SYSTEM PERFORMANCE
TEST REPORT

from the Independent Evaluation of the

ATLANTA DRIVER ADVISORY SYSTEM (ADAS)

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SYSTEM PERFORMANCE TEST REPORT

from the Independent Evaluation of the

ATLANTA DRIVER ADVISORY SYSTEM (ADAS)

September 18, 1997

Prepared for the ADAS Field Operational Test (FOT) Partners:
Scientific Atlanta
Federal Highway Administration
Georgia Department of Transportation
Federal Express
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To: ADAS Partners (See Atttached Distribution List)

Subject: ADAS System Performance Test Report (Final)

Attached is the final version of the subject Test Report. If you have questions, my telephone number is 770-528-7832.

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LIST OF ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Exchange
ADAS	Atlanta Driver Advisory System
ASC	ADAS System Controller, an ADAS component
ATIS	Advanced Traveler Information System
ATMS	Advanced Transportation (or Traffic) Management System
BIOS	Basic Input/Output System
DOS	Disk Operating System, the standard Personal Computer (PC) operating system
DPIU	Data Processing Interface Unit, an ADAS component
DRAM	Dynamic Random Access Memory
DRN	Digital Radio Network
EMI/EMC	ElectroMagnetic Interference/ElectroMagnetic Compatibility
EX	Extendibility and Improvement, an evaluation goal for this FOT
FCC	Federal Communications Commission
FM	Frequency Modulation
FOT	Field Operational Test
GByte	Gigabyte(s), one trillion bytes (a measure of information or data quantity)
GDOT	Georgia Department of Transportation
GPS	Global Positioning System, a satellite constellation that allows receivers on the earth to locate themselves precisely in three dimensional space
HERO	Highway Emergency Response Operator
ITS	Intelligent Transportation Systems, technology aids to transportation functions
IVD	In-Vehicle Display, an ADAS component
IVS	In-Vehicle System, the vehicle based portion of ADAS
Km	Kilometer
LADA	Local Area Driver Advisory, an ADAS service
LAT	Local Area Transceivers, an ADAS component
MHz	Megahertz
MOE	Measure of Effectiveness
mph	Miles per hour
MRS	Mobile Radio Set
PCMCIA	Personal Computer Memory Card International Association, a standard interface specification for portable computers.
PDU	Power Distribution Unit
RDB	Relational Data Base
POC	Point of Contact
RF	Radio Frequency, a term used to describe signals within the radio frequency portion of the electromagnetic spectrum, which spans from about 10KHz (KHz = kilohertz = 1,000 hertz) to 100GHz (GHz = gigahertz = one trillion hertz)
SP	System Performance, an evaluation goal for this FOT
SRP	Short Range Polling, one of the functions performed by the LATs
STIC	Subcarrier Traffic Information Channel, a sideband channel on standard frequency modulation stations designed to carry traffic information

TCP/IP	Transfer Control Protocol/Internet Protocol
TMC	Transportation Management Center
UNIX	A specific computer operating system
WADA	Wide Area Driver Advisory, an ADAS service
WAT	Wide Area Transceiver, an ADAS component

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1. INTRODUCTION

This document reports on the systems performance evaluation of the Atlanta Driver Advisory System (ADAS).

1.1 PURPOSE

The purpose of this report is to:

- provide an updated description of the system evaluated,
- provide an updated description of the actual evaluation and test,
- present the data collected,
- present the analysis and results.

1.2 FIELD OPERATIONAL TEST (FOT) OVERVIEW

This US Department of Transportation FOT was performed as one of several Advanced Traveler Information System (ATIS) projects being accomplished under the Intelligent Transportation Systems Program. The ADAS was designed to provide information to travelers driving in the urban area of Atlanta. Information provided included congestion, incidents, weather, sports scores, current movies, traveler services, in-vehicle signing, and two-way test messaging.

1.3 SCOPE OF REPORT

This report details the scope of the effort employed to evaluate the systems performance of ADAS. A complete, updated description of ADAS, as implemented by Scientific Atlanta, is provided in Section 2. The system description provided in this report is significantly different from the description in the evaluation plan.[1] Changes from the planned evaluation, data collection, and analysis described in the detailed test plan along with changes necessitated by the final system implementation and the data available for evaluation are described in Section 3. The detailed test plan should be used as the basis from which changes in this report are presented.[2] The data processing and analysis are provided in Section 4. Section 5 presents the results.

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[1] Garnto, Ira W., Wiiliam Youngblood, and Lee Rodegerdts, Georgia Institute of Technology; Dr. Kasim Alli and Dr. Ed Davis, Clark Atlanta University; Dr. Ruth Amegard-Frank, Dr. Michele Terranvoa, and Monica Huff, Concord Associates, Incorporated; Evaluation Plan for the Atlanta Driver Advisorv System Field Operational Test, Revision 3, April 25, 1996.

[2] Gamto, Ira W., Detailed Test Plan for Evaluating System Performance of the Atlanta Driver Advisory System, Georgia Tech Research Institute, April 25, 1996.

2. SYSTEM EVALUATED

This section presents the features, components, and functions of the ADAS as evaluated.

2.1 ADAS FEATURES

ADAS was designed and implemented to provide information to travelers in selected vehicles within the metropolitan area of Atlanta, Georgia. The information provided was intended to assist travelers in avoiding congestion and incidents; in tracking their progress and in selecting an exit from the instrumented section of I-85; in finding needed services such as gas stations, restaurants, motels, government buildings, and tourist attractions along the instrumented section of I-85; and in knowing the local weather, sports scores, and current movies playing in the Atlanta area. A capability for two-way messages was also provided.

A major part of the information provided to the vehicles was generated by the Advanced Transportation Management System (ATMS) which is operated by the Georgia Department of Transportation (GDOT). The ATMS was intended to determine the congestion levels and incidents occurring on I-75 and I-85 within the I-285 perimeter using a system of video imaging detection cameras (with video processing) mounted along the I-75 and I-85 Freeways, and to provide that information to ADAS over a local network. The congestion and incidents on I-285, I-20, and GA-400 was to be provided using Atlanta Showcase and other resources (radars, helicopters, DOT calls received, GDOT personnel, Highway Emergency Response Operators (HEROs), and spotters). During the data collection period, the video imaging detection cameras and video processors did not operate reliably, so much of the data for I-75 and I-85 entered into ATMS was done manually using Atlanta Showcase resources, state troopers, and GDOT personnel. Other information added to the ADAS (weather, sports scores, movies, and other messages) was entered by the ADAS operator.

Approximately one hundred seventy vehicles were instrumented for this evaluation. Federal Express provided approximately 85 custom ¾ ton step vans, expedite vans, and tractor trailers, and GDOT provided approximately 85 vehicles of various sizes and types. Vehicles that were selected by the two organizations included different daily missions. For instance, Federal Express provided vehicles that ran scheduled delivery and pick-up routes to businesses in the urban area as well as vehicles that made longer daily trips for major pick-ups or deliveries, such as from the airport to their local processing centers. GDOT provided vehicles that were used for incident management, maintenance, and supervisory functions.

ADAS provided for exchange of traveler information over three wireless links between the central facility and the 170 equipped vehicles. One wireless link was the Subcarrier Traffic Information Channel (STIC) one-way transmission, broadcast on subcarriers of two established Frequency Modulation (FM) radio stations near the center of Atlanta. The second and third wireless links were via multiple channels in the 220 MHz band assigned to ATIS by the Federal Communications Commission (FCC). The first of the two 220 MHz links consisted of a single channel transceiver operating from atop the Georgia Pacific Building in the center of Atlanta while interacting with companion transceivers in the vehicles. The central transceiver was referred to as the Wide Area Transceiver (WAT). The second 220 MHz link consisted of six short range transceivers located along I-85 (between I-20 on the south end and I-285 on the north end), which also interacted with matching receivers and transmitters in the vehicles. The infrastructure transceivers were referred to as Local Area Transceivers (LAT).

ADAS provided a variety of services to the vehicle drivers as summarized in Table 1, Summary of ADAS Services. On the Wide Area Driver Advisory (WADA) service, information was provided to the test vehicles on a nearly real-time basis via the STIC link. Segment congestion levels provided the vehicle driver a relative rating of the speed of the traffic on the segments of the map displayed in the vehicle. Incident information included the incident type (stalled vehicle, multiple vehicle accident, or construction) and segment.

Table 1 Summary of ADAS Services

Service	Wireless Link	Data Involved
Wide Area Driver Advisory (WADA)	Subcarrier FM (STIC), one-way	- Segment* Congestion Levels - Incidents - Weather - Events
Two-Way Test Messaging (Originally called Simulated Mayday)	220 MHz Wide Area Transceiver (WAT), single channel, two-way	- Message, vehicle to ADAS System Controller (ASC) - Acknowledgment, WAT to vehicle - Response, ASC/WAT to vehicle - Acknowledgment, vehicle to WAT
Local Area Driver Advisory (LADA)	220 MHz roadside Local Area Transceivers, one-way	- Traveler services map - In-vehicle signing

A segment is defined as a length of Interstate (all lanes) from one Interstate interchange to the next Interstate interchange.

Weather reports, sports scores, and current movies playing in Atlanta were provided as pure text; i.e., no attempt was made to display them on the map. Weather reports were provided without expiration codes. Subsequent weather reports replaced existing reports. Events, such as sports scores and movies expired at the end of the day and were updated and re-entered the next day.

The Two-Way Test Messaging Link, originally called a Simulated Mayday Service, allowed a vehicle to pass a test message to the ADAS System Controller (ASC). The test message was generated by the vehicle, received by the WAT, and forwarded to the ASC. The WAT automatically sent an acknowledgment of receipt of the message to the vehicle as it forwarded the message to the ASC. When the test message was received at the ASC, the ASC operator could either generate a tailored response message or have the computer automatically send a pre-programmed standard response message. During data collection, the ASC operator used the pre-programmed standard message for all responses. When the standard response message was received, the vehicle sent a message to the WAT acknowledging receipt of the standard response.

The LADA Service provided two items of information via the LATs, traveler services and in-vehicle signing. Traveler services, such as gas, food, lodging and medical facilities, which were available at the next interchange were displayed on a stick drawing of the interchange. For the in-vehicle signing function, the ADAS display showed a "pop-up" sign announcing the next interchange to the driver as the vehicle approached.

2.2 COMPONENTS OF THE SYSTEM UNDER TEST

The components which made up the overall system under test included the ASC in the Transportation Management Center (TMC), the STIC Subsystem, the Two-Way Messaging Subsystem, the LAT Subsystem, and the In-Vehicle Subsystem. Refer to Figure 1, ADAS System Block Diagram, for the discussion of these components that follows.

2.2.1 ADAS System Controller

The ASC was physically located in the TMC. It consisted of a console which held the computer, peripherals, and a STIC receiver. The computer was a SPARCstation 5 Workstation that had an 85 MHz processor, 64 MB RAM, two internal l-GB hard disks, CD-ROM drive, **1.44 MB** floppy drive, and an external 4 mm 5 gigabyte (GB) tape drive. A 20-inch color monitor was installed. The ASC was connected directly to the TMC data processor by an Ethernet 10 Base T using TCP/IP to obtain the congestion and incident data. The STIC receiver was included to allow the ASC operator to sample the STIC broadcast as desired.

The ASC was connected to the STIC encoders and the 220 MHz Wide Area Transceiver by phone lines. An optical cable (installed for the ATMS) was used to connect the ASC to the 220 MHz Local Area Transceivers.

The data extracted from the ATMS processor were sub-segment speed ranges and incidents. Algorithms in the ASC converted the sub-segment speed ranges to segment speed ranges for display to the driver. The ASC operator had the option of adding, updating, or editing information obtained by the **ASC** from the ATMS before forwarding to the vehicles; however, during the data collection period, the operator did not edit the ATMS data. The ASC operator entered information about the weather, sports, movies, etc. on a daily basis. In-vehicle signing and traveler services maps were pm-loaded into the computer and did not require updates during the test.

The ASC was **staffed** by an operator from 7:00 am to 7:00 PM, five days per week on normal business days during the data collection period. When the ASC operator was not present, the ASC was placed in an automatic operational mode.

A data recording capability for the ASC was provided to archive data for later reduction and analysis by the evaluators.

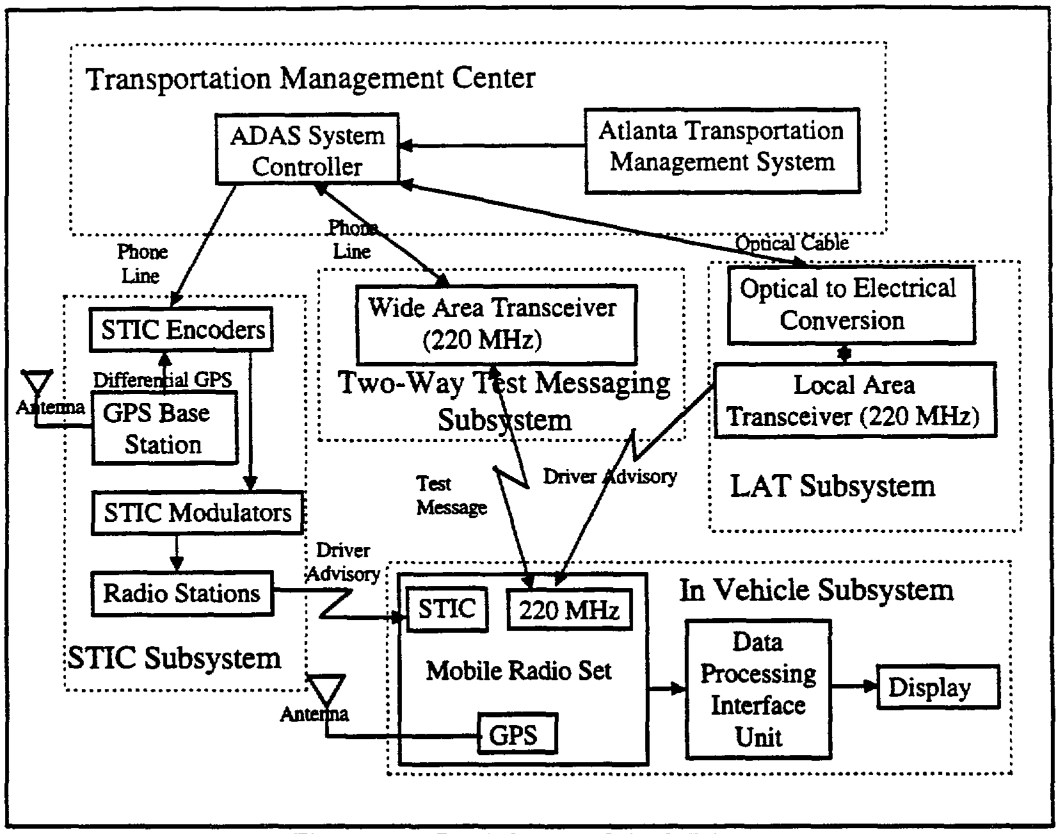

Figure 1 ADAS System Block Diagram

2.2.2 STIC Subsystem

The STIC Subsystem was used to transmit WADA information over a large area using a technique developed by the MITRE Corporation. It was designed to cover the area inside the I-285 perimeter plus 5 kilometers beyond. The WADA data was sent as an ASC data stream to FM Radio Stations WRFG and WREK near the center of Atlanta. At the radio stations, the data were combined with differential Global Positioning System (GPS) data and encoded for transmission to the vehicles. The encoded data stream was then modulated and broadcast on subcarriers of the FM signals. This subsystem was a one-way (simplex) radio system.

2.2.3 Test Messaging Subsystem

The Test Messaging Subsystem was used by the vehicle drivers to send test messages (simulated mayday signals) to the ASC. A telephone line connected the ASC to a 220 MHz WAT mounted atop the Georgia Pacific Building near the center of Atlanta. This subsystem was designed to have a 25 mile range. The transceiver received the Radio Frequency (RF) signals from the vehicles and forwarded them to the ASC over the telephone line. ASC acknowledgments and responses were sent to the transceiver for broadcast to the vehicles. The Test Messaging Subsystem was a two-way (duplex) radio system.

2.2.4 Local Area Transceiver Subsystem

The LAT Subsystem was a short range Digital Radio Network (DRN) placed along I-85 between I-20 on the south end and I-285 on the north end. Each LAT transmitted at the lowest possible power level to minimize interference between LATs. The LAT subsystem operated on three of the ten allocated channels for the 220 MHz signal. The LAT channels were staggered from LAT-to-LAT to reduce the probability of interference. All data was routed between the ASC and the LATs on the ATMS fiber optic network. The location of the six LATs is shown in Table 2, Local Area Transceiver Locations.

Table 2 Local Area Transceiver Locations

LAT Number	Location
1	Between Tom Moreland Interchange and Chamblee Tucker
2	Between Chamblee Tucker and Shallowford
3	Between Shallowford and Clairmont
4	Between Clainnont and North Druid Hills
5	Between GA 400 and the 1-75/I-85 split
6	Between 10th and North Streets

2.2.5 In Vehicle Subsystem

The In Vehicle Subsystem (IVS) consisted of a Mobile Radio Set (MRS), a Data Processing Interface Unit (DPIU), an In-Vehicle Display (IVD), and a Power Distribution Unit (PDU, not shown in Figure 1).

The MRS contained a STIC receiver and demodulator, a GPS receiver, and a 220 MHz transceiver set (one transmitter and two receivers). The vehicle's existing FM antenna was used (or one was supplied if the vehicle had none) for the STIC receiver. A quarter wave monopole antenna was provided for the 220 MHz transceiver set, and a magnetically mounted patch antenna was used for the GPS receiver. The radios, PDU, and DPIU were housed in four small boxes **which** were mounted on **a** plate installed in the vehicle.

The DPIU contained an Intel 80386, 25 MHz processor employing the Disk Operating System (DOS) and Phoenix BIOS (Basic Input Output System). There were 0.5 MB of static solid-state memory and 0.5 MB of Dynamic Random Access Memory (DRAM) It received inputs from the MRS and provided data for display on the IVD. The DPIU provided the capability to record data for later analysis using a PCMCIA (Personal Computer Memory Card International Application) port.

The DPIU maintained the vehicle's location and the location of each of the 220 MHz LAT coverage areas in its memory. One 220 MHz receiver was automatically tuned to the proper LAT frequency based on the vehicle's location (as determined by the DPIU using the output from the GPS receiver and the differential GPS from the STIC receiver).

The IVD was a five inch electro-luminescent display with touchscreen capability, which displayed both graphics and text. Pixel resolution was 320 x 240. The IVD displayed WADA congestion and incident icons and messages, LADA traveler service maps and signing, and Two-Way Test Messages. It allowed the driver to interface with the system by touching sectors and soft buttons on the screen to call up available data, zoom in or zoom out, and send test messages.

Approximately 170 vehicles received the ADAS IVS with half being Federal Express vehicles and half being GDOT vehicles. A corporate decision by Federal Express dictated that the displays in their vehicles had to be blank when the vehicles were in motion. Because of this requirement, Scientific Atlanta prepared two versions of the DPIU software. The Federal Express software blanked the display as soon as their vehicles reached 5 mph (5 mph was chosen to allow for variations in the calculated GPS speed which was used for the movement determination). The GDOT software allowed the display to operate when the vehicle was in motion.

2.3 ADAS FUNCTIONS

In this section, each item of information for each ADAS service will be identified and described.

The information from ADAS was provided to the driver on the IVD. When the vehicle was started, a metro map screen was automatically displayed within approximately 30 seconds. Overlaid on the metro map were the congestion and incident icons generated from STIC messages. Also available on the metro map screen were three soft buttons - one each for the event screen, the send message screen, and the current roadway screen. From the metro map screen, the driver could either move to a zoom map screen of the partitioned area of the metro area or move to one of the other three screens. The use of each of these screens is described below. Appendix A provides the vehicle operator's manual on how to interface with the system using the IVD Appendix A will be helpful in understanding the descriptions which follow.

23.1 Wide Area Driver Advisory Service

The categories of information available from the WADA Service were congestion (icons and descriptions), incidents (icons and descriptions), and events (weather, sports scores, and movies). Each category is described below.

Congestion Congestion information was provided to the vehicle driver in two forms. Small square icons depicting one of four speed ranges were placed on the display adjacent to the applicable Interstate segment with the meaning described below.

1.0-10 mph, blinking black square
2. 10-30 mph, black square
3.30-50 mph, gray square
4.50 mph or greater, open square.

The driver could touch one of 16 sectors on the metro map screen to move to a zoom screen of the sector touched. The zoom screen provided additional icons for more detailed congestion information. The driver could touch an icon on one of the 16 zoom screens to determine the icon's meaning. When an icon was touched, the map was replaced with a text screen which stated the value of the congestion. A soft button on this screen allowed the driver to return to the zoom map screen.

Incidents Incident information was provided to the driver in two forms. They were displayed on the metro map adjacent to the applicable segment of the Interstate. An inverted triangle which was open inside indicated there was an incident somewhere in the segment. An inverted triangle which was black inside indicated that construction was occurring somewhere in the segment. By touching one of 16 partitions on the metro map, the zoom map would be displayed. When the incident icon on the zoom map screen was touched by the driver, the zoom map screen was replaced with a text screen which provided a description of the condition causing the icon. If the condition was construction, the text simply stated construction was in progress and provided a speed range. If the condition was a vehicle mishap, the text described whether it was a stalled vehicle or one or more vehicles in an accident and provided a speed range.

Events Events were provided to the driver in text format. On the metro map screen, a soft button labeled "Event" was touched by the driver to access the events. Events included the day's abbreviated weather report, sports scores from recent games, and, on occasion, movies playing at theaters in the Atlanta area. The events had to be loaded into the system by the ASC operator, and were to be loaded each morning at 7:00 AM.

2.3.2 Two-Way Message Service

The Two-Way Message Service provided a vehicle driver the ability to send a message to and receive a response from the ASC. The vehicle driver selected the message screen on the IVD by touching the "Message" soft button on the metro map screen. When the message screen appeared, the driver could initiate a Two-Way Message by pressing the "Send" soft button. A test message containing the vehicle's identification number and location was then sent from the vehicle to the WAT on the Georgia Pacific Building. The WAT would automatically respond with a WAT acknowledgment to the vehicle that the message had been received. Until the WAT acknowledgment was received, the vehicle would automatically re-broadcast the message each five seconds for 10 additional times (a total of 11 tries). As soon as the WAT acknowledgment was received in the vehicle, uplink re-broadcasts ceased. If a WAT acknowledgment was not received after 11 tries, the IVD notified the driver that the message did not go through.

When the WAT received the message, it would convert it to a digital stream and send it to the ASC. In the ASC the incoming message was recorded for future data analysis and an ASC response was automatically sent in digital form to the WAT. The ASC response was encoded at the WAT and broadcast to the vehicle. The message was re-broadcast to the vehicle each 5 seconds for 10 additional tries, or until the WAT received a vehicle acknowledgment. When the ASC response was received in the vehicle, a vehicle acknowledgment was sent to the WAT.

2.3.3 Local Area Driver Advisory Service

The categories of information provided by the LADA Service were the traveler services maps and in-vehicle signing. All LADA Services were transmitted over the 220 MHz LATs. The in-vehicle subsystem switched the 220 MHZ radio to the appropriate LAT frequency depending upon the location and direction of the vehicle on I-85 based on differential GPS. Both categories of service are described below.

Traveler Services Mans Simple traveler services maps were generated by Scientific Atlanta for all interchanges along I-85 between I-20 in the center of town and I-285 on the north (see Appendix B). The maps were stored in memory in the ASC and broadcast to the vehicles as they transited the LAT section of I-85. Traveler service information was overlaid on the map so that it become an integral part of the display. The types of service included were gas, food, motels, hospitals, major government buildings, and tourist attractions which are available at or near the interchange.

To select a traveler service map, the driver touched the "Current Roadway" soft button on the metro map screen. If the vehicle was approaching one of the interchanges along the LAT section of I-85, a stick map of the interchange would be visible on the screen. Incorporated into the map at the approximate location would be the traveler services available at that interchange.

In-Vehicle Signing In-vehicle signs to announce the next approaching interchange were generated by Scientific Atlanta and stored in memory in the ASC. The signs were broadcast to the vehicle as it traveled along the LAT section of I-85. If the IVD was on either the metro map or the current roadway screen, a pop-up sign identifying the approaching interchange would overlay the screen for approximately 5 seconds. The pop-up signs changed as a function of the location of the vehicle and direction the vehicle was traveling. Differential GPS was used to trigger the in-vehicle sign to be displayed. After 5 seconds, the pop-up sign moved to a bar across the top edge of the screen until after the interchange had been passed.

2.3.4 Digital Data Collection Capability

Capabilities were designed and implemented in the system to provide digital data for evaluation. In the ASC, data was stored in the computer for later downloading to magnetic tape. On a weekly basis, ASC data was made available to the evaluators from this source. In the vehicles, PCMCIA card slots were provided in the DPIU for data collection. Data was collected from the vehicles as scheduled by the evaluators.

2.3.5 Data Collection and Archiving for Evaluation

As described above, two sources of digital data were made available for the systems performance evaluation. Digital data from the ASC was written onto 4 millimeter tapes as ASCII text by a UNIX computer system. Blank tapes were furnished by the evaluators to the ASC operator for collection of the data. Digital data from the vehicles was written onto PCMCIA cards as ASCII text by a DOS computer system. The PCMCIA cards were furnished to the vehicles by the evaluators for data collection. A set of instructions was provided to the drivers by the evaluators to assist in the installation and removal of the cards and to request that test messages be sent from the vehicle (see Appendix C). Typically, the cards were supplied to be installed for two days at a time. The evaluators rotated the cards between the fleets (Federal Express and GDOT) and among the functional operations in the two fleets.

Federal Express operations included delivery in the morning and pick up of packages at local addresses from their Cheshire Bridge Center, delivery in the morning and pick up in the evening of packages from their Centers to Hartsfield Airport, and expedited delivery of packages from Hartsfield Airport to all locations in the Atlanta area.

GDOT operations included Motor Vehicle Emergency Response (MOVER), maintenance, and HERO (Highway Emergency Response Operator) vehicles. MOVER team members were categorized as using their vehicles to travel between home and work and to travel from work to other locations for meetings. Typically, the vehicles were little utilized. Maintenance operations were categorized by vehicle use for 4 to 6 hours per day. HERO vehicles were used on the urban Interstates continuously during eight hour shifts.

The ASC data were archived on 4 millimeter master tapes as ASCII text by a DOS computer system for future use. A list of the ASC files is in Appendix D.

The PCMCIA data were reformatted from a single column of ASCII data to a form directly importable into Microsoft Access as a relational data base (RDB). Once the PCMCIA data were placed into the RDB, system performance analysis was performed for the STIC Subsystem, the Two-Way Message Subsystem, and the LADA Subsystem PCMCIA data were archived on 4 millimeter master tapes as ASCII text by a DOS computer system. A list of the PCMCIA files is in Appendix E.

Comment Forms (see Appendix F) generated by the evaluators were provided to all vehicles. The Comment Forms were intended to collect driver inputs on problems and perceptions with the system. Special emphasis was placed on Comment Forms by supplying additional forms as PCMCIA cards were distributed to vehicles. During these periods, the drivers were asked to complete an additional form, and to return the completed form with the PCMCIA card.

3. TEST DESCRIPTION

This section provides updates to the evaluation plan[3] and the system performance test description in the detailed test plan.[4] First, the objectives, measures of effectiveness, and hypotheses are restated from the evaluation plan. Then updates to the objectives, measures of effectiveness, and hypotheses are presented followed by corresponding changes to the test procedures based on those updates and further necessitated by the changes in system and data collection implementation.

3.1 PLANNED EVALUATION OBJECTIVES, MEASURES OF EFFECTIVENESS, ANDHYPOTHESES

The five subordinate evaluation objectives under the System (technical) Performance Evaluation Goal were (taken from the detailed test plan and repeated here):

Objective SP-1: Assess the technical performance of the ADAS Wide Area Driver Advisory (WADA) Service.

Objective SP-2: Assess the technical performance of the ADAS Two-Way Test Message Service.

Objective SP-4: Assess the technical performance of the ADAS Local Area Driver Advisory (LADA) Service.

Objective SP-5: Assess the technical performance of the ADAS Short Range Polling (SRP) Service

Objective SP-8: Assess the suitability of the ADAS equipment for operational use.

Three System Performance related objectives under the Extendibility (EX) and Improvement Goal are to be evaluated.

Objective EX-1: Assess the degree to which the system performance experience of the ADAS FOT will transfer to other circumstances and locations.

Objective EX-5: Determine the degree of compatibility of the ADAS services, capabilities, and technologies for use in the national ITS System Architecture.

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[3] Garnto, Ira W., William Youngblood, and Lee Rodegerdts, Georgia Institute of Technology; Dr. Kasim Alli and Dr. Ed Davis, Clark Atlanta University; Dr. Ruth Arengard-Frank, Dr. Michele Terranvoa, and Monica Huff, Concord Associates, Incorporated; Evaluation Plan for the Atlanta Driver Advisory System Field Operational Test, Revision 3, April 25.1996.

[4] Gamto, Ira W., Detailed Test Plan for Evaluating System Performance of the Atlanta DriverAdvisory System, Georgia Tech Research Institute, April 25,1996.

Objective EX-6: Identify specific ways in which the system performance experienced in the ADAS FOT could be improved.

Table 3 presents the objectives, measures of effectiveness, and hypotheses as they were stated in the detailed test plan. Adjustments were made to the test as a result of budget, schedule, and system implementation changes. Those adjustments made to the objectives, measures of effectiveness, and hypotheses are identified below. The resulting changes made to the procedures are identified in the test description section.

Table 3 Test Objectives, Measures of Effectiveness, and Hypotheses

Objectives	Measures of Effectiveness	Hypotheses[1]
SP-1. WADA System	Timeliness of information received	Vehicle drivers will not perceive a delay
	Accuracy of information received	Vehicle drivers will not receive incorrect information
	Probability of receiving messages on any opportunity by geographic sector and time block	At least 95% of area including I-285 plus 5 kilometer (km) will receive messages with a probability of 0.6 or greater
		Temporal influences will not impact receipt of the signal
	Probability of any message being received within five transmit cycles within the FOT area.	The probability of receiving any message within the area including I-285 plus 5 km will be at least 0.99
SP-2. Two-Way Test Message System Performance	Time delay from initiation of test to receipt of response	Vehicle drivers will not perceive excessive delays
	Probability of successful transfer of a test message, or ASC response (separately) on any attempt, by sector and time block	Probability of successful test message or response (separately) is at least 0.33 in all sectors within 25 miles of the WAT site
		Tempo influences will not impact receipt of signals
	Probability of test messages being received at ASC, and responses being received in vehicles within the FOT area	At least 95% of two-way test messages and responses will be successful within a 25 mile area of the WAT site
SP-4. LADA Services System Performance	Percent of instances signing and services provided	At least 95% of messages will be received, processed by the in-vehicle system (IVS)
		Signing and services will be provided correctly
	Lead time before exit information is available to driver	All signing and services information will be provided in time for appropriate response
SP-5. Short Range Polling System Performance	Percent of vehicles responding to SRP	At least 90% of vehicles will respond to each SRP
	Accuracy of speed calculations	Average speed calculations will match average speeds calculated from GPS positions within 10%
SP-8. ADAS Suitability	Time the system is expected to operate between failures	N/A
	Average time to repair the system	N/A
	Percent of time the system is available for use	N/A

Table 3 Test Objectives, Measures of Effectiveness, and Hypotheses

Objectives	Measures of Effectiveness	Hypotheses[1]
EX-1. ADAS System Performance Extendibility	Degree of extendibility of ADAS to other circumstances and locations	ADAS is extendible to other circumstances and locations
EX-5. Compatibility of ADAS with ITS System Architecture	Degree of compatibility of ADAS to ITS Architecture	ADAS will be compatible with ITS Architecture
EX-6. ADAS System Performance Improvement	Degree of improvement to ADAS which can be realized	System Performance is optimized

[1]When statistical values are stated (e.g. at least 95% of area), they will be reported at the 90% confidence level in the test report.

3.2 ADJUSTMENTS TO THE TEST OBJECTIVES, MEASURES OF EFFECTIVENESS, AND HYPOTHESES

Adjustments to the test objectives, measures of effectiveness, and hypotheses are presented below. They are presented objective-by-objective in the same order as shown in the preceding section with only deletions and changes to the entries in Table 3 being presented. If a deletion or change is not discussed, the Measure of Effectiveness (MOE) or hypothesis remained the same.

3.2.1 SP-1, WADA System Performance

The MOE that states "Probability of receiving messages on any opportunity by geographic sector and time block" was evaluated for geographic sector but not time block.

The coverage area which was specified as "including I-285 plus 5 kilometer (km)" was not evaluated. Instead, the programmed GPS area (26 arc minutes by 26 arc minutes, or approximately 26 by 26 nautical miles), which is approximately the same area, was evaluated.

The hypothesis stating that "Temporal influences will not impact receipt of the signal" was not investigated. This hypothesis was dropped during budget adjustments before data collection began.

The MOE that states the "Probability of any message being received within five transmit cycles within the FOT area" was not investigated as stated. Scientific Atlanta did not synchronize time between the ASC and the DPIU. Further, they did not program the STIC test message which would have allowed evaluators to determine a known time difference between the two time bases. Without time synchronization or a known time difference, the original issuance of a STIC message could not be correlated with receipt of a STIC message in the vehicle. Instead, an MOE that is stated as "Total percentage of messages received in the test sample" was evaluated. The corresponding hypothesis was 'The total percentage of messages received in the test sample will be at least 99%."

3.2.2 SP-2, Two-Way Test Message System Performance

The measure of effectiveness that states the "Probability of successful transfer of a test message, or ASC response (separately) on any attempt, by sector and time block" was not evaluated. The lack of synchronized time or a known time difference between the ASC and the DPIU made this test impossible. Thus, neither of the hypotheses for this objective was evaluated.

The coverage area which was specified as "within a 25 mile area of the WAT site" was not evaluated. Instead, the programmed GPS area (26 arc minutes by 26 arc minutes), which is approximately the same area, was evaluated.

3.2.3 SP-4, LADA Services System Performance

The hypotheses that states that "At least 95% of messages will be received, processed by the in-vehicle system (IVS)" was not evaluated. Instead, the resultant displays in the vehicle were evaluated to determine that all intended traveler services and m-vehicle signing was displayed.

3.2.4 SP-5, Short Range Polling System Performance

The Short Range Polling function was not implemented by Scientific Atlanta, so neither MOE was evaluated.

3.2.5 SP-8, ADAS Suitability

The evaluation of this objective was dropped during budget and schedule adjustments, so none of the MOEs were evaluated.

3.2.6 EX-1, ADAS System Performance Extendibility

Evaluation of this objective was changed from a rigorous analysis to comments on those issues which became apparent and were recorded **during** the evaluation. Thus, the MOE was changed to "Comments on extendibility of ADAS to other circumstances and locations."

3.2.7 EX-5, Compatibility of ADAS with ITS System Architecture

The evaluation of this objective was dropped during budget and schedule adjustments, so the MOE was not evaluated.

3.2.8 EX-6, ADAS System Performance Improvement

Evaluation of this objective was changed from a rigorous analysis to comments on those issues that became apparent and were recorded during the evaluation. Thus, the MOE was changed to "Comments on improvements to ADAS which can be realized."

3.3 SUMMARY OF TEST DESCRIPTION

In this section, the actual test scheme will be presented. Deviations (and the rationale for the deviations) from the data collection, processing and analysis methods presented in the detailed test plan will be presented, MOE-by-MOE for each objective.

3.3.1 Objective SP-1, WADA System Performance

3.3.1.1 Timeliness and Accuracy of WADA Information MOE

Comment Forms were prepared and furnished to the drivers in each ADAS vehicle. In addition, Comment Forms were made a matter of special interest during periods when PCMCIA cards were installed in the vehicles.

Concord Associates was to have included items in their questionnaires and focus group meetings concerning the timeliness and accuracy of information received in the vehicles. Though data was collected, the user acceptance evaluation by Concord Associates was canceled by Scientific Atlanta, and no data was furnished.

Because of the lack of the synchronization or a known time difference between the ASC and the DPIU, a delay time between the issuance of a signal and receipt of the signal in the vehicle could not be determined.

For this MOE, only cursory comments from the driver questionnaires will be included in the analysis section.

3.3.1.2 Probability of Receiving Messages by Geographic Sector MOE

Temporal impacts to the STIC subsystem was not evaluated as described earlier.

The coverage area was evaluated using approximately 2 minute of arc boxes instead of one minute of arc boxes (See Figure 2 for an overlay of the boxes on the metro map of Atlanta.). The change from one arc minute to two arc minutes was necessitated due to the shortened schedule for data collection and analysis. Originally, a four month data collection period with an additional month to complete the analysis was scheduled. Instead, the evaluators were given two months for the entire data collection and analysis period.

The latitude and longitude offset values used as the axes in Figure 2 were generated by the IVS. They are in a Scientific Atlanta format referred to as SA B-64.

The method stated in the detailed test plan for determining STIC coverage based on searching the PCMCIA card files for STIC message sequence numbers in all vehicles after issuance of the message by the ASC could not be done. Since the ASC and DPIU times were not synchronized, a first receipt of the message in a vehicle could not be determined. Instead, an alternate method was used as described in the next paragraph.

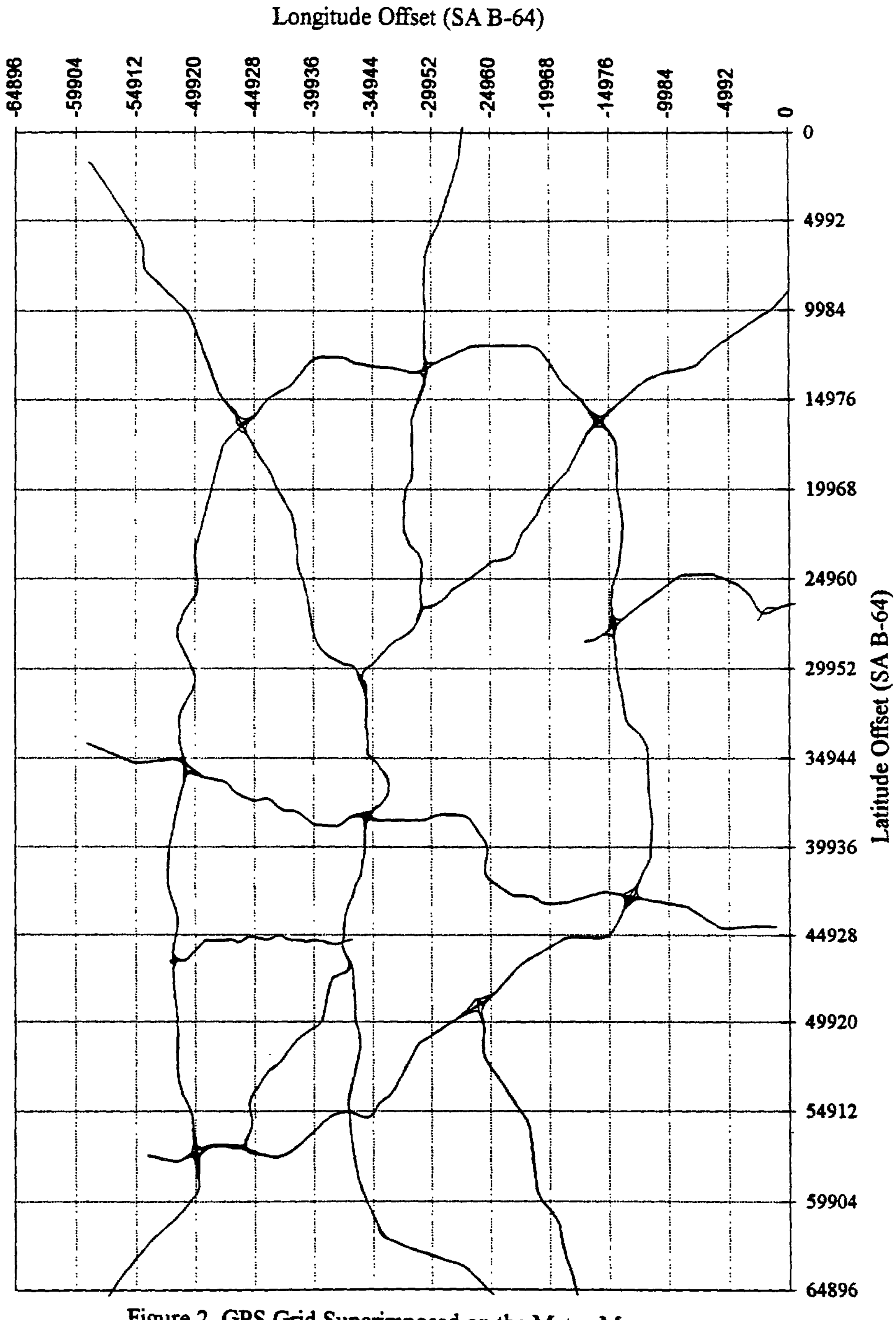

Figure 2. GPS Grid Superimposed on the Metro Map

By observing the STIC message data in the PCMCIA card files, it became evident that the messages issued by the ASC were repeatable from cycle to cycle (each cycle was 34 seconds). Thus, to determine the coverage of the STIC subsystem, the following method was used.

1. Each PCMCIA file was queried to determine in which 2 arc minute boxes the vehicle operated. The Microsoft Access relational data base program was used. That section of the file was evaluated to determine the number of STIC messages that were received as the vehicle traveled through the box.

2. An average number of STIC messages was determined for the box. Since the message sequence numbers only changed when the ASC received updated speed or incident data from the ATMS, the message sequence numbers were stable and repeated from cycle-to-cycle. As repeatable cycles were found, the messages in the cycles were counted to determine an average. In those sections of the file where the coverage was very low, adjacent sections were used to determine an average.

3. The total time spent in a box was calculated by subtracting the box entry time from the box exit time.

4. The number of STIC cycles that the vehicle spent in the box was determined by dividing the total time spent in the box (Step 3) by 34 seconds, the length of time required for one STIC cycle.

5. The total number of messages that could have been received in the box was calculated by multiplying the average number of messages (Step 2) in a cycle by the number of cycles (Step 4) the vehicle spent in the box.

6. The number of messages not received in the box was determined by subtracting the number of messages received (Step 1) from the number of messages that should have been received (Step 5).

7. The number of messages received and the number of messages that should have been received in each two arc minute box was recorded for the entire coverage area.

All data included in the coverage analysis was taken by the evaluator vehicle. Thus, the data analyzed represents only those days and periods when the evaluator was active in collecting data. No attempt was made to determine influences due to time, ambient condition, vehicle type, or direction of travel.

3.3.1.3 Percent of All Messages Received MOE

Percentages for each 2 arc minute box and an overall percentage for the test were calculated. The percentages determined were for the data in the analysis; they do not relate to the overall period of operation. Only the data from the coverage MOE was used for this MOE.

3.3.2 Objective SP-2, Two-Way Test Message System Performance

3.3.2.1 Time Delay MOE

The procedure for collecting the test message data was not changed. However, the method for determining the time delay between initiation of a test message and receipt of the ASC response in the vehicle was changed since the ASC time base and the DPIU time base were not synchronized, and the planned test message was not implemented to provide a known time difference between the ASC and the DPIU.

To determine the delay between issuance of a test message and receipt of an ASC response in the vehicle, computer searches were made of all PCMCIA files to determine:

- when the "Send Message" button on the IVD was pressed,
- how many uplink transmissions resulted from the "Send Message" action,
- whether a **WAT** acknowledgment was received in the vehicle, and
- whether an ASC response was received in the vehicle.

Since uplink transmissions resulting from the "Send Message" action repeated each 5 seconds until a total of 11 messages had been sent, the number of uplinks was used to determine how long the vehicle waited for an ASC response. The data was analyzed to show the average delay in each 2 arc minute box.

All PCMCIA data collected during the collection period, including the evaluator's vehicle, was used for this analysis.

3.3.2.2 Probability of Successful Messaging MOE

Coverage analysis was accomplished using the same boxes as was used for the STIC coverage. Even though the system specification stated different coverage areas for the STIC and the Two-Way Message Subsystems, only one grid for coverage was available. The grid used was the GPS location grid recorded on the PCMCIA cards. Thus, Figure 2 applies equally to the STIC and the Two-Way Message Subsystems.

As stated in the detailed test plan (and the instructions in Appendix C), each vehicle driver was asked to send messages at approximately 15 minute intervals when they bad a PCMCIA card installed in the DPIU. **When** the evaluator vehicle was being used for data collection, the driver also exercised the messaging system often, much more frequently than each 15 minutes requested in the instructions to the Federal Express and GDOT drivers.

Using Microsoft Access, the PCMCIA files were searched to find the instances when a driver sent a message from the vehicle. Also searched during the query were the number of additional uplink repeats, the WAT acknowledgment, and the ASC response. By observing the extracted data, a count could be made of the number of uplinks and whether a WAT acknowledgment and an ASC response were received. In cases where a WAT acknowledgment was received but not an ASC response, it was labeled as an anomaly and counted in the data as a failure. It was counted as a failure because the vehicle did not receive a message on the IVD stating that a message had been received in the ASC. When the ASC acknowledgment was received in the vehicle, it was counted as a success. The message, when received in the vehicle, would state that it had been received in the ASC, give the time of receipt, state the vehicle DPIU number, and state the fleet assignment of the vehicle (Federal Express, GDOT, or Georgia Tech (evaluator's vehicle)).

All PCMCIA data collected during the collection period, including the evaluator's vehicle, was used for this analysis.

3.3.3 Objective SP-4, LADA System Performance

3.3.3.1 LAT-to-Vehicle Communications Success and Services Accuracy MOE

Instead of using Federal Express and GDOT vehicles for this objective, only the evaluator's vehicle was used. Because of the success with transmitting the traveler services maps and in-vehicle signing to the vehicles over the LATs, data from additional vehicles would not have affected the results.

It was discovered during the test that all the maps and in-vehicle signs for all exits on the entire LAT section of I-85 could be sent to a vehicle traveling at traffic speeds from only one LAT. Thus, the scheme to have a rolling update of the maps and signs as the vehicle transited the LAT section was unnecessary. Since each LAT could load the entire DPlU LADA memory for all exits and signs, the test became one of determining whether all LATs could be received by the vehicle. All the LATs would **need** to be received by each vehicle because any vehicle could enter a road segment near any of the LATs To ensure each LAT could be received, the IVS in the evaluator vehicle was cycled off for approximately one minute and then cycled on adjacent to each LAT.

To ensure that signing and services were correctly presented to the driver, the evaluator vehicle was driven along the LAT section while observing the IVD to ensure correct exits and signs were presented. At each interchange along the section, the evaluator exited the Interstate to verify that the services shown on the map were correct. A record of the observations was made by the evaluator.

3.3.3.2 Lead Time Before Exit MOE

This MOE was evaluated as was stated in the detailed test plan with one exception. Because of the heavy traffic and speeds encountered on the Interstate, another driver was asked to accompany the evaluator. Recordings were made of the vehicles odometer readings when:

- the interchange map appeared,
- the in-vehicle sign appeared,
- the in-vehicle sign moved to the top bar of the display,
- the exit was passed by the vehicle, and
- the interchange map changed to the next map or disappeared from the display.

Using the odometer readings, calculations were made that show the:

- distance before the exit that the in-vehicle sign appeared,
- distance before the exit that the interchange map appeared, and
- distance after the exit that the interchange map disappeared.

3.3.4 Objective EX-1 System Performance Extendibility

3.3.4.1 Comments on Extendibility to Other Circumstances and Locations MOE

As stated earlier, evaluation of this MOE was changed from a rigorous analysis of all aspects of ADAS to commenting on extendibility based on the data analysis and records made during the test. Since the system was not operable during the Olympics, comparisons between ADAS's performance during the Olympics and ADAS's performance at other times can not be made. Questionnaires, recorded observations, and suitability records were not available because of budget constraints.

3.3.5 Objective EX-6, System Performance Improvement

3.3.5.1 Comments on Improvement MOE

As was stated earlier, evaluation of this MOE changed from a rigorous analysis of all elements of ADAS to commenting on improvement based on the analysis done and records made during the test.

4. DATA PROCESSING AND ANALYSIS

This section presents data processing and analysis. The manipulation of the digital data to put it into a useful format is discussed. Summaries of the non-digital data are presented. Then the analysis for each MOE under each objective is presented. The data collection period was from October 21, 1996 to December 20, 1996.

4.1 DIGITAL DATA PROCESSING

4.1.1 ASC Data

Digital data from the ASC were provided to the evaluators on a weekly basis on 4 mm magnetic tape. It was written to the tape using a UNIX based computer. As the tapes were received, they were loaded onto the evaluator's UNIX based computer, and all files were downloaded and checked for readability of content. The files were then transferred to a DOS based computer where they were written onto another 4 mm magnetic tape. This DOS based computer generated tape became the master tape. Before writing the files to the master tapes, they were again checked for readability. The ASC data was not used for evaluating the system since it could not be correlated with data in the vehicles.

4.1.2 PCMCIA Data

Digital data from the vehicles were recorded on PCMCIA cards inserted into slots in the DPIU. Generally, the cards were placed in the vehicles for two days; however, on occasion they were left in the vehicles for longer periods of time. Each time the vehicle was started, a new file was begun. Thus, vehicles which made many quick, short trips had many small files in the cards while vehicles which made few stops had a few large files. To manage the data, a single consolidated file was made for each vehicle for each day.

When the cards were received from the vehicles, the data was in a single column with each record being one item of data, such as a STIC message sequence number. The evaluators prepared a program to manipulate the single column of data so that it could be entered into a Microsoft Access data base as a table with 36 columns (of which 28 were usable). A sample of the data in the 28 columns is presented below. An explanation of the data in the fields is in Table 4.

Count	Date	Vehicle	GPS Time	GPS Lat	GPS Lon	Speed	STIC Msg#	2Way Test	Enc ACK	Resp Msg#
3337	261196		6:07:53 PM	28467	39628	049.6	566	1	0	
3338	261196		12:00:00 AM			.	567	0	0	
3339	261196		12:00:00 AM			.	568	0	0	
3340	261196		12:00:00 AM			.	569	0	0	
3341	261196		12:00:00 AM			.	570	0	0	
3342	261196		6:07:58 PM	28616	39529	050.2	571	1	0	
3343	261196		6:08:03 PM	28752	39415	048.6		0	1	65534
3344	261196		6:08:08 PM	28878	39282	048.5		0	0	

MAYDAY VEH	Resp ASC Time	Resp DPIU Time	Vehicle Ack	LADA Msg#	mmevent	mmcrdwy	mmmsg
	12:00:00 AM	12:00:00 AM	0		0	0	1
	12:00:00 AM	12:00:00 AM	0		0	0	0
	12:00:00 AM	12:00:00 AM	0		0	0	0
	12:00:00 AM	12:00:00 AM	0		0	0	0
	12:00:00 AM	12:00:00 AM	0		0	0	0
	12:00:00 AM	12:00:00 AM	0		0	0	0
17953	6:06:28 PM	6:08:02 PM	1		0	0	0
	12:00:00 AM	12:00:00 AM	0		0	0	0

mmzoom	esview	esmm	zoomout	mmzicon	ritxt	crmap	mssend	msmap
0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Table 4 PCMCIA Field Contents

Field	Content
Count	Provides a count of the records in the table
Date	The date of the data recording in the vehicle, ddmmyy
Vehicle	The Electronic Serial Number (ESN) of the vehicle
GPS Time	The GPS time the record was made, written each 5 seconds
GPS Lat	The GPS latitude of the vehicle in project coordinates defined elsewhere, written each 5 seconds
GPS Lon	The GPS longitude of the vehicle in project coordinates defined elsewhere, written each 5 seconds
Speed	The GPS speed of the vehicle recorded each 5 seconds
STIC Msg#	A STIC message sequence number
2Way Test	A "1" indicates that the IVD has made an uplink transmission of a two-way test message, otherwise the field is "0"
Enc ACK	A "1" indicates that the WAT has acknowledged receiving the uplink transmission, otherwise the field is "0"
Resp Msg#	A two-way message sequence number (always 65534) assigned by the ASC
MAYDAY VEH	The ESN of the vehicle initiating the two-way message
Resp ASC Time	The time the ASC sent the response, in ASC time base
Resp DPIU Time	The time the DPIU received the response, in DPIU time base
Vehicle Ack	A "1" indicates the vehicle has acknowledged to the WAT that the ASC response was received
LADA Msg#	A LADA message sequence number
mmevent	A "1" indicates the "Event" soft button on the metro map display has been touched, otherwise a "0"
mmcrdwy	A "1" indicates the "Current Roadway" soft button on the metro map display has been touched, otherwise a "0"
mmmsg	A "1" indicates the "Message" soft button on the metro map display has been touched, otherwise a "0"
mmzoom	A "1" indicates a zoom sector soft button on the metro map display has been touched, otherwise a "0"

Table 4 PCMCIA Field Contents

Field	Content
esview	A "1" indicates the "View More" soft button on the event screen display has been touched. otherwise a "0"
esmm	A "1" indicates the "Metro Map" soft button on the event screen display has been touched, otherwise a "0"
zoomout	A "1" indicates the "Metro Map" soft button on the zoom display has been touched, otherwise a "0"
mmzicon	A "1" indicates an icon soft button on the zoom display has been touched, otherwise a "0"
ritxt	A "1" indicates the "Zoom Map" soft button on the text display has been touched, otherwise a "0"
crmap	A "1" indicates the "Metro Map" soft button on the current roadway display has been touched, otherwise a "0'
mssend	A "1" indicates the "Send" soft button on the message screen display has been touched, otherwise a "0"
msmap	A "1" indicates the "Metro Map" soft button on the message screen display has been touched, otherwise a "0"

4.2 NON-DIGITAL DATA

4.2.1 ASC Operator Logs

Copies of the ASC Operator logs were provided to the evaluators on a weekly basis during the data collection period. The ASC Operator logs were used to determine the operational time periods of the subsystems that were under evaluation. It was understood that the operator logs could only be used to record the operators reaction to the data provided to him. For instance, the operator could record when the ASC was in communication with the encoders and modulators at the transmit sites, but the operator could not determine whether the transmitters or transceivers were operational. Even though a STIC receiver was provided for the operator, it was not clear from the log how useful it was for determining operational condition.

The ASC was manned by one operator from 7:00 AM to 7:00 PM on Monday, Tuesday, and Wednesday. A second operator was sometimes at the ASC during the same hours on Thursday and Friday. The system was left in an autonomous mode at all other times.

The operator logs were only one measure of whether the subsystems were operational. The PCMCIA data generally showed clearly whether the subsystems were operational. STIC and LADA data were always received in some of the boxes in any file provided the STIC and LADA subsystems were operational. Likewise, if the operator tried to send two-way messages, acknowledgments and responses were always received in some boxes if the WAT was active.

4.2.2 Comment Forms

As reported elsewhere in this report, comment forms were distributed to each vehicle and briefed during training sessions as being important to the evaluation. In addition, a comment form was included with each PCMCIA card package sent to a vehicle. However, very few forms (19 total) were completed and returned. Appendix F contains a copy of the completed comment forms, and was used to construct the table in the analysis section which follows.

4.2.3 Evaluator Log and Other Hand Recorded Data

An evaluator log was used to record important dates, comments, and observations by the system performance evaluator. Other data was recorded by hand during the data collection period and used for the analysis. In particular, the LADA odometer readings collected to determine the distance before an interchange when the traveler service map and in-vehicle signs appeared on the display were recorded as the evaluator vehicle was driven along the Interstate.

4.3 ANALYSIS BY TEST OBJECTIVE AND MEASURE OF EFFECTIVENESS

4.3.1 Objective SP-1, WADA System Performance

4.3.1.1 STIC Digital Data Summary

Before analysis of the MOEs could begin, the digital data had to be summarized. The summaries prepared from the STIC data for the WADA service are presented below.

Figure 3 presents the STIC summary data for each 2 minute of arc box for the GPS coverage area. Data in Figure 3 was generated using the files from the PCMCIA cards. In each box containing data, the number above the line represents the number of messages received while the vehicle was in the box, and the number below the line represents the number of messages not received while the vehicle was in the box. No data was received in two boxes (latitude 49920 to 54912, longitude -59904 to -64896 and latitude 59904 to 64896, longitude 0 to -4992). Attempts were made to obtain coverage in these two boxes; however, the active data collection period ended before the evaluators were successful. The analysis method used to determine coverage means that the evaluator vehicle did not operate in these two boxes. If the vehicle had operated in these two boxes without receiving STIC messages, the analysis method would have resulted in a number above the line of zero and a number below the line equal to the average number of STIC messages which should have been received.

In several boxes, a negative number can be found below the line. The negative value indicates that the algorithm used to determine the number of non-successes resulted in a negative value, e.g. the number of messages that should have been received based on the average number of messages per cycle times the number of cycles was less than the number of messages received. In actuality, when negative values are found below the line in a box, that box should be interpreted as having 100 percent reception for the vehicle at that time.

Using the summary data in Figure 3, Figure 4 was generated. It presents the Percentage of messages received by the vehicle in each box. Each percentage was calculated as:

$$A = \frac{Nr}{Nr+Nn} \times 100\%$$

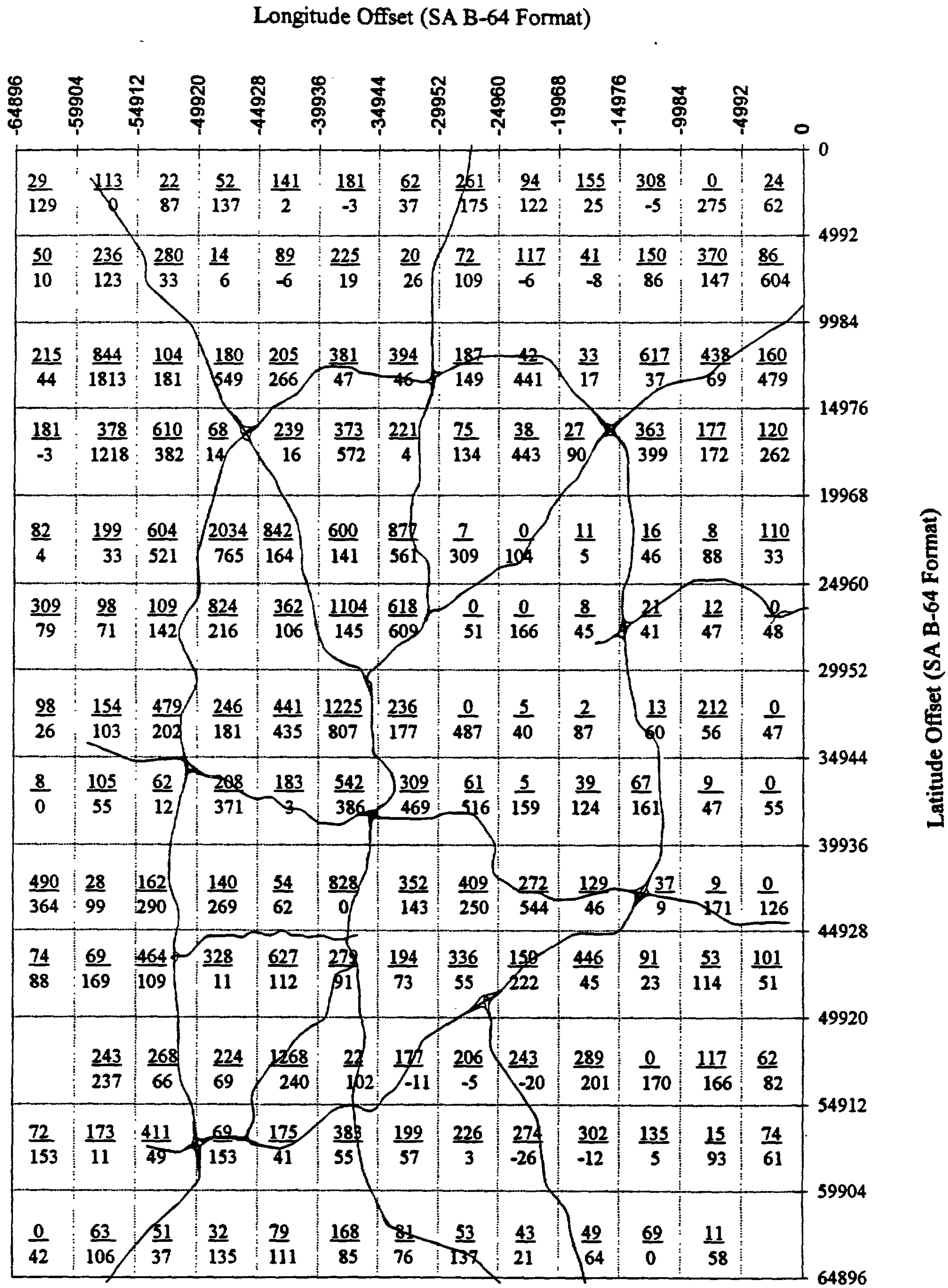

Figure 3. STIC Coverage

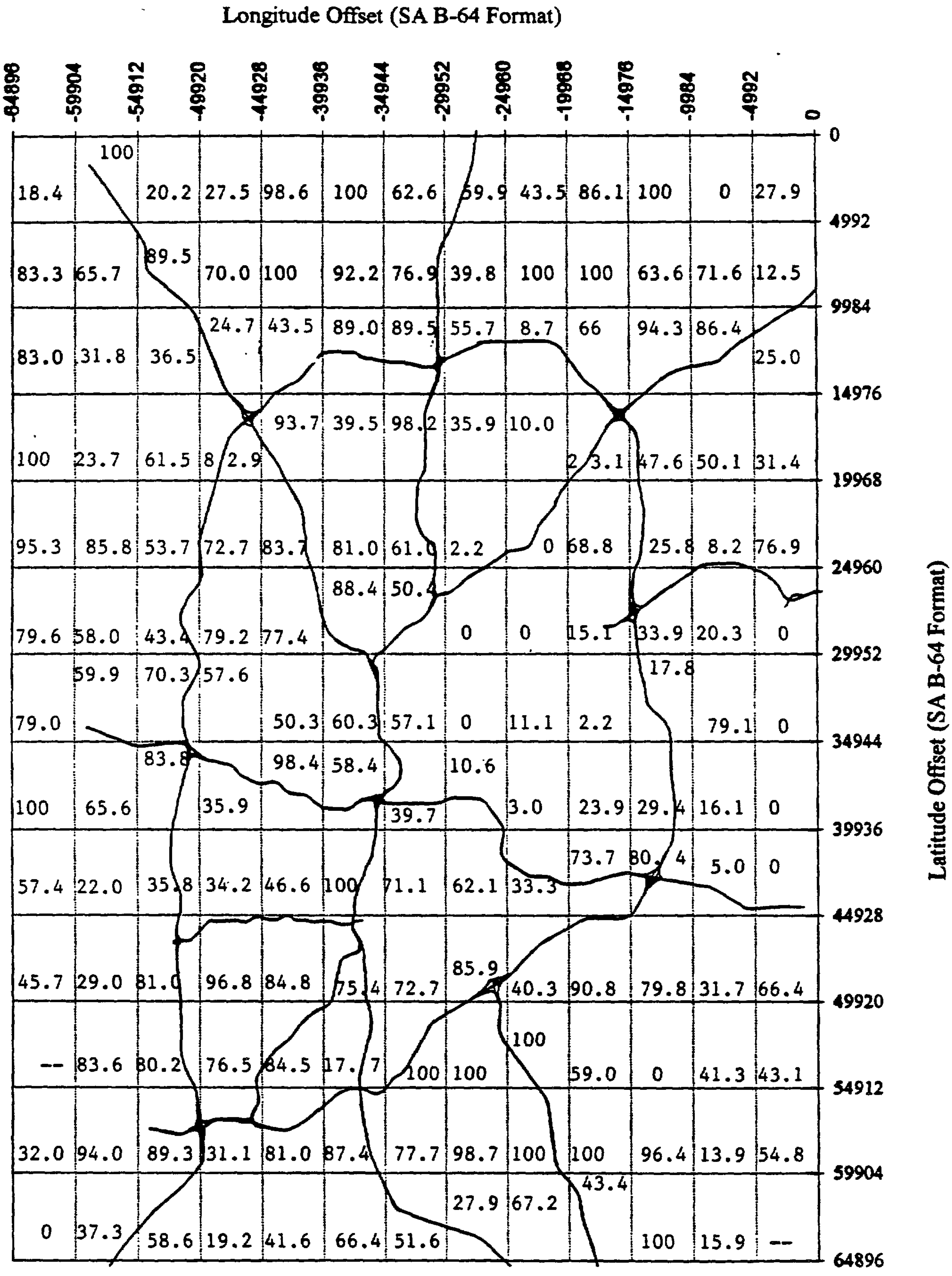

Figure 4. STIC Coverage Percentages

where: A is the average
Nr is the number or messages received
Nn is the number of messages not received.

The data in Figure 4 will be used in the analysis of the "Probability of receiving messages by geographic sector" MOE below.

4.3.1.2 Timeliness and Accuracy of WADA Information MOE

There were 19 Comment Forms turned in, 8 from Federal Express and 11 from GDOT. The comments are summarized in Table 5 as negative comments on system or information problems, or as positive comments on either the system or the information provided.

Table 5 Summary of Comments

Negative Comments				Positive Comments			
System Problems		Information Problems		System		Information	
Fed Ex	GDOT	Fed Ex	GDOT	FedEx	GDOT	FedEx	GDOT
7	13	5	4	0	3	0	4

The synopsis of the comments from the Points of Contact (POCs, see Appendix F) was prepared after asking the POCs whether their drivers were using the system. Generally, the comments from the POCs are more negative than positive as was the comment forms. The overall impression from the comments was that the POCs were not very interested in whether the system was being used and seldom received comments from the drivers; however, when they did receive comments, usually the comments were negative.

4.3.1.3 Probability of Receiving Messages by Geographic Sector MOE

Figure 3 presents the number of STIC messages received by the evaluator vehicle in each 2 arc minute box as well as the number of STIC messages not received in each 2 arc minute box. Large variations can be seen from box to box; however it is difficult to draw any conclusions based on those variations. Additional summaries were generated from the figure to determine the trend in coverage as a function of geographic sector.

Table 6 Percentage of Successes Versus Latitude, STIC Messages

Latitude	Successes	Non-Successes	Percentage of Successes
0 to 4992	1442	1043	58.0
4992 to 9984	1750	1143	60.5
9984 to 14976	3800	4138	47.9
14976 to 19968	2870	3703	43.7
19968 to 24960	5390	2774	66.0
24960 to 29952	3477	1766	66.3
29952 to 34944	3111	2708	53.5
34944 to 39936	1598	2358	40.4
339936 to 44928	2910	2373	55.1
44928 to 49920	3212	1163	73.4
49920 to 54912	3119	1297	70.6
54912 to 59904	2508	3151	79.6
59904 to 64896	699	872	44.5

Table 6 presents the STIC coverage data as a function of latitude within the coverage area. The Successes column contains the sum of the number of messages received in that latitude row from Figure 3. Likewise, the Non-Successes column contains the sum of the number of messages not received in that latitude row from Figure 3. The Percentage of Successes is the number of Successes divided by the sum of the number of Successes plus the number of Non-Successes.

From Table 6 it is evident that the success rate is better to the south of the center of town although a couple of latitudes to the north are stronger than others to the north (see 4992 to 9984 and 19968 to 24960). Since both STIC radio stations were near the center of town, the analysis indicates more shielding (interruption of line-of-sight between the transmitter and the receiver antennas) to the north.

Table 7 Percentage of Successes Versus Longitude, STIC Messages

Longitude	-59904 to -64896	-54912 to -59904	-49920 to -54912	-44928 to -49920	-39936 to -44928	-34944 to -39936	-29952 to -34944	-24960 to -29952	-19968 to -24960	-14976 to -19968	-9984 to -14976	-4992 to -9984	0 to -4992
Successes	1608	2703	3626	4119	4705	6311	3740	1893	1283	1531	1887	1431	737
Non-Successes	1168	4038	2111	2876	1552	2447	2267	2370	2210	729	1032	1503	1910
Percentage of Successes	57.9	40.1	63.2	58.9	75.2	72.1	62.3	44.4	36.7	67.7	64.6	48.8	27.8

Table 7 presents the STIC coverage data as a function of longitude within the coverage area. The Successes row contains the sum of the number of messages received in the respective longitudinal column in Figure 3 while the Non-Successes row contains the sum of the number of messages not received in that longitudinal column in Figure 3. The Percentage of Successes is the number of successes divided by the sum of the number of Successes plus the number of Non-Successes in that column.

Reception was better to the west than to the east. The column representing a longitude of 0 to -4992 with a success percentage of 27.8 indicates that the system was not well positioned or powered to accommodate vehicles operating there.

Table 8 Percentage of Successes by Quadrant

	-64896 to -34944	-2995 to 0	
Successes	12,377	4,148	0 to 29952
Non-Successes	7,912	5,261	
Percentage of Successes	61%	44.1%	
Successes	8,352	4,382	34944 to 64896
Non-Successes	4,081	3,716	
Percentage of Successes	67.2%	54.1%	

When successes are viewed by quadrant, the coverage is more clearly defined. Table 8 presents the coverage by quadrant for the STIC message successes. The table was prepared by summing the successes and non-successes in the first and last six columns and rows in Figure 3 to arrive at sums for each of the four quadrants. For balance, Row 7 and column 7 were not included in the sums. The resultant percentages of successes clearly shows that reception was best to the west than to the east, and that the south was better than the north. The northeast quadrant was by far the poorest with 44.1%. That sector of Atlanta is generally lower in elevation than other metro areas. For this reason, it appears that the STIC signal from both FM radio stations was more shielded from the vehicle in that quadrant.

A final calculation was made to determine the probability of geographic coverage of the STIC area. There are 169 boxes that represent 2 arc minutes each in the geographic area. Two boxes did not receive any messages and therefore, must be eliminated. Three additional boxes received less than the 38 data points required by the test plan for a 0.6 probability in each box to arrive at 95 percent geographic coverage. These three boxes must be eliminated leaving 164 boxes. A count of the boxes with 60 or greater percent successes in Figure 4 results in 78 boxes. Thus 78 boxes of 164 boxes had a probability of 0.6 of receiving a message, resulting in 47.6 percent coverage.

4.3.1.4 Percentage of All messages Received

To determine the overall percentage, the total messages received (35,886) was divided by the total of the messages received plus the messages not received (61,867). The overall percentage of messages received was 58%. Only 20 of 169 boxes, 11.8%, received 95% or more of the messages that should have been received.

Even though the overall percentage is less than the hypothesis of 95 percent, the DPIU in the vehicles retained the symbology sufficiently long that very little drop-out occurred. The system retained congestion and incident icons from the last STIC cycle for five minutes before the icons were removed. At 65 mph, a vehicle travels 5.4 miles in five minutes while a vehicle traveling 45 mph travels 3.75 miles in five minutes. Thus, in a five minute hold period, a vehicle at these speeds can transit an entire 2-arc minute box without coverage and not lose the display symbology.

4.3.2 Objective SP-2, Two-Way Test Message System Performance

4.3.2.1 Two-Way Test Message Digital Data Summary

Before analysis of the MOEs could begin, the digital data had to be summarized. The summaries accomplished on the digital data for the Two-Way Message service is presented below.

Figure 5 presents the results of the digital data analysis to summarize the two-way message data from the PCMCIA cards. The data in the figure summarizes all two-way data collected during the data collection period. The data in the 2-arc minute boxes is defined as follows.

- A space was reserved for an upper number set and a lower number set in each box.
- The first number in the upper number set is the number of successful two-way test messages executed from the vehicle. A successful two-way test message was one that was sent from the vehicle with a resultant response received in the vehicle.
- The value in parentheses in the upper number set is the average number of five second uplinks (an uplink is defined as an RF transmission from the vehicle) which occurred before a response was received. For instance, a value of 1.7 represents 8.5 seconds, which means that, in that box, from the time the soft button “Send Message” was touched until the DPIU recorded the ASC response, an average of 8.5 seconds had elapsed.

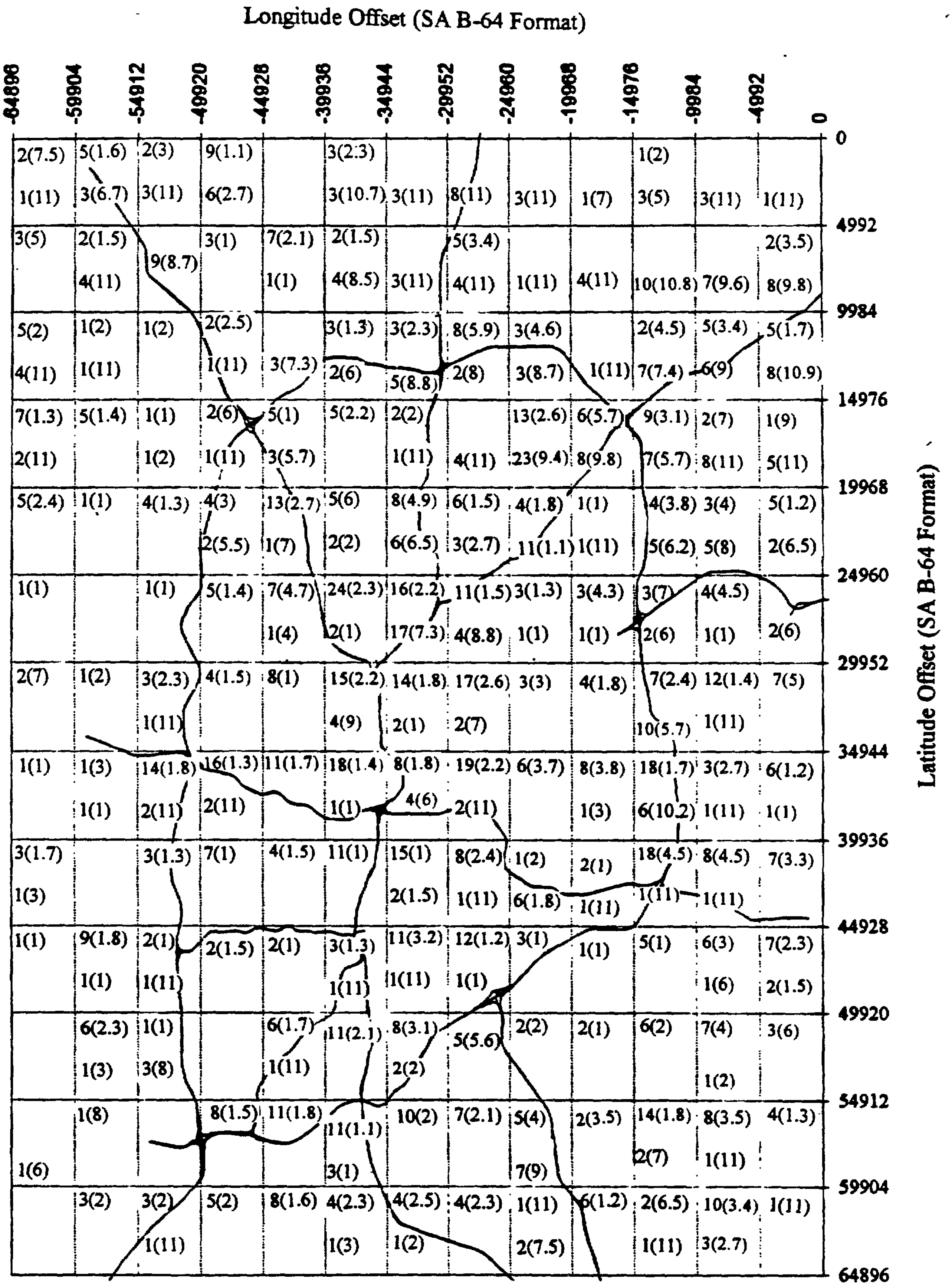

Figure 5. WAT Coverage

The first number in the lower number set is the number of unsuccessful two-way messages attempted from the vehicle. An unsuccessful attempt occurs when the “Send Message” soft button is depressed and an ASC response is not received for 11 uplink tries (55 seconds have elapsed), or a WAT acknowledgment was received in less than 11 uplink tries but an ASC response was not received. A WAT acknowledgment could be received while the vehicle was in a coverage area, but the vehicle moved to a non-coverage area before the ASC response was received. One scenario is that a large truck or building could have blocked the ASC response. Another possibility is that the modem connecting the 220 MHz radio output to the DPIU dropped off line from some other factor than shielding before the vehicle received the ASC response.

- The value in parentheses in the lower number set has the same meaning as in the upper number set.

There are seven 2-arc minute boxes in Figure 5 without data. Even though the evaluator transited those boxes, attempts to send two-way messages were apparently not made. If more time had been available to collect data, data could have been collected in those boxes; however, it was understood from the start of the test that because of the low rate of data available from the two-way test, it would be difficult to cover all boxes and to collect significant numbers of data points in each box.

In many boxes, there is only an upper number set or a lower number set. As stated above, the low data rate means that one would suspect sparse data for such a short data collection period.

4.3.2.2 Tie Delay MOE

In observing the data in Figure 5, there is an entire range of average responses for both those messages which were successful and those not successful. When an average value of 1 is recorded as the number of uplink tries, the time may actually be less than 5 seconds; however, recordings in the PCMCIA cards were only made once each 5 seconds.

During the test collection period, there were 830 successes from 1,190 tries. For successful messages, the average number of uplinks was 2.37, or 11.85 seconds. For non-successful messages, the average number of uplinks was 7.8 1, or 39.05 seconds.

4.3.2.3 Probability of Successful Messaging MOE

By summing both the successful and non-successful two-way messages for each latitude from Figure 5, additional insight into the two-way message service performance can be seen. Table 9 was formed by summing the values from Figure 5 horizontally and then calculating a percentage of the successes by dividing the successes by the sum of the successes and the non-successes. Note that the percentages increase from the top of the coverage area (smallest latitude value) to the bottom of the coverage area (largest latitude value). The WAT is located on a building in the 34944 to 39936 latitude. To the north, the WAT antenna was shielded by several taller buildings, and the signal had less opportunity for line-of-sight receptions and transmissions. The farther north the vehicle was from the antenna, the greater the slice of shielding and the more non-successes that resulted. To the south, there were fewer tall buildings with a resultant increase in line-of-sight opportunities.

Table 9 Percentage of Successes Versus Latitude
Two-Way Test Messages

Latitude	Successes	Non-Successes	Percentage of Successes
0 to 4992	22	41	34.9
4992 to 9984	24	55	30.4
9984 to 14976	38	43	46.9
14976 to 19968	58	63	47.9
19968 to 24960	63	38	62.4
24960 to 29952	80	29	73.4
29952 to 34944	97	20	82.9
34944 to 39936	129	21	86.0
339936 to 44928	87	12	87.9
44928 to 49920	64	8	88.9
49920 to 54912	57	8	87.7
54912 to 59904	81	14	85.3
59904 to 64896	50	10	83.3

By summing the successes and non-successes along the longitudinal values and calculating the percentages of successes, Table 10 was generated. The resultant percentages show slightly better reception to the west; however, they are relatively constant for all the longitudinal values, except -19968 to -24960. The exception, 43.6 percent, was driven by the many non-successes north of the WAT antenna, which is still a latitudinal effect. The slightly higher percentages to the west are indicative of the fact that the Georgia Pacific Building is on the southwestern edge of the downtown area which results in better communications to the southwest.

The overall number of successful two-way messages was 830 of 1,190 attempts, or 69.7 percent.

Table 10 Percentage of Successes Versus Longitude
Two-Way Test Messages

Longitude	-59904 to -64896	-54912 to -59904	-49920 to -54912	-44928 to -49920	-39936 to -44928	-34944 to -39936	-29952 to -34944	-24960 to -29952	-19968 to -24960	-14976 to -19968	-9984 to -14976	-4992 to -9984	0 to -4992
Successes	31	35	35	67	82	115	99	102	44	35	89	68	49
Non-Successes	9	11	21	12	10	23	47	31	57	18	54	39	28
Percentage of Successes	77.5	76.1	62.5	84.8	89.1	83.3	67.8	76.7	43.6	66	62.2	63.6	63.6

4.3.3 Objective SP-4, LADA System Performance

4.3.3.1 LAT-to-Vehicle Communications Success and Services Accuracy MOE

The initial LADA test was to determine whether the vehicle receiver would be automatically tuned to the correct frequency for each **LAT.** Table 11 provides the results of the test. Data was collected at least twice (once in each direction; i.e., northbound (NB) and southbound (SB)) for each LAT. The time recorded in the table was read from the evaluator's wrist watch. Time was used to ensure the discipline of turning the IVS "On" and "Off." N/A indicates the lVS was not switched **Off** because **LADA** information had not been received from that **LAT.**

Two **LATs** (numbers 2 and 5) were not received in either direction. **A** final check on those two LATs was made on a northbound trip as an additional check on their operation. The probable causes of not receiving their transmissions were:

Table 11 Data on LAT Reception

LAT	Travel Direction	Time On	Time Off	LADA Display
6	SB	12:55	12:59	yes
6	NB	1:01	1:05	yes
5	NB	1:05	1:07	no
5	SB	1:26	1:29	no
4	NB	1:08	1:11	yes
4	SB	1:23	1:24	yes
3	NB	1:12	1:13	yes
3	SB	N/A	1:23	yes
2	NB	1:13	N/A	no
2	SB	1:20	N/A	no
1	NB	N/A	1:15	yes
1	SB	1:18	1:19	yes
5	NB	1:43	1:45	no
2	NB	1:51	1:52	no

- The LATs were not transmitting
- The LATs were not correctly tuned
- The DPIU was not programmed for the correct frequency
- The vehicle did not know when it was within the frequency box for those two LATs.

Because the LAT corridor was in the most unsuccessful coverage area for STIC, because the differential GPS was transmitted as part of the STIC signal, and because differential GPS was needed to be able to tune to the LATs, it is probable that the loss of STIC information caused the inability of the vehicle to properly tune to LATs 2 and 5.

During verification that the maps being displayed were correct (see Appendix B for the maps), only minimal errors were found. Those were:

- At Exit 33, Shallowford Road, Southbound and Northbound - The Dial Inn had changed names to Super 8 Motel.
- At Exit 30, Cheshire Bridge, Southbound and Northbound - The Varsity was drawn on the wrong side of La Vista Avenue.
- At Exit 34, Chamblee-Tucker, Southbound - The Nite Club shown on the Northbound map is not shown on the Southbound map.
- At Exit 3 1, North Druid Hills, Northbound - The Hampton Inn and Diner shown on the Southbound map is not shown on the Northbound map.

4.3.3.2 Lead Tie Before Exit MOE

Table 12 presents the data recorded and calculations made which show the distances before and after the exits that the traveler service maps were displayed. These distances become important when the vehicle driver wishes to respond to the information by exiting the Interstate. It is especially important if the vehicle is in the left-most lane when the driver decides to exit at the next interchange as a result of information on the map.

In Table 12, the values in the column labeled "Distance Before Exit" is the difference between the "Odometer Readings at Appearance of Map" column and the "Odometer at Exit" column.. The value in the "Distance After Exit" column is the difference between the "Odometer at Exit" column and the "Odometer When Map Deleted" column. While the map appears reasonably early (0.5 miles) before most of the exits, several maps (see exits 26S, 96, 97S, 93S, 94N, 96N, 98N, and 101N) appear so near the exit that a driver would have problems changing lanes safely and exiting.

Table 12 Distances Before/After Exits Traveler Services Map Displayed

Time	Exit	Odometer at Appearance of Map (miles)	Odometer at Exit (miles)	Odometer when Map Deleted (miles)	Distance Before Exit (miles)	Distance After Exit (miles)
	34S	0.35	0.9	1.35	0.55	0.45
10:49	33S	0.35	1.15	1.75	0.8	0.6
10:50	32S	0.75	2.4	3.0	1.65	0.6
10:52	31S	0.00	0.9	1.3	0.9	0.4
10:54	30S	0.3	1.0	1.6	0.7	0.6
10:58	26S	0.15	0.25	0.9	0.1	0.65
10:59	99S	0.9	2.25	2.45	1.35	0.2
11:00	96,97S	0.45	0.75	1.4	0.3	0.65
11:01	93S	0.4	0.85	2.15	0.45	1.3
12:51	94N	0.35	0.5	1.2	0.15	0.7
12:51	96N	0.35	0.75	1.2	0.4	0.45
11:07	98N	0.25	0.65	1.2	0.4	0.55
11:09	101N	0.2	0.65	0.8	0.45	0.15
11:10	103N	0.8	1.45	1.8	0.65	0.35
11:11	28N	0.8	1.95	3.6	1.15	1.65
11:11	29N	0.8	3.15	3.6	2.35	0.45
11:14	31N	0.6	1.75	2.3	1.15	0.55
11:15	32N	0.3	1.25	1.6	0.95	0.35
11:17	33N	0.6	2.5	2.8	1.9	0.3
11:19	34N	0.8	1.85	2.8	1.05	0.95

Note: Exits 94N and 96N values were recorded on a subsequent run.

There was a large variation in the distances the map was left on the display after passing the exit. Some of the variation was probably attributable to the fact that some exits are close together while others are further apart There is probably little reason for the map to be left on the display for even a small distance after the exit has been passed. If the exit is of interest to the driver, another map in the opposite diction will be presented should the driver turn around and come back to the exit of interest.

Table 13 presents the in-vehicle sign data and analysis. The distances before the exit when the sign appears is the difference between "Odometer at In-Vehicle Appearance" and "Odometer at Exit." Many of the distances are very small and would not serve well as notification that an exit is rapidly approaching. In one case (Exit 96N), the exit is passed before the sign appears.

4.3.4 Objective EX-1, System Performance Extendibility

4.3.4.1 Comments on Extendibility to Other Circumstances and Locations MOE

Extendibility of each of the ADAS services is discussed below.

Table 13 Distance Before Exit In-Vehicle Sign Appears

Exit	Odometer at Sign Appearance (miles)	Odometer at Exit (miles)	Distance (miles)
34S	0.8	0.9	0.1
33S	0.0	0.1	0.1
32S	0.2	1.0	0.8
31S	0.75	1.50	0.75
30S	0.15	0.55	0.4
26S	0.1	1.0	0.9
100,99S	0.25	0.85	0.6
97S	0.2	0.45	0.2 (1)
93S	0.1	0.45	0.35
94N	0.35	0.4	0.05
96N	0.8	0.65	-0.15(2)
98N	0.3	0.5	0.2
100N	0.25	0.75	0.5
101N	0.25	0.45	0.2(3)
103N	0.3	0.75	0.45
28N	.05	0.35	0.3
29N	0.0	0.45	0.45
31N	0.25	0.65	0.4
32N	0.2	0.6	0.4
33N	0.15	0.85	0.7
34N	0.55	1.2	0.65

Notes: 1. Sign is for Courtland, Freedom Parkway, Butler, 0.2 is distance to Courtland
2. Sign appeared after exit.
3. Sign reads N. Williams St. exit.

WADA To extend WADA to other locations would require radios that could automatically tune to any FM radio station. All encoding and modulation techniques would need to be standardized for all areas.

Two-Way Messages This service would be the easiest of the three to be extended provided the frequency and other vehicle interfaces were standardized. It could be extended in both location and circumstance. The location extendibility would require that the WAT antenna(s) be located and provided with sufficient power to cover the entire urban area (or rural area, if desired) so that coverage could be nearly 100 percent. An extended circumstance could be additional messaging capability by modifying the software to allow the vehicle to be in contact with its fleet dispatcher.

LADA The LADA is not easily extendible in the form implemented by ADAS. In ADAS, the service relied on unique frequencies being preset in the LATs and pre-programmed into the DPIU. Further, the system required differential GPS to be capable of tuning to the correct frequency for the nearest LAT. Current Roadway maps could be supplied provided the frequency problem could be solved. Traveler services updates would be more of a problem since businesses at interchanges along the Interstates frequently change. However, if the services could be updated and the frequency problem solved, the ADAS implementation could provide the service for any area.

4.3.5 Objective EX-6, System Performance Improvement

4.3.5.1 Comments on Improvement MOE

There were many areas needing improvement in ADAS. Several areas are identified below.

1. Better displays would be needed. The displays provided for the test vehicles could not be seen in even moderate sunlight.
2. Better positioning of the displays would be needed. The displays in the vehicles in this FOT were not optimized for the driver. Often they were well below the dash causing the driver to divert his attention from the roadway to view the display.
3. Several vehicles suffered electrical and/or frequency interference after the systems were installed in the vehicles. A thorough EMI/EMC study would be needed to ensure the system does not interfere with existing electronic and RF systems in the vehicles.
4. To divert the driver's attention from the roadway to the display, even if optimally placed, is dangerous. Synthetic voice assistance should be implemented for important functions to reduce risk.
5. Improvement is needed to increase the coverage for the WADA and Two-Way Message services. There should be nearly 100 percent coverage within the area designated to receive the service. For the WADA service, either use radio stations with better antennas and higher power that already broadcast to the area without drop-outs, or add more stations strategically placed to increase coverage. For the Two-Way Message service, either provide an equivalent single WAT and antenna with improved location and power, or increase the number of WATs and antennas to eliminate shielding.
6. Re-evaluate the five minute holding period for congestion and incident icons in the WADA service (when no signals are being received). In five minutes, traffic patterns can change rapidly, and in five minutes, vehicles can travel several miles with bad information.
7. A fully qualified, full-time operator is required for the system. The system operator must be capable of determining when correct, timely information is being supplied by the ATMS, and the system operator must have the capability to determine that the entire system is functioning. The operator must know that the signals are being broadcast and received throughout the covered area. Several satellite receiver systems strategically placed in the coverage area with feeds to the ASC operator could provide this information.

a. Often the in-vehicle signs and maps in the LADA service were late in being presented. Improvement would be needed in presenting the information further away from the exits to allow the vehicle driver sufficient time to react to the information presented.

9. Improved training should be provided to the vehicle drivers.
10. A more thorough post-installation checkout should be accomplished after vehicle installation.

5. RESULTS

This section presents the results of the system performance evaluation of ADAS by comparing the hypotheses to the data analysis.

5.1 OBJECTIVE SP-1, WADA SYSTEM PERFORMANCE

5.1.1 Probability of Receiving Messages by Geographic Sector MOE

Instead of 95 percent coverage with a probability of 0.6 or greater, the coverage was 47.6 percent. Coverage was better south and west of the radio stations with the northeast section of Atlanta having the poorest coverage.

5.1.2 Percent of All Messages Received MOE

The percentage of all messages received in the test sample was 58% instead of 99%.

5.1.3 STIC General Comments

The ADAS demonstrated a technical capability to:

- accept a data stream containing sub-segment congestion and incident information from an ATMS,
- use the ATMS sub-segment congestion and incident information streams to calculate congestion and incident data for segments of roadway,
- transmit a coded and modulated signal containing the congestion and incident iuformation from an existing FM radio station,
- receive that signal in a vehicle,
- demodulate and decode the signal, and
- display the results on a screen in the vehicle.

During the period when ADAS data was being collected, the ATMS was having problems in providing complete and timely data. The ATMS's Video Imaging Detection cameras were not yet operational, and other sources were used to collect the necessary traffic data. These other sources apparently could not provide thorough coverage of the entire area, resulting in situations where observed congestion was not reported via the ADAS.

There were frequent comments from the GDOT and FedEx POCs and drivers (both solicited and unsolicited) that reported the obvious ADAS performance problems during the FOT. Many of these problems seemed related to a lack of understanding of the purposes of an FOT and the conditions under which the ADAS was being developed and installed. The training provided to some of the drivers did not suffice to provide this understanding nor to motivate them to be interested participants in the test. The poor performance of the system during its initial stages seemed to demotivate some drivers. Installing the in-vehicle subsystem in phases without clearly describing what was happening to the drivers also seemed to demotivate them. These initial system performance problems appeared to leave avoidable negative impressions on the users. These comments do not represent a user acceptance analysis, but rather report the apparent user's perspective on ADAS system performance.

5.2 OBJECTIVE SP-2, TWO-WAY TEST MESSAGE SYSTEM PERFORMANCE

5.2.1 Tie Delay MOE

Drivers comments related to whether the system operated, not whether the system was timely. The results of calculations presented in Section 4 showed that the average tune to get a response when successful (notification to driver that message received by ASC) was 11.85 seconds and to get a response when unsuccessful (notification to driver that message did not get through) was 39.05 seconds.

5.2.2 Probability of Successful Messaging MOE

The probability of transmitting a test message and receiving a test response varies throughout the coverage area, and the overall probability is 69.7 percent.

5.2.3 Percent of Successful Messages MOE

As reported in Section 4, the total percent of successful messages was 69.7, which did not satisfy the hypothesis of 95 percent.

5.2.4 General Comments

The technical capability to send a two-way message (simulated mayday) from a vehicle to a computer in the TMC, and to send a response from the TMC to the vehicle, was demonstrated.

In most instances during this test, the vehicle was in motion. Since the vehicle was in motion, it had many opportunities to get a message to the TMC (11 by design), and an equal opportunity to get a message from the TMC to the vehicle. If a real mayday situation existed, the vehicle would probably not be in motion. If the vehicle were stationary, the location would entirely determine whether success could be expected Because of the long delay times in receiving au automated response in the vehicle, it is probable that, had the same number of test messages been sent from stationary vehicles, the number of successes would be much less than the reported 69.7 percent.

5.3 OBJECTIVE SP-4, LADA SYSTEM PERFORMANCE

5.3.1 LAT-To-Vehicle Communications Success and Services Accuracy MOE

Using differential GPS, a receiver in a vehicle can be tuned properly to receive a unique frequency from a transmitter within its vicinity as it travels along a road. Maps annotated with traveler services can be transmitted to vehicles traveling at Interstate speeds. The maps that are transmitted and annotated with traveler services can be made as accurate as desired by the provider.

5.3.2 **Lead** Time Before **Exit MOE**

Both in-vehicle signs and traveler service maps can be made available before the exits that they represent. However, this test did not demonstrate that they were provided sufficiently early to allow for safe reactions by the vehicle driver.

5.3.3 General Comments

ADAS demonstrated the technical capability to:

- develop freeway interchange maps containing traveler services,
- code the maps and services in software,
- send the coded data stream to a transmitter,
- modulate a transmitted RF signal with the data stream,
- use GPS to tune a receiver in a fast moving vehicle to receive the signal,
- demodulate the data stream from the modulated RF signal, and
- display the recreated map and services in the vehicle at predetermined locations.

During the test, it was found that two LAT transmitters (2 and 5) could not be received by the vehicle. It is probable that the transmitters could not be received because the STIC could not be received to update the GPS in the vehicle. From a systems perspective, establishing nearly 100 percent coverage for STIC would have eliminated this problem.

Errors discovered in the traveler services displayed on the maps in the vehicles would be easily corrected. However, the errors found indicate that any services function provided to vehicles must be constantly verified and updated as needed.

Many of the lead times for appearance of the in-vehicle signs and traveler service maps before the exits were considered to be too short. Adjusting the location in the software resident in the DPIU to have the signs and maps appear sooner could correct this problem.

5.4 OBJECTIVE **EX-1, SYSTEM** PERFORMANCE EXTENDIBILITY

5.4.1 Comments on Extendibility to Other Circumstances and Locations MOE

Before ADAS, or any other m-vehicle system, could be expected to be functional throughout the country, standards must be developed and future systems must be implemented according to those standards. Of the services provided by ADAS, the suggested order of implementation beyond Atlanta would be (based on ease of implementation):

- Two-Way Messages
- WADA
- LADA

5.5 OBJECTIVE EX-6, SYSTEM PERFORMANCE IMPROVEMENT

5.5.1 Comments on Improvement MOE

Improvement comments are provided in Section 4.