues, Users, and Impacts. Drawing on the results of this evaluation each heading is followed by one or more appropriate recommendations. Many of these recommendations, while based in large part on the evaluation of the Otay Mesa International Border Crossing, are also applicable to similar such situations in any international border environment.

7.1 TECHNOLOGY

7.1.1 Installed DSRC and Ancillary Equipment

A careful site survey must be conducted prior to planning and specifying hardware installations at any border crossing. A thorough site survey is necessary due to obstacles, both physical and institutional, and in order to assess both common and exceptional patterns of movement of vehicles within and adjacent to the site to be instrumented.

The calibration of readers and antennae should be given careful consideration and include adjustments for as many environmental and geographic factors as is possible at the given site. Careful tuning of antennae footprints according to traffic patterns and the technical capabilities of the instruments.

Climatic conditions at each border crossing will dictate the level of precaution that must be taken to protect equipment from the environment. Weather shielding and sturdiness of construction would prevent damage or malfunction due to harsh weather conditions and exposure of equipment to a large number and variety of personnel.

In general, the hardware must be selected to be appropriate to the characteristics and limitations of the particular border crossing application, and conversely the application must accommodate the limitations of the hardware available whenever possible.

Other approaches

The need to investigate other approaches to automated data exchange within the border crossing environment must be acknowledged. Other methods of information exchange exist that accommodate that interchange between fixed and mobile entities. These methods should be examined and evaluated to determine their appropriateness for the border crossing environment.

7.1.2 On-vehicle systems

Brake Monitoring System

The brake monitoring system demonstrated during this evaluation certainly has the potential to provide some value to both fleet management and law enforcement in the future. However, there was not enough testing or information available during this evaluation to draw any conclusions or make any recommendations regarding this equipment.

Transponder Loading Devices

Due to logistics requirements identified by the industries working in the border crossing environment, it is recommended that an investigation take place of other means of acquiring the necessary data to identify the necessary shipment other than the TL#. It is recommended that explore storing information in a more economical fashion, or explore other means of identifying truck loads.

7.2 OPERATIONAL

7.2.1 Processes

With processes so heavily instituted into the border crossing businesses, some process change will be required in order to improve efficiency and improve integration of technology into the changing processes. There is a continued need to explore ways for businesses to file required paperwork to provide the information necessary for border clearance in as efficient a means as possible. Even with the introduction of technology solutions, businesses are still doing things the old way. Until duplicative / parallel processing is removed, we will not be able to determine the real benefits of integrating technology into either current or future processes. Public and private systems need to be sufficiently integrated in order to remove the need for parallel processing and add real value to the expedited border crossing process.

7.2.2 Business Model

In the future, we cannot be certain what is going to happen to existing processes like drayage and near-border storage. There is a huge potential for change or shift in these areas. An example of a such change might be an in-country hub in San Antonio where processing would occur inland instead of on the border at Laredo. Since we don't know much about what's going to happen, there is a need to investigate potential impacts that these border systems will have on the business model and what impacts that such changes would have on the border. Texas and Michigan currently do not have border inspection stations like the ones at Otay Mesa or Calexico in California. The question then becomes how will be able to ensure safety and credential compliance if we move processing inland? There is a need to gain a better understanding of manner and magnitude of the business model change given any of the potential international border business scenarios.

7.3 INSTITUTIONAL ISSUES

7.3.1 Border economics

International border business has been created based on inefficiencies in the border crossing system. There are many interdependent relationships, such as that between the drayage operators and the customs brokers. If all this border business went away, there would be serious economic impacts along the border regions. There is a need to identify what would be the potential economic impacts on the border communities and identify some means to mitigate adverse impacts without hampering efforts to improve efficiency of process.

7.3.2 Interagency Relationships

The two major government entities providing instruction, guidance, oversight, and funding toward the IBEX project, the subject of this evaluation, were the US Treasury Department and the US Department of Transportation. The fact is that we have two agencies each with a somewhat different focus. Treasury's primary mission, relative to this effort, is to track movements across the international border for accurate trade information and to minimize contraband. US DOT's primary mission is ensuring safety of vehicles, drivers, and the public while facilitating international goods movement. The two agencies have the common interest of improving the efficiency of cross-border movements, but nevertheless, it is a secondary goal. The systems to date can support all three of those goals, but still questions still remain regarding how to do this. Will a different approach be required to accomplish both agency goals? Other programs being pursued by each agency are impacting what may actually be deployed on the borders (CVISN, ENCAP, etc.) We need to continue coordination to ensure that standards, protocols, and approaches pursued in each effort do not create unnecessary hardships for the creation of other border systems and participation in border processes.

7.4 USERS

Users are generally positive about cross border technologies. However there are some issues that require further investigation, and some answers that will need to be provided to users participating in future tests or deployments. Users need to know what's in it for them if they install on-board safety systems in their vehicles? What value do the systems provide? Without a thorough system test or a system to evaluate, we don't really know. There is a need to investigate the use of on-board systems by both regulatory agencies and industry customers. There remains a need to find out how well they work in a variety of real highway conditions, determine long term reliability, and explore the impacts of the way equipment is handled from driver to driver. For example, what value will a tractor brake monitoring system provide if a driver uses trailer brakes all the time?

7.5 IMPACTS

7.5.1 Time savings

A challenge in designing automated solutions at an international border is determining the right operational approach for the particular site in order to maximize the benefits of time savings and compound throughput. We cannot be certain how traffic will change over time and cannot understand the impact of different scenarios without the aid of modeling. Modeling of traffic management, flows, and patterns for different compound instrumentation scenarios such that we can determine the optimum configuration in order to get highest level of efficiency without compromising the ability to manage processes for eliminating contraband. By using models, planners gain a better understanding of traffic conditions on either side of the port, and whether changes will have substantial effect without compromising safety. Results of modeling exercises will help get industry enrolled and participating in future projects, and explicitly demonstrate improvements in compound throughput.

7.5.2 Safety

There was not enough data collected to determine how well on board sensors work. Therefore it cannot be determined whether it is possible to expect a cooperative effort between carriers and agencies to share information in the interest of monitoring vehicle safety.

8 APPENDICES

Appendix - A

International Border Electronic Crossing (IBEX)
Interview Guide

I. General Background (All)

1. What is the name of the organization for which you work? (For all interviewees)
2. Please briefly describe your position and responsibilities? (For all interviewees)
3. How long have you held your current position? (For all interviewees)
4. How did you learn about IBEX? What were the main reasons for involving / not involving your organization in the IBEX project?
5. Is there anyone else that should be included in this interview? Or in a future / additional interview?

II. TRAFIC System (Regulatory Agencies (Customs), Carriers, Customs Brokers, Shippers, Receivers)

Background

1. How often do you use a computer in the course of your work? (All day, Occasionally, Couple times a week, etc.)
2. Would you consider yourself an experienced computer user? (Years experience? Level of expertise: Single application user? Multiple application user? Operating system experience? Programmer?)
3. What other types of automated systems have you worked with? Do you currently work with?

Technical Performance

4. Have you participated in the technical administration of the TRAFIC hub computer system?
5. If yes, what functions do you perform?
6. (NATAP-Customs, Sys Dev) What were the causes for duplicate reads of the Trip / Load Numbers after the truck exited the compound? Technical problems? User issues?
7. (NATAP- Customs, Carrier) How well did the signal lights installed for NATAP at the US border function? Were they visible? Did drivers report regularly how well signals functioned?
8. (Customs, Carrier) How often were drivers diverted to the usual clearance procedures due to NATAP clearance functions not being available?

User Acceptance

9. Approximately how often have you used / interacted with installed equipment at the compound?
10. What features of the TRAFIC system do you like?
11. What features of the TRAFIC system do you dislike?
12. How easy is it to use the TRAFIC system components?
13. Did the TRAFIC system respond in an acceptable amount of time?

14. Would continued investment in this type of technology at the International border crossings be worthwhile to you or your organization?
15. Did the TRAFIC system perform reliably while you were using it?
16. Did the TRAFIC system perform its functions accurately while you were using it?
17. Did you feel comfortable with the level and type of training provided for the TRAFIC system?
18. Was the purpose and function of the TRAFIC system explained to you during training?
19. Were manuals and support documentation provided for the TRAFIC system acceptable / useful?

Transportation Process Impacts

20. (NATAP) How long was the average queue time for a NATAP shipment on the US import side? Export side?
21. (NATAP) How often did inspectors not recognize that you were carrying NATAP shipments? How did the driver respond?

III. On-Vehicle Equipment (Carriers, Regulatory Agencies (Customs, CHP, Caltrans), Insurance industry)

Background and Baseline

1. What automated vehicle maintenance or monitoring processes have you worked with prior to this test? For what purpose and for how long?
2. (Carriers) Please describe your current brake system maintenance and repair routine and procedures.
3. (Carriers) Would you be willing to share maintenance and repair records for the vehicles with installed equipment for periods prior to and after installation of the brake monitoring equipment?
4. (CHP) What types of automated systems is the CHP currently using that you find useful?

Technical Performance

5. What were your observations regarding the performance of any monitoring equipment installed on your vehicle(s)?
6. Did you keep track of equipment performance anomalies while using the installed equipment?
7. (NATAP) How well didthe advisory light / signal function on the in-cab transponder? Was it easily seen by the driver? Could it be heard? Did it change color from red to green when appropriate?

User Acceptance

8. (Carriers)What equipment was installed on your vehicle(s)? For what periods of time? [Brake temperature & adjustment sensors, SmartLog, Cargo seal, and / or Transponder]
9. For each type of equipment with which you have experience, what features do you like?
10. For each type of equipment with which you have experience, what features did you dislike?
11. How easy is it to use the equipment?
12. Does the equipment have an acceptable response time when performing required functions?

13. Did the equipment perform reliably while you were using it?
14. Did the equipment perform its functions accurately while you were using it?
15. Did you feel comfortable with the level and type of training provided for the equipment that you used or tested?
16. Was the purpose and function of the equipment explained to you during training?
17. Were manuals and support documentation provided for the equipment acceptable/useful?
18. Is the information useful as delivered via the currently proposed PCMCIA card system?
19. Would you buy this equipment? Why?
20. (CHP)Would you find information supplied by an On-vehicle brake temperature and adjustment monitoring systems to be useful for safety compliance or vehicle inspection purposes?
21. (CHP)Is the information useful when delivered via the currently proposed PCMCIA card system?
22. Would you find information provided by electronic cargo seals to be useful/acceptable as a method of providing cargo tampering indications and security?
23. Do you find information supplied by the SmartLog to be useful?

Transportation Process Impacts

24. What impacts do you see any of the tested equipment having on any of your business processes? (business– competitiveness, service marketability, profitability, budget reallocation, cost of insurance; operations– driver and vehicle management and utilization, dispatching, scheduling; maintenance– safety compliance, brake maintenance management; administration– maintenance tracking, route/itinerary verification, safety record compliance)

IV. Transponder Loading Device (Carriers, Shippers)

Background

1. How often do you use computers?
2. Do you consider yourself computer literate?
3. Did you use the handheld transponder loading device or the system developer software with a laptop computer to enter data into transponders on your vehicle(s)? How long have you used either data entry device?
4. Do you own any of the computer equipment required for this demonstration?
5. What equipment was supplied to you for this demonstration?
6. What equipment/software did you install? What equipment/software was installed was installed for you?

Technical Performance

7. What were your observations regarding the performance of the transponder loading device?
8. What were your observations regarding the performance of the software provided for the laptop computer?
9. (NATAP) How many tries did it take you to load the Trip/Load Number into the transponder initally? Over time?

10. (NATAP) What method did you use to erase the Trip / Load Number after a NATAP trip? Who did this? When? Where (in US, Mexico, Both)?
11. What were your observations regarding the performance of any ancillary equipment provided or used during this demonstration? (Cabling, wiring, connectors, etc.)

User Acceptance

12. What features of the TLD or software do you like?
13. What features of the TLD or software do you dislike?
14. Is it easy to use the TLD or software?
15. Does the TLD or software have an acceptable response time when performing required functions?
16. Did the TLD or software perform reliably while you were using it?
17. Did the TLD or software perform its functions accurately while you were using it?
18. Did you feel comfortable with the level and type of training provided for the TLD or software that you used or tested?
19. Was the purpose and function of the TLD or software explained to you during training?
20. Were manuals and support documentation provided for the TLD or software acceptable / useful?
21. Is the information useful as delivered via current TLD display or software?
22. Would you buy this equipment?
23. Would you find information provided by electronic cargo seals to be useful / acceptable as a method of providing cargo tampering indications and security?

Transportation Process Impacts

[Coordinate with NATAP evaluator for this data]

V. Institutional Issues

1. What do see as the most pressing issues for industries serving and using the international border today? In the future? For your organization in particular?
2. What role do you think technology will play in expediting / hindering border crossing processes?
   [Coordinate with NATAP Evaluator re: overlap in interviewees & data]

VI. Baseline Questions for Carries and Manufacturers

1. Questions regarding baseline fleet safety maintenance and management, and on-board vehicle component monitoring system information. TBD prior to brake monitoring system tests.