Expanded Satellite-based Mobile Communications Tracking System

Final Report

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

June 2007

FOREWORD

The Federal Motor Carrier Safety Administration's (FMCSA's) main goal is to save lives and reduce injuries in crashes involving commercial motor vehicles (CMVs) while enhancing the efficiency of commercial vehicle operations and improving the security of hazardous materials transport.

This project builds on two previous FMCSA tests of technologies focused on improving CMV security and efficiency: the Hazardous Materials Safety and Security Field Operational Test and the Untethered Trailer Tracking and Control System Pilot Test. In 2004, the Senate Conference Report 108-401 stated that further CMV tracking capabilities were necessary:

"As proposed by the Senate, the conference agreement directs $2,000,000 from funds provided for the high-priority initiative program for an expanded satellite-based communications system to monitor and track hazardous materials and high-value cargo in uncovered areas of the United States."

The present final report supersedes the Expanded Satellite-based Mobile Communications Tracking System Requirements Report of March 2007. This report summarizes the pilot test of a satellite-based mobile communications system in Alaska and Hawaii. The information in this document can be used by motor carriers and the public-sector emergency response and enforcement communities.

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FMCSA-RRT-07-008		

4. Title and Subtitle	5. Report Date
Expanded Satellite-based Mobile Communications Tracking System Final Report	**June 2007**
	6. Performing Organization Code
7. Author(s) Amy Houser (FMCSA); David Williams and Mala Raman (Battelle); and Derrick Vercoe, Peggy Erlandson, and Jennifer Wittpenn (QUALCOMM)	8. Performing Organization Report No.
9. Performing Organization Name and Address **Battelle Memorial Institute** **505 King Avenue** **Columbus, OH 43201**	10. Work Unit No. (TRAIS) 11. Contract or Grant No. **DTMC75-04-F-00105**
12. Sponsoring Agency Name and Address Department of Transportation Federal Motor Carrier Safety Administration **Office of Research and Analysis** 1200 New Jersey Ave. SE, Room 600 West Washington, DC 20590	13. Type of Report and Period Covered Final Report, January 2004 – January 2007 14. Sponsoring Agency Code FMCSA

15. Supplementary Notes
The program manager for this Federal Motor Carrier Safety Administration (FMCSA) project is Ms. Amy Houser.

16. Abstract

This U.S. Department of Transportation (USDOT) Federal Motor Carrier Safety Administration (FMCSA) project was authorized in the 2004 Senate Conference Report 108-401:

As proposed by the Senate, the conference agreement directs $2,000,000 from funds provided for the high-priority initiative program for an expanded satellite-based mobile communications system to monitor and track hazardous materials and high-value cargo in uncovered areas of the United States.

As a result, a regional assessment and 3-month pilot test was conducted to test a wireless, satellite-based mobile communications tracking system to monitor hazardous materials and high-value cargo in order to improve communications in certain regions of Alaska and Hawaii, where satellite-based tracking services were only partially available.

This document represents the Final Report for this pilot test of an Expanded Satellite-based Mobile Communications Tracking System.

17. Key Words	18. Distribution Statement
Asset Tracking System, Commercial Motor Vehicles, Efficiency, Hazardous Materials, Mobile Communications, Motor Carriers, Safety, Satellite, Satellite-based, Security, Tethered Tracking System, Tractor-Trailers	

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	**Unclassified**		**N/A**

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized.

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH					LENGTH		
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
		AREA					AREA		
in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.0016	square inches	in^2
ft^2	square feet	0.093	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.836	square meters	m^2	m^2	square meters	1.195	square yards	yd^2
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi^2	square miles	2.59	square kilometers	km^2	km^2	square kilometers	0.386	square miles	mi^2
		VOLUME					VOLUME		
fl oz	fluid ounces	29.57	milliliters	ml	ml	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	l	l	liters	0.264	gallons	gal
ft^3	cubic feet	0.028	cubic meters	m^3	m^3	cubic meters	35.71	cubic feet	ft^3
yd^3	cubic yards	0.765	cubic meters	m^3	m^3	cubic meters	1.307	cubic yards	yd^3
		MASS					MASS		
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.202	pounds	lb
T	short tons (2,000 lbs)	0.907	megagrams	Mg	Mg	megagrams	1.103	short tons (2,000 lbs)	T
		TEMPERATURE (exact)					TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8 C + 32	Fahrenheit temperature	°F
		ILLUMINATION					ILLUMINATION		
fc	foot-candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-lamberts	3.426	candela/m2	cd/m2	cd/m2	candela/m2	0.2919	foot-lamberts	fl
		FORCE and PRESSURE or STRESS					FORCE and PRESSURE or STRESS		
lbf	pound-force	4.45	newtons	N	N	newtons	0.225	pound-force	lbf
psi	pound-force per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	pound-force per square inch	psi

*** SI is the symbol for the International System of Units. Appropriate rounding should be done to comply with Section 4 of ASTM SI10-02**

ACKNOWLEDGEMENTS

The FMCSA Expanded Satellite-based Mobile Communications Tracking System Project included input from Government, public sector, and transportation industry professionals. FMCSA established a partnership with a review team comprised of participants from the Transportation Security Administration (TSA), Federal Highway Administration (FHWA), Maritime Administration (MARAD), Pipeline and Hazardous Materials Safety Administration (PHMSA), and Department of Defense (DoD). An expert panel comprised of stakeholders from Landstar, J.B. Hunt, GeoLogic Solutions, and Skybitz provided expert opinions and advice for this project. We appreciate the contributions of this group:

Elaine Chaudoin, J.B. Hunt	Tom Cuthbertson, GeoLogic Solutions, Inc.
Jay Folladori, Landstar	Sam Gill, Skybitz

A group of industry commercial carriers in Alaska and Hawaii contributed to the success of the pilot test. These carriers volunteered their time, personnel, and commitment in order to fulfill their roles. We offer sincere appreciation for their involvement and would like to recognize them individually. This project could not have been completed without their participation and substantial contributions.

Alaska West Express Fairbanks, AK	Dave Johnson John Jansen
Weaver Bros., Inc. Anchorage, AK	Allen (A.B.) Brown Dave Johnson Jerry South
Lynden Transport Anchorage, AK	Blaine Ghan Andy Collins Harry McDonald Lisa Marquiss Tammy Alexander
Shell Motiva Shell Oil Products, U.S. Honolulu, HI	Wayne Condit

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ACRONYMS

AKDOT	Alaska Department of Transportation
Alcan	Alaska-Canada Highway
AVL	Automatic Vehicle Location
BC	British Columbia
CMV	Commercial Motor Vehicles
DEM	Digital Elevation Model
DoD	Department of Defense
EAL	External Application Links
EIRP	Effective Isotropic Radiated Power
ESCT	Expanded Satellite-based Mobile Communications Tracking
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FOT	Field Operational Test
GEO	Geosynchronous Orbit
GIS	Geographic Information System
GPS	Global Positioning System
GSO	Geostationary Satellite Orbit
HazMat or HM	Hazardous Materials
HERO	Hazards of Electromagnetic Radiation Ordinance
ID	Identification number
Lat/Long	Latitude and Longitude
LEO	Low-Earth-Orbit
LTL	Less-Than-Truckload
MARAD	Maritime Administration
MDI	Mobile Data Interchanges
MEO	Middle-Earth-Orbit
MIPR	Mobile-Initiated-Position-Reporting
NMC	Network Management Center
NSS	New Skies Satellites
OOC	Out Of Coverage
OTA	Over-The-Air
PHMSA	Pipeline and Hazardous Materials Safety Administration
PLMRS	Private Land Mobile Radio Service
QoS	Quality of Service
RMA	Return Material Authorization

SCTG	Standard Classification of Transported Goods
SR	State Route
SMCT	Satellite-based Mobile Communications Terminal
TAPS	Trans-Alaska Pipeline System
TSA	Transportation Security Administration
USGS	U.S. Geological Survey
WMD	Weapons of Mass Destruction
WPB	Wireless Panic Button

EXECUTIVE SUMMARY

The Federal Motor Carrier Safety Administration's (FMCSA's) main goal is to save lives and reduce injuries in crashes involving commercial motor vehicles (CMVs), while enhancing the efficiency of commercial vehicle operations and improving the security of hazardous materials transport.

This FMCSA initiative was authorized in the 2004 Senate Conference Report 108-401:

As proposed by the Senate, the conference agreement directs $2,000,000 from funds provided for the high-priority initiative program for an expanded satellite-based mobile communications system to monitor and track hazardous materials and high-value cargo in uncovered areas of the United States.

As a result, FMCSA conducted a regional assessment and 3-month pilot test to test a wireless, satellite-based mobile communications tracking system to monitor hazardous materials and high-value cargo in order to improve communications both in Alaska and Hawaii, where satellite-based tracking services were only partially available. During the pilot test, an Expanded Satellite-Based Mobile Communications Tracking (ESCT) system was tested in the operations of five carriers along major routes in Alaska and Hawaii. For this project, the QUALCOMM wireless satellite-based mobile communications system was tested. The system included:

- Direct two-way data communication between the driver and the carrier with a driver interface unit for two-way text communications
- Position of the tractor with the time and date of the transmitted message
- Tethered trailer tracking
- Panic alerts

The equipment for this system is shown in Figure 1**.**

Figure 1. Technologies Installed for ESCT System Test

Commercial hazardous materials carriers in both Alaska and Hawaii participated in this pilot test. Carriers in Alaska included Alaska West Express (38 tractors), operating out of Fairbanks, and Carlile Transportation Systems (25 tractors and 20 trailers), Lynden Transport (12 tractors), and Weaver Brothers (25 tractors), all operating out of Anchorage. For the pilot test in Hawaii, Shell Motiva, a local fuel delivery carrier, operated a total of five trucks on the islands of Maui, Hawaii and Kauai. The carriers identified the primary routes on which commercial carriers transported hazardous materials and/or high-value loads in the regions.

During the pilot test, the ESCT systems installed on the participating trucks were set to record position locations once every 15 minutes. When a position location was recorded, an indication of the satellite communication status was also recorded. This status indicated whether the vehicle was in or out of coverage (OOC). All data sent to or received from the mobile units went through QUALCOMM's Network Management Center (NMC) in San Diego, California.

In addition to the automated data collection, a series of site visits was conducted to test the technologies and interview participants. Interviews with carrier drivers, dispatchers, and management personnel were structured to gauge the impacts of the technologies on operational environments, and the usefulness of the technology in daily operations and service to the carriers' customers. These interviews indicated that two-way communications were improved during the pilot tests in both Alaska and Hawaii. The Alaskan carriers indicated that prior to the pilot test, large areas in Alaska had no two-way communication coverage—specifically, much of the James Dalton Highway, significant portions of State Route (SR) 3 (between Fairbanks and Anchorage), and most of SR 2 and SR 4 were uncovered by commercially available terrestrial (cellular) communications.

With the use of the ESCT systems, spots remained for which OOC reports were received. Likely indicators of the causes for these continued OOC reports included mountainous terrain, man-made structures such as loading/unloading facilities, and oversized loads on trailers blocking the line of sight from the ESCT system to the satellite. Table 1 and Table 2 provide a summary of the total number of position reports and OOC reports collected during the pilot test.

Table 1. OOC Reports in Alaska by Route

Route Name	Total Miles	Total Position Reports	Total OOC Reports	Percentage of OOC Reports
Dalton Hwy	412	61,945	15,000	24
Route 1	531	26,808	1,466	5
Route 2	373	23,337	2,604	11
Route 3	323	22,005	2,733	12
Route 4	268	2,255	128	6
Route 6	142	295	16	5
Route 8	133	8	0	0
Route 9	37	124	3	2
Total	**2,219**	**136,777**	**21,950**	**16**

Table 2. OOC Reports in Hawaii by Route

Route Name	Total Miles	Total Position Reports	Total OOC Reports	Percentage of OOC Reports
Route 11	154	920	0	0
Route 19	56	1,247	0	0
Route 31	53	1	0	0
Route 36	16	673	0	0
Route 37	24	139	0	0
Route 50	33	234	13	6
Route 56	38	371	11	3
Route 190	39	48	0	0
Route 340	22	49	0	0
Route 360	33	0	0	N/A
Route 380	6	321	0	0
Route 550	19	0	0	N/A
Total	**493**	**4,003**	**24**	**1**

Despite certain gaps in coverage, the three tested technologies—satellite-based mobile communications, panic buttons, and tethered trailer tracking—had positive effects on both the safety and security of hazardous materials shipments in Alaska and Hawaii, compared to operations conducted prior to the use of the technologies. The two-way communication capabilities of the ESCT systems improved communications over a larger region than previously available, thereby improving operational safety and security. Drivers used the ESCT systems to request assistance from dispatchers, convey vehicle and road-related information (e.g., delays, weather conditions), and report delivery status to dispatchers. Dispatchers used the ESCT systems to respond to driver requests (both emergency and operational), manage their fleet movements, assign routes, and provide better visibility to their customers regarding shipment status. When emergency situations were encountered during the pilot test, dispatchers could respond quickly because the drivers used the panic button features, which provided two-way communication capability between them and their company dispatchers. Use of the tethered trailer tracking technology provided better visibility by supplying tracking and trailer status information (connected or disconnected) to the participating carrier.

With enhanced tracking capabilities for both trucks and trailers, carriers were able to improve their operations and their service to their customers. Better asset visibility allowed the carriers to provide more accurate delivery-time estimates, leading to better utilization of their overall fleet assets. More reliable delivery-time estimates helped the carriers schedule necessary loading and personnel resources at their terminals. As a result, these systems helped to improve the security and efficiency of carriers' operations in Alaska and Hawaii.

1.0 INTRODUCTION

The Federal Motor Carrier Safety Administration's (FMCSA's) main goal is to save lives and reduce injuries in crashes involving commercial motor vehicles (CMVs) while enhancing the efficiency of commercial vehicle operations and improving the security of hazardous materials transport.

Following the terrorist events of September 11, 2001, FMCSA and the trucking industry have been working toward securing trucking operations, particularly in the area of hazardous materials transportation. Reducing the vulnerability of truck operations to acts of violence is vital, since these motor carriers could be identified as potential targets of attack, used as a means of transferring destructive materials within the country, and used as weapons to attack other targets. In two previous FMCSA projects, several technologies have been tested and evaluated to improve the safety, security, and efficiency of CMV operations: the Hazardous Materials Safety and Security Field Operational Test (HazMat FOT) and the Untethered Trailer Tracking and Control Project. In these projects, vehicle and cargo tracking systems provided vehicle location information in the continental United States to a dispatcher on a regular basis with the added capability to provide information to carrier-authorized third parties, such as public sector agencies.

In 2004, the Senate Conference Report 108-401 stated that further tracking capabilities were necessary for CMVs:

> *"As proposed by the Senate, the conference agreement directs $2,000,000 from funds provided for the high-priority initiative program for an expanded satellite-based communications system to monitor and track hazardous materials and high-value cargo in uncovered areas of the United States."*

The primary purpose of the FMCSA Expanded Satellite-based Mobile Communications Tracking (ESCT) project was to pilot test a wireless, satellite-based mobile communications tracking system to track hazardous materials and high-value cargo and to improve communications in areas where satellite-based tracking services were not available or were partially available. In these locations, mobile satellite-based communications services may not have been widely deployed due to the unique geography of these regions or other factors. As a result, a major goal of this project was to test a system that could potentially improve communications along major routes in these regions during emergencies, while enhancing trucking operations. For this project, the QUALCOMM wireless satellite-based mobile communications system was tested. The system included:

- Direct two-way data communication between the driver and the carrier with a driver interface unit for two-way text communications; free-form, macro (formatted text messages) or binary messages (converted to binary form)
- Position of the tractor and time and date of the transmitted message
- Tethered trailer tracking
- Panic alerts

Key stakeholders included:

- Motor carriers that transport shipments from origin to destination
- Shippers that prepare and offer the shipments for transportation
- Receivers (consignees) who accept and verify the shipments at destination
- Federal, state, and local Government agencies that are concerned with the safety, security, inspection, regulation, and documentation of the drivers, vehicles, and shipments during transport

The regions selected for the project were Alaska and Hawaii. The largest state in the United States, Alaska is approximately 2.3 times the size of Texas and has nearly 13,000 total miles of highways and roads. Alaska's most important thoroughfare is the Alaska Highway, also known as the Alaska-Canada Highway or Alcan. This highway, approximately 1,390 miles long, runs from Dawson Creek, British Columbia to Fairbanks, Alaska. Route numbers include BC Highway 97, Yukon Highway 1, and Alaska Route 2. Figure 2 shows the Alcan Highway as Route 2 from Fairbanks into Canada.

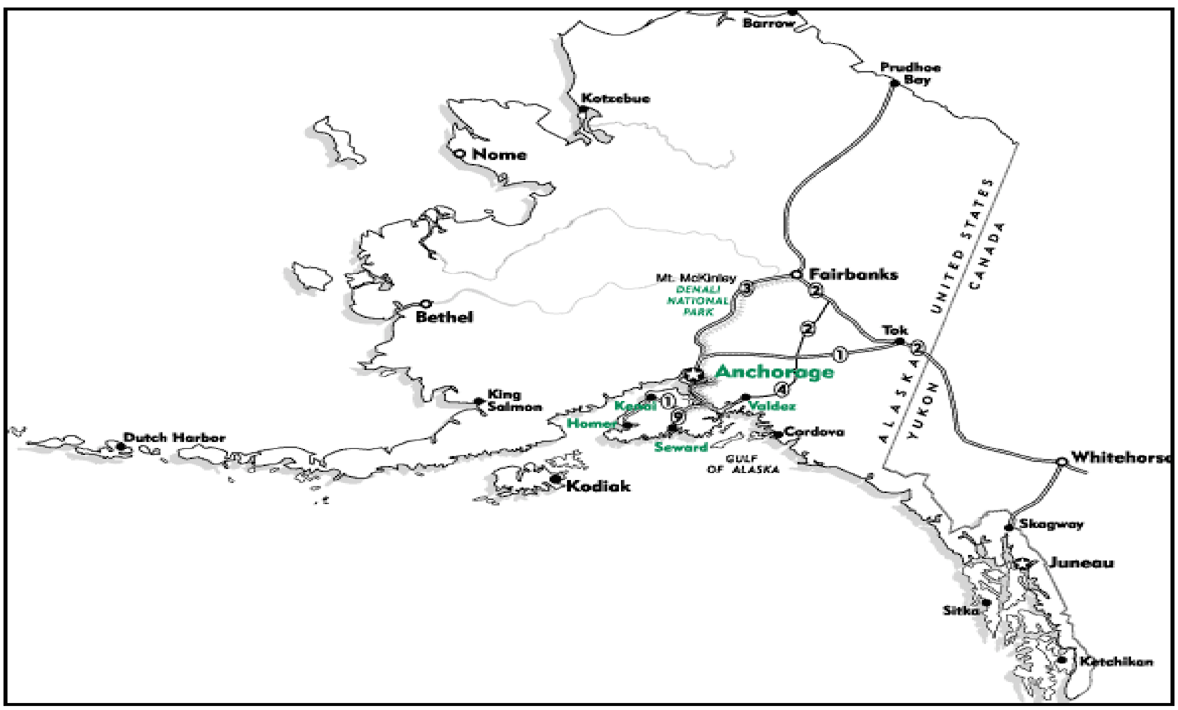

Figure 2. Alaska Highway (Alcan) Route 2

Source: Carlile Transportation Systems, 2006.

The James Dalton Highway in Alaska is a 414-mile stretch of road that parallels the northern-most section (Figure 3) of the 800-mile length of the Trans-Alaska Pipeline System (TAPS). The pipeline is vulnerable to potential sabotage or damage that could disrupt the flow of oil. In addition, the vast and harsh nature of the Alaskan region and the limitations in currently available communications systems make vehicle breakdowns and other emergencies potentially life-threatening situations in this region.

Figure 3. James Dalton Highway
Source: Carlile Transportation Systems, 2006.

While far smaller in size in terms of total land mass than Alaska, the Hawaiian Islands share a need for expanded satellite-based mobile communications to help address productivity, safety, security, and environmental concerns. There are more than 4,000 total miles of highways and roads in Hawaii. The mix of hazardous materials shipments in Hawaii mirrors that of Alaska and the continental United States.

To address these issues in Alaska and Hawaii, the ESCT pilot test was conducted for approximately 90 days from November 2005 through January 2006. Different configurations of ESCT system technologies were installed on 105 tractors. The trucks were utilized in the daily operations of four carriers in Alaska and one in Hawaii, each with different carrier operational profiles.

2.0 EXISTING REGIONAL CONDITIONS

Prior to initiating a pilot test, existing regional conditions were defined in Alaska and Hawaii to determine the need for ESCT systems, which included:

- Addressing the types and quantities of high-value and hazardous materials cargo transported in Alaska and Hawaii, and the carriers that haul them
- Addressing the unique geographic conditions in Alaska and Hawaii

2.1 GOODS TRANSPORTED IN ALASKA AND HAWAII

As shown in Table 3, trucks transport the highest tonnage of shipments in the United States, as compared to other modes. Similarly, in Alaska and Hawaii, commodities are primarily shipped by truck, as indicated in Table 4 and Table 5. For Alaska, these data refer to shipments that are carried to, from, and within Alaska. For Hawaii, these data refer to shipments transported within individual Hawaiian islands.

Table 3. 2002 U.S. Shipment Characteristics

Mode of Transportation	Tons (Thousand)	Percentage of Total Tons	Average Miles per Shipment
All modes	**11,667,919**	**100.0**	**546**
Single modes	**11,086,660**	**95.0**	**240**
Truck [a]	7,842,836	67.2	173
For-hire truck	3,657,333	31.3	523
Private truck	4,149,658	35.6	64
Rail	1,873,884	16.1	807
Water	681,227	5.8	568
Air (incl. truck and air)	3,760	Z	1,919
Pipeline [b]	684,953	5.9	N/A
Multiple modes	**216,686**	**1.9**	**895**
Other and unknown modes	**364,573**	**3.1**	**130**

a “Truck” as a single mode includes shipments that were made only by private truck, for-hire truck, or a combination of private and for-hire truck.
b Estimates for pipeline exclude shipments of crude petroleum.

Key for Tables: Z =an estimate equal to 0 or less than 1 unit of measure.
N/A = not applicable.

Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey.

Table 4. 2002 Mode of Transportation Shipment Characteristics for Alaska

Mode of Transportation	Tons (Thousand)	Percentage of Total Tons	Average Miles per Shipment
All modes	**36,498**	**100.0**	**166**
Single modes	**35,811**	**98.1**	**141**
Truck [a]	14,266	39.1	69
For-hire truck	7,139	19.6	179
Private truck	7,120	19.5	36
Rail	N/A	N/A	401
Water	1,529	4.2	376
Air (incl. truck and air)	42	0.1	1,063
Pipeline [b]	1,946	5.3	N/A
Multiple modes	**N/A**	**N/A**	**656**
Other and unknown modes	**N/A**	**N/A**	**N/A**

a "Truck" as a single mode includes shipments that were made only by private truck, for-hire truck, or a combination of private and for-hire truck.
b Estimates for pipeline exclude shipments of crude petroleum.

Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

Table 5. 2002 Mode of Transportation Shipment Characteristics for Hawaii

Mode of Transportation	Tons (Thousand)	Percentage of Total Tons	Average Miles per Shipment
All modes	**23,659**	**100.0**	**214**
Single modes	**18,971**	**80.2**	**69**
Truck [a]	11,494	48.6	13
For-hire truck	3,290	13.9	11
Private truck	8,011	33.9	13
Rail	Z	Z	Z
Water	547	2.3	480
Air (incl. truck and air)	13	Z	1,094
Pipeline [b]	6,919	29.2	N/A
Multiple modes	**4,259**	**18.0**	**1,277**
Other and unknown modes	**429**	**1.8**	**N/A**

a "Truck" as a single mode includes shipments that were made only by private truck, for-hire truck, or a combination of private and for-hire truck.
b Estimates for pipeline exclude shipments of crude petroleum.

Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

Table 6 and Table 7 summarize the types and quantities of commodities shipped within Alaska and Hawaii in 2002. Hazardous materials represent the majority of commodities transported in both states, a fact which supports the need for truck tracking capabilities for the secure movement of these types of cargo.

Table 6. 2002 Commodity Shipment Characteristics for Alaska

SCTG[a] Code	SCTG[a] Commodity Description	Tons (Thousand)	% of Total Tons	Value (Million$)	Average Miles per Shipment
17	Gasoline and aviation turbine fuel	9,487	26.0	2,257	108
18	Fuel oils	4,592	12.6	923	N/A
19	Coal and petroleum products	1,314	3.6	255	N/A
31	Non-metallic mineral products	1,153	3.2	128	56
15	Coal	1,147	3.1	34	255
05	Meat, fish, seafood, and their preparations	519	1.4	1,013	732
07	Other prepared foodstuffs, fats, and oils	212	0.6	183	157
	Commodity unknown	80	0.2	26	N/A
08	Alcoholic beverages	49	0.1	94	279
32	Base metal in primary or semi-finished forms and in finished basic shapes	46	0.1	57	103

[a] SCTG: Standard Classification of Transported Goods. There are 41 two-digit SCTG commodity codes.

Table 7. 2002 Commodity Shipment Characteristics for Hawaii

SCTG[a] Code	SCTG[a] Commodity Description	Tons (Thousand)	% of Total Tons	Value (Million$)	Average Miles per Shipment
17	Gasoline and aviation turbine fuel	6,294	14.1	1,899	N/A
18	Fuel oils	5,671	13.7	1,203	N/A
12	Gravel and crushed stone	4,061	8.9	55	N/A
31	Nonmetallic mineral products	2,535	8.1	224	N/A
07	Other prepared foodstuffs, fats, and oils	1,046	5.7	1,094	82
19	Coal and petroleum products	382	5.6	103	N/A
11	Natural sands	271	5.1	7	110
08	Alcoholic beverages	126	3.2	307	54
26	Wood products	109	2.3	159	N/A
24	Plastics and rubber	76	2.3	295	87

Source for Tables 6 and 7: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

2.1.1 Hazardous Materials and High-Value Loads Transported in Alaska and Hawaii

Alaska

The majority of the hazardous materials trucking carriers operating in Alaska transport flammable liquid products, as shown in Table 8.[1] According to the Bureau of Transportation Statistics and the U.S. Census Bureau, approximately 15.9 million tons of gasoline and aviation turbine fuel, fuel oils, and coal and petroleum products are shipped in Alaska. In addition, Class 1 munitions are also carried throughout the state, because of the military bases in Alaska.[2] The Alaska Department of Transportation (AKDOT) estimates that more than 800 commercial trucks over 12,000 lbs. (unladed empty weight) are authorized to carry hazardous materials in Alaska.

Table 8. Hazardous Material Shipment Characteristics by Hazard Class in Alaska: Percentage of Total for 2002

Hazard Class and Description		Tons (%)
Class 1:	Explosives	0.2
Class 2:	Gases	9.7
Class 3:	Flammable liquids	81.6
Class 4:	Flammable solids	0.5
Class 5:	Oxidizers and organic peroxides	0.6
Class 6:	Toxic (poison)	0.4
Class 7:	Radioactive materials	Z
Class 8:	Corrosive materials	4.1
Class 9:	Miscellaneous dangerous goods	2.8
Total*		**100**

*Total percentage may not equal 100%, due to independent rounding.

Key: Z = represents an estimate equal to 0 or less than 1 unit of measure.
Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

Hawaii

Approximately 40–50 percent of all hazardous materials transported in Hawaii are Class 3 petroleum products. According to the Bureau of Transportation Statistics and the U.S. Census Bureau, approximately 12 million tons of gasoline, aviation turbine fuel, and fuel oils are shipped in Hawaii. The second most common hazardous materials transported are Class 5 pesticides or oxidizers and Class 6 fertilizers. The transport of radioactive materials is less common throughout the state. Other types of hazardous materials hauled in Hawaii include Class 1 explosives (quantities of which fluctuate depending upon the level of development and

[1] From presentation at Intelligent Transportation System and Commercial Vehicle Operations Deployment Showcase, January 2003, Trish Hanlon, ITS/CVO Project Manager, Alaska Department of Transportation.
[2] Dan Breeden, Chief Commercial Vehicle Enforcement, AKDOT Commercial Vehicle Enforcement.

quarrying in Hawaii), Class 2.3 chlorine and ammonia, and Class 2.2 regular gases used for medical purposes.[3]

2.1.2 Types of High-Value Cargo Transported by Truck in Alaska and Hawaii

As with hazardous materials shipments in Alaska and Hawaii, high-value loads transported by trucks are not typically tracked or continuously monitored en route in these states.

Alaska

The AKDOT indicated that high-value goods transported through the state include equipment and Class 7 radioactive test materials going to the North Slope and oil fields. A number of electronics modules transported to Prudhoe Bay are high-value loads valued as high as $30 million to $40 million.[4] Table 9 shows the value of the commodities shipped within Alaska in 2002.

Table 9. 2002 Commodity Shipments in Alaska

Commodity (SCTG[a])		Value Million$
17	Gasoline and aviation turbine fuel	2,257
05	Meat, fish, seafood, and their preparations	1,013
18	Fuel oils	923
35	Electronic and other electrical equipment and components and office equipment	351
34	Machinery	294
36	Motorized and other vehicles (including parts)	292
19	Coal and petroleum products	255
07	Other prepared foodstuffs and fats and oils	183
33	Articles of base metal	129
31	Non-metallic mineral products	128

[a] SCTG: Standard Classification of Transported Goods. There are 41 two-digit SCTG commodity codes.

Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

3 John Bowen, Chairman of Hawaii Local Emergency Planning Commission (LEPC).
4 Dan Breeden, Chief Commercial Vehicle Enforcement, AKDOT Commercial Vehicle Enforcement.

Hawaii

Carriers in Hawaii provided a range of estimates for the dollar value that qualifies a load as "high-value." The estimates ranged from $60,000 to $2 million, depending on the size of a carrier's operation. Some loads with lower dollar values may be considered "high value," based on how the shipper or receiver perceives the value and importance of the cargo.[5] Interviews with a small number of carriers revealed the following types of high-value loads being shipped throughout the state: athletic shoes, electronics, batteries, beer, household goods, automobiles, auto parts, airplane fuselages, and military equipment.[6] Table 10 shows the value of commodities shipped within Hawaii in 2002.

Table 10. 2002 Commodity Shipments in Hawaii

Commodity (SCTG[a])		Value Million$
17	Gasoline and aviation turbine fuel	1,899
43	Mixed freight	1,847
18	Fuel oils	1,203
07	Other prepared foodstuffs and fats and oils	1,094
21	Pharmaceutical products	763
30	Textiles, leather, and articles of textiles or leather	752
35	Electronic and other electrical equipment and components and office equipment	692
40	Miscellaneous manufactured products	430
23	Chemical products and preparations	316
08	Alcoholic beverages	307

[a] SCTG: Standard Classification of Transported Goods. There are 41 two-digit SCTG commodity codes.

Source: Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

2.1.3 Vehicles Hauling Hazardous Materials

According to recent data available from AKDOT, 10,092 commercial trucks over 12,000 lbs. (unladed empty weight) were registered in 2002. Nearly 3,000 of these trucks are considered "heavy duty" (i.e., 26,000 lbs. or more, unladed empty weight). Approximately 11 percent of all commercial trucks in Alaska carried hazardous materials[7]; therefore, more than 1,100 commercial trucks over 12,000 lbs. are authorized to carry hazardous materials in Alaska. The 2002 U.S. Census reports that approximately 6 percent of the 5,200 registered commercial vehicles in Hawaii transport hazardous materials.

5 Clem Driscoll, C.J. Driscoll and Associates
6 Clem Driscoll, C.J. Driscoll and Associates
7 2002 U.S. Census

2.1.4 Estimated Number of Hazardous Materials and High-Value Loads

The total number of hazardous material loads that Alaskan and Hawaiian carriers haul in a month varies greatly. Based on interviews with typical fleets in Alaska and Hawaii, the estimated number of loads hauled per truck per month ranges from 10 to 60 loads. For example, an Alaskan carrier representative estimated that his company hauls only a few loads each month, but travels long distances.[8]

The percentage of loads that are hazardous materials and high-value loads varies greatly among the carriers in Alaska and Hawaii. For example, one of the carriers interviewed in Hawaii estimated that as few as 15 percent of its loads involve hazardous materials. However, the same carrier estimated that as many as 75 percent of its loads are high-value. One Alaska carrier indicated that it transports 100 percent hazardous materials.[9]

Many of the hazardous material loads in Hawaii are smaller loads not covered by the USDOT weight regulations—that is, loads which do not require placards.[10] This fact, combined with the fact that the states of Alaska and Hawaii do not require the monitoring and reporting of hazardous material loads, makes it difficult to accurately estimate the total number of hazardous material loads in these states.

2.1.5 Principal Ways in Which Trucks Are Routed

There are three primary ways in which carriers route their drivers:

- Fixed route: the same route with the same stops on a regular schedule—daily, weekly, or monthly
- Pre-scheduled for the day: the schedule for the driver is different every day, but still pre-planned
- Dynamic response: drivers are actively dispatched throughout the day

Based on a small set of interviews with carriers in Alaska and Hawaii, it seems that several fleets hauling hazardous materials and high-value goods pre-schedule the drivers' routes.

2.1.6 Average Length of Haul

The length of haul for a driver in Alaska ranges from 10 miles to 1,500 miles. The average number of miles per shipment for the top 10 commodities being shipped in Alaska is 241 miles.[11] Based on interviews of Hawaiian carriers, the length of haul ranges from approximately 75 miles to 100 miles. The average number of miles per shipment for the top 10 commodities being shipped in Hawaii is 83 miles.[12]

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8 Clem Driscoll, C.J. Driscoll and Associates
9 Clem Driscoll, C.J. Driscoll and Associates
10 John Bowen, Chairman of Hawaii LEPC
11 Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.
12 Bureau of Transportation Statistics (USDOT) and U.S. Census Bureau, 2002 Commodity Flow Survey, United States Data, Dec 2004.

2.2 GEOGRAPHIC FEATURES AND ROUTES OF ALASKA AND HAWAII

One reason that satellite-based mobile communications tracking systems have not been deployed on a large scale in Alaska and Hawaii has to do with the geographic features in these regions.

Alaskan and Hawaiian carriers and emergency responders describe the terrain as mountainous with gulches.

Alaska's geography can be categorized in four main areas, including two mountain ranges (the Pacific Mountain System and the Rocky Mountain System), a central plateau, and the North Slope or coastal plain. The Pacific Mountain System runs from the Aleutian Islands down through south-central Alaska and down the Pacific coast to southern California. The Rocky Mountain System consists of glacier-made mountain peaks that rise to 9,000 feet above sea level in the east, with lower elevations in the west. The central plateau is located between the Pacific Mountain System in the south and the Rocky Mountain System of Alaska in the north. The North Slope lies north of the Rocky Mountain System and slopes gradually toward the Arctic Ocean.[13] The highest point in Alaska is Mt. McKinley; the lowest is the point at which the state meets the Pacific Ocean, the Bering Sea, and the Arctic Ocean.

The Hawaiian Islands are approximately 2,400 miles southwest of the continental United States. Comprised of eight main islands, Hawaii stretches 1,523 miles and covers 10,932 square miles. Since the islands were formed by volcanoes, they contain several mountains and valleys. The highest point in the state is Mauna Kea, reaching 13,796 feet; the lowest point is at sea level.[14]

Throughout these mountainous regions, goods are transported via roads through both remote and industrial areas. In Alaska, the routes are more dangerous and include gravel surfaces on roads that lead to the more remote areas. For example, the only road leading to Prudhoe Bay is unpaved, and becomes extremely dangerous during the spring and fall when the road is wet and the ground is soft.

2.2.1 Movement of Goods to Other Regions

According to the AKDOT, Alaska receives more cargo from and through Canada than it ships out by truck. Although oil and fish constitute the majority of shipments out of Alaska, these items are not typically moved via truck.[15] Because Hawaii is comprised of islands, transportation of hazardous materials to other regions is via maritime systems and air transport.

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13 Source: www.netstate.com.
14 Source: www.netstate.com.
15 Dan Breeden, Chief Commercial Vehicle Enforcement, AKDOT Commercial Vehicle Enforcement.

3.0 MOBILE COMMUNICATIONS SYSTEMS IN ALASKA AND HAWAII

To determine the most feasible type of ESCT system for this project, research was conducted in the broad area of vehicle communications and the specific area of satellite communications.

3.1 BACKGROUND

A wide range of communications systems have been available and used by fleets in the United States for over 30 years. These communications systems range from mobile radio, which has been available for over 30 years, to analog, which has been available for over 20 years, to paging networks which have been available for over 10 years. Mobile communications tracking systems, sometimes referred to as automatic vehicle location (AVL) systems, were introduced in the 1980s and have been in use since that time.[16] As shown in Figure 4, mobile communication systems can be broadly categorized depending upon the method of delivery: terrestrial-based, (i.e., data over cellular telephony, private land mobile radio service (PLMRS), and packet radio), and satellite-based.

Terrestrial mobile communications refers to a class of communications in which the transmitters and receivers are located on the ground using cellular towers. Satellite-based mobile communications are a class of communications in which there is a set of transmitters and receivers located in a satellite orbit. A communications satellite is a radio relay station in orbit above the earth that receives, amplifies, and redirects analog and digital signals carried on a specific radio frequency. Communications data passes through a satellite using a signal path known as a transponder. Typically, satellites have between 24 and 72 transponders. A single transponder is capable of handling up to 155 million bits of information per second.

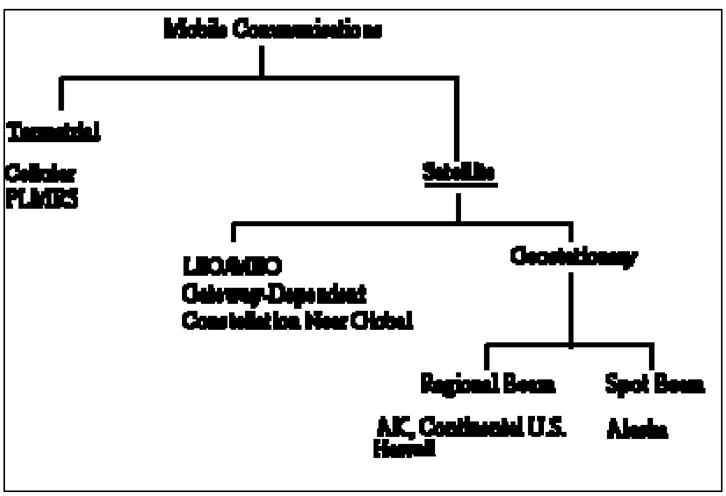


Figure 4. Methods of Providing Mobile Communications

16 U.S. Fleet Automatic Vehicle Location (AVL) System Market & Suppliers, C.J. Driscoll & Associates, Feb 2003.

In general, satellite communications are well-suited to providing blanket communications over large land masses where it would be impractical or economically limiting to do so with terrestrial systems. Satellite systems are categorized according to the orbit(s) which they occupy. Low Earth Orbit (LEO) systems typically use a constellation of low-powered satellites that can provide global coverage when equipped with Gateway Earth Stations. These satellites are in a polar orbit at an altitude of a few hundred kilometers, in which each revolution takes between 90 minutes and a few hours. The satellites in a LEO swarm are strategically spaced so that from any point on the surface, at least one satellite is always on a line of sight. A LEO satellite system allows the use of simple, non-directional antennas, offers reduced latency, and does not suffer from solar fade.

A geostationary satellite is an Earth-orbiting satellite, placed at an altitude of approximately 22,300 miles directly over the Equator, which revolves in the direction of the Earth's rotation (west to east). At this height, these satellites rotate around the Earth at the same speed as the Earth rotates around its axis; in that way, the satellites remain stationary above a point on the Earth (normally directly above the Equator). Satellites in geostationary satellite orbit (GSO) are typically high-powered satellites with spot beams that provide localized coverage, regional beams that often contour to a country or a specific region of interest, or hemispheric beams that cover up to one-third of the Earth from a single orbit. A geostationary satellite can be accessed using a directional antenna aimed at the spot in the sky where the satellite appears to hover.

Middle-Earth-Orbit (MEO) systems orbit the Earth at a height between 1,000 and 22,300 miles above the Earth's surface. Since MEO satellites are closer to the Earth than geostationary satellites, Earth-based transmitters with relatively low power and modest-sized antennas can access the MEO system. Because MEO satellites orbit at higher altitudes than LEO satellites, the useful footprint (coverage area on the Earth's surface) is greater for each MEO satellite. MEO satellites are mainly used in global positioning systems (GPS) and are not stationary in relation to the rotation of the Earth.

The geographic area of the Earth's surface to which a satellite can transmit, or from which it can receive, is called the satellite's "footprint." The footprint can be tailored to include beams with different frequencies and power levels. Satellites transmit information within radio frequency bands. The frequency bands most frequently used by satellite communications companies are called C-band and the higher Ku-band. There are advantages and disadvantages of each with respect to cost, path diversity, and the complexity of the mobile communication equipment used.

3.2 COMMUNICATIONS SYSTEMS CURRENTLY USED IN ALASKA AND HAWAII

To evaluate the feasibility of testing ESCT systems in specific regions, preliminary research was conducted to determine existing communications systems for CMV carriers in Alaska and Hawaii and to assess the need for improved communications. GPS tracking of any kind was not widely deployed, according to carriers and state agencies interviewed in Alaska and Hawaii.[17] State agencies indicated that cell phones and two-way radios were the drivers' primary modes of communication in case of an emergency or a hazardous materials incident. In such a situation, the driver would typically place a call to 911 via cell phone, and the 911 operators would dispatch the first responders.[18] Based on several interviews with Alaskan and Hawaiian carriers who rely primarily on cell phone communications with drivers, only about 30 percent are using automated dispatch software.[19]

In Alaska, there are also approximately 1,100 licensed operators of PLMRS systems, which are effective for short-haul voice and data communications for a wide range of applications, such as transportation, emergency services, and ship-to-shore communications. However, these bands are often congested. Interference is common, and the range, which depends upon propagation conditions and the availability of repeaters (i.e., receivers/transmitters usually located on hilltops, to extend the coverage of PLMRS), makes this service unsuitable for critical applications that require guaranteed receipt of mobile communications.

In Hawaii, voice and data communications are possible throughout the main highways from cellular telephone service and PLMRS. The geographic area is small and the costs of providing service are reasonable. This is in sharp contrast to Alaska, which includes many thousands of uninhabited square miles and whose overall population density is very low. Nevertheless, regions throughout the Hawaiian Islands are not well serviced by terrestrial communications, and satellite communications offer the advantage of contiguous coverage.

While some carriers in Alaska and Hawaii were reasonably satisfied with their communication methods, carriers also commented about gaps in mobile communications coverage in parts of both states. These carriers relayed challenges, such as inability to reach drivers, dispatch centers via two-way radios, or first responders in a timely manner.[20] Also, the AKDOT noted that cell phone coverage suffers from communications gaps in areas such as the Glenn Highway from Anchorage to Fairbanks, on which there are 30- to 40-mile stretches offering no coverage.

As a result, Alaska and Hawaii represented important regions to examine to track hazardous materials and high-value loads with satellite-based mobile communications systems.

For the pilot test in these states, the QUALCOMM satellite-based mobile communications deployed in the continental United States could not provide sufficient service quality without modification of the system's terminal. Figure 5 shows the satellite coverage in the continental

17 Clem Driscoll, C.J. Driscoll and Associates.
18 Kaumana Fire Department.
19 Clem Driscoll, C.J. Driscoll and Associates.
20 Clem Driscoll, C.J. Driscoll and Associates.

United States using the mobile unit system with the current AMC-3 satellite provider, whose coverage does not reliably extend service to Alaska and Hawaii.

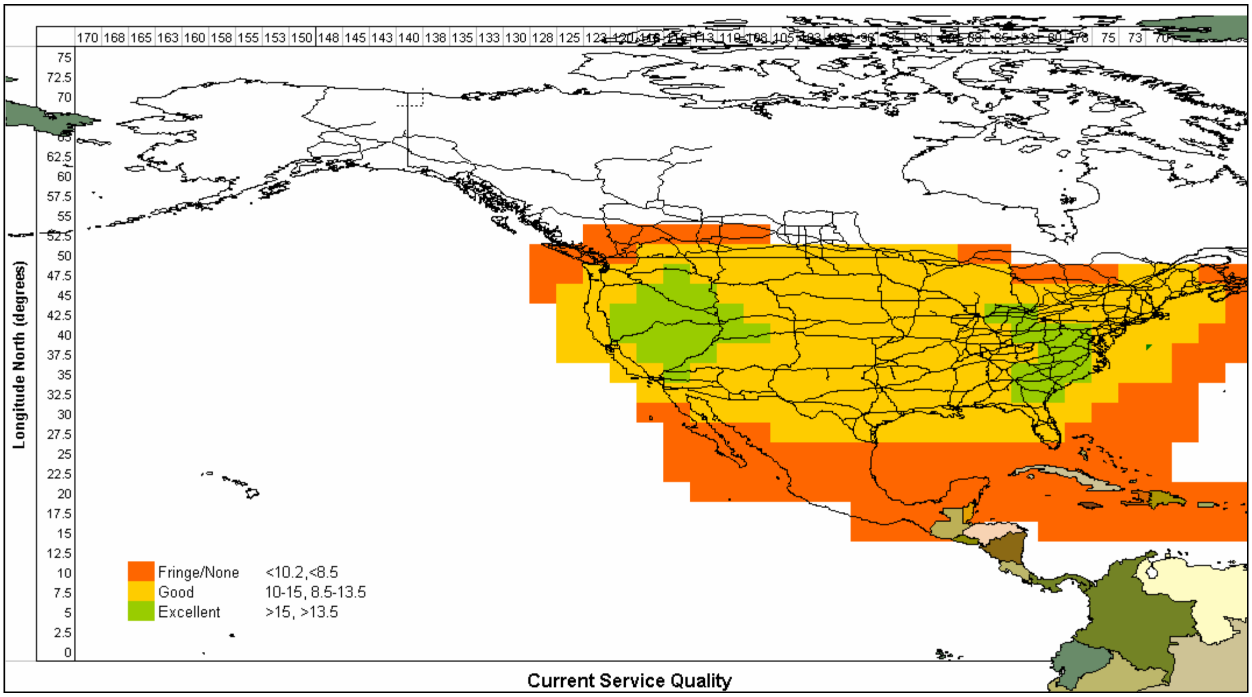


Figure 5. AMC-3 Satellite Coverage for the QUALCOMM Mobile Communications System

Source: Qualcomm, 2004.

3.3 SATELLITE COVERAGE FOR ESCT SYSTEMS

Several different types of satellite coverage were evaluated for the QUALCOMM ESCT systems that would be tested in this project. LEO constellations often have the advantage of providing path diversity by having more than one satellite available for communication, which is attractive for mobile satellite applications. This is an important technical advantage over geostationary systems in general and in particular at high latitudes, where the elevation angle to the satellite is low and the probability of horizon blockage increases. However, while the LEO satellite systems may have advantages of path diversity over GSO satellite systems, the cost of providing LEO satellite service over large areas was determined to be prohibitively high, unless there were high traffic demands. As a result, GSO satellite systems providing spot and regional beam coverage were investigated for use in this project.

First, service providers of spot beam coverage were considered. Spot coverage was offered by New Skies Satellites (NSS) on its NSS-5 satellite. This particular beam had six 36 MHz transponders, yet the decision to steer the beam to cover Alaska depended upon NSS's ability to readily sell services on those transponders, which it considered unlikely. Figure 6 shows the coverage that could have been provided by the NSS-5 satellite with the beam steering option.

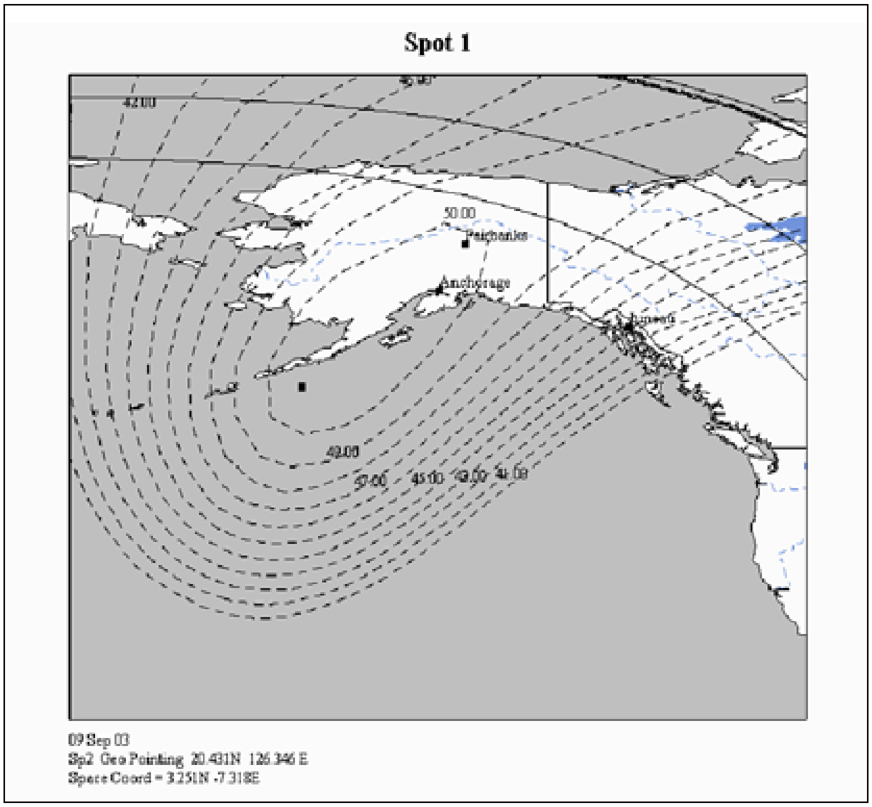


Figure 6. NSS-5 Satellite Coverage in Alaska

Source: QUALCOMM, 2004.

If this solution were selected, the transponder costs would be high, because of NSS's inability to readily sell services on those transponders if the beam were moved to point at Alaska. That being the case, and given the limited traffic density possible from an Alaska-only beam, this solution would not be cost-effective in the long term.

For these reasons, the spot beam solution was not considered further, and satellites with regional coverage of the continental United States and Alaska were investigated. Table 11 provides a review of current GSO satellites that provide regional coverage in Alaska.

Table 11. Current Satellites Providing Coverage in Alaska

Name	Location	Operator	Comments
AMC-16	85W	SES Americom	Elevation angle unfavorable
IA5	97W	INTELSAT	Full transponder power needed
AMC-15	105W	SES Americom	Not available
Galaxy 10R	123W	PanAmSat	Best match
Horizons 1	127W	PanAmSat	Second best match
IA7	129W	INTELSAT	Full transponder power needed

AMC-16 had the highest level of effective isotropic radiated power (EIRP), but because of its location at 85W, its use would result in very low elevation angles. AMC-15, exclusively used for a Direct-2-Home Internet service, had high power and reasonable location. Two INTELSAT satellites, IA5 and IA7, required the full transponder power to reach the edge of the service area and were not favorable economically.

In comparison, the beams on two PanAmSat satellites, Galaxy 10R and Horizons 1, reached the edge of the service area at Prudhoe Bay, and the use of high-power transponders meant that the service could be operated using half of the transponder power, providing an acceptable economic solution. Figure 7 shows the EIRP contours for the Galaxy 10R satellite, which are a measure of the signal strength radiated from the satellite. For reliable service, the EIRP needed to be 44 dBW or better throughout the desired service area, where dB is decibels and W is watts. At Prudhoe Bay, the signal strength just met this requirement, because of a difficulty of generating high signal strength at areas close to the North Pole. As a result, the Galaxy 10R GSO satellite with regional beam coverage was selected for use in this project.

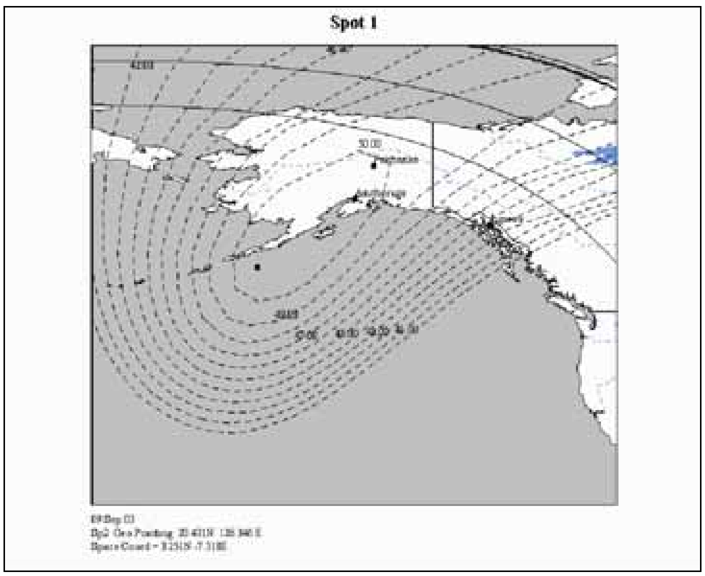


Figure 7. Galaxy 10R EIRP Contours

Source: QUALCOMM, 2004.

4.0 PRELIMINARY DRIVE TESTS IN ALASKA AND HAWAII

Prior to the initiation of the 3-month pilot test for this project, limited preliminary drive tests were conducted during October and November 2004. A drive test involved installing satellite-based mobile communications tracking systems on one or two vehicles, calibrating the units to report on similar reporting cycles, and driving these vehicles over prescribed routes to collect preliminary data.

Two tests were conducted for validation of Galaxy 10R satellite coverage of the major areas in Alaska and Hawaii. The Alaska drive test consisted of two vehicles with two satellite-based mobile communications tracking systems on each vehicle. One satellite mobile communications tracking system was the standard mobile unit used in the continental United States, and the second contained a reconfigured antenna and a 2W-power transceiver. The vehicles were driven along a predetermined route that covered the major highways in Alaska. A quality of service (QoS) test determined whether any modifications to the system's antenna were required so that it could acquire and maintain the satellite signal. In addition, some preliminary testing was done to determine the approximate coverage provided by the satellite (i.e., satellite footprint).

The Hawaii drive test involved one vehicle with two satellite-based mobile communications tracking systems. One satellite mobile communications tracking system was the standard mobile unit used in the continental United States and the second contained a reconfigured antenna and a 2W-power transceiver.

4.1 TEST METHODOLOGY

During the preliminary drive tests, QUALCOMM and PanAmSat performed calculations to ensure that there was enough power and bandwidth to provide communications with a defined QoS (link budget test), so as to determine whether QUALCOMM's off-the-shelf mobile communications equipment would meet coverage requirements for service in both Alaska and Hawaii.

The engineering analysis showed that, in addition to using PanAmSat in place of QUALCOMM's continental U.S.-based satellite provider, modifications included:

- **Optimizing the mobile unit antenna for coverage in Alaska.** This required a design and development effort to lower the elevation angle of the antenna to maximize the signal strength throughout Alaska, and to prevent signal drop-outs if vehicles were not level (i.e., trucks on steep hills).
- **Using a higher-powered 2W transceiver.** The conventional unit sold commercially by QUALCOMM for use in the continental United States uses a 1W transceiver. This higher-powered, 2W transceiver was needed to ensure that reliable communications from the mobile unit to the satellite could be guaranteed at the edge of the service area in northern Alaska, where the sensitivity of the satellite was weakest. The 2W receiver was also required in the ESCT systems tested in Hawaii.

Based upon the mobile unit antenna reconfiguration and the preliminary drive tests, the quality of service for Alaska and Hawaii was re-calculated as shown in Figure 8.

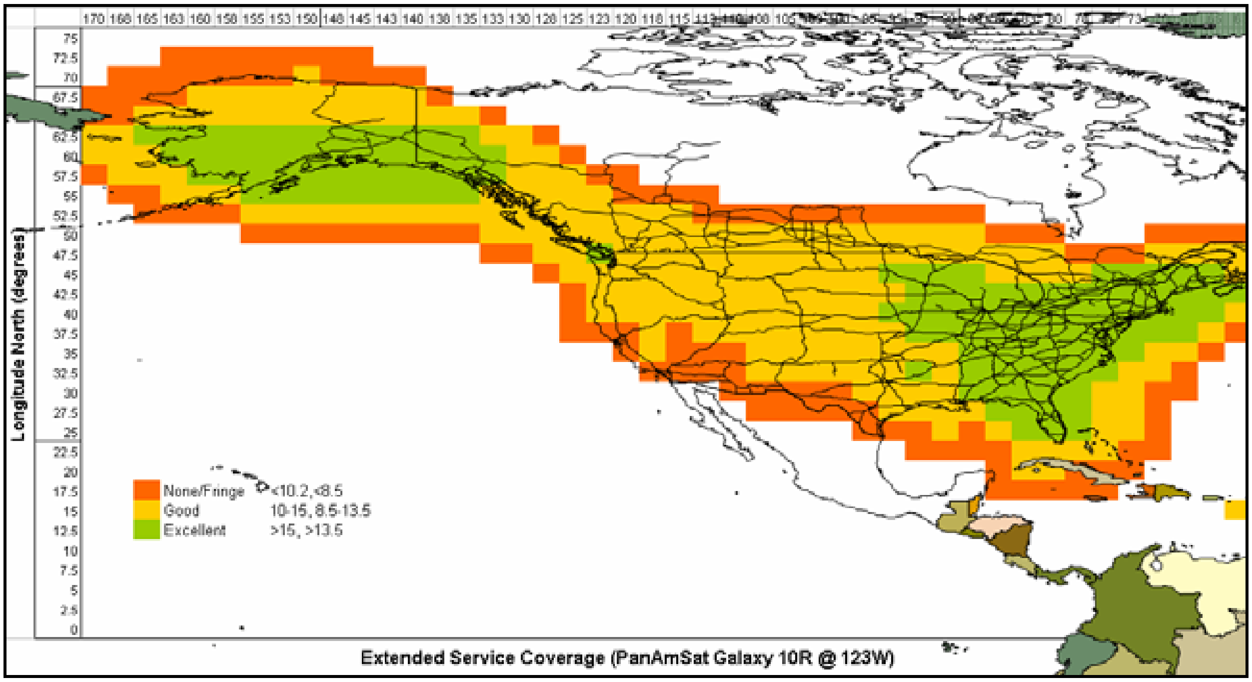


Figure 8. Extended Service Quality

Source: QUALCOMM, 2004.

During the fall 2004 drive tests, the performance of each mobile unit was monitored several times per day. In the mobile unit system, all airlink parameters (E_b/N_0 [a measure of signal strength—energy per bit per noise power spectral density], number of re-transmits and position, etc.) were automatically recorded in a comprehensive file for each mobile unit. To obtain a good sample of signal strengths, each mobile unit was configured for the fast mobile-initiated-position-reporting (MIPR) mode for the test. Each mobile unit reported its position and signal strength every 15 minutes for a subsequent analysis of signal strength. The drivers also sent messages to the test manager regarding terrain descriptions, which helped to correlate unexpected signal strengths with time-of-day and/or position.

4.2 PASS/FAIL CRITERIA

The mobile unit air link required that both the forward and the return links meet specified minimum signal strengths, measured in E_b/N_0 , for the system to work. These minimum level limits were:

- Forward link $E_b/N_0 > 9.0$ dB
- Return link $E_b/N_0 > 7.5$ dB

Yet commercial mobile communication services could not be offered unless there were a 2–3 dB margin in each link, where the minimum E_b/N_0 values for service, and the pass/fail criteria for all systems, were:

- Forward link $E_b/N_0 > 11.0$ dB
- Return link $E_b/N_0 > 9.5$ dB

Improving the forward link involves using more transponder power, while improving the return link involves using more mobile unit power.

4.3 DRIVE TEST RESULTS—ALASKA

Figure 9 shows the drive test route in Alaska. The red crosses on the map indicate position reports received over the air from the test vehicle.

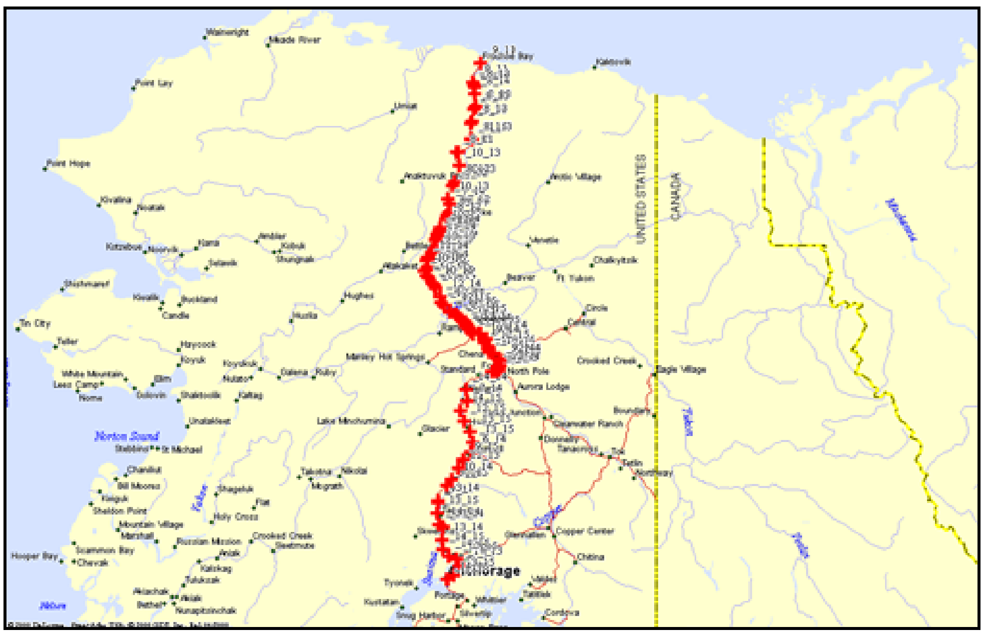


Figure 9. Drive Test Route for Alaska

Source: QUALCOMM, 2004.

4.3.1 Coverage Results Using PanAmSat Galaxy 10R Satellite and the Reconfigured Mobile Unit

Figure 10 shows the signal strength results from the ESCT systems that were tested in the Alaska drive tests. These histograms show the frequency of occurrence on the vertical axis plotted against signal strength on the horizontal axis. Two plots are provided, one each for the forward and return links, including the pass/fail limits. As indicated, the signal strengths for both the forward and return link measurements were above the pass limit.

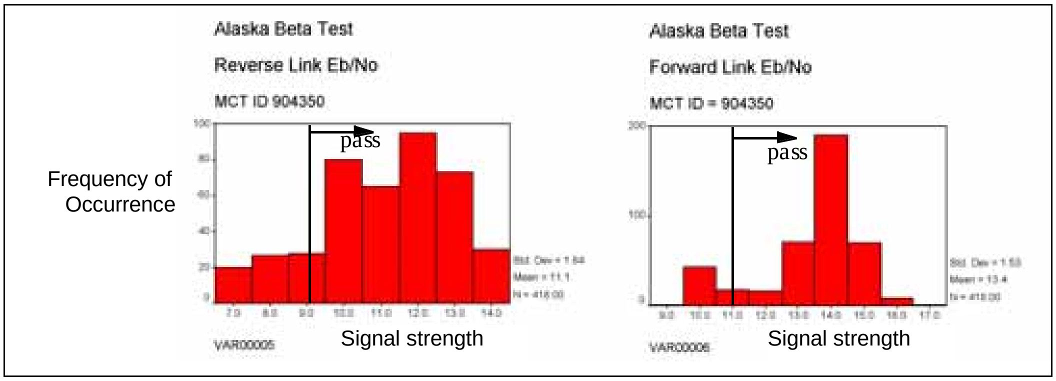


Figure 10. Performance Using Galaxy 10R and 2-Watt Mobile Unit in Alaska

Source: QUALCOMM, 2004.

As shown in Table 12, the drive test results revealed that reliable performance was possible using the ESCT system with an antenna optimized for service quality in Alaska. The test data were from the "worst case" part of the service area with respect to satellite G/T and pointing angle. (G/T refers to the gain to noise temperature ratio, which is a measure of satellite receiver sensitivity.) In all cases, there was sufficient signal strength to close both the forward and the return links (E_b/N_0 = 9.0dB and 7.5 dB, respectively).

Table 12. Signal Strengths Using Galaxy 10R in Alaska

Link Direction	Measured E_b/N_0 (mean)	E_b/N_0 to Close Link	E_b/N_0 Commercial Service	% of Measurements Below Minimum
Reverse	11.1 dB	7.5 dB	9.5 dB	11.2%
Forward	13.4 dB	9.0dB	11.0 dB	10.5%

4.4 DRIVE TEST RESULTS—HAWAII

The routes driven in the drive tests in Hawaii on the islands of Oahu and Hawaii are shown in Figure 11 and Figure 12. These routes represented the major roads throughout Oahu and Hawaii, including some minor roads that lead to military bases. The red crosses on the maps indicate position reports received over the air from the test vehicle.

Figure 11. Oahu Fall 2004 Drive Test

Source: QUALCOMM, 2004.

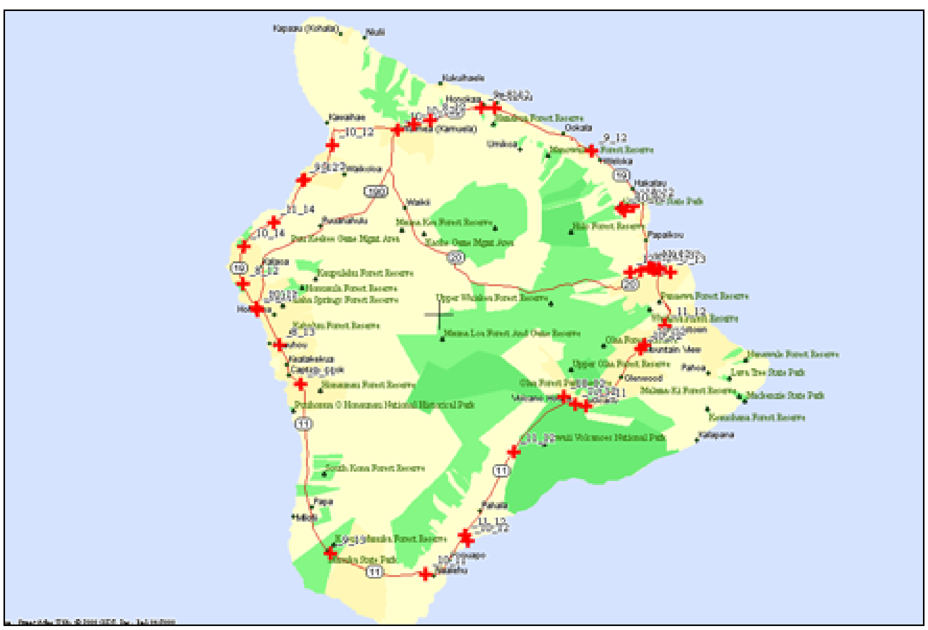


Figure 12. Hawaii Fall 2004 Drive Test

Source: QUALCOMM, 2004.

4.4.1 Coverage Results Using PanAmSat Galaxy 10R Satellite and the Reconfigured Mobile Unit

Figure 13 shows the signal strength results from the reconfigured mobile unit that was used for the test.

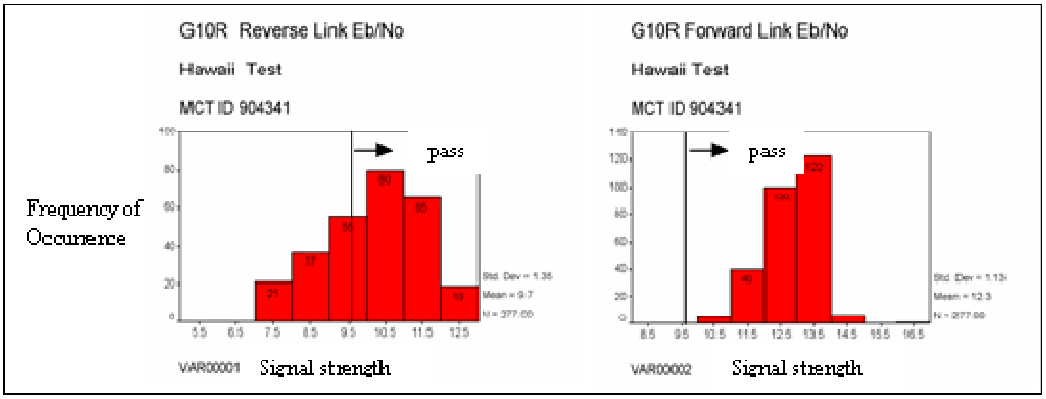


Figure 13. Performance Using Galaxy 10R and 2-Watt Mobile Unit in Hawaii

Source: QUALCOMM, 2004.

As shown in Table 13, the data collected from the drive test revealed that signal strength were sufficient to close both the forward and return links (E_b/N_0 = 9.0dB and 7.5 dB, respectively).

Table 13. Signal Strengths Using Galaxy 10R in Hawaii

Link Direction	Measured E_b/N_0 (mean)	E_b/N_0 to Close Link	E_b/N_0 Commercial Service	% of Measurements Below Minimum
Reverse	9.7 dB	7.5 dB	9.5 dB	20.9%
Forward	12.3 dB	9.0 dB	11.0 dB	17.0%

Comparing the results against the values set for commercial service shows that a maximum of 20.9 percent of the measurements were below the commercial threshold line. However, this was acceptable, since the re-transmission scheme causes the messages to be re-sent and delivered in both directions.

4.4.2 Summary of Drive Tests and Analysis

Since the commercial deployment of its satellite-based mobile communications systems, QUALCOMM has performed extensive analyses of satellite coverage in the continental United States using not only independent testing, but also coverage data received from carriers. Those analyses revealed that, as long as the mobile equipment was in the line of sight of the applicable satellite, there was ubiquitous coverage of the continental United States.

Data obtained from the series of drive tests showed that the existing QUALCOMM satellite-based mobile communications systems deployed in the continental United States did not adequately cover Alaska and Hawaii. These drive tests of the QUALCOMM satellite-based mobile communications system verified that while the PanAmSat Galaxy 10R satellite provides sufficient coverage in Alaska and Hawaii, the geographical coverage does not extend throughout the continental United States.

In order to provide satellite-based communications throughout the entire United States with the QUALCOMM satellite-based mobile communications system, two separate satellite providers and two different configurations of mobile units were required. The ESCT system tested in Alaska required a low-look antenna and a 2W transceiver. Figure 14 provides a graphical depiction of the modified "look angle" reduced from 0 to approximately 30 degrees above the horizon required for satellite communications in Alaska. The standard QUALCOMM mobile communications system used in most of the continental United States has a look angle from 0 to approximately 45 degrees above the horizon. The ESCT systems tested in Hawaii did not require a low-look-angle antenna, because Hawaii is much farther south than Alaska. However, these systems did require the use of the higher-powered 2W transceiver.

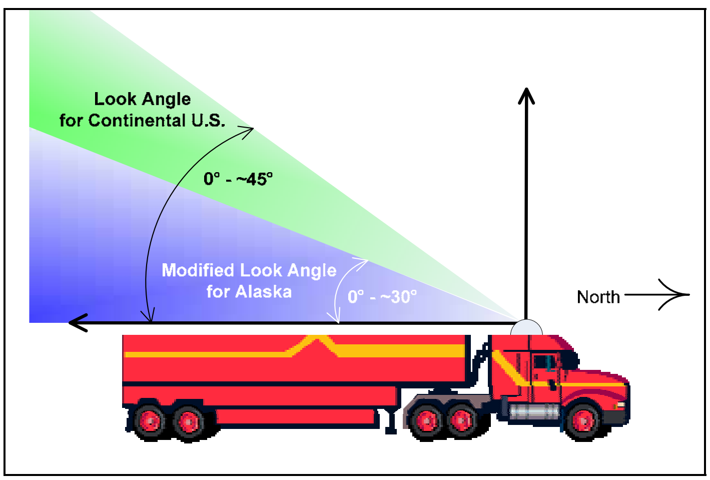


Figure 14. Modified Look Angle for QUALCOMM ESCT System

5.0 TECHNOLOGIES

The ESCT system pilot test included a variety of technologies consisting of hardware, software, and network subsystems. This section provides descriptions of these technologies. Table 14 gives an overview of the functional requirements for the ESCT system tested in this project. Appendix A provides further details about the functional requirements met by the technologies tested in the ESCT system pilot test.

Table 14. Top-Level Requirements Overview

1.	**Messaging**—The system shall provide the ability to send and receive text messages and macros (pre-formatted messages) between dispatchers and the tractors.
2.	**Location and Mapping of Tractors**—The system shall provide a mapping of tractor locations. It shall provide a location history for a tractor with mapping.
3.	**Location and Mapping of Tethered Trailers**—The system shall provide trailer location updates from tractor positions when tethered.
4.	**Times and Positions of Trailer Connections and Disconnections**—The system shall provide time and position messages for connection and disconnection events.
5.	**Panic Button Alerts**—The system shall automatically send out a panic message displaying time, date, and location of the tractors.

For the pilot test, QUALCOMM provided their satellite-based mobile communications and tracking system, panic buttons, and tethered trailer tracking system. The technologies that comprised the ESCT system are summarized in Table 15, and their features are described below.

Table 15. ESCT System Provided by QUALCOMM

Product Name	Functional Capability
OmniTRACS	• Satellite-based wireless communication, vehicle tracking, and messaging • Over-the-air (OTA) messaging protocols
Tethered Trailer Tracking Unit	• Tethered trailer tracking • Accurate time and location identification of trailer/tractor connections and disconnections
Panic Buttons	• In-cab and wireless panic alerts
Network Communications	• Satellite link provided over the Galaxy 10R geostationary Ku-band satellite with coverage of Alaska and Hawaii
Network Management Center	• OTA messaging protocols • Customer Interface Protocol and Network Management Infrastructure
QTRACS and TrailerTracs Customer Application Software	• Tractor Mobile Communications Tracking System Customer Site Application • Trailer Mobile Communications Tracking System Customer Site Application

5.1 WIRELESS SATELLITE-BASED MOBILE COMMUNICATIONS SYSTEM

As shown in Figure 15, the QUALCOMM wireless satellite-based mobile communications system (OmniTRACS) consists of a satellite-based mobile communications terminal (SMCT) installed inside a CMV cab and a dome antenna GPS receiver that is mounted on the roof of a tractor. For the pilot test, messages and position information, including the latitude, longitude, and time, were shown through an application that enabled the carrier's dispatcher to view the location of the tractor on a map. Using a computer interface, the carrier's dispatchers tracked the tractors and viewed position histories of vehicles' locations en route.

Figure 15. Wireless Satellite-based Mobile Communications System

Source: Qualcomm, 2004.

5.2 TETHERED TRAILER TRACKING SYSTEM

The QUALCOMM tethered trailer tracking unit shown in Figure 16 provides near-real-time connection and disconnection events viewable on a map that are captured and transmitted as alerts to the dispatcher. In conjunction with the SMCT, the dispatcher is notified with time and location information that a trailer has been connected or disconnected from the tractor.

Figure 16. Tethered Trailer Unit

Source: Qualcomm, 2004.

5.3 IN-CAB AND WIRELESS PANIC BUTTONS

Panic buttons provide real-time emergency alerts from the driver to the dispatcher. As shown in Figure 17, an in-cab panic button is mounted inside the vehicle to send an emergency alert. A wireless panic button (WPB) that can be carried by the driver to remotely send an emergency alert is shown in Figure 18. Both the WPB and the OmniTRACS wireless satellite-based mobile communications system used in the pilot test received the Department of the Navy's Hazards of Electromagnetic Radiation to Ordnance (HERO)[21] certification.

Figure 17. In-Cab Panic Button

Source: Qualcomm, 2004.

Figure 18. Wireless Panic Button

Source: Qualcomm, 2004.

21 "NAVSEA OP 3565/NAVAIR 16-1-529," Eleventh Revision of 1 May 2002.

5.4 NETWORK COMMUNICATIONS—MOBILE COMMUNICATIONS SYSTEM

During the pilot test, the satellite communications link was provided over the Galaxy 10R geostationary Ku-band satellite for the ESCT system. As shown in Figure 19, the information was transmitted to the communications satellite and down to the tractor's wireless SMCT. The messaging from the tractor returned to the customer fleet management center in the opposite direction. All QUALCOMM messages and positions from the satellite communications were routed through a commercial Network Management Center (NMC) in San Diego, California, with a back-up NMC located in Las Vegas, Nevada. Both centers are fully redundant from a network standpoint. The NMC processes over 8 million messages per day. NMC and technical hotline support operate 24 hours a day, 7 days a week. Information was sent from the customer fleet management center to the NMC via the Internet.

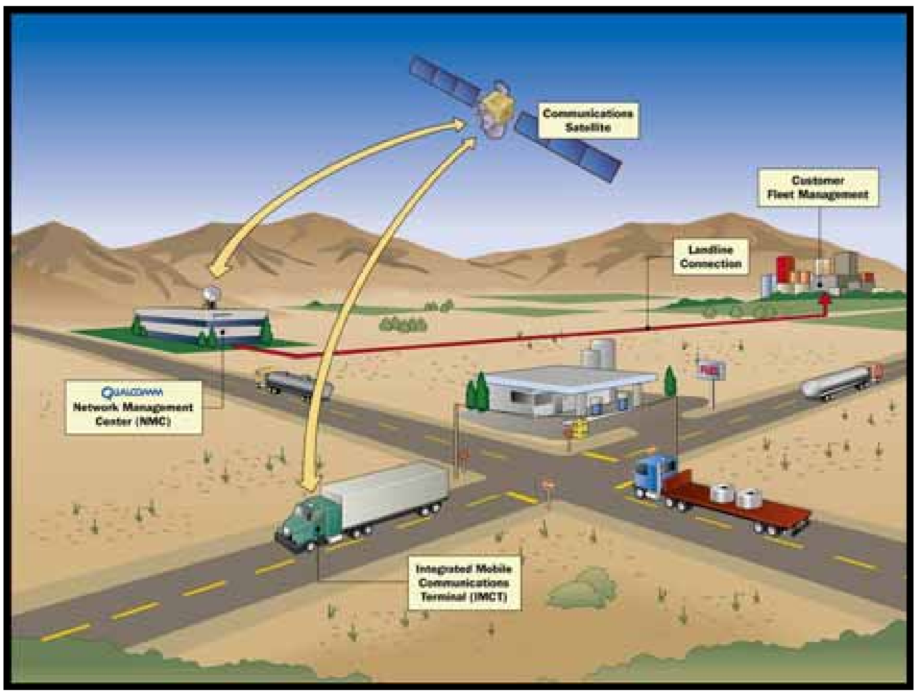


Figure 19. Wireless Satellite-based Communications

Source: QUALCOMM, 2004.

5.5 MOBILE COMMUNICATIONS SYSTEM CUSTOMER SITE APPLICATION

Host software is the communications link to the SMCT system. The site applications fully support data from the user's host computer to the NMC with Mobile Data Interchanges (MDI). The host controls and manages system features; supports messaging capabilities to and from the tractor, as well as throughout the entire company; supports position data; and enables direct integration of systems applications through a large library of External Application Links (EAL). A screen capture of a display message in QUALCOMM'S QTRACS host software is shown in Figure 20. The tethered trailer tracking side of the host provides exception-based alerts notifying dispatch personnel of unauthorized trailer connections and disconnections.

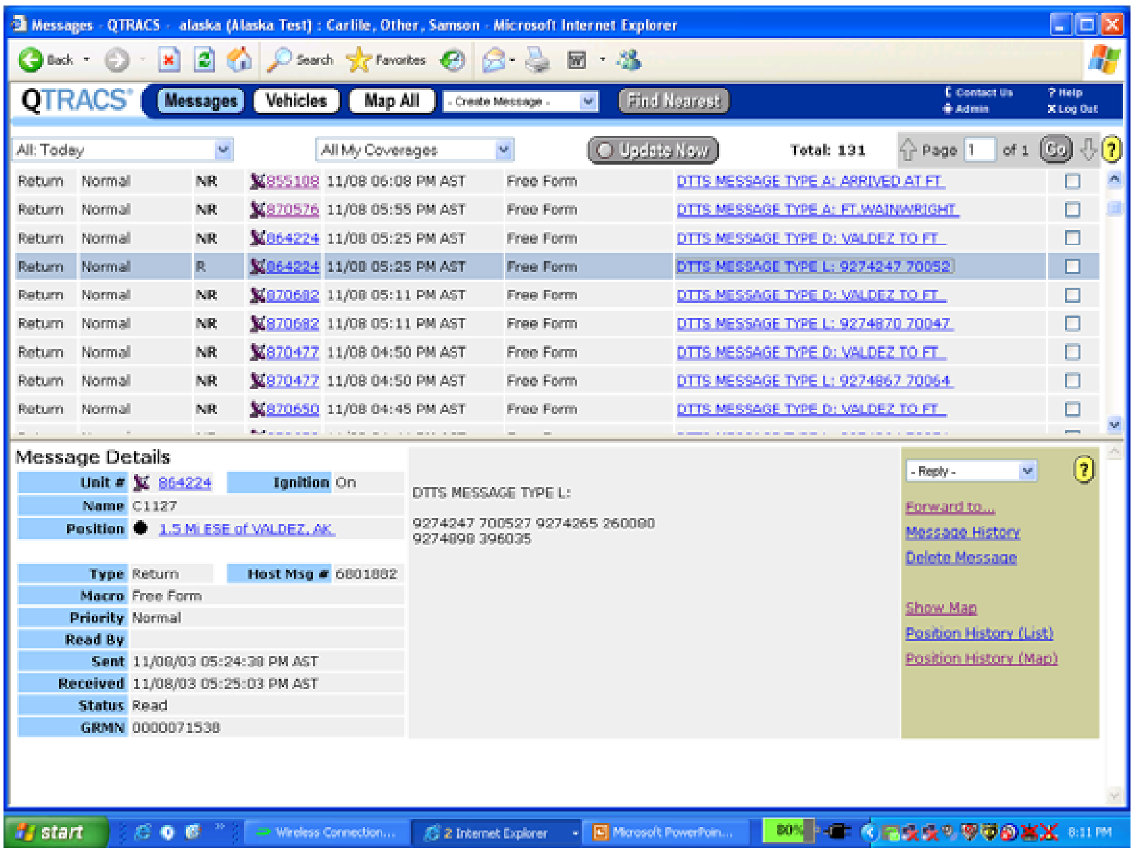


Figure 20. Screen Capture of a Display Message in QTRACS

Source: QUALCOMM QTRACS, 2003.

6.0 PILOT TEST OPERATIONAL SCENARIOS

Two different operational scenarios for Alaska and Hawaii were developed for the pilot test. Table 16 shows the scenarios selected for the pilot test and the technologies that were included in each scenario.

Table 16. Technology Solution Scenarios by Uncovered Region

Scenario	Description	Technology Components
1	Alaska	• Satellite Mobile Communication Systems (100 units) • In-cab Panic Buttons (100 units) • Wireless Panic Buttons (100 units) • Tethered Trailer Tracking (20 units)
2	Hawaii	• Satellite Mobile Communication Systems (5 units) • In-cab Panic Buttons (5 units) • Wireless Panic Buttons (5 units)

6.1 SCENARIO 1—ALASKA REGION

Scenario 1 included four carriers of the high-value goods and hazardous materials. Alaska West Express operated primarily out of their Fairbanks terminal. Carlile Transportation Systems, Lynden Transport, and Weaver Brothers, Inc. operated primarily out of terminals located in Anchorage, Alaska. While shippers and consignees are critical links in the overall safety and security of hazardous materials shipments, they did not have a direct role in this pilot test scenario. The carriers supplied 20 trailers and 100 tractors.

The key users of the system were the dispatchers and drivers. The dispatchers monitored the routes, tractor positions, trailer connections and disconnections, messages, and panic button alerts. The drivers used the on-board satellite terminal to send and receive standard messaging and macros. The technologies installed on each truck are listed in Table 17 by carrier, each of which is described below. Technologies are mapped to the high-level functional requirements described earlier.

Table 17. Scenario 1 Technologies by Tractors and Trailers

Carrier	Tractors/ Trailers	Technologies				Functional Requirements
Carlile	25 Tractors 20 Trailers	Satellite communications on all tractors	20 tethered trailer tracking units	In-cab and wireless panic buttons	Web/mapping on host system with back-office integration	1,2,3,4,5 [a]
Lynden	12 Tractors	Satellite communications on all tractors	No tethered trailer tracking units	In-cab and wireless panic buttons	Web/mapping on host system	1,2,5 [a]
Alaska West Express	38 Tractors	Satellite communications on all tractors	No tethered trailer tracking units	In-cab and wireless panic buttons	Web/mapping on host system	1,2,5 [a]
Weaver Brothers	25 Tractors	Satellite communications on all tractors	No tethered trailer tracking units	In-cab and wireless panic buttons	Web/mapping on host system	1,2,3,4,5 [a]

[a] Refer to Table 14 for functional requirement designations.

6.1.1 Carlile Transportation

Carlile Transportation Systems is one of Alaska's largest trucking companies, with more than 100 company-owned trucks and 800 pieces of trailer equipment. Its operation covers Alaska, including Anchorage, Fairbanks, Valdez, Kenai, Prudhoe Bay/Deadhorse, and Seward, with service to and from the lower 48 States. In addition to less-than-truckload (LTL) dry freight and specialized heavy haul equipment, Carlile transports all major classes of hazardous materials, including munitions, commercial explosives, and hazardous waste. Carlile Transportation Systems was the first authorized DoD munitions carrier in Alaska. Maintaining in-transit visibility of their sensitive loads, drivers, and equipment is critical.

Carlile dispatches line haul tractors out of Anchorage with runs reaching as far as 900 miles into Prudhoe Bay. Before the pilot test, it had had only minimal success with communications throughout this stretch of road. During the pilot test, the dispatchers tracked tractor locations, monitored trailer connections and disconnections, sent and received text messages, and received alerts from panic button activations. The drivers sent and received text messages using the in-cab driver interface unit and activated the in-cab or wireless panic buttons to report emergencies.

6.1.2 Lynden Transport

Lynden Transport is a leading provider of innovative, multimodal transportation solutions. The combined capabilities of the Lynden Companies include truckload and LTL transportation; scheduled and charter barges; intermodal bulk chemical hauls; scheduled and chartered air freighters; domestic and international air forwarding; international ocean forwarding; remote site construction; sanitary bulk commodities hauling; and rail and multimodal logistics.

Lynden Transport was the first trucking company in Alaska to provide scheduled, over-the-road freight service via the Alcan Highway to major Alaska communities. Lynden dispatches a localized LTL pick-up and delivery operation out of their Anchorage terminal. The average length of haul is about 100 miles. Lynden monitored efficiencies throughout the pilot test in regard to customer service, safety, and utilization. The dispatchers also tracked tractor locations, monitored trailer connections and disconnections, sent and received text messages, and received alerts from panic button activations. The drivers sent and received text messages using the in-cab driver interface unit and activated the in-cab or wireless panic buttons to report emergencies.

6.1.3 Alaska West Express

Alaska West Express provides truckload transportation throughout the United States and Canada, specializing in shipments to and from Alaska. Alaska West Express is experienced in transporting liquid- and dry-bulk products and hazardous and non-hazardous chemicals and petroleum products. Alaska West Express delivers 95 percent of all the chemicals (10 million gallons per year) delivered to the North Slope of Alaska. Alaska West Express has terminals in Anchorage and Fairbanks, Alaska, as well as in Milton, Washington.

Alaska West Express dispatches a line haul and truckload operation out of their Fairbanks Terminal. Their average length of haul is 1,000 miles. Alaska West Express is also a 30-percent owner-operator fleet, making them the only mixed operation in this pilot test. During the pilot test, the dispatchers tracked tractor locations, monitored trailer connections and disconnections, sent and received text messages, and received alerts from panic button activations. The drivers sent and received text messages using the in-cab driver interface unit and activated the in-cab or wireless panic buttons to report emergencies.

6.1.4 Weaver Brothers, Inc.

Weaver Brothers, Inc. was founded in Oregon in 1946. In 1955, Weaver brothers moved their main operations to Anchorage. Weaver Brothers provides local, line haul, and fuel deliveries; drayage, dry, and reefer vans; and low-boy trailers. They have terminals in Anchorage, Fairbanks, and Kenai. Their loads vary, but are typically bulk fuel (high-risk) and high-value electronics. Other commodities include hot oil and sulfuric acid. Weaver Brothers also serve companies providing ocean liner service from the Pacific Northwest.

Weaver Brothers dispatch line haul and local fuel deliveries out of their Anchorage terminal. The average length of haul is typically local—30- to 50-mile runs—with occasional line haul runs exceeding 900 miles. Weaver Brothers was the pilot test’s only split operation, providing both long-haul and local delivery. They were also the only high-value carrier in the Alaska scenario. During the pilot test, the dispatchers tracked tractor locations, monitored trailer connections and disconnections, sent and received text messages, and received alerts from panic button activations. The drivers sent and received text messages using the in-cab driver interface unit and activated the in-cab or wireless panic buttons to report emergencies.

6.2 SCENARIO 2—HAWAII REGION

Scenario 2 included the tracking of bulk fuel deliveries on three islands in the state of Hawaii. Five Shell Motiva fuel delivery trucks were part of this pilot test. The technologies installed in each truck for Scenario 2 are listed in Table 18.

Table 18. Scenario 2 Technologies by Tractors

Number of Tractors	Technologies			Carrier	Functional Requirements
5	Satellite communications on all tractors	In-cab and wireless panic buttons	Web/mapping on host system	Shell Motiva	1,2,5 [a]

[a] Refer to Table 14 for functional requirement designations.

Shell Motiva is located in Oahu, Hawaii, and provides fuel delivery service on all of the major Hawaiian Islands. Their typical runs range from 10 to 200 miles throughout the islands. The five vehicles used for this pilot test were located on three different islands. Two were on the island of Maui, two on the island of Hawaii, and one on the island of Kauai. During the pilot test, the dispatchers monitored tractor locations and received alerts from panic button activations. All dispatching activities throughout the islands were controlled from Shell's dispatch center in Honolulu, Hawaii. The drivers activated the in-cab or wireless panic buttons to report emergencies.

6.3 ROLES AND RESPONSIBILITIES OF PILOT TEST PARTICIPANTS

Table 19 provides a summary of the roles and responsibilities of participants in the pilot test. Although shippers and consignees received benefits from the ESCT systems, their day-to-day roles and responsibilities did not change with the addition of the technologies deployed during the pilot test.

Table 19. Roles and Responsibilities

Role	Responsibilities
Shipper	• Created manifests; no direct system interaction
Carrier/Dispatcher	• Created and monitored routes • Sent and received messages • Located tractors and displayed vehicle positions on the map • Found and displayed a specific tractor or all tractors at a specific location or landmark • Displayed position history on a map for a selected tractor • Verified positions sent from tractors • Verified trailer connections and disconnections • Verified that the panic alert was sent • Verified tractor position at time of panic alert • Verified that panic alert escalation procedures were followed • Modified Mobile Initiated Position Report (MIPR) settings from 15 minutes to 5 minutes for one tractor, and then verified granular positioning for 15 minutes
Driver	• Sent and received messages • Activated the on-board and wireless panic buttons
Consignee	• Received load; no direct system interaction

During the pilot test, drivers used the ESCT system terminals in the cabs of their trucks to send and receive text messages and macros relating to load assignments, pick-ups, and deliveries, and to send updates to their dispatchers on the estimated time of arrival and any unexpected delays encountered en route. In addition, the drivers were responsible for using the panic buttons if they experienced a safety- or security-related emergency. The drivers had no direct interface with the tethered trailer tracking unit. Drivers received load and trailer assignments from dispatchers via the text-messaging capabilities of the ESCT system and were responsible for picking up specific trailers. When the driver connected or disconnected the electrical "seven-way" connector between the tractor and trailer, the tethered trailer tracking system and ESCT system automatically generated an alert and sent that message to the dispatcher.

The carrier's dispatcher used the ESCT system to make load assignments to drivers (via text message and macros), to monitor trucks en-route by viewing the location of tractors on a map, and to monitor the connections and disconnections of trailers equipped with the tethered trailer tracking system. In addition, the dispatchers were responsible for responding to panic alerts. When a driver pressed a panic button, dispatchers would receive both a text message alert sent automatically through the ESCT system and a telephone call based on a pre-defined escalation procedure filed with QUALCOMM's NMC. Then, the dispatcher would use the graphical tracking features of the QTRACS host system to determine the location of the driver who initiated the panic alert and communicate with the driver to determine the nature of the alert. When the dispatcher understood the extent of the emergency, it was his/her responsibility to initiate the appropriate response from either carrier resources or notify appropriate emergency response personnel.

For the pilot test, dispatchers kept manual logs related to selected events. As shown in Appendix B, a log entry was completed when any of the following events occurred:

- Receipt of panic alert messages
- Assignment of a trailer to a tractor and confirmation of a correct pick-up and the time
- Attempts to locate a trailer
- Loss of communications with a driver
- Use of the ESCT systems for a new capability that was not possible prior to the installation of the systems

Dispatchers, drivers, and management personnel were also asked to participate in staged-event testing during site visits. The messages and data expected from both the daily operations and the staged tests are shown in Table 20 and Table 21.

Table 20. Anticipated Messages and Data from Daily Operations

Technology	Exercise	Objective	Expected Data Fields
ESCT System Terminal Two-Way Text Communication	Send and receive free-form messages Send and receive macro messages	Demonstrate and test the ability to send/receive text messages between a driver and dispatcher via satellite communications	Tractor unit ID, time transmitted, time received, date, free-form text or macro
ESCT System Terminal Tractor Position Reports	Automatic vehicle position reporting	Demonstrate and test the ability to send and receive periodic vehicle position reports, and track the progress of a vehicle on a map	Tractor unit ID, time of report, time received, date, satellite availability (Y/N), latitude, longitude, speed, heading
Tethered Trailer Tracking	Connect/disconnect trailer and tractor	Demonstrate and test the ability to identify when a trailer is connected or disconnected to a tractor, confirm that the correct trailer is connected or disconnected, and track the trailer while connected to the tractor	Trailer unit ID, connect/disconnect, time reported, time received, latitude, longitude, speed, heading
Panic Button (In-cab and Wireless)	Alert notification Configure alert notifications Receive email, pager, and desktop notification of alert	Demonstrate and test the ability of drivers to alert dispatchers to emergencies through the use of wireless and dash-mounted panic buttons	Tractor unit ID, time reported, time received, latitude, longitude, speed, heading

Table 21. Anticipated Messages and Data from Staged-Event Testing

Technology	Exercise	Objective	Expected Data Fields
ESCT System Two-Way Text Communication	Send and receive free-form messages Send and receive macro messages	Demonstrate and test the ability to send/receive text messages between a driver and dispatcher via satellite communications	Tractor unit ID, time transmitted, time received, date, free- form text or macro
ESCT System Tractor Position Reports	Automatic vehicle position reporting	Demonstrate and test the ability to send and receive periodic vehicle position reports, and track the progress of a vehicle on a map	Tractor unit ID, time of report, time received, date, satellite availability (Y/N), latitude, longitude, speed, heading
Tethered Trailer Tracking	Connect/disconnect trailer and tractor	Demonstrate and test the ability to identify when a trailer is connected or disconnected to a tractor, confirm that the correct trailer is connected or disconnected, and track the trailer while connected to the tractor	Trailer unit ID, connect/disconnect, time reported, time received, latitude, longitude, speed, heading
Panic Button (In-Cab and Wireless)	Alert notification Configure alert notifications Receive email, pager, and desktop notification of alert	Demonstrate and test the ability for drivers to alert dispatchers to emergencies through the use of wireless and dash-mounted panic buttons	Tractor unit ID, time reported, time received, latitude, longitude, speed, heading

7.0 PILOT TEST RESULTS

The focus of the 3-month pilot test was to test the functionality of the system and determine the communication coverage along routes in Alaska and Hawaii using the ESCT system. The 3-month ESCT system pilot test included both field and staged-event testing.

During the field testing, the ESCT system terminal automatically reported locations every 15 minutes as the carriers conducted their normal daily operations along major routes. The carriers in Alaska used the text-messaging capability with their drivers on average less than once per day per vehicle. The carrier in Hawaii did not use the text-messaging capabilities. Another part of the field test data collection involved the carriers completing manual logs for:

- Receiving and responding to panic alert messages
- Assigning trailers to tractors, confirming the correct pick-up, and noting the time
- Locating a trailer
- Losing communications or inability to contact a driver
- Identifying problems and unmet expectations

A copy of the manual log form used during the test is provided in Appendix B. Appendix C contains a summary of each manual log received during the pilot test from each carrier.

During the pilot test, three site visits—two in Alaska and one in Hawaii—occurred in which each carrier was asked to conduct staged-event testing. The staged testing involved carrier dispatchers and drivers performing a pre-determined procedure or “script” to test specific ESCT system functionalities, such as panic button alerts, which were likely to be used infrequently in typical daily operations. Both automated data and manual logs were collected, in addition to interviews of the carrier drivers, dispatchers, and managerial personnel.

Table 21 shows the technology tested, testing exercise, testing objective, expected data collection counts, and measures of effectiveness planned as part of the on-site staged testing events. The interview guide is included in Appendix D and the test script is included in Appendix E.

Table 22 lists the identified limitations of using the staged-event testing, which differed from real-world operations.

Table 22. Limitations and Implications of Staged-Event Testing

Limited Number of Tests—To minimize impacts on the carrier's daily operations, a limited number of staged-event tests were conducted.
Tests Conducted Only at Carrier Terminals—Staged-event testing was conducted only at the carrier's terminal locations in Alaska and Hawaii.
Pre-Alerting of Personnel for Panic Messages—Carrier personnel responsible for responding to panic alerts were pre-notified when the panic message testing was taking place.
Vehicles Not Moving During Staged Tests—Due to operational and liability concerns, all staged-event testing took place at carrier's terminal locations while vehicles were not moving.

Following the data collection, the location data and associated communication logs were analyzed using a geographic information system (GIS) to determine the coverage of the major roadways in both states and the occurrence of reported failed data transmissions. GIS maps were used to identify locations of communication gaps. The data were reviewed to determine whether at least one position report was accurately generated for every 5 miles that each tractor traveled. Then the locations where the satellite was reportedly unavailable were identified. If multiple reports of loss of satellite coverage were identified in the same proximity, additional investigations, such as verifying terrain in relation to PanAmSat satellite position using topography map data in the GIS, were conducted to explore the plausible causes.

7.1 COMMUNICATION COVERAGE

Determining the communication coverage using the ESCT system along routes in Alaska and Hawaii involved a multi-step process to identify locations without communication coverage. The following sections describe the approach to develop route profiles.

7.1.1 Data Filtering and Normalization

During the pilot test, the ESCT system was installed on 105 tractors (100 in Alaska, five in Hawaii), and the tethered trailer tracking system was installed on 20 trailers (all with Carlile Transportation in Anchorage, Alaska). The reporting interval of each ESCT system unit was set to report four position reports per hour. Every 15 minutes, the system would “wake up,” record its position, and take a reading to determine whether PamAmSat satellite coverage was available at that location. During each 1-hour interval, the first three position reports were archived and then sent with the fourth report at the end of the hour. A position report was also sent with other messages, such as macros, text messages, panic alerts, and trailer connections/disconnections.

The automated data elements and fields recorded for each message are identified in Table 23. Automated data element details are indicated in Table 24.

Table 23. Data Elements and Data Fields Collected from Automated Data Logs

System Type	Functional Category	Technology	Data Elements	Data Fields
Satellite-based Wireless Communications Systems	Tractor Communica-tions	OmniTRACS Wireless Satellite- based Mobile Communications System	• Macro messages • Text messages • Binary messages • Positions	• Time stamp • Macro # and version • Origin (tractor) • Lat/Long and length • Type (text/binary) • User fields
Satellite-based Wireless Communications Systems	Tractor and Cargo Tracking	Position Location Tracking	• Positions	• Time stamp • Origin (tractor) • Lat/Long • Proximity (city, town, landmark)
Web-based Host System	Data Manageme nt and Storage	QTRACS/Web	• Two-way text messaging • Mapping • Panic alerts • Trailer connect and disconnect status	• Tractor communica-tions data fields • Trailer tracking data fields • Panic buttons data fields
Tethered Trailer Notification and Tracking	Trailer Tracking	Tethered Trailer Tracking	• Connects • Disconnects	• Time stamp • Trailer ID • Origin (tractor) • Lat/Long • Event type
Real-Time Emergency Notification	Panic Buttons	On-board Panic Button	• Panic alert	• Time stamp • Tractor number • Alert • Lat/Long
Real-Time Emergency Notification		Wireless Panic Button	• Panic alert	• Time stamp • Tractor number • Alert • Lat/Long

Table 24. Automated Data Element Details

Primary Data Element	Sub-Data Element
Transaction Type	Position Report OmniTRACS Forward Message* OmniTRACS Return Message** OmniTRACS Forward Macros OmniTRACS Return Macros Panic Message Tethered Trailer Event
Customer Name	Alaska West Weaver Brothers Lynden Carlile Shell Motiva
Date	Date of Transaction
Receive Time	For a position report—Receive time is the time that the dispatcher received the position For a forward message—Receive time is the actual time that the vehicle received the message For a return message—Receive time is the actual time that the dispatcher received the message
Time Zone	U.S. Time Zones
Vehicle ID	Uniquely assigned truck ID for each truck by carrier
Trailer ID	Uniquely assigned trailer ID for each trailer by carrier
Trailer Serial #	Serial ID Information on the trailer hitch
Event Type	Vehicle Position Vehicle Message (Forward or Return) Panic Message Trailer Connection Trailer Disconnection
Latitude	Latitude Position in Degrees
Longitude	Longitude Position in Degrees
Proximity	Closest Position (landmark, city, etc.) to the vehicle at the time of the transaction
Position Type	Regular, Archived, and Archived Out of Coverage (OOC)
Ignition Status	ON or OFF
Message Length	Length of message
Binary or Text	Type of message

* Forward message is from dispatcher to driver
** Return message is from driver to dispatcher

Remove Data from Outside of Alaska and Hawaii

Approximately 96 percent of the pilot test data was collected within Alaska and Hawaii. During the data collection period, each Alaskan carrier had at least one trip outside the state to pick up or deliver loads in Canada and the lower 48 states of the United States. Figure 21 shows the data points collected in the field test. Table 25 provides a summary of the different types of messages (e.g., position reports, panic alerts) received within and outside of the states of Alaska and Hawaii. Only data received within the states of Alaska and Hawaii were used for route analysis.

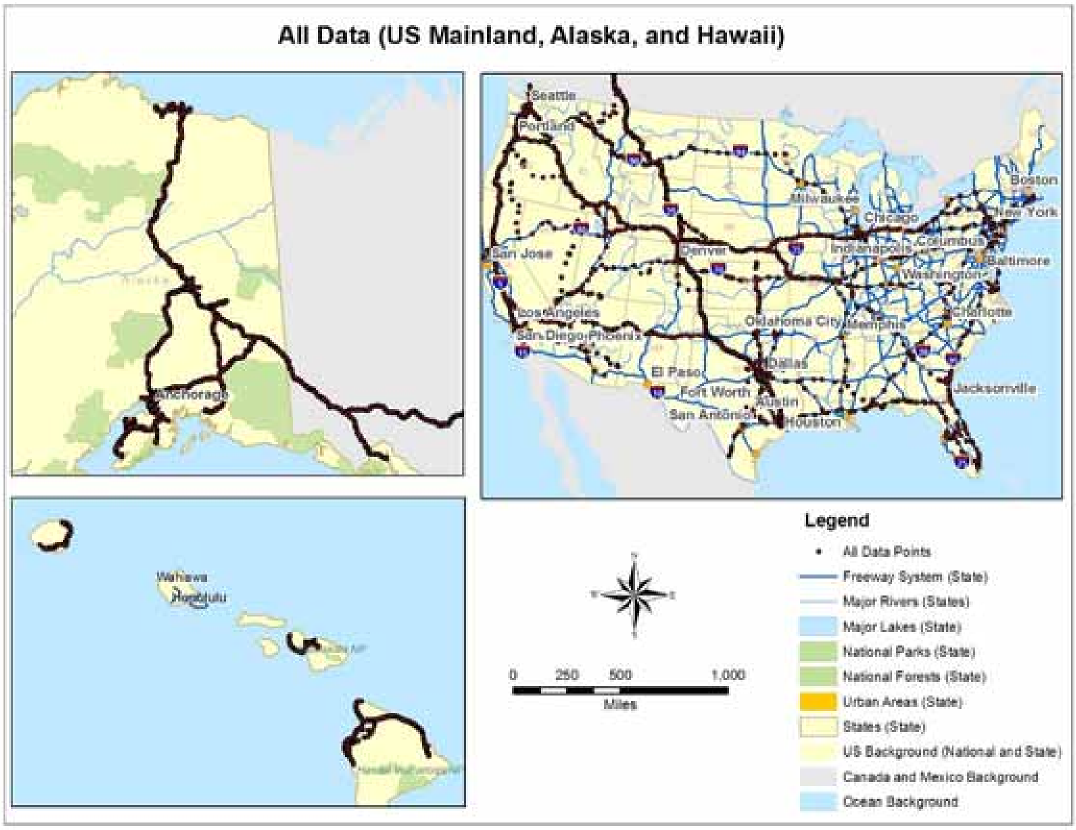


Figure 21. Plot of All Field Test Data

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Table 25. Recorded Messages

Transaction Type	Total Number of Messages	Alaska	Hawaii	Outside of Alaska
Position Reports	261,027	227,996	21,653	11,378
Forward Messages	552	522	6	24
Return Messages	1,466	1,421	8	37
Forward Macros	4	4	0	0
Return Macros	20	20	0	0
Panic Messages	54	51	3	0
Tethered Trailer Event	132	90	0	42
Total	**263,255**	**230,104**	**21,670**	**11,481**

Select Position Report Data

The position reports were used for determining communication coverage along the major routes. To determine the coverage on major routes, 227,996 position reports in Alaska and 21,653 position reports in Hawaii were recorded and used to determine the satellite coverage along routes.

Remove Position Reports When the Vehicle is Not Moving

When the vehicles' engines were shut off, the ESCT systems continued to record positions for 1 hour. To determine the coverage on major routes, position reports that were sent when the ignition was off were not analyzed, since these reports were assumed to represent destinations off the major routes. Table 26 shows the position reports for Alaska and Hawaii based on the vehicle's ignition status.

Table 26. Ignition Status of Position Reports in Alaska and Hawaii

Position Reports	Ignition On	Ignition Off	Total
Alaska	197,162	30,834	227,996
Hawaii	5,635	16,018	21,653
Total	202,797	46,852	249,649

The Hawaiian carrier Shell Motiva had almost three times as many "ignition-off" position reports as "ignition-on," due to their fuel delivery operations of short trips with frequent stops for loading and unloading fuel at retail fueling stations. The deliveries in Alaska did not include the same large portion of frequent stops. Although Weaver Brothers, Inc. delivered fuel in Alaska, none of their fuel delivery vehicles were part of the pilot test.

7.1.2 Incorporate Data into Geographical Information System

Two separate software applications were used as part of the data analysis: ArcGIS (a commercially available GIS software package) and Battelle's Multimodal Geospatial Analysis Tools (a data visualization tool developed by Battelle to facilitate viewing and analyzing GIS data). The process used to import the field test data into the GIS applications and conduct the analysis is described below.

Define Geographic Routes

The first step in using the GIS applications was to define the routes that the vehicles traversed in the 3-month pilot test. These routes were most likely the routes that are used when transporting hazardous materials and/or high-value loads. Table 25 identifies the length of each route for Alaska, and the percentage of that route traversed by vehicles with the ESCT systems in this pilot test. For the routes in Alaska, pilot test vehicles traversed the entire length of all routes shown in Table 27, except State Route 6 and State Route 8. The first 29 miles of State Route 6 was traversed from Fox, Alaska to the northeast. Only the first half mile of State Route 8 was traversed to the intersection with State Route 3 in the southwest. Figure 22 provides a color-coded map of the major routes for Alaska. The arrows indicate the direction used in evaluating the overall route profiles.

Table 27. Percentage of Routes in Alaska Traversed by Pilot Test Carriers

Alaskan Routes	Route Length (Miles)	% Traversed by Instrumented Vehicles[22]	Pilot Test Carriers with Instrumented Vehicles Traversing the Route
James Dalton Highway	412	100%	A, C, L, W
State Route 1 (Glenn Highway)	531	100%	A, C, L, W
State Route 2 (Alaska Highway)	373	100%	A, C, L, W
State Route 3 (George Parks Highway)	323	100%	A, C, L, W
State Route 4 (Richardson Highway)	268	100%[23]	A, C, L, W
State Route 6 (Steese Highway)	142	13%	A, C, L, W
State Route 8 (Denali Highway)	133	7%	A
State Route 9 (Seward Highway)	37	100%	A, C, W

A = Alaska West Express
C = Carlile Transportation
L = Lynden Transport
W = Weaver Brothers, Inc.

22 Percentages based on dividing the number of 10-mile segments that included position location reports by the total number of 10-mile segments for the route.

23 The coverage for SR 4 is reported at 100 percent. Instrumented trucks traveled over the entire 268 miles of this route. However, when the position reports were recorded and separated into half-mile segments (for analysis within the GIS system), there were not position location reports in every half-mile segment.

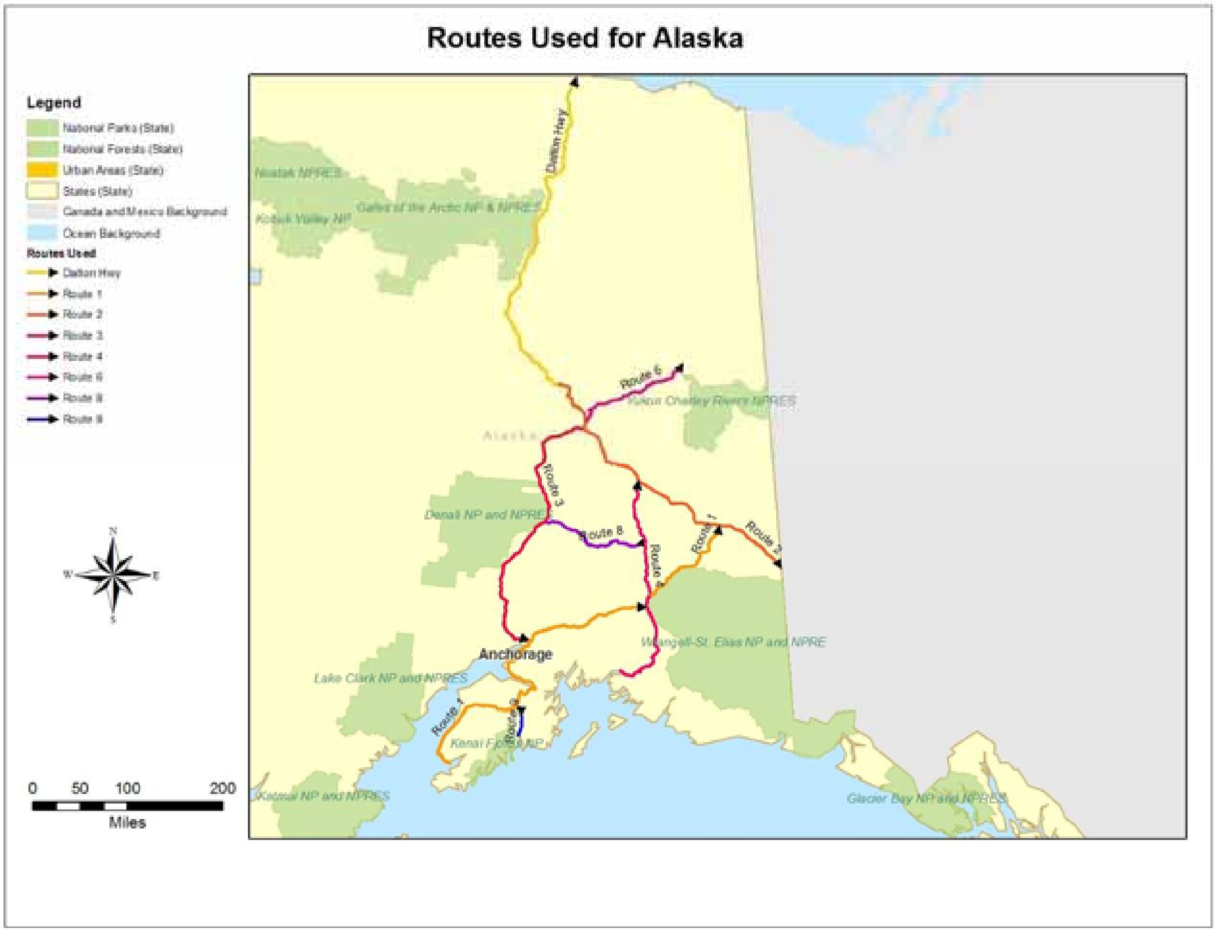


Figure 22. Major Routes in Alaska

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Table 28 shows the lengths of the routes and the percentage of the routes traversed in Hawaii by pilot test vehicles. The routes in Hawaii were shorter than those in Alaska, and fewer pilot test vehicles (two on Maui, two on Hawaii and one on Kauai) traversed these routes. Since the carrier in Hawaii delivered fuel from their terminals to locations where they serviced fueling stations, the pilot test vehicles did not travel along the entire routes into the less densely populated areas. Figure 23, Figure 24, and Figure 25 show the routes in Hawaii, Maui, and Kauai, respectively. The arrows indicate the direction used in evaluating the overall route profiles.

Table 28. Percentage of Routes in Hawaii Traversed by Shell Motiva

Route	Route Length (Miles)	Percentage Traversed by Shell Instrumented Vehicles[24]
State Route 11	155	44%
State Route 19	56	100%
State Route 190	39	100%
State Route 31	53	17%
State Route 36	16	100%
State Route 37	24	67%
State Route 340	22	33%
State Route 360	33	0%
State Route 380	6	100%
State Route 50	33	50%
State Route 56	38	75%
State Route 550	19	0%

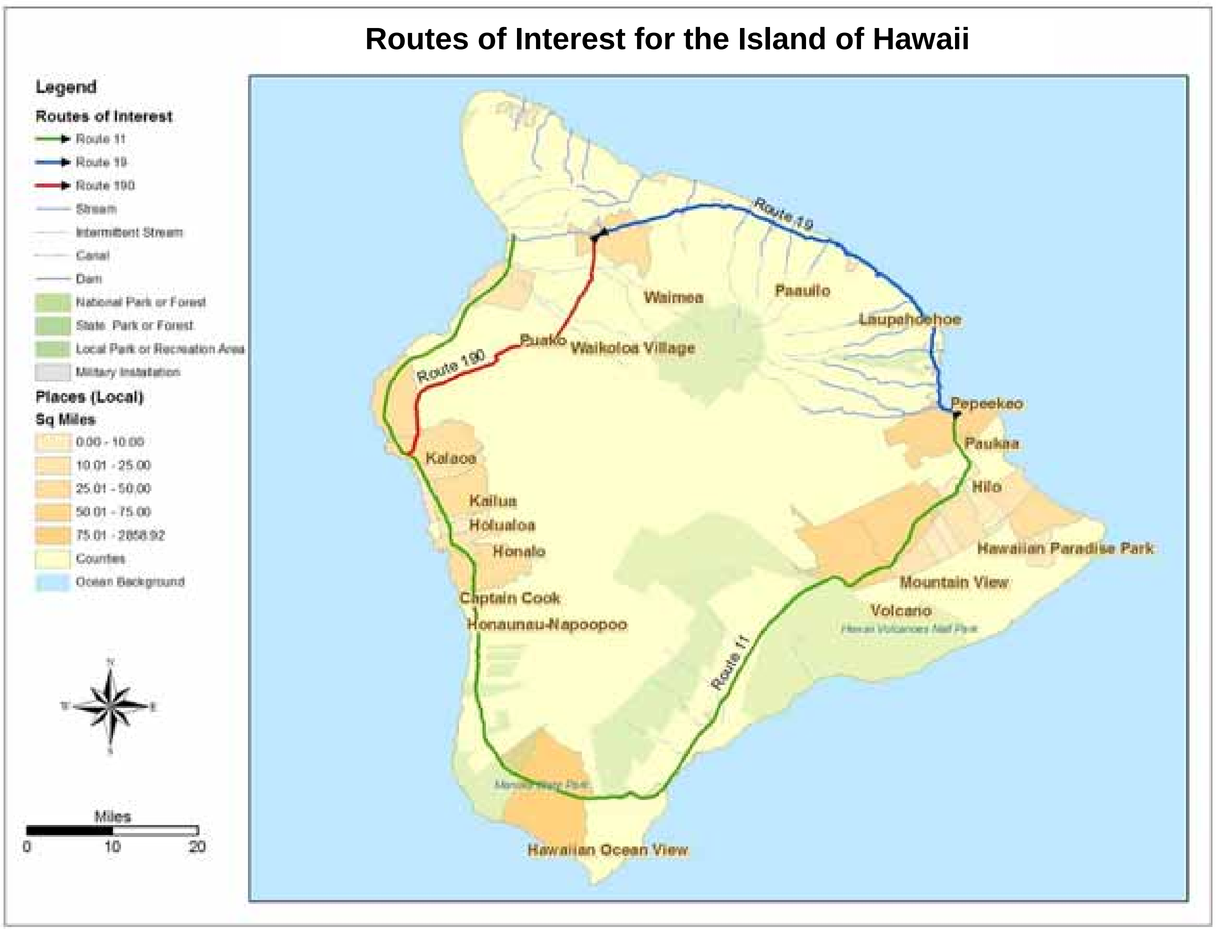


Figure 23. Major Routes on the Island of Hawaii

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

[24] Percentages based on dividing the number of 10-mile segments that included position location reports by the total number of 10-mile segments of the route.

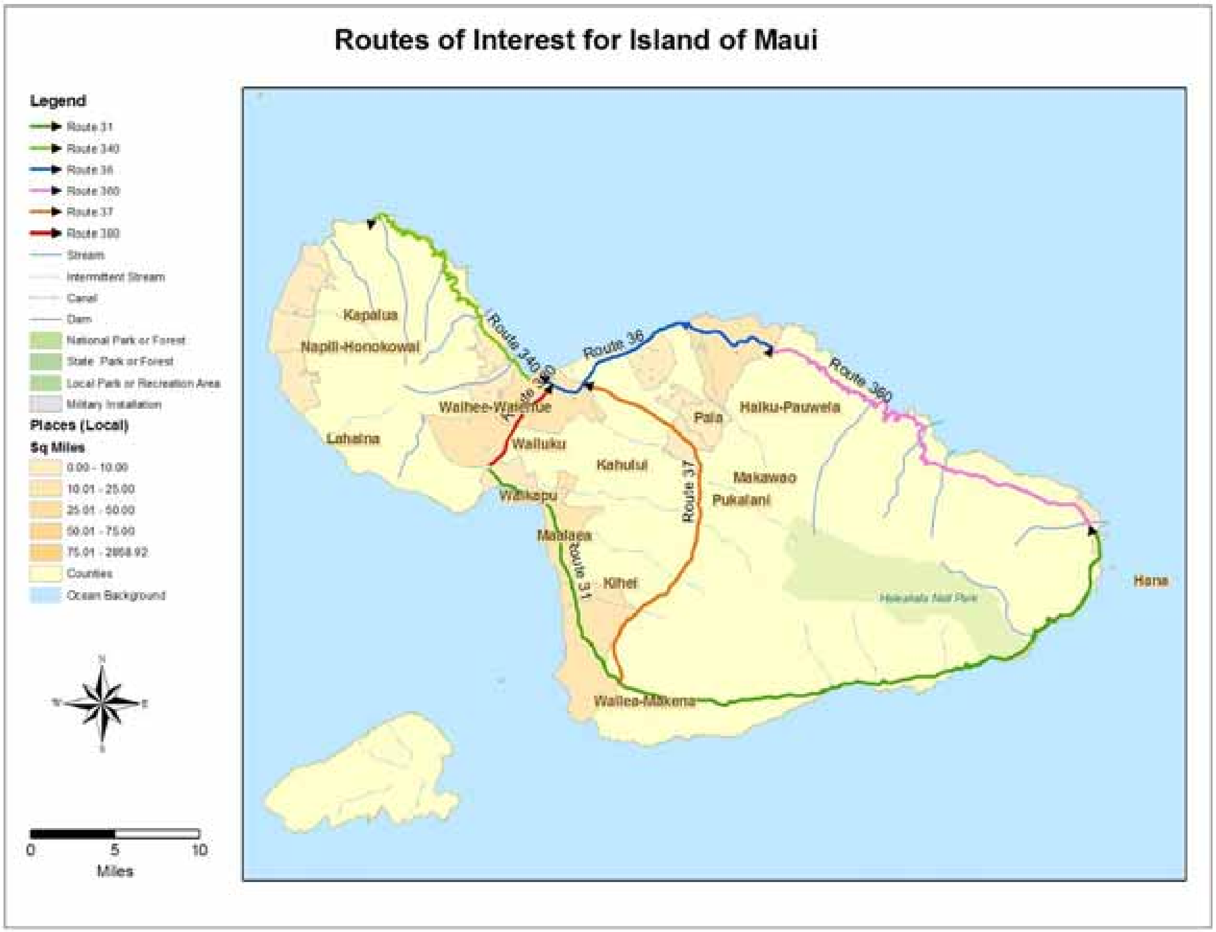


Figure 24. Major Routes on the Island of Maui

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

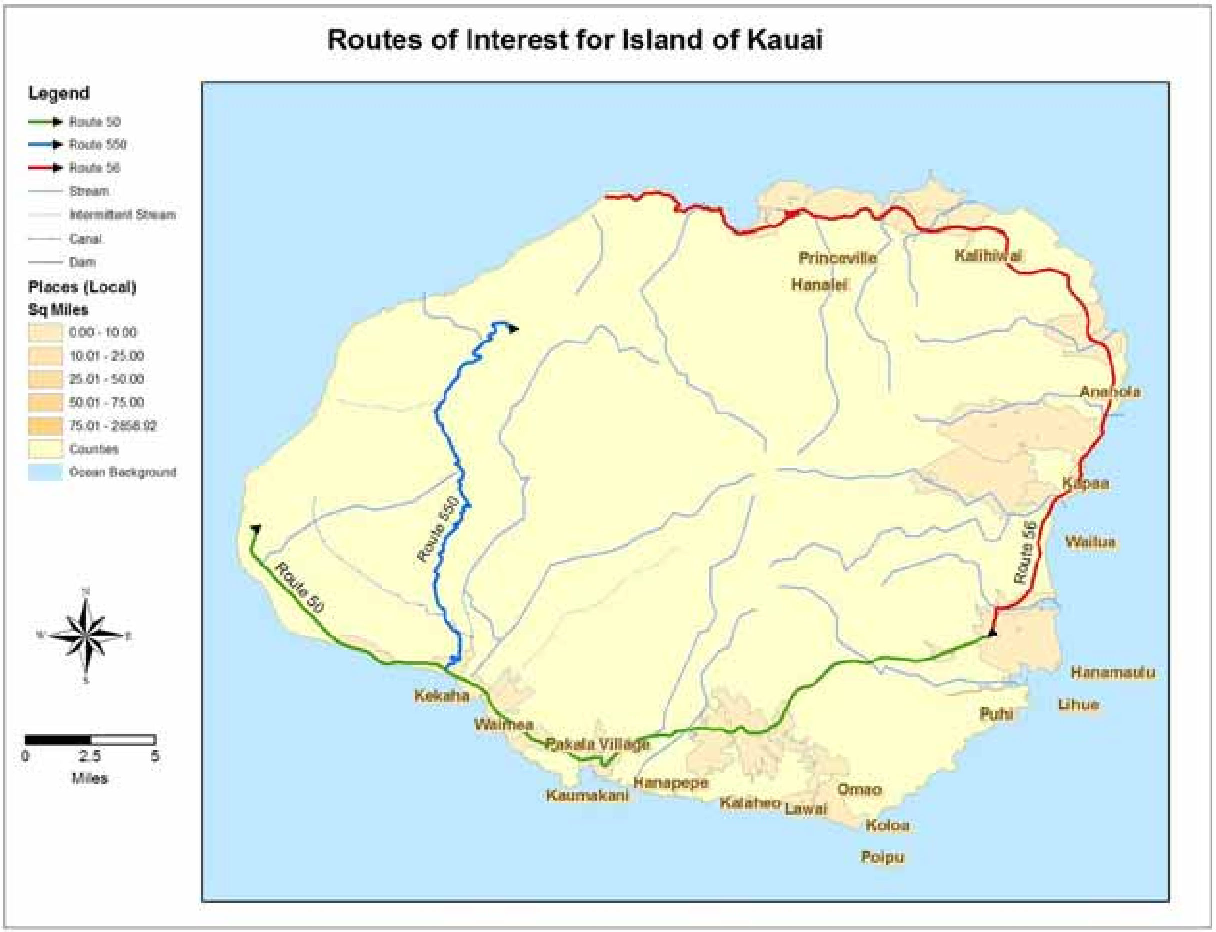


Figure 25. Routes on the Island of Kauai

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Identify and Remove Data Falling Outside the Major Routes

After the routes were created in the GIS map database, the recorded position data from the ESCT systems were input into a Microsoft Access database, converting the latitude and longitude (lat/long) fields from degree:minute:second format to decimal degree format, and creating the geodatabase to plot the position reports as data points on a GIS map layer.

Next, the field test data were mapped to the appropriate routes within the GIS application by "snapping" each data point to a route (within a 0.02 decimal degree tolerance). The decimal degree unit is based on the lat/long system. Latitude and longitude constitute the spherical reference system used to measure locations on the Earth's surface. The degree:minute:second format of the lat/long was converted into decimal degrees using the following formula:

Decimal degrees = Degree + Minute/60 + Second/3,600.

Since decimal degrees are based on the lat/long system, the equivalent length of 0.02 decimal degrees in miles depends on the location at which it is measured. In Alaska, 0.02 decimal degrees is equivalent to approximately 1.37 miles. In Hawaii, 0.02 decimal degrees is equivalent to approximately 1.44 miles. As the data were input into GIS maps, some data were not associated with the major routes in the pilot test. Data that did not fall within the 0.02 decimal degree range of a major route were filtered out. Table 29 shows the portion of the total position reports (with ignition on) for Alaska and Hawaii that were outside the major routes.

Table 29. Position Reports (Ignition On) On and Off Major Routes

Position Reports	On Major Routes	Off Major Routes	Total
Alaska	136,777	60,385	197,162
Hawaii	4,003	1,632	5,635
Total	140,780	62,017	202,797

Approximately 23 percent of the off-route reports were in Alaska. The majority of these data resulted from vehicles at terminal facilities and on minor roads that were not along the major routes where coverage was being tested. Over 28,000 off-route reports were in the immediate Fairbanks vicinity, and over 11,000 in the Anchorage vicinity. As shown in Figure 26, the majority of the off-route reports in the Fairbanks area were near the Alaska West Express terminal facility and other city streets near the area. The data for the Anchorage area displayed off-route reports near terminal facilities and the surrounding city streets.

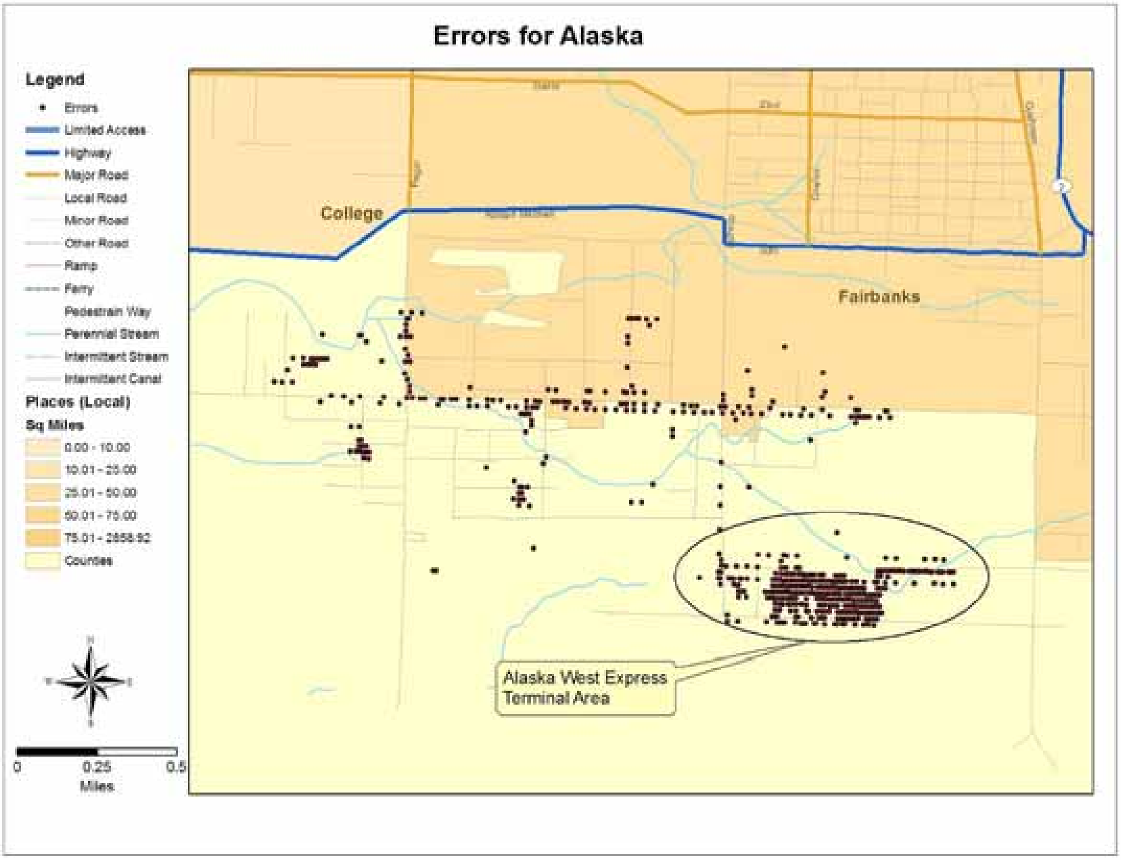


Figure 26. Off-route Data in the Fairbanks, Alaska Area

Source: Data: USGS World Digital Terrain Model (DTM).

Table 30 and Table 31 summarize the total number of position reports and route mileage for Alaska and Hawaii, respectively. The rows titled "Off-route" in these tables correspond to those data points that did not map to one of the selected routes.

Table 30. Position Reports by Route in Alaska

Route Name	Total Miles	Total Position Reports
Dalton Hwy	412	61,945
Route 1	531	26,808
Route 2	373	23,337
Route 3	323	22,005
Route 4	268	2,255
Route 6	142	295
Route 8	133	8
Route 9	37	124
Subtotal	2,219	136,777
Off-route Data	N/A	60,385
Total	**2,219**	**197,162**

Table 31. Position Reports by Route in Hawaii

Route Name	Total Miles	Total Position Reports
Route 11	154	920
Route 19	56	1,247
Route 190	39	48
Route 31	53	1
Route 36	16	673
Route 37	24	139
Route 340	22	49
Route 360	33	0
Route 380	6	321
Route 50	33	234
Route 56	38	371
Route 550	19	0
Subtotal	**493**	**4,003**
Off-Route Data	N/A	1,632
Total	**493**	**5,635**

Select Out-of-Coverage Data by Route

The final filtering step involved separating the data into reports with and without coverage from the PanAmSat satellite. The ESCT system recorded its position and PanAmSat satellite coverage status (in or out of coverage) four times per hour. The system generated two types of position reports—regular and archived. When a regular report was sent every hour, it included the previous three archived reports. In Figure 27, a screen capture from the QUALCOMM QTRACS host application system shows regular and archived OOC reports.

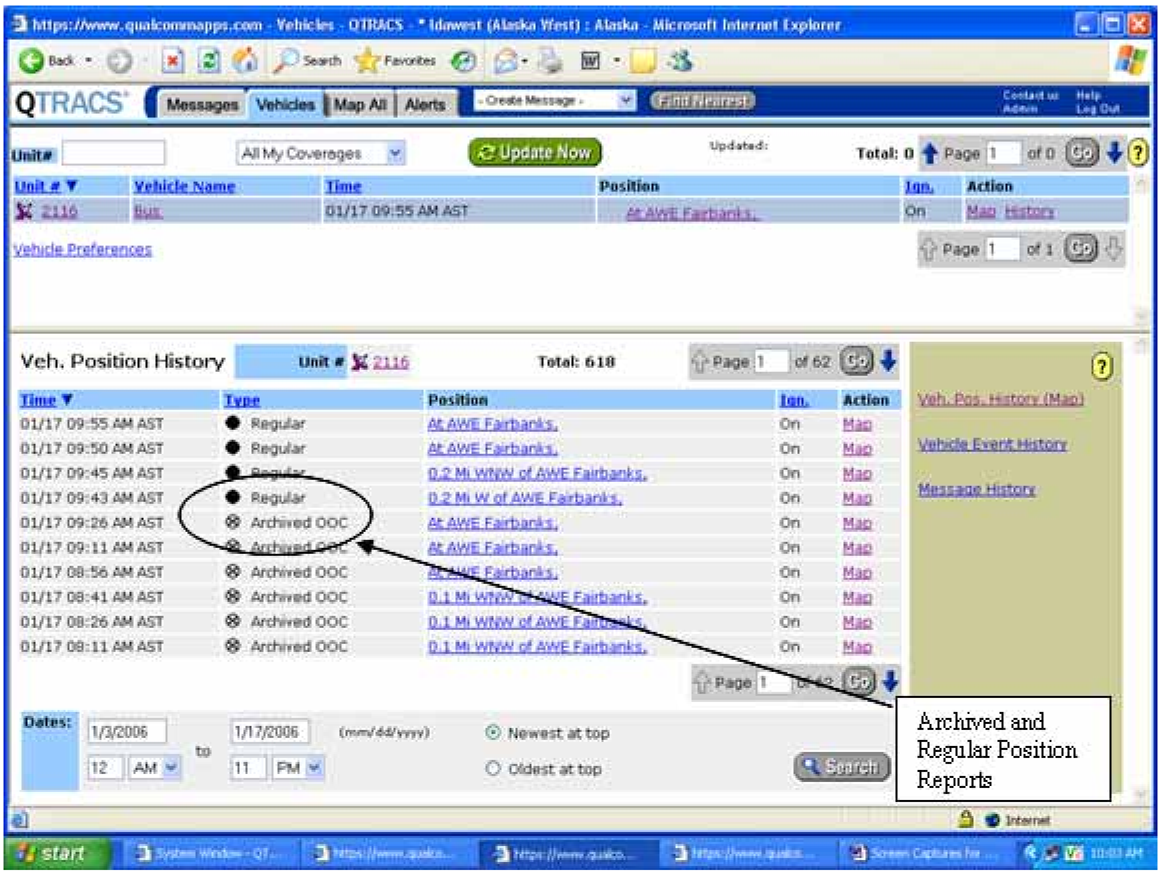


Figure 27. Screen Capture from QTRACS Application Showing Regular and Archived OOC Position Reports

Source: QUALCOMM QTRACS, 2006.

The archived reports were categorized as either in coverage or OOC. At each 15-minute interval, the ESCT system used the GPS satellites for vehicle locations. If coverage was available from the PanAmSat satellite, the data were recorded as "archived." If PanAmSat satellite coverage was not available, the data were recorded as "archived OOC." Since the ESCT system has a store-and-forward capability, the ESCT system stored the OOC messages and automatically sent them when communication was reestablished with the satellite.

If PanAmSat satellite coverage were available at the scheduled time each hour, the regular message and three archived messages would be sent. However, if communication coverage from the PanAmSat satellite were unavailable at the hourly interval, the ESCT sent these messages when PanAmSat satellite coverage was available. The data indicated time periods longer than an hour between messages sent, which in turn indicated the unavailability of the PanAmSat satellite communication coverage at the time regularly scheduled for messages. Table 32 and Table 33 provide the total position reports and OOC reports by routes for Alaska and Hawaii, respectively.

Although the data showed where the communication problems (i.e., generation of OOC reports) occurred, they did not provide the reasons for the problems. As a result, specific locations of the OOC reports, terrain data, and the opinions of carrier personnel provided indicators of possible reasons for communication blockage.

Table 32. OOC Reports in Alaska by Route

Route Name	Total Miles	Total Position Reports	Total OOC Reports	Percentage of OOC Reports
Dalton Hwy	412	61,945	15,000	24%
Route 1	531	26,808	1,466	5%
Route 2	373	23,337	2,604	11%
Route 3	323	22,005	2,733	12%
Route 4	268	2,255	128	6%
Route 6	142	295	16	5%
Route 8	133	8	0	0%
Route 9	37	124	3	2%
All Routes	**2,219**	**136,777**	**21,950**	

Table 33. OOC Reports in Hawaii by Route

Route Name	Total Miles	Total Position Reports	Total OOC Report	Percentage of OOC Reports
Route 11	155	920	0	0%
Route 19	56	1,247	0	0%
Route 190	39	48	0	0%
Route 31	53	1	0	0%
Route 36	16	673	0	0%
Route 37	24	139	0	0%
Route 340	22	49	0	0%
Route 360	33	0	0	N/A
Route 380	6	321	0	0%
Route 50	33	234	13	6%
Route 56	38	371	11	3%
Route 550	19	0	0	N/A
All Routes	**494**	**4,003**	**24**	**1%**

7.1.3 Creation of Route-specific Profile Charts

Potential reasons for OOC reports and for the unavailability of satellite coverage include blockages of the line of sight from the ESCT system to the satellite caused by large buildings, overhead obstructions at terminals and/or shipper facilities, oversized loads, and terrain. No data related to weather impact on the satellite communication coverage were collected; however, the participating carriers indicated that weather is a significant operational factor influencing how they conduct their day-to-day business. None of the carriers indicated any observed weather impact on the performance of the ESCT system technologies.

Often referred to as creating the “urban canyon” effect, large buildings in downtown areas can block the line of sight from satellite-based mobile communication systems to satellites. In Anchorage, most of the OOC data points are in the downtown area. In addition, many terminals and shipper/consignee locations are large, industrial environments with buildings and overhead structures near and surrounding the loading and unloading facilities; their presence causes the urban canyon effect. Figure 28 shows a picture of one of Shell Motiva’s trucks parked under an overhead loading facility at their Maui terminal.

Figure 28. Weaver Brothers Truck Carrying a Tall, Oversized Load

Source: Weaver Brothers, Inc., 2006.

During the pilot test, satellite communication was also blocked from oversized loads transported by some of the Alaska carriers, as shown in Figure 28. Due to the ESCT system antenna’s low-look-angle, a tall load could block the line of sight to the satellite, especially as the vehicle in question was traveling northbound. This communication blockage could occur frequently since many of the loads carried north to the Prudhoe Bay area are large support equipment for the oil drilling industry.

Figure 29. Shell Motiva Fuel Delivery Truck's Communication Blocked by Overhead Facility

Source Battelle, 2006.

However, geographical location and terrain were other, more prominent factors blocking the line of sight from the ESCT systems to the satellite. Due to the ESCT system antenna's low-look-angle and Alaska's extensive mountainous terrain, Alaska carriers experienced more difficulties maintaining communication coverage. For example, Figure 30 shows a Carlile truck traveling through mountainous terrain in Alaska. Hawaii has considerable mountainous terrain throughout the island chain, but the majority of the routes traversed during the pilot test were close to the shoreline with an unobstructed view of the satellites.

Figure 30. Alaskan Carriers Experience Extreme Terrain Challenges for Maintaining Communication Coverage

Source: Carlile Transportation Systems, 2006.

In order to determine if and where terrain-related features had an impact on the satellite communications during the pilot test, U.S. Geological Survey (USGS) Digital Elevation Model (DEM) data were incorporated with the GIS data analysis to generate an elevation "profile" for each of the routes.

For example, Figure 31 shows the elevation profile for the James Dalton Highway in Alaska. Elevation data were averaged over half-mile segments in order to generate a single elevation point for each segment for individual routes. The route shown in this figure is 412 miles long, beginning approximately 30 miles north of Fairbanks and extending north to the Prudhoe Bay area. The elevation chart in Figure 31 identifies the average elevation of the roadway (feet above sea level) by mile.[25] Profile charts were created for each route in the pilot test by combining an elevation profile chart for each route with a plot of the total position reports and OOC position reports. The position reports and OOC reports were grouped in similar half-mile segments to facilitate the graphical depiction and determine possible indicators of the OOC reports (i.e., mountainous terrain, terminal facilities, truck stops).

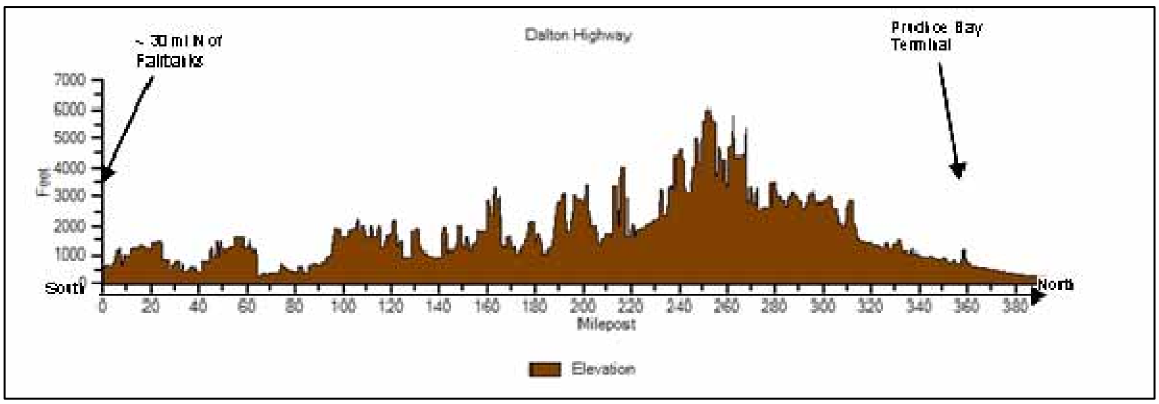


Figure 31. James Dalton Highway Elevation Profile

Source: Elevation Data, USGS World Digital Terrain Model (DTM).

25 Throughout this section, all height references in "feet" refer to a measurement of the feet "above sea level," unless otherwise stated.

7.1.4 Profile Charts for Alaska Routes

This section presents the individual profile charts for each of the pilot test routes in Alaska, characteristics of each route, and a discussion of the OOC data on each route.

James Dalton Highway

The James Dalton Highway—frequently referred to as the "Haul Road"—begins approximately 30 miles north of Fairbanks and runs north for over 400 miles, ending in the Prudhoe Bay area, as shown in Figure 32. The highway traverses some of the most rugged terrain in the United States, as shown in Figure 33, which provides a satellite image of the James Dalton Highway from mileposts 192 to 206 near Wiseman.

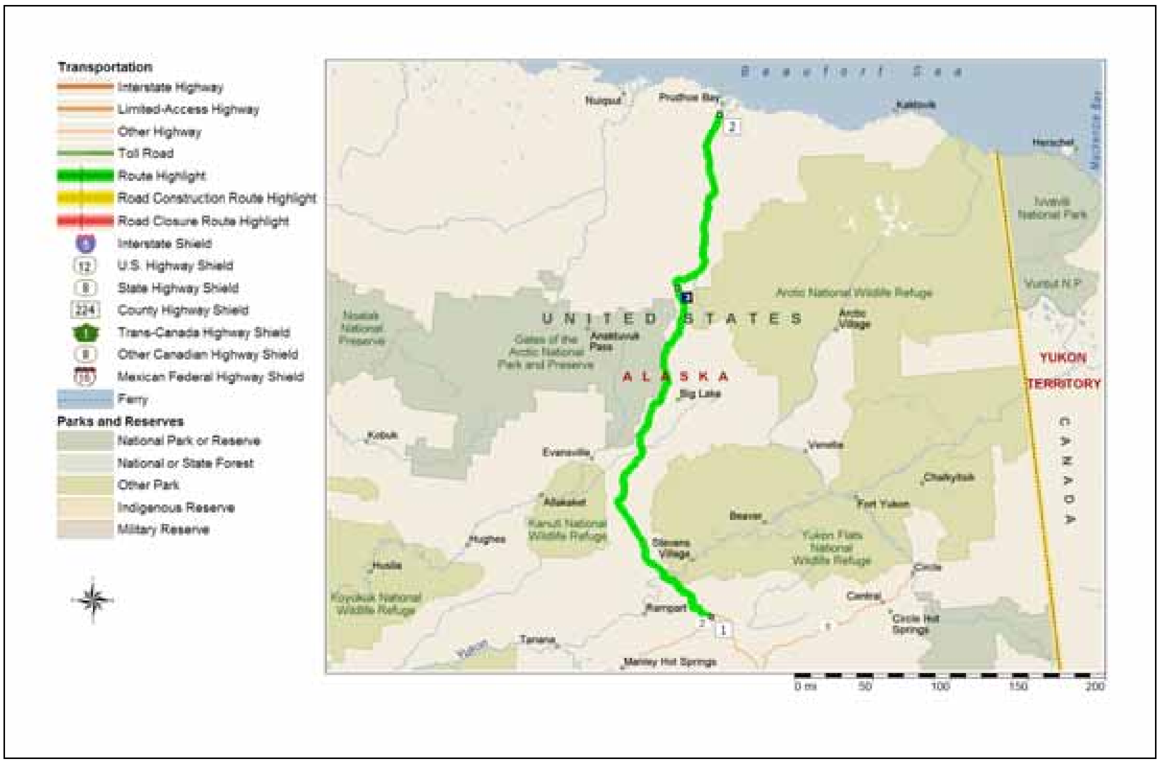


Figure 32. Map of James Dalton Highway[26]

Source: Data: Microsoft MapPoint North America, 2004.

[26] The numbered boxes at the beginning and end of highlighted routes were required within Microsoft MapPoint to highlight the routes. They have no significance for the data collected for this analysis.

Figure 33. Satellite Image of James Dalton Highway Near Wiseman
Source: Google Maps, 2006.

The James Dalton Highway passes by the Kanuti National Wildlife Refuge, through parts of the eastern section of the Gates of the Arctic National Park and Preserve, and crosses the mountain range at the Atigun Pass before heading into the northern tundra area surrounding Prudhoe Bay. At Prudhoe Bay, the route turns west for approximately 80 miles[27] along the Beaufort Sea. Figure 34 provides the profile charts for the James Dalton Highway.

Position Location Reports for James Dalton Highway

Overall, 61,945 position reports were sent by the ESCT systems on the James Dalton Highway. The second chart in Figure 34 shows a plot of the total number of position reports from the ESCT systems recorded (per half-mile segment) over the route. The spikes in the number of data points along the route correspond to the locations where drivers will typically stop for rest breaks, equipment checks, or food. The four primary spikes in these data correspond to the Bakers Knob Truck pull-out (mile post 100), the Cold Foot Midway Point (milepost 184), the top of the Atigun Pass (milepost 258), and the Prudhoe Bay terminal (milepost 360). Drivers will often stop at Atigun Pass, before beginning the steep descent down either side of the mountain, to confirm that their loads are secure and to check their brakes.

[27] Distances cited in the textual descriptions of the routes are approximately straight-line distances. Actual road-miles for each route were identified in Section 8.1.

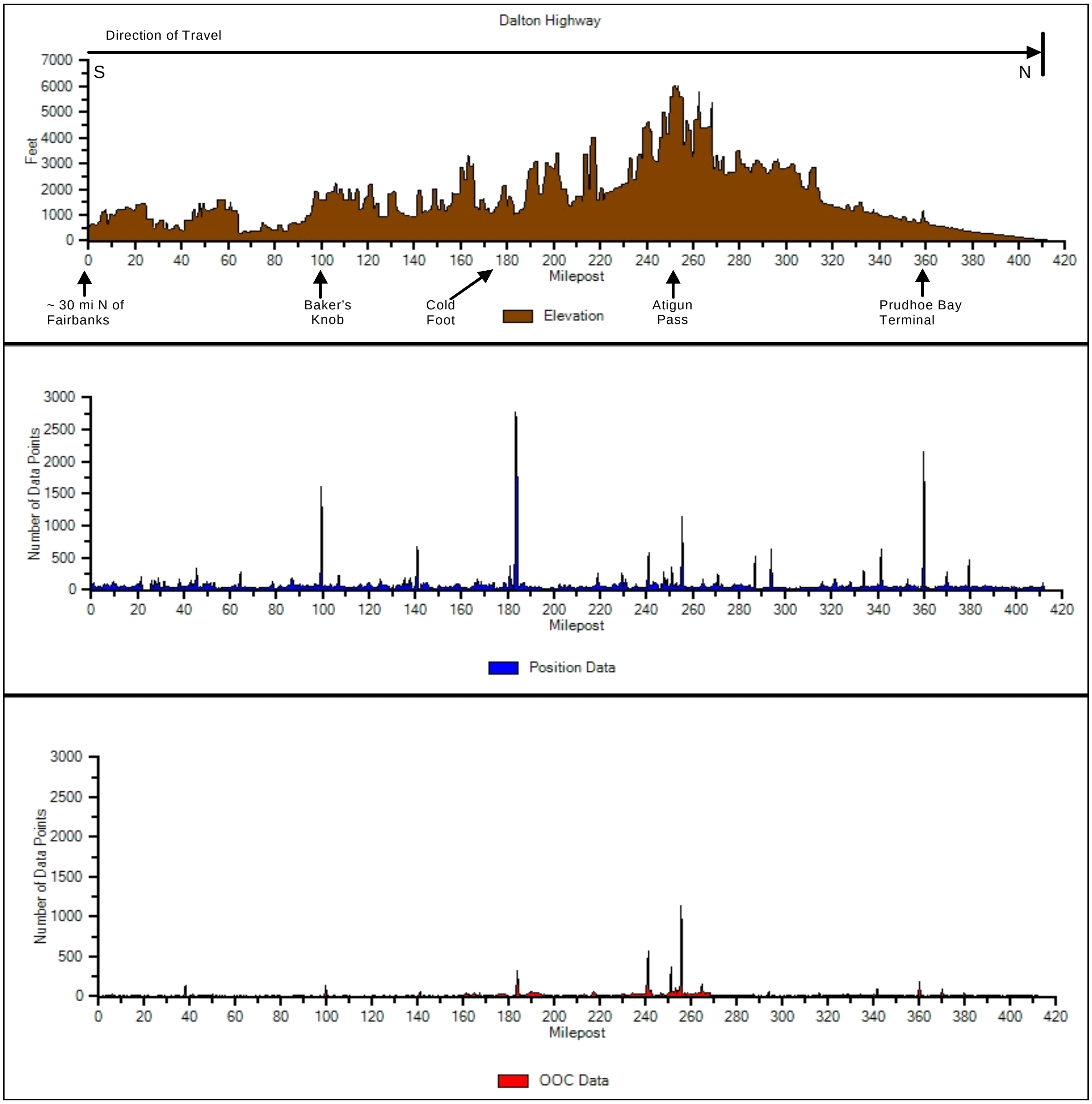


Figure 34. James Dalton Highway Profile Charts

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Out-of-Coverage Reports for James Dalton Highway

The third chart in Figure 34 is a plot of the total number of OOC reports over the route. A total of 15,000 OOC reports (over 24 percent of total position reports for this route) from the ESCT system were recorded on the James Dalton Highway. Based on discussions with carrier dispatch and management personnel and a comparison of the terrain in the areas where OOC reports were generated, OOC reports may have occurred for the following reasons:

- Many trips involve the transport of oversized loads to the Prudhoe Bay area from the south to north. Oversized loads could block the ESCT's antenna from a clear view to the satellite.
- As seen from the elevation chart, this entire route is very mountainous; therefore, the terrain could block the line of sight from the ESCT's antenna to the satellite.

Table 34 presents the summary of the position reports and OOC reports for each 10-mile segment of the James Dalton Highway. Figure 35 provides a histogram of OOC reports shown as a percentage of the total number of position reports throughout the route.

Table 34. Position and OOC Reports by 10-Mile Road Segment on James Dalton Highway

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
0-10	1,456	214	15%	B, M, O
10-20	1,130	164	15%	B, M, O
20-30	1,249	123	10%	B, M, O
30-40	1,149	300	26%	B, M, O
40-50	1,649	216	13%	B, M, O
50-60	1,112	140	13%	B, M, O
60-70	1,264	132	10%	B, M, O
70-80	890	161	18%	B, M, O
80-90	1,424	150	11%	B, M, O
90-100	2,851	254	9%	B, M, O
100-110	1,380	129	9%	B, M, O
110-120	1,051	107	10%	B, M, O
120-130	1,384	137	10%	B, M, O
130-140	1,523	159	10%	B, M, O
140-150	1,909	223	12%	B, M, O
150-160	1,136	158	14%	B, M, O
160-170	1,208	450	37%	B, M, O
170-180	1,264	368	29%	B, M, O

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
180-190	6,678	792	12%	B, M, O
190-200	732	599	82%	C, M, O
200-210	900	265	29%	C, M, O
210-220	1,211	413	34%	C, M, O
220-230	1,460	267	18%	C, M, O
230-240	988	590	60%	A, M, O
240-250	2,448	1,293	53%	A, M, O
250-260	2,583	2,454	95%	A, M, O
260-270	1,117	882	79%	A, M, O
270-280	1,366	233	17%	M, O
280-290	1,478	274	19%	M, O
290-300	1,286	206	16%	M, O
300-310	634	168	26%	M, O
310-320	964	230	24%	D, P, O
320-330	1,417	317	22%	D, P, O
330-340	1,256	277	22%	D, P, O
340-350	1,708	362	21%	D, P, O
350-360	1,090	263	24%	D, P, O
360-370	3,043	402	13%	D, P, O
370-380	1,698	366	22%	D, P, O
380-390	1,031	255	25%	D, P, O
390-400	834	219	26%	D, P, O
400-410	743	229	31%	D, P, O
410-420	251	59	24%	D, P, O

Key to Indicators of OOC Reports:

A Atigun Pass
B Bakers Knob
C Cold Foot Turn-Out Area (Buildings and Large Number of Trucks in Area)
D Continual Downslope from South to North
M Mountainous Terrain
O Oversized Loads
P Prudhoe Bay Area Terminals (Buildings and Overhead Load/Unload Facilities)

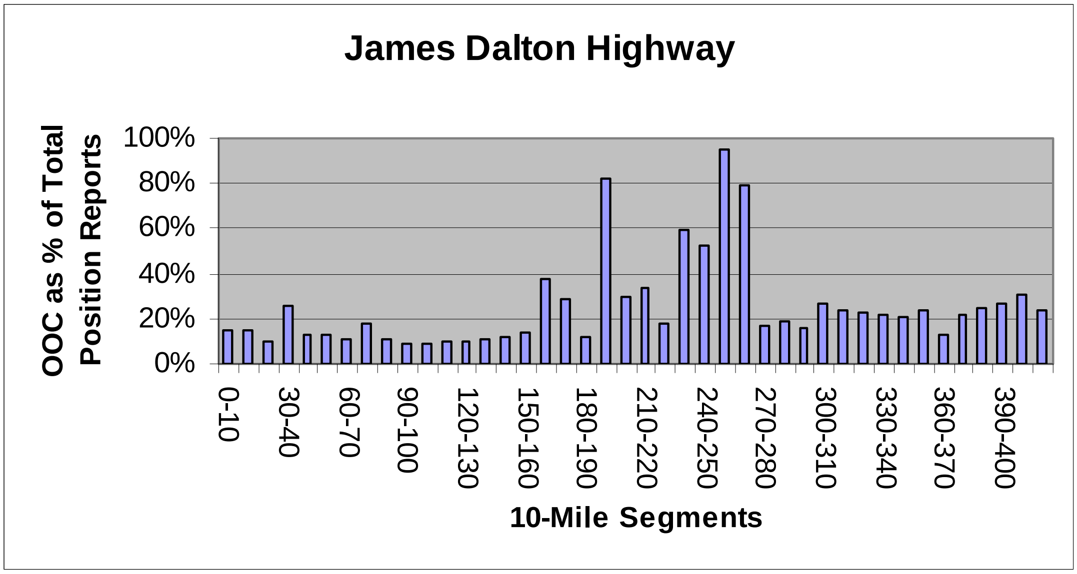


Figure 35. OOC Reports as a Percentage of Total Position Reports for James Dalton Highway

Several areas along the James Dalton Highway experienced large numbers of OOC reports. Each of these locations experienced spikes in the number of OOC reports, from several hundred to over 2,400 just north of the Atigun Pass. OOC reports ranging from 9 percent to 95 percent of the total position reports occurred at 10-mile intervals along this route.

- **Prudhoe Bay Area**. In the north, the Prudhoe Bay area (mileposts 318–406) had OOC reports throughout an 80-mile stretch. Drivers and carrier management indicated that there are many buildings and overhead facilities at the various loading and unloading facilities in the area.
- **Atigun Pass Area**. In the Atigun Pass region, over 70 percent of the messages were OOC reports from milepost 230 to milepost 270. Over a span of 30 to 35 miles, the route approaching this mountainous pass (going from south to north) changes elevation from 4,500 feet near milepost 240 to more than 6,000 feet at milepost 260, with drops to 3,000 feet within a distance of 20 miles between mileposts 270 and 280. Vehicles travel in and out of many valleys along this mountain range.
- **Cold Foot Midway Point**. Cold Foot Midway Point is a common stopping place to and from Prudhoe Bay, since it is the only facility along the 420-mile route where drivers can stop for food and other services. While stopped at this facility, drivers frequently left their vehicles idling to stay warm; therefore, the ESCT system remained "on" and continued reporting positions. As shown on the elevation chart in Figure 33, the surrounding terrain is also mountainous. From mileposts 190 to 200, some 82 percent of the messages were OOC reports, which could have resulted from the terrain blocking the line of sight from the ESCT's antenna to the satellite.
- **Bakers Knob**. Baker's Knob is a truck pull-out where drivers often stop for brief rests. As with Cold Foot, the surrounding terrain is mountainous, and there are frequently many

trucks parked at this facility. OOC reports ranged from 9 to 37 percent of the total messages for each of the 10-mile intervals in this area from milepost 0 to milepost 190.

State Route 1 (Glenn Highway)

As shown in Figure 36 State Route (SR) 1 was the longest route in the pilot test, covering more than 530 miles.

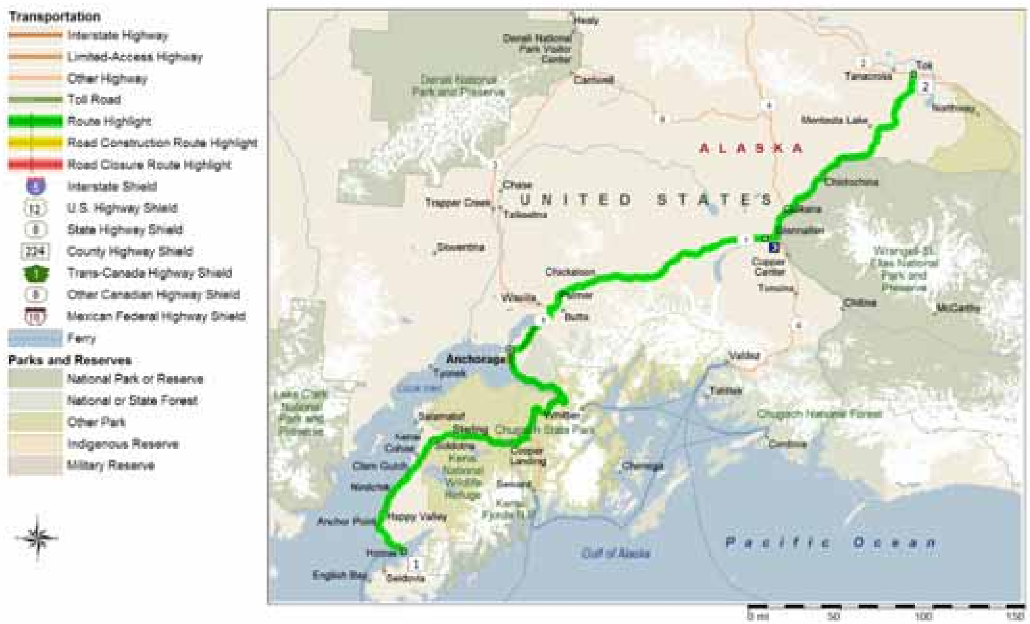


Figure 36. Map of SR 1 from Homer to Tok, Alaska

Source: Data: Microsoft MapPoint North America, 2004.

SR 1 starts in the south at Homer and runs north along the eastern coast of the Cook Inlet for approximately 80 miles to Soldotna. At Soldotna, SR 1 turns east (approximately 60 miles) crossing the Kenai National Wildlife Refuge until it meets SR 9 (Seward Highway). From the intersection with SR 9, SR 1 turns back north (approximately 80 miles), skirting around the eastern tip of the Turnagain Arm of Cook Inlet, and continues north to Anchorage. From Anchorage, SR 1 heads east (approximately 180 miles) until it reaches the southern intersection with SR 4 (Richardson Highway) near Glennallen. At this point, SR 1 breaks and picks up again approximately 20 miles north on SR 4 near Gulkana. From the northern intersection with SR 4, SR 1 heads northeast (approximately 115 miles), skirting the northern edge of the Wrangell-St. Elias National Park and Preserve until it ends where SR 1 meets SR 2 (Alaska Highway) in Tok. Figure 37 presents the profile charts for SR 1.

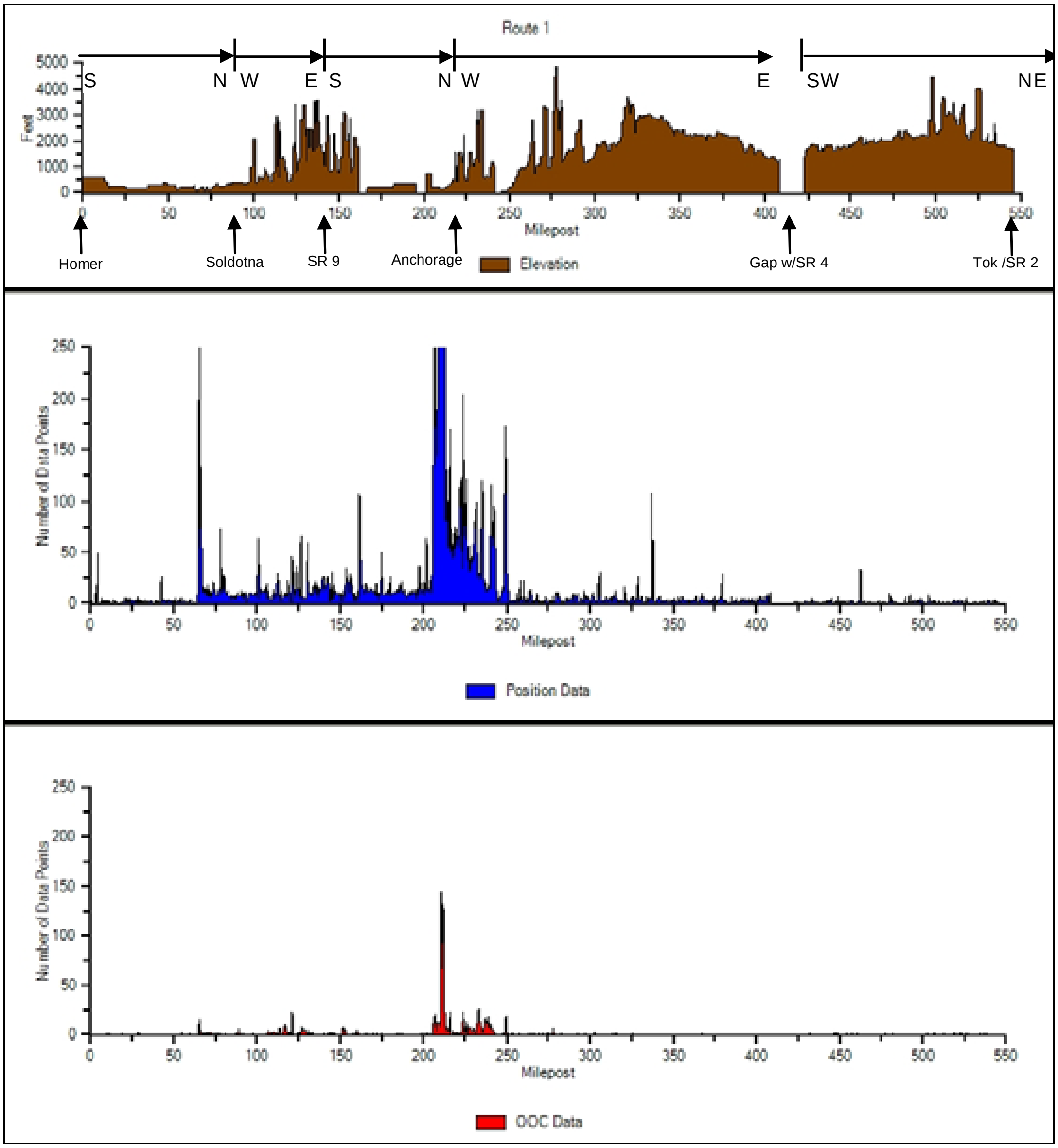


Figure 37. SR 1 Profile Charts

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Position Location Reports for State Route 1

The second chart in Figure 37 **s**hows the number of position reports recorded on SR 1 during the pilot test. A total of 26,808 position reports from the ESCT systems were recorded along SR 1. Overall, 1,466 OOC reports, or approximately 5 percent of the total of 26,808 position reports were recorded on SR 1. However, the majority of these position reports and OOC reports were recorded in the Anchorage vicinity and along the route between Anchorage and Soldotna. The spikes in the numbers of both position reports and OOC reports around milepost 210 are in the same areas as the terminal facilities for Weaver Brothers, Carlile Transportation, and Lynden. The terminal facilities of all three of these are within a mile of each other and less than 1 mile off SR 1, as shown in Figure 38. In order to provide better visibility of the data, the Y-axis scale on the position reports and OOC reports presented in Figure 36 was set to a maximum of 250 reports. However, in the segment of SR 1 between mileposts 210 and 212 (Anchorage area), the number of position reports at this location exceeded 3,600.

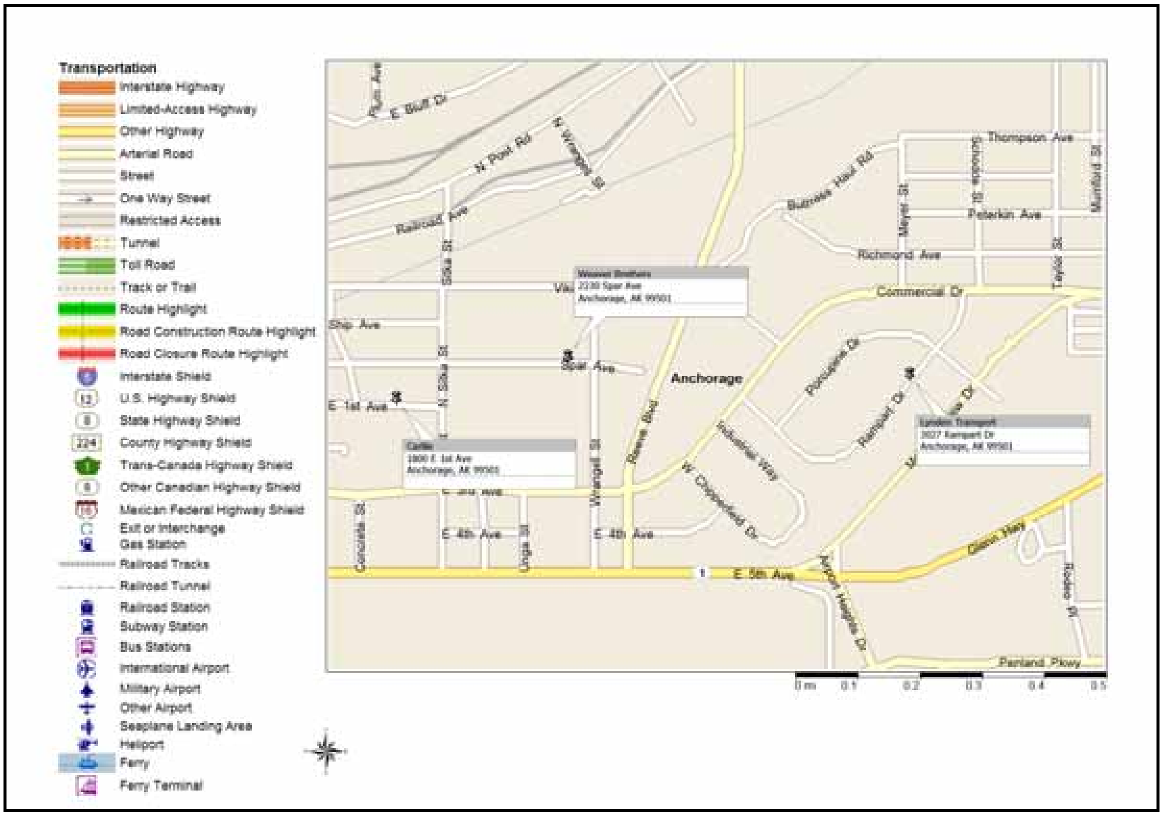


Figure 38. Location of Anchorage Carriers' Terminal Facilities

Source: Data: Microsoft MapPoint North America, 2004

Smaller spikes in position location data occurred in the south near the Cohoe and Kasilof areas (about milepost 65) and north near Chistochina, about 85 miles southwest of Tok, where drivers frequently stop.

Out-of-Coverage Reports for State Route 1

Table 35 presents a summary of the position reports and OOC reports for each 10-mile segment of SR 1. Figure 39 provides a histogram of OOC reports shown as a percentage of the total number of position reports throughout the route. OOC reports ranging from 0 percent to 39 percent of the total number of messages occurred at 10-mile intervals along this route.

Table 35. Position and OOC Reports by 10-Mile Road Segment on SR 1

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
0-10	82	0	0%	
10-20	26	5	19%	
20-30	54	4	7%	
30-40	30	0	0%	
40-50	76	2	3%	
50-60	42	4	10%	
60-70	581	25	4%	
70-80	311	17	5%	
80-90	194	12	6%	
90-100	172	3	2%	
100-110	260	16	6%	• Mountainous Terrain
110-120	216	62	29%	• Mountainous Terrain
120-130	310	63	20%	• Mountainous Terrain
130-140	336	15	4%	• Mountainous Terrain
140-150	292	14	5%	• Mountainous Terrain
150-160	264	31	12%	• Mountainous Terrain
160-170	430	13	3%	• Mountainous Terrain
170-180	257	4	2%	
180-190	257	4	2%	
190-200	248	1	0%	
200-210	2,445	116	5%	• Anchorage Terminals with Overhead Load or Unload Facilities and Indoor Maintenance Facilities • Carlile and Weaver Brothers Terminals Located in Small Valley
210-220	14,598	584	4%	• Anchorage Terminals with Overhead Load or Unload Facilities and Indoor Maintenance Facilities • Carlile and Weaver Brothers Terminals Located in Small Valley
220-230	1,500	106	7%	• Mountainous Terrain • Oversized Loads
230-240	945	202	21%	• Mountainous Terrain • Oversized Loads
240-250	1,029	63	6%	

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
250-260	130	8	6%	
260-270	96	8	8%	
270-280	49	19	39%	• Mountainous Terrain
280-290	92	3	3%	
290-300	111	2	2%	
300-310	117	5	4%	
310-320	86	7	8%	
320-330	106	1	1%	
330-340	229	0	0%	
340-350	63	0	0%	
350-360	65	0	0%	
360-370	70	1	1%	
370-380	88	0	0%	
380-390	40	2	5%	
390-400	55	1	2%	
400-410	86	1	1%	
410-420	–	–	–	No Data. SR 1 Splits at Junction with SR 4.
420-430	15	0	0%	
430-440	23	6	26%	
440-450	32	4	13%	
450-460	27	2	7%	
460-470	53	2	4%	
470-480	20	1	5%	
480-490	36	2	6%	
490-500	39	0	0%	
500-510	34	6	18%	• Mountainous Terrain near Tok and SR 2
510-520	21	4	19%	• Mountainous Terrain near Tok and SR 2
520-530	28	7	25%	• Mountainous Terrain near Tok and SR 2
530-540	24	6	25%	• Mountainous Terrain near Tok and SR 2
540-550	18	2	11%	• Mountainous Terrain near Tok and SR 2

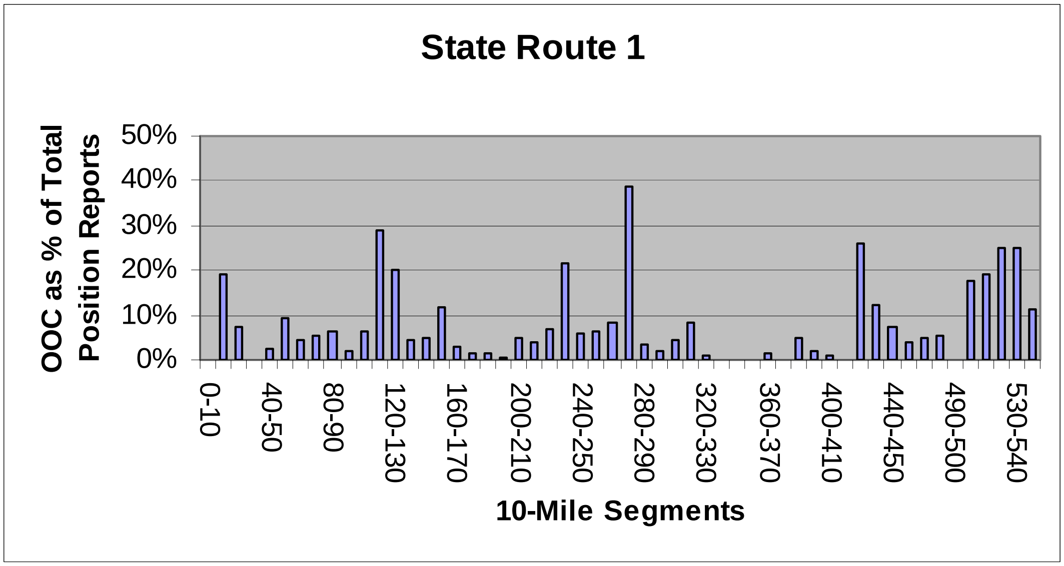


Figure 39. OOC Reports as a Percentage of Total Position Reports for SR 1

As shown in Table 35, the largest number of OOC reports occurred between mileposts 200 and 220 near the three carriers' terminal locations, where vehicles are serviced, loaded, unloaded, and parked awaiting dispatch. Due to the harsh climate, all of these terminals have in-door maintenance garages and wash bays, which blocked the line of sight from the ESCT systems to the satellite. Carriers indicated that this blockage at their terminals did not negatively impact their operations or the use of the ESCT systems. Although each carrier had OOC reports in this area, Weaver Brothers and Carlile had more than Lynden; this could be attributed to Lynden's having 12 vehicles with ESCT systems, while Carlile and Weaver Brothers each had 25. Also, the terminals for Carlile and Weaver Brothers are located in a small valley that parallels SR 1, where the line of sight from the ESCT systems to the satellite could be blocked. Lynden is located on a hill and does not have this immediate obstruction of their units.

The second largest number of OOC reports occurred immediately east of the Anchorage area between mileposts 220 and 240, where elevation changes from 500 feet to over 3,000 feet. Several OOC reports also occurred along the 70-mile section of SR 1 (mileposts 100–170) along the Kenai National Wildlife Refuge, which turns north toward Anchorage, where the elevation ranges from 500 feet to over 3,200 feet.

State Route 2 (Alaska Highway)

SR 2 covers over 373 miles, starting in the north at the junction of SR 1 and the James Dalton Highway (about 50 miles due north of Fairbanks) and ending in the south at the U.S.-Canadian border, as shown in Figure 40. From the intersection with the James Dalton Highway, SR 2 goes south (approximately 60 miles) to Fox, where it intersects SR 6 (Steese Highway). Continuing south (approximately 15 miles), SR 2 intersects SR 3 (George Parks Highway) in Fairbanks. From Fairbanks, SR 2 continues south (approximately 95 miles) to Delta Junction, at the intersection with SR 4 (Richardson Highway). From Delta Junction, SR 2 heads southeast (approximately 200 miles) through Tok (junction with SR 1), along the northern edge of the

Tetlin National Wildlife Refuge until it ends at the U.S.-Canadian border. Figure 41 presents the profile charts for SR 2.

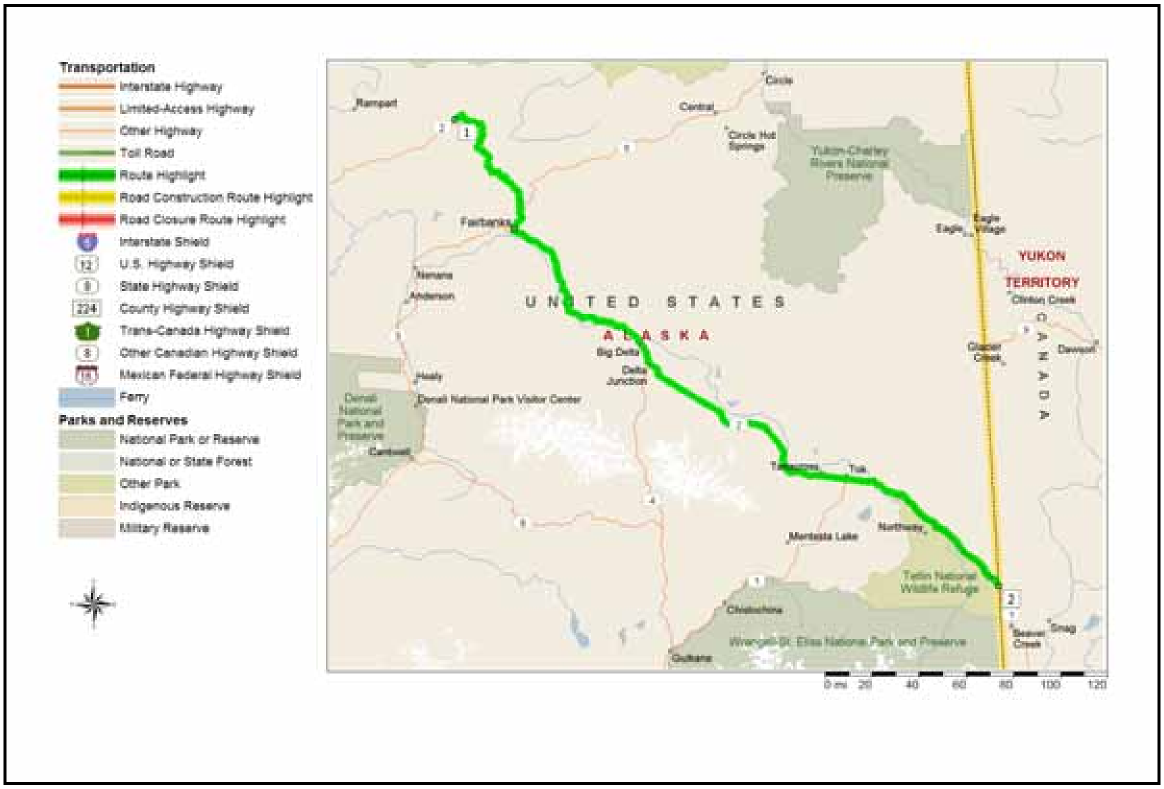


Figure 40. Map of SR 2 from James Dalton Highway to United States-Canadian Border

Source: Data: Microsoft MapPoint North America, 2004.

Position Location Reports for State Route 2

The second chart in Figure 41 shows the 23,337 position reports sent by the ESCT systems along SR 2 during the pilot test. This route has three distinct “sections,” and the number of position reports varied considerably between the sections. The three sections are (1) between the James Dalton Highway and Fairbanks; (2) between Fairbanks and Delta Junction; and (3) between Delta Junction and the U.S.-Canadian border. The vast majority of the position reports were recorded on the 75-mile stretch between Fairbanks and the intersection with the James Dalton Highway in the north. At a truck turn-out at the intersection of SR 2 and the James Dalton Highway, vehicles would often congregate before heading north towards Prudhoe Bay.

Two spikes in position location reports occurred on SR 2. The spike at milepost 60 is near the town of Fox, where the presence of a truck weigh station caused a considerable number of position reports. The second large spike in position location reports occurred between mileposts 70 and 80 in the Fairbanks area, where the Alaska West Express terminal is located. The Y-axis scale was maximized at 500 to provide better visibility of the majority of the position-report and OOC data. Yet, near milepost 75, some 3,762 position location reports occurred.

The Fairbanks-Delta Junction segment of SR 2 received moderate travel, with a third small spike in reports near Tok.

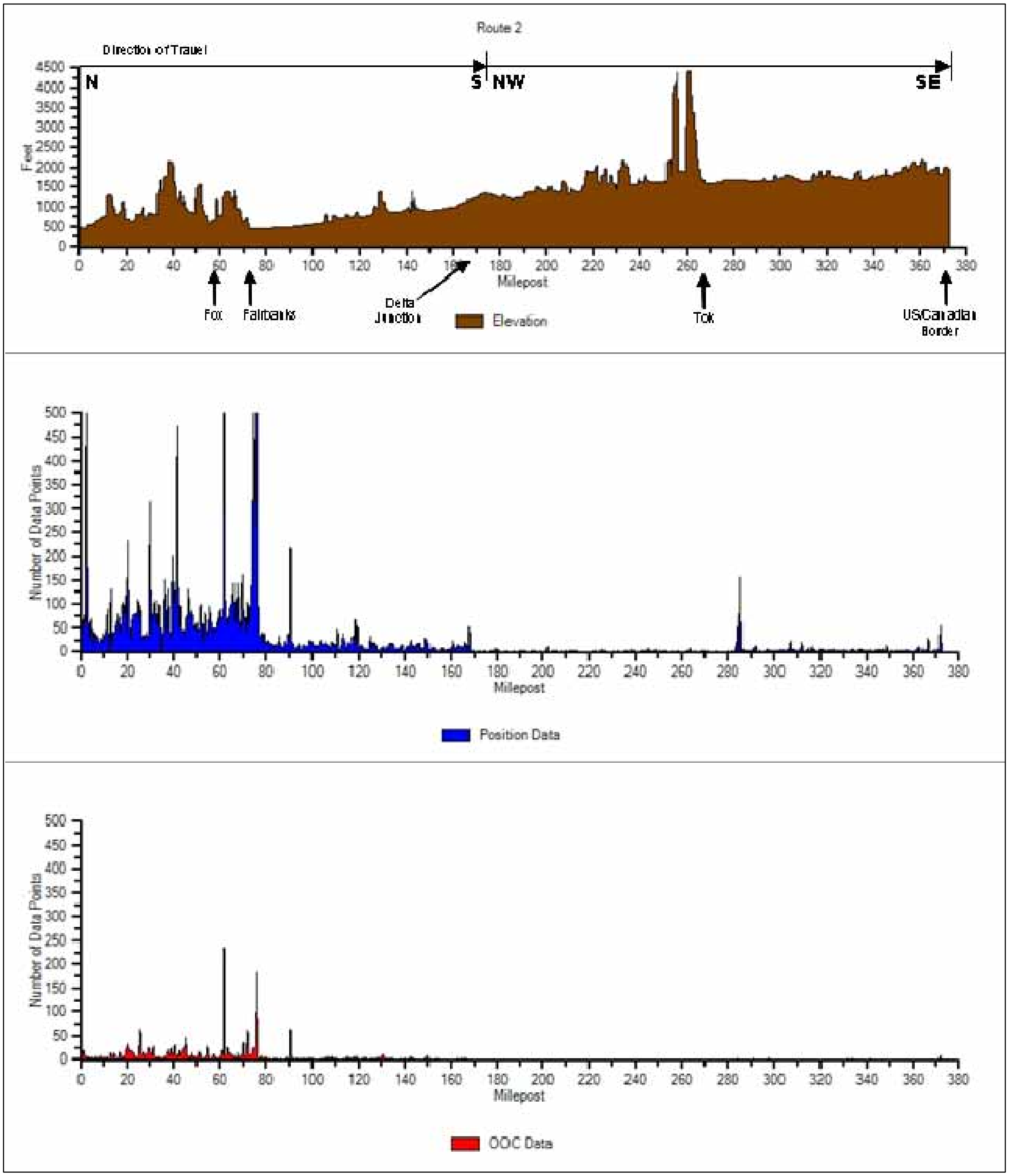


Figure 41. Profile Charts for SR 2

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Out-of-Coverage Reports for State Route 2

Overall, there were 2,604 OOC reports (over 11 percent of 23,337 position reports) sent by the ESCT systems along SR 2. Table 36 presents the summary of the position reports and OOC reports for each 10-mile segment of SR 2. Figure 42 provides a histogram of OOC reports shown as a percentage of the total number of position reports throughout the route. OOC reports ranging from 0 percent to 26 percent of the total position reports occurred at 10-mile intervals along this route.

Table 36. Position and OOC Reports by 10-Mile Road Segment on SR 2

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
0-10	1,325	112	8%
10-20	1,182	152	13%
20-30	1,301	337	26%
30-40	1,731	203	12%
40-50	1,886	282	15%
50-60	1,125	138	12%
60-70	4,951	415	8%
70-80	6,061	483	8%
80-90	346	35	10%
90-100	483	107	22%
100-110	307	46	15%
110-120	460	51	11%
120-130	216	43	20%
130-140	193	51	26%
140-150	249	33	13%
150-160	123	21	17%
160-170	223	20	9%
170-180	36	2	6%
180-190	18	0	0%
190-200	29	1	3%
200-210	34	2	6%
210-220	25	0	0%
220-230	26	3	12%
230-240	29	2	7%
240-250	44	2	5%
250-260	21	3	14%
260-270	27	0	0%
270-280	13	2	15%
280-290	255	4	2%
290-300	64	7	11%
300-310	78	6	8%
310-320	76	4	5%
320-330	63	7	11%
330-340	56	7	13%

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
340-350	71	3	4%
350-360	48	4	8%
360-370	87	6	7%
370-380	75	10	13%

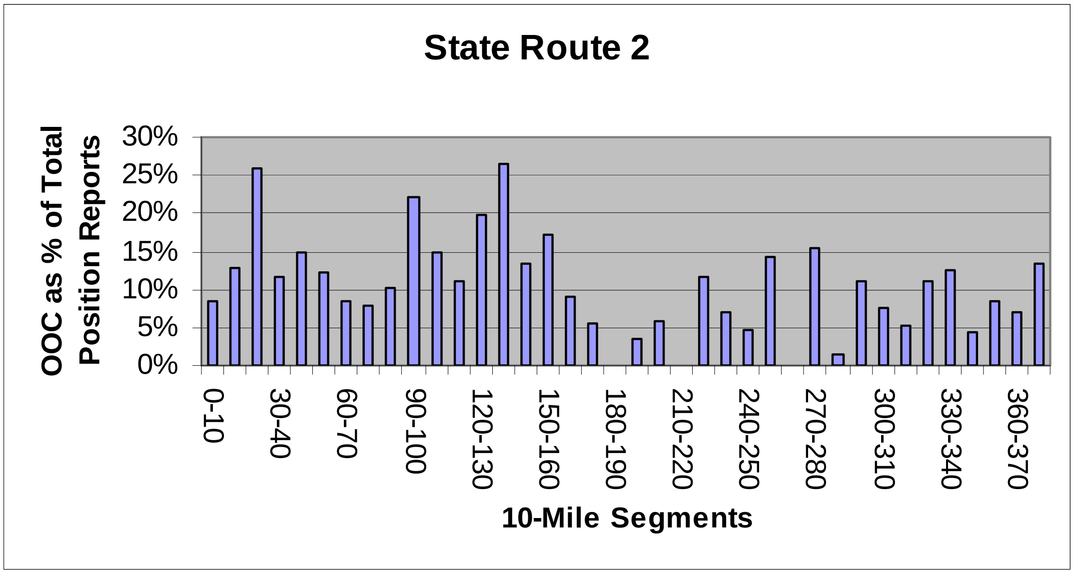


Figure 42. OOC Reports as a Percentage of Total Position Reports for SR 2

The largest number of OOC reports occurred on the northern section of SR 2 between the James Dalton Highway and Fairbanks. Although not as extreme as some segments on other routes, over its 75-mile stretch, this section of SR 2 has significant elevation changes from 500 feet to over 2,000 feet. The number of OOC reports peaks in areas with deep valleys, such as between mileposts 20 and 30. Also, the two spikes in OOC reports mirror the spikes in the position location reports at Fox (weigh station with overhead obstructions) and in Fairbanks (terminal location for Alaska West Express).

For the middle segment of SR 2 between Fairbanks and Delta Junction, the elevation chart indicates a gradual increase in elevation from north to south, starting with an elevation of approximately 500 feet in Fairbanks and rising to approximately 1,200 feet at Delta Junction. There are two elevation peaks on this section (near mileposts 130 and 140) and the OOC reports show a relative increase in those areas.

Relatively few OOC reports occurred along the southern segment of SR 2; however, few vehicles with the ESCT systems traversed this area, as indicated by the low number of position location reports. The data collected on this segment of SR 2 indicated a minimal OOC number of reports on this lower 200-mile-plus section of SR 2.

State Route 3 (George Parks Highway)

SR 3 covers 323 miles, starting in the north at Fairbanks (junction of SR 2 and SR 3) and ending in the south at the junction of SR 3 and SR 1, approximately 30 miles northeast of Anchorage, as shown in Figure 43.

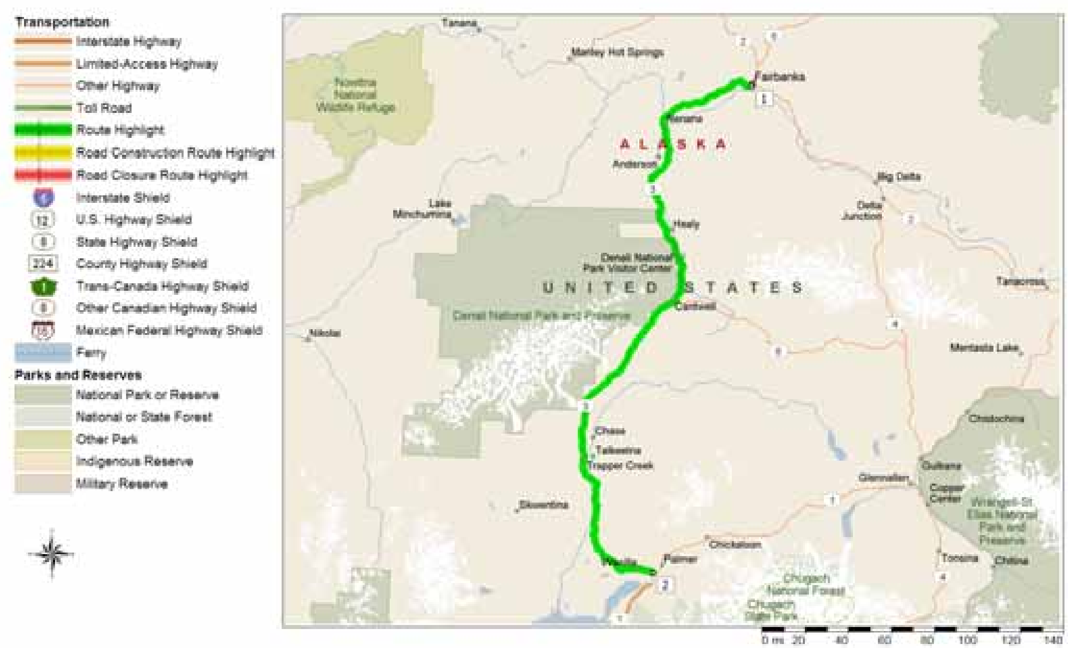


Figure 43. Map of SR 3

Source: Data: Microsoft MapPoint North America, 2004.

SR 3 begins in Fairbanks and heads west (approximately 50 miles) to Nenana. SR 3 turns south in Nenana and skirts the eastern edge of Denali National Park and Preserve (approximately 90 miles), where it intersects with SR 8 (Denali Highway). From the intersection with SR 8, SR 3 continues south along the Denali National Park and Preserve (approximately 170 miles) until it ends at the intersection with SR 1 (Glenn Highway), approximately 30 miles northeast of Anchorage. Figure 44 presents the profile charts for SR 3.

Position Location Reports for State Route 3

Overall, there were 22,005 position reports sent by the ESCT systems along SR 3. A large spike of position location reports occurred at the beginning of SR 3, which corresponds to reports in and around the Fairbanks terminal location of Alaska West Express. The Y-axis scale of the second and third charts in Figure 44 was maximized at 500 to provide better visibility of the majority of the position reports and OOC data. The actual numbers near milepost 0 in the Fairbanks area were 3,987 position location reports and 652 OOC reports. Other spikes in the number of reports occurred near Trapper Creek at milepost 260 and near the intersection of SR 3 with SR 1 at milepost 315. At milepost 260, the presence of a popular truck stop resulted in a spike in position reports at this location. Around milepost 315, several of the drivers reside in the area and frequently park their trucks at home between trips.

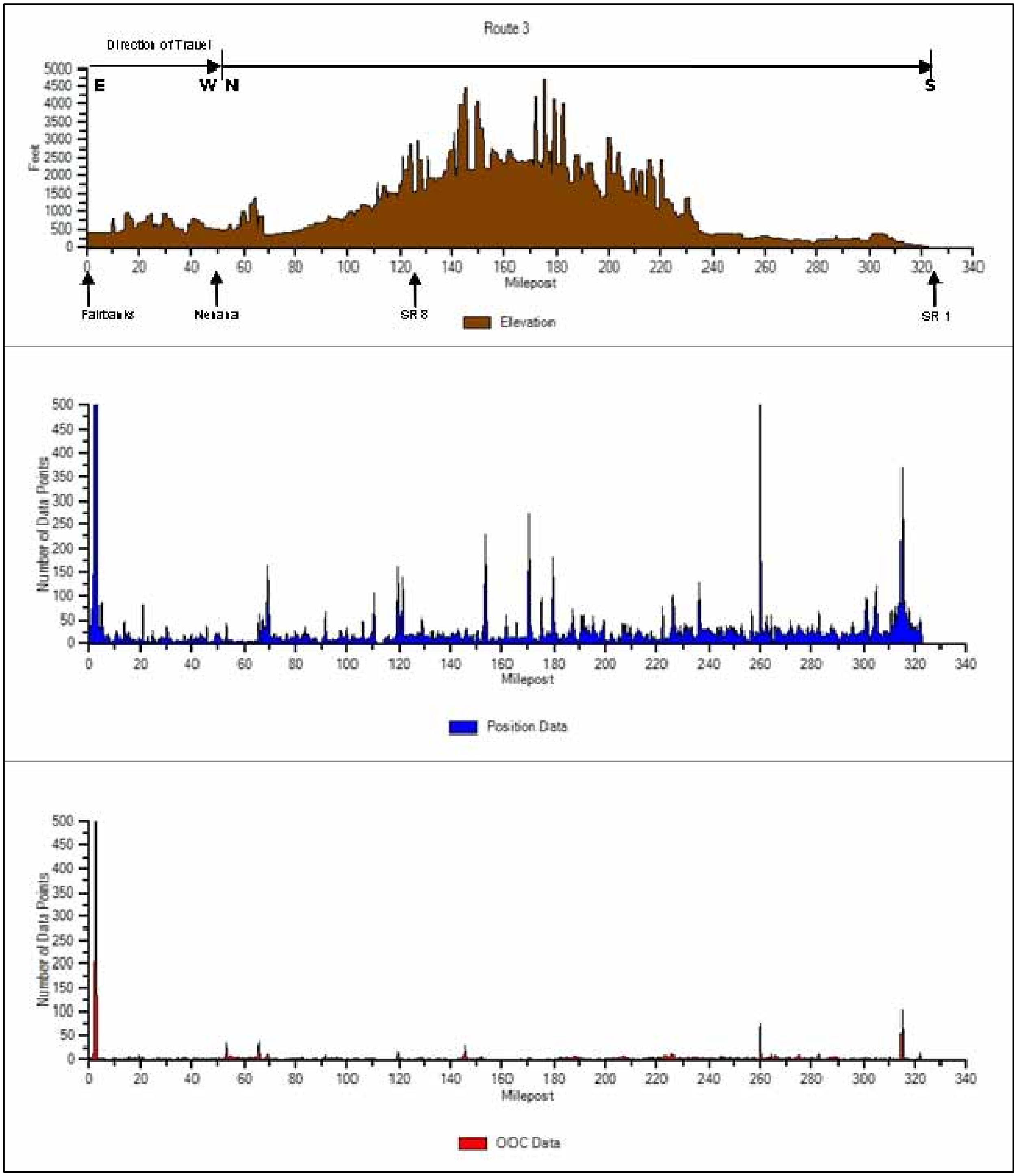


Figure 44. Profile Charts for SR 3

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Out-of-Coverage Reports for State Route 3

Overall, 2,733 OOC reports (12 percent of the 22,005 position reports) were sent by the ESCT systems along SR 3. Table 37 presents the summary of the position reports and OOC reports for each 10-mile segment of SR 3. Figure 45 provides a histogram of OOC reports expressed as a percentage of the total number of position reports throughout the route.

As with the position report data, three spikes in the OOC data occurred along the route. The first and largest spike was near the Alaska West Terminal in the Fairbanks area, where maintenance, loading, unloading, and other operations take place. Alaska West Express indicated that this did not have a negative impact on their operations or on their use of the ESCT systems. The second spike in the OOC data occurred in the Trapper Creek area at milepost 260 near the truck stop, where relatively large numbers of vehicles are often parked close together. The last spike in OOC data on SR 3 occurred before the junction with SR 1 at milepost 315, where several drivers park their trucks at their residences.

State Route 4 (Richardson Highway)

SR 4 covers 268 miles, starting in the south in Valdez and ending in the north at Delta Junction at the junction of SR 4 and SR 2, as shown in Figure 46. SR 4 begins in Valdez and extends east (approximately 50 miles) before turning north near Mt. Bill Mitchell. Then SR 4 runs (approximately 85 miles) along the western edge of the Wrangell-St. Elias National Park to the junction with SR 1. From the northern junction with SR 1, SR 4 extends north (approximately 135 miles) and ends in Delta Junction at the intersection with SR 2. Figure 47 provides the profile charts for SR 4.

Position Location Reports on State Route 4

During the pilot test, SR 4 was not a heavily traveled road, but 2,255 position location reports were sent by the ESCT systems along this 268-mile stretch of road during the test. Position reports were recorded throughout the route with three spikes of data.

The first spike in the number of position location reports occurred at the beginning of the route in and around the city of Valdez, as well as at the loading and unloading facilities in the area. The second spike occurred around Gulkana at milepost 130 near a gold barge and mining facility where periodic pick-up and drop-off activity occurred. The final spike in position location reporting occurred at the end of this route in Delta Junction, which has a military base pick-up and drop-off point.

Table 37. Position and OOC Reports by 10-Mile Road Segment on SR 3

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
0-10	6,806	868	13%	Alaska West Express Fairbanks Terminal
10-20	285	54	19%	Mountainous Terrain
20-30	245	36	15%	Mountainous Terrain
30-40	188	40	21%	Mountainous Terrain

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
40-50	235	38	16%	Mountainous Terrain
50-60	185	109	59%	Mountainous Terrain
60-70	483	119	25%	Mountainous Terrain
70-80	312	34	11%	Mountainous Terrain with Rising Elevation from North to South
80-90	273	36	13%	Mountainous Terrain with Rising Elevation from North to South
90-100	282	58	21%	Mountainous Terrain with Rising Elevation from North to South
100-110	293	30	10%	Mountainous Terrain with Rising Elevation from North to South
110-120	415	35	8%	
120-130	616	41	7%	Intersection with SR 8
130-140	311	27	9%	Mountainous Terrain with Significant Elevation Changes
140-150	337	71	21%	Mountainous Terrain with Significant Elevation Changes
150-160	532	25	5%	Mountainous Terrain with Significant Elevation Changes
160-170	317	8	3%	Mountainous Terrain with Significant Elevation Changes
170-180	836	17	2%	Mountainous Terrain with Significant Elevation Changes
180-190	419	80	19%	Mountainous Terrain with Significant Elevation Changes
190-200	614	30	5%	Mountainous Terrain with Significant Elevation Changes
200-210	328	69	21%	Mountainous Terrain with Significant Elevation Changes
210-220	330	44	13%	Mountainous Terrain with Significant Elevation Changes
220-230	535	116	22%	Mountainous Terrain with Significant Elevation Changes
230-240	667	67	10%	Mountainous Terrain with Significant Elevation Changes
240-250	523	72	14%	Mountainous Terrain with Significant Elevation Changes
250-260	438	57	13%	Trapper Creek Truck Stop
260-270	1,345	148	11%	
270-280	525	83	16%	
280-290	529	87	16%	
290-300	415	33	8%	
300-310	771	39	5%	
310-320	1,396	139	10%	Drivers Parking Trucks at Home Near Intersection with SR 1
320-330	219	23	11%	

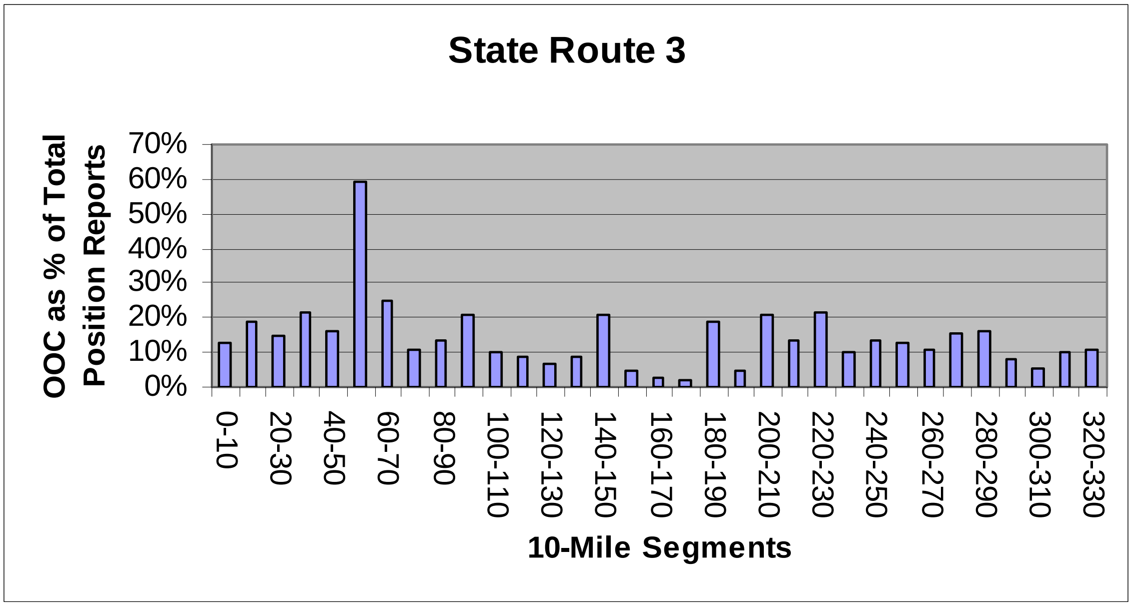


Figure 45. OOC Reports as a Percentage of Total Position Reports for SR 3

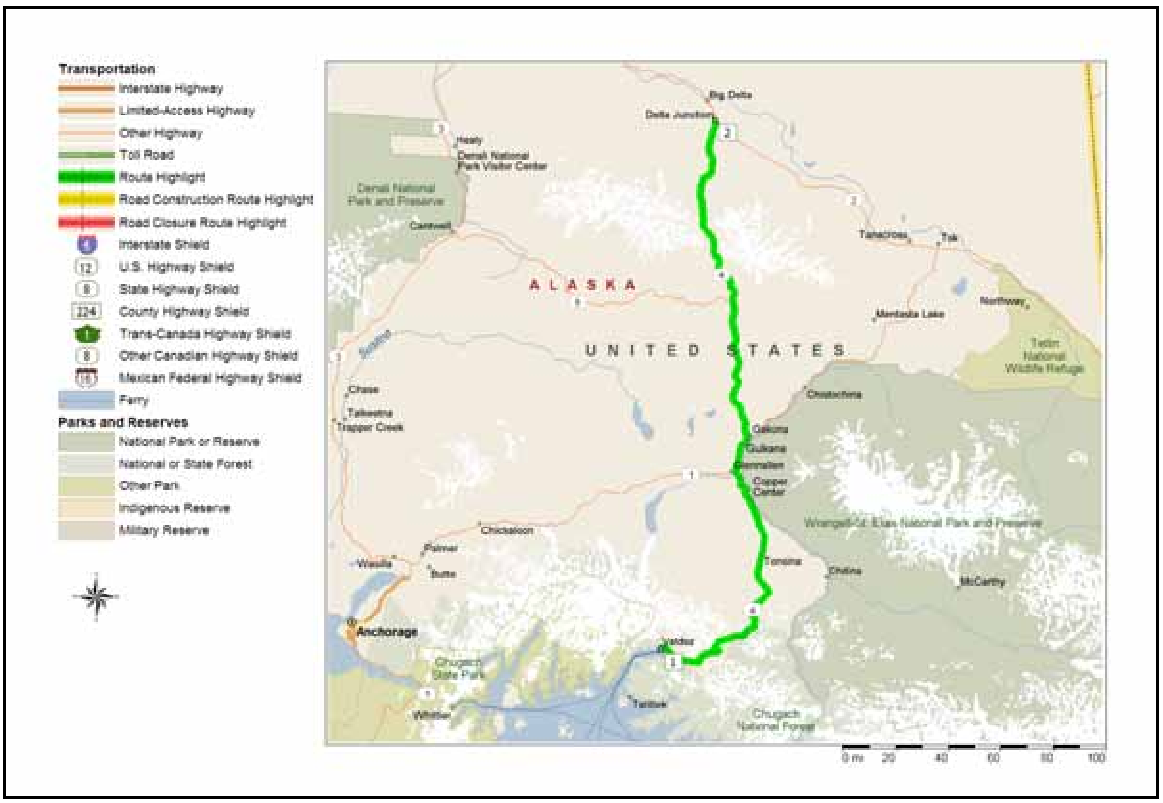


Figure 46. Map of SR 4

Source: Data: Microsoft MapPoint North America, 2004.

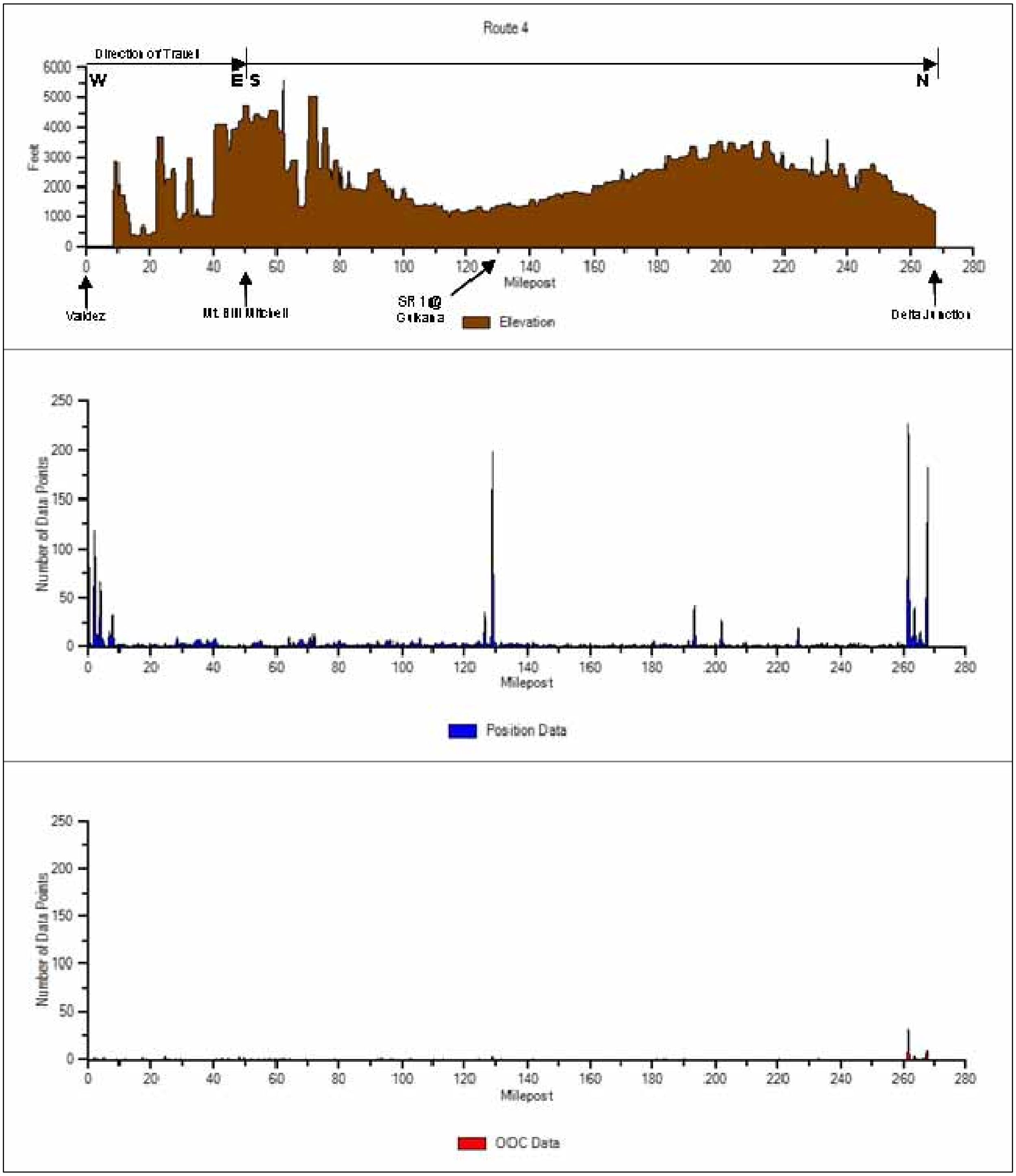


Figure 47. SR 4 Profile Charts

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Out-of-Coverage Reports on State Route 4

A total of 128 OOC reports (over 5 percent of the 2,255 position reports) were sent by the ESCT systems along SR 4 during the pilot test. Table 38 presents the summary of the position reports and OOC reports for each 10-mile segment of SR 4. Figure 48 provides a histogram of OOC reports expressed as a percentage of the total number of position reports throughout the route. The largest spike of OOC reports on SR 4 occurred near Delta Junction, a pick-up and drop-off point for many military loads, with loading and unloading facilities and a downhill slope from south to north.

Table 38. Position and OOC Reports by 10-Mile Road Segment on SR 4

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total	Possible Indicators of OOC Reports
0-10	423	10	2%	• Valdez Terminal (Load and Unload Facilities) • City of Valdez
10-20	28	5	18%	• Mountainous Terrain • Mt. Bill Mitchell
20-30	42	8	19%	• Mountainous Terrain
30-40	77	0	0%	• Mt. Bill Mitchell
40-50	33	11	33%	• Mountainous Terrain
50-60	39	5	13%	• Mt. Bill Mitchell
60-70	54	6	11%	• Mountainous Terrain
70-80	56	1	2%	
80-90	48	0	0%	
90-100	57	4	7%	
100-110	53	2	4%	
110-120	50	2	4%	
120-130	285	5	2%	• Gulkana Gold Barge and Mining Facility
130-140	46	1	2%	
140-150	34	1	3%	
150-160	17	0	0%	
160-170	21	0	0%	
170-180	24	0	0%	
180-190	34	2	6%	
190-200	69	1	1%	
200-210	52	0	0%	
210-220	21	0	0%	
220-230	38	1	3%	
230-240	26	2	8%	
240-250	27	0	0%	
250-260	21	0	0%	
260-270	580	61	11%	• Long, Downhill Slope from South to North • Pick-Up and Drop-Off Point for Military Loads (Load and Unload Facilities)

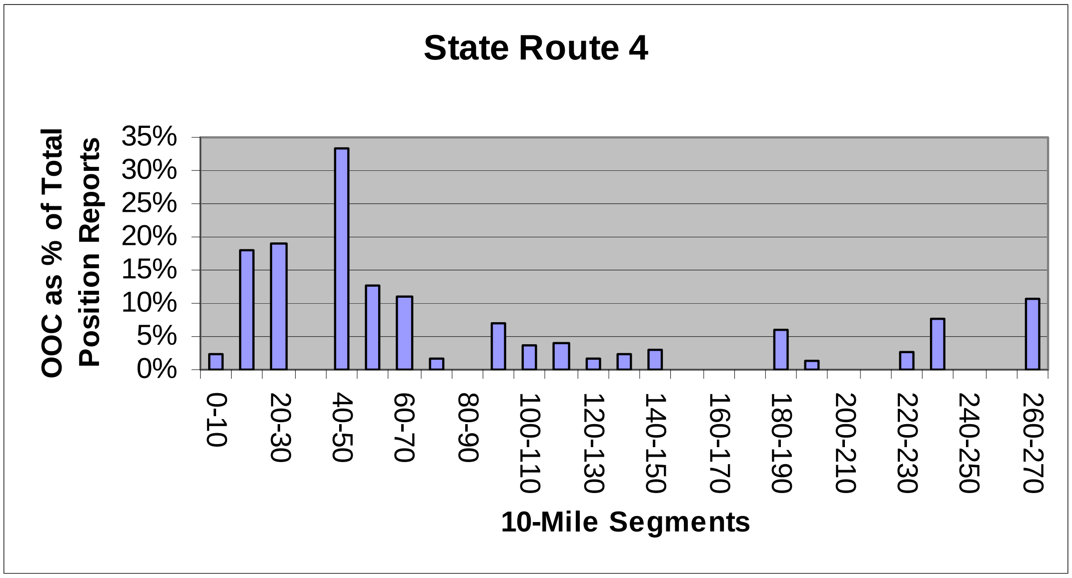


Figure 48. OOC Reports as a Percentage of Total Position Reports for SR 4

State Route 6 (Steese Highway)

SR 6 is 142 miles long, starting at Fox, just north of Fairbanks, at the junction with SR 2 and extends northeast to Circle, as shown in Figure 49.

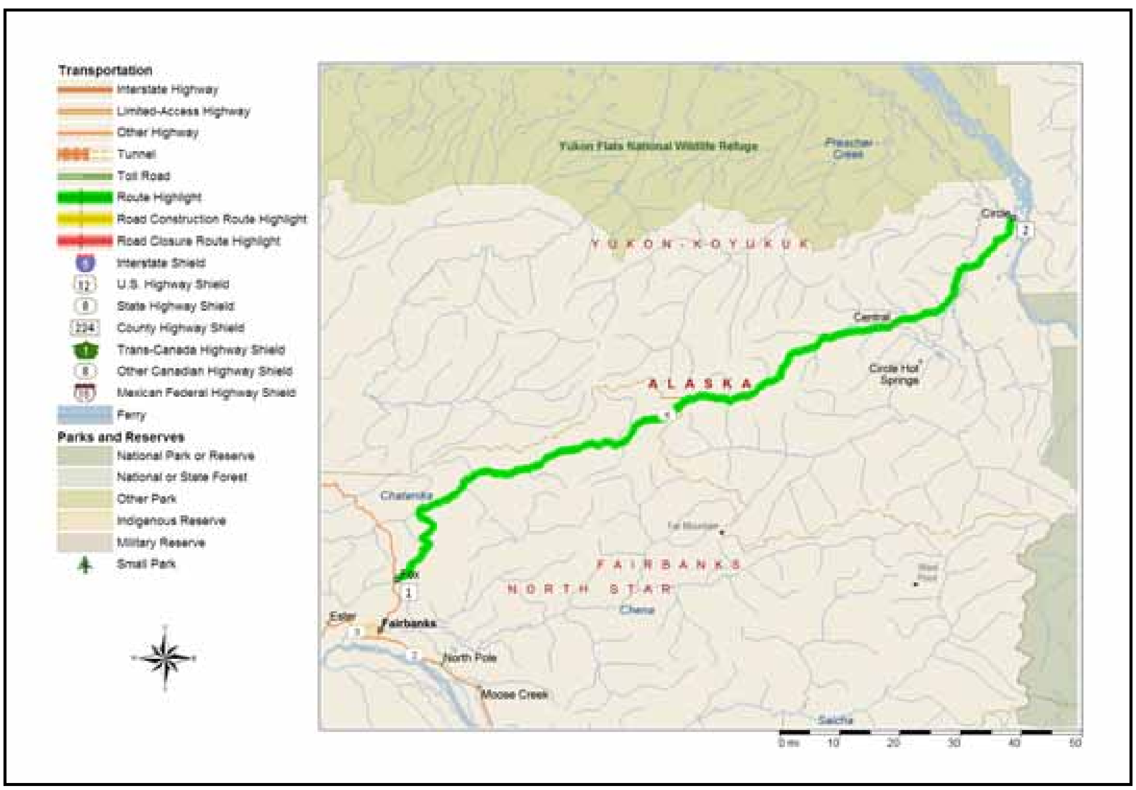


Figure 49. Map of SR 6

Source: Data: Microsoft MapPoint North America, 2004.

During the pilot test, vehicles with the ESCT system traversed only the first 29 miles of the route from Fox to Long Creek Road. The profile charts for SR 6 are shown in Figure 50.

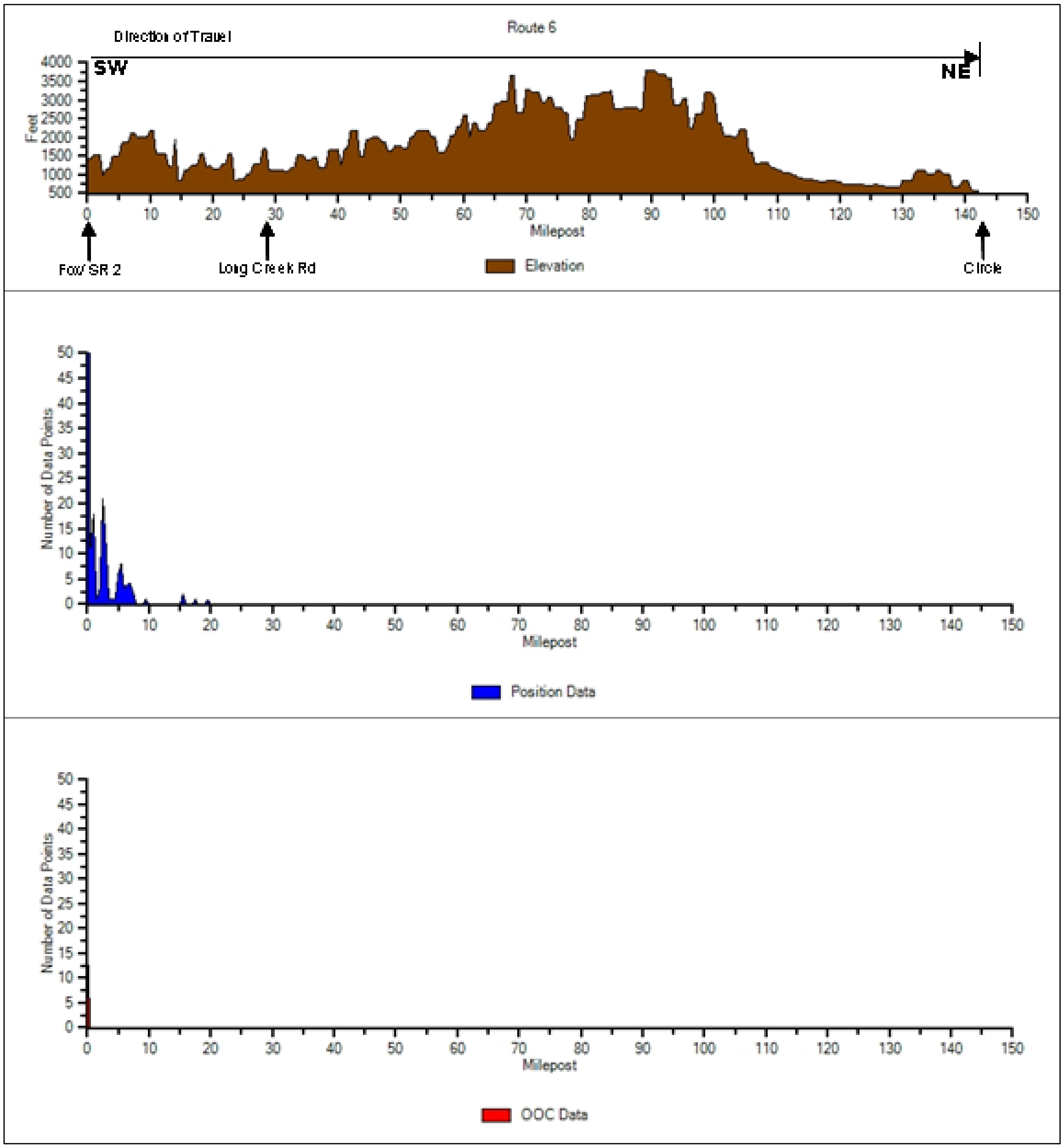


Figure 50. Profile Charts for SR 6

Source: Data: USGS World DTM; Roadway Data: ESRI Street Map.

Position Location Reports and Out-of-Coverage Reports on State Route 6

During the pilot test, 295 position reports were sent by the ESCT systems along the first 20 miles of SR 6. As shown in Table 39, 16 OOC reports (over 5 percent of the 295 position reports) were recorded within the first 10-mile segment, near the junction with SR 2 in Fox. Figure 51 provides a histogram of OOC reports shown as a percentage of the total number of position reports throughout the route. These OOC position reports were recorded in the vicinity of the truck weigh station in Fox with many vehicles stopping in close proximity.

Table 39. Position and OOC Reports on SR 6

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
0-10	291	16	5%
10-20	4	0	0%
20-150	0	0	N/A

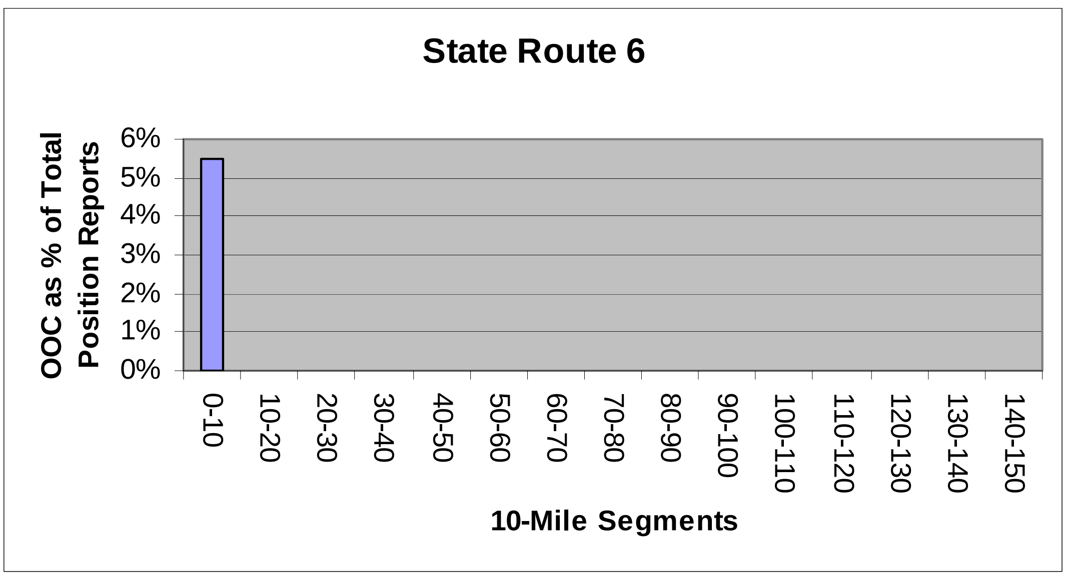


Figure 51. OOC Reports as a Percentage of Total Position Reports for SR 6

State Route 8 (Denali Highway)

As shown in Figure 52, SR 8 extends east-west between SR 3 and SR 4. Starting at Cantwell in the southeast corner of the Denali National Park and Preserve, SR 8 runs east 133 miles to the intersection with SR 4 near Paxson Lake. The profile charts for SR 8 are presented in Figure 53.

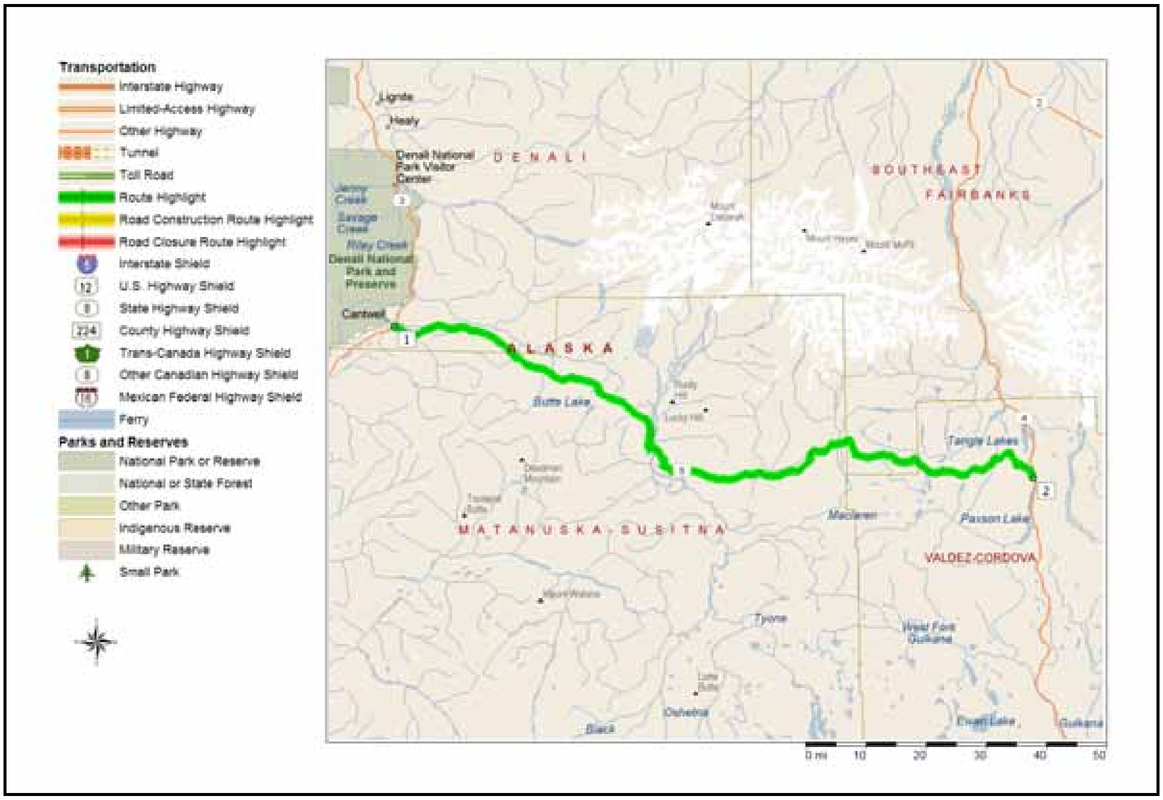


Figure 52. Map of SR 8

Source: Data: Microsoft MapPoint North America, 2004.

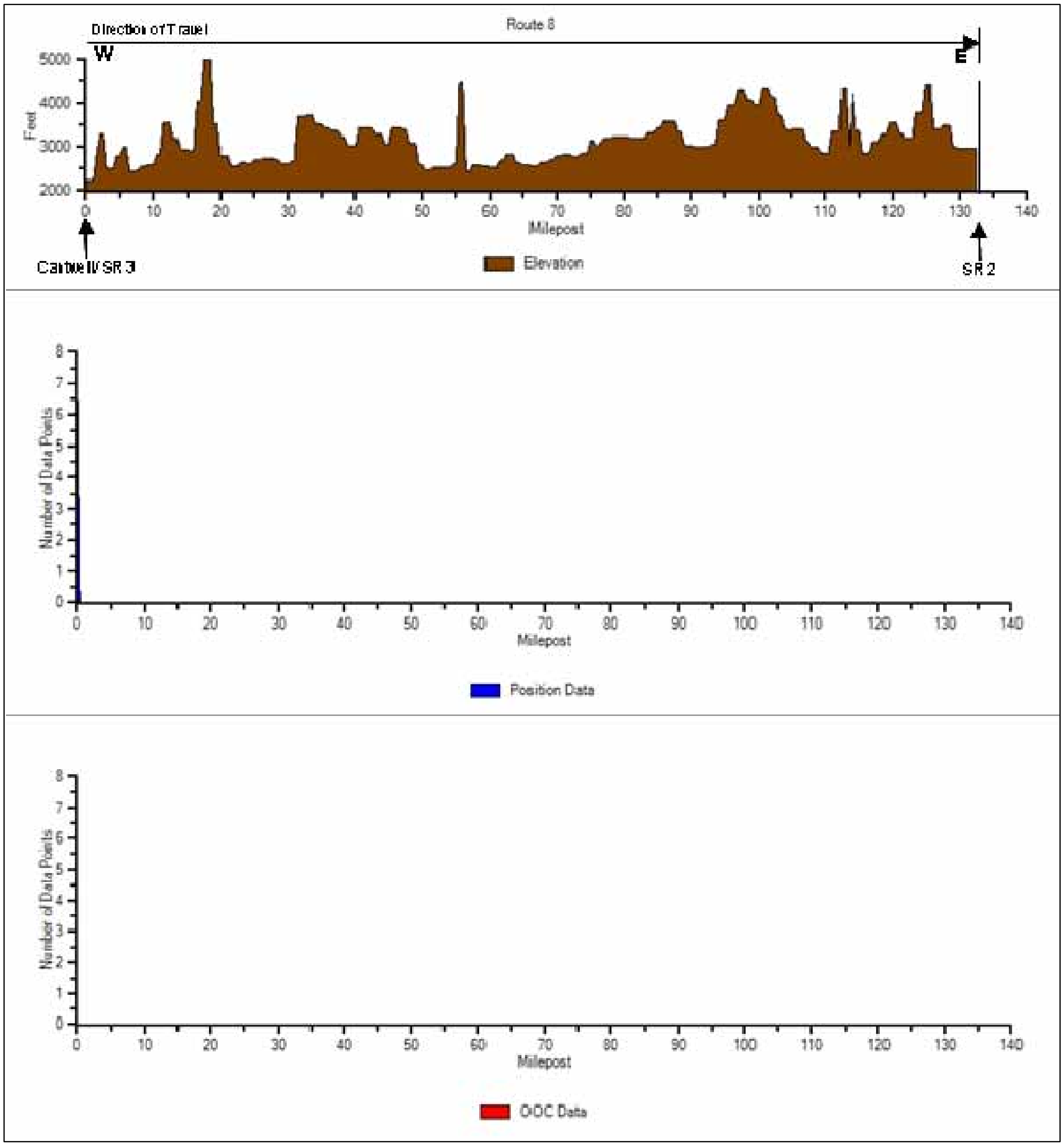


Figure 53. Profile Charts for SR 8

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Position Location and Out-of-Coverage Reports on State Route 8

Only eight position location reports were sent by the ESCT systems along SR 8 near the intersection with SR 3 in the west. As shown in Table 40, there were no OOC reports for SR 8.

Table 40. Position and OOC Reports on SR 8

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
0-10	8	0	0
10-140	0	0	N/A

State Route 9 (Seward Highway)

SR 9 runs south-north for 37 miles from Seward to the intersection of SR 1 in the Kenai Peninsula, as shown in Figure 54. Starting at the Seward Port, SR 9 extends north, crosses a large mountain (elevation approximately 4,000 feet) at the southern tip of Kenai Lake, then drops back down into a valley (elevation approximately 600 feet) as it continues to the eastern edge of the lake, until it reaches Moose Pass (elevation approximately 4,000 feet). From Moose Pass, SR 9 turns west to SR 1 in the Kenai Peninsula. The profile charts for SR 9 are shown in Figure 55.

Figure 54. Map of SR 9

Source: Data: Microsoft MapPoint North America, 2004.

Position Location Reports on State Route 9

For the pilot test, the ESCT systems recorded 124 position location reports on SR 9. The largest spike in the data occurred at the Seward terminal area, where vehicles waited to be loaded and unloaded. A second smaller spike occurred at the end of the route where it meets SR 1. In Figure 55, the Y-axis scale was adjusted to 20 to provide better visibility of the majority of the position report and OOC data. There were 48 position location reports near mileposts 1 (Seward Port area) and 37 (SR 1 intersection).

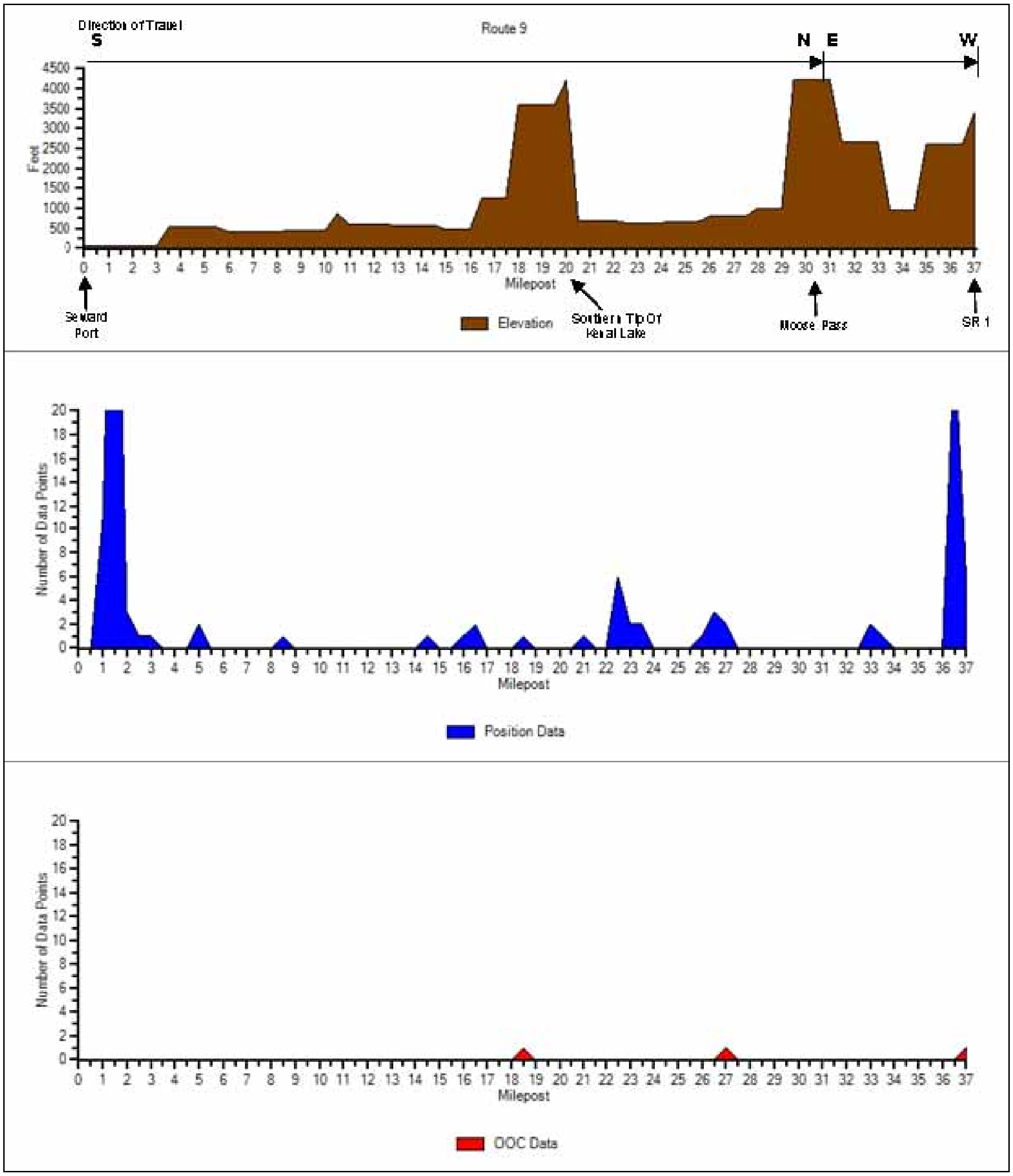


Figure 55. Profile Charts for SR 9

Source: Elevation Data: USGS World DTM; Roadway Data: ESRI Street Map.

Out-of-Coverage Reports on State Route 9

Table 41 presents the summary of the position reports and OOC reports for each 10-mile segment of SR 9. Figure 56 provides a histogram of OOC reports expressed as a percentage of the total number of position reports throughout the route. Three OOC reports were sent by the ESCT systems along this route. One occurred at each of the two spikes in terrain (Moose Pass and near the southern tip of Kenai Lake), and the third occurred at the intersection with SR 1. This route runs along the southern edge of the state with a relatively low terrain profile.

Table 41. Position and OOC Reports by 10-Mile Road Segment on SR 9

Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
0-10	67	0	0%
10-20	5	1	20%
20-30	17	1	6%
30-40	35	1	3%

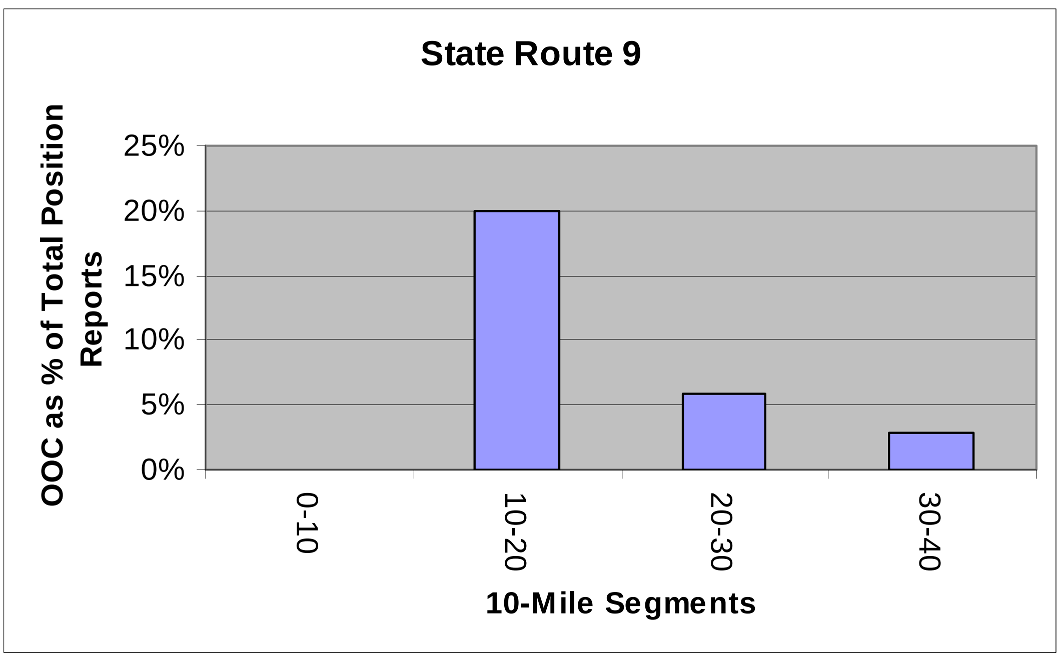


Figure 56. OOC Reports as a Percentage of Total Position Reports for SR 9

7.1.5 Profile Charts for Hawaii Routes

Over 4,000 position location reports were recorded on the three Hawaiian islands during the pilot test, but only 24 (less than 1 percent) OOC reports were recorded. All 24 of the OOC reports recorded for the test occurred on Kauai. On all of the routes traversed, the participating carrier, Shell Motiva, delivered fuel from its terminal locations on the islands to various fueling stations. Due to the small number of trucks with ESCT systems (one on Kauai, two on Maui, and one on Hawaii), the quantity of data collected throughout Hawaii, Maui, and Kauai was significantly less than the amount of data collected in Alaska.

Routes on the Island of Hawaii

Figure 57 shows the routes for the pilot test on the Island of Hawaii—Routes 11, 19, and 190.

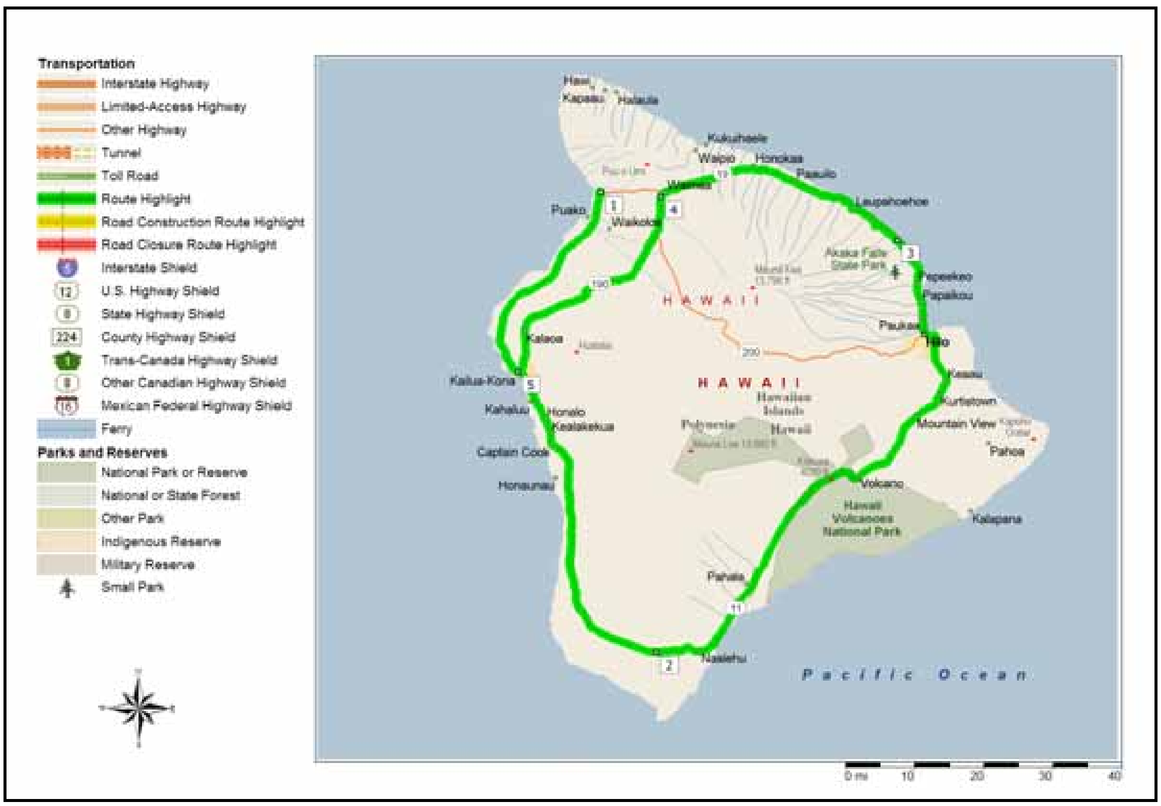


Figure 57. Map of Routes on the Island of Hawaii

Source: Data: Microsoft MapPoint North America, 2004.

SR 11 is 155 miles long. It starts on the northwestern side of the island near Puako. It goes through Kailua-Kona and then around the southern tip of the island, ending on the eastern side at Hilo, where it intersects with SR 19. SR 19 is 56 miles long; it originates at the junction with SR 11 on the eastern edge of the island in Hilo and extends north through Paauilo and ends in Waimea at the junction with SR 190. SR 190, which is 39 miles long, starts in Waimea at the junction with SR 19 and continues southwest to Kailua-Kona, where it ends at the junction with SR 11.

Position Location Reports on the Island of Hawaii

Two vehicles with the ESCT system traversed the routes on the Island of Hawaii and generated 2,215 position location reports during the pilot test. Over 56 percent of the data was collected on SR 11. Table 42 presents the summary of the position reports and OOC reports for each 10-mile segment on the Island of Hawaii.

Table 42. Position and OOC Reports by 10-Mile Road Segment on the Island of Hawaii

State Route	Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
11	0-10	138	0	0%
11	10-20	67	0	0%
11	20-30	76	0	0%
11	30-40	84	0	0%
11	40-50	14	0	0%
11	50-60	0	0	N/A
11	60-70	0	0	N/A
11	70-80	0	0	N/A
11	80-90	0	0	N/A
11	90-100	0	0	N/A
11	100-110	0	0	N/A
11	110-120	0	0	N/A
11	120-130	0	0	N/A
11	130-140	0	0	N/A
11	140-150	32	0	0%
11	150-160	509	0	0%
19	0-10	272	0	0%
19	10-20	176	0	0%
19	20-30	222	0	0%
19	30-40	180	0	0%
19	40-50	236	0	0%
19	50-60	161	0	0%
190	0-10	10	0	0%
190	10-20	11	0	0%
190	20-30	12	0	0%
190	30-40	15	0	0%

Figure 58 provides the location of these position reports. As shown in this figure, a significant number of road-miles were not traversed by one of the carrier's vehicles, because the carrier did not deliver fuel to the southeastern part of the island.

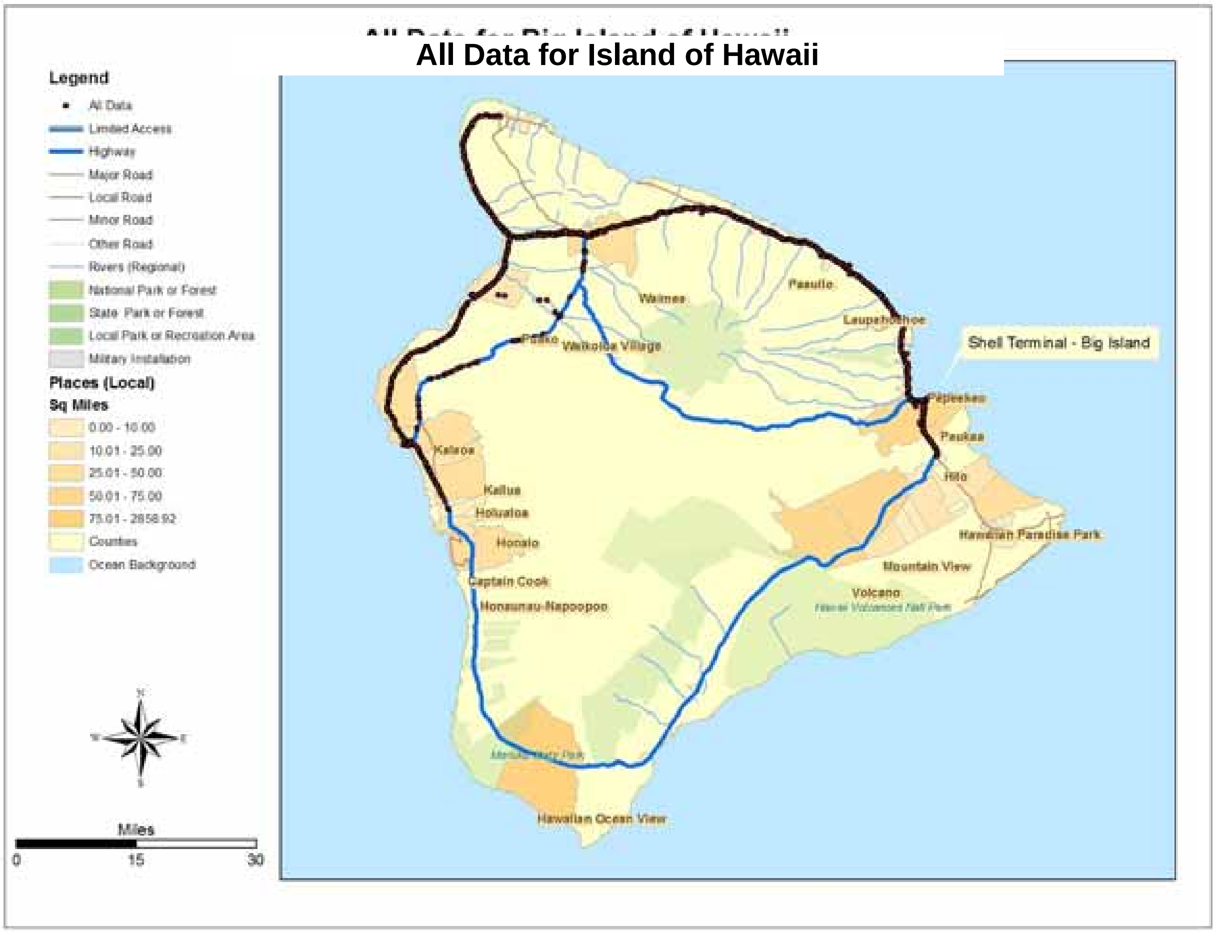


Figure 58. Position Location Reports on the Island of Hawaii
Source: Roadway Data: ESRI Street Map.

Out-of-Coverage Reports on the Island of Hawaii

No OOC reports were recorded on the Island of Hawaii during the pilot test.

Routes on the Island of Maui

Figure 59 highlights the state routes on the Island of Maui—Routes 31, 36, 37, 340, 360, and 380. SR 31 is 53 miles long and begins approximately seven miles south of Kihei. It extends south around the edge of the island to the intersection with SR 360 near Hana. SR 36 is 16 miles long and begins in Maui and extends east along the northern edge of the island to the junction with SR 360. SR 37 is 24 miles long and begins at the junction with SR 31 in the southwest corner of the island, extends north to Pukalani, and then west into Maui at the junction with SR 36. SR 340 is 22 miles long and begins in Maui at the junction with SR 32, extends north around the northeastern tip of the island, and ends at the junction with SR 30. SR 360 is 33 miles long and begins at the junction with SR 31 in the southeast corner of the island near Hana and extends around the northern edge of the island to the junction with SR 36. SR 380 is only 6 miles long; it begins in the south-central part of the island at the junction with SR 30 and extends north to Maui and the junction with SR 36, ending at the Maui airport.

Figure 59. Map of Routes on the Island of Maui

Source: Data: Microsoft MapPoint North America, 2004.

Position Location Reports on the Island of Maui

Two vehicles with the ESCT system generated a total of 1,183 position location reports on Maui during the pilot test. Figure 60 provides the location of these position reports. The participating carrier's vehicles traveled from their terminal facility near the airport to the fueling stations throughout the island; however, they did not travel on all of the road segments.

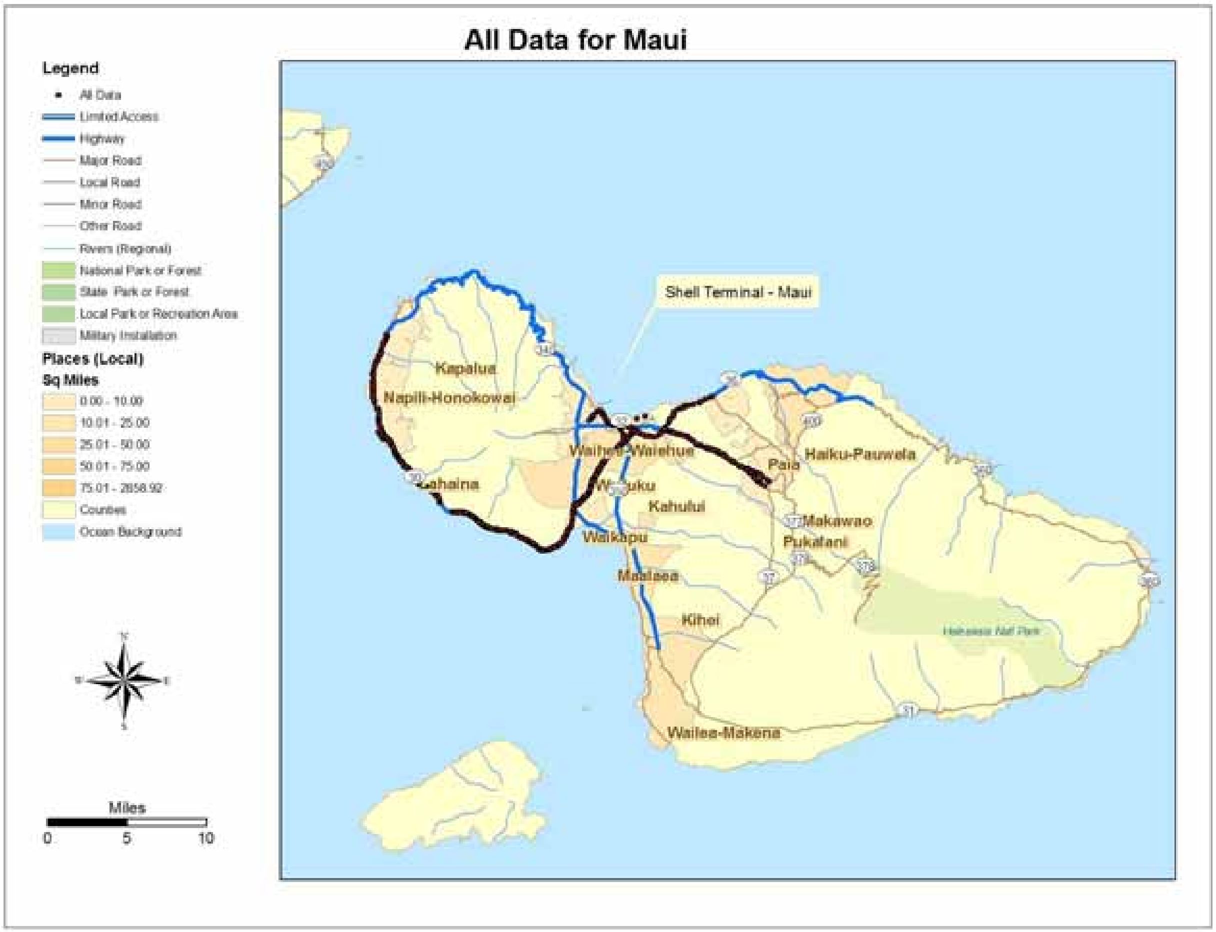


Figure 60. Position Location Reports on the Island of Maui

Source: Roadway Data: ESRI Street Map.

Out-of-Coverage Reports on the Island of Maui

No OOC reports were recorded on the Island of Maui during the pilot test. Table 43 presents the summary of the position reports and OOC reports for each 10-mile segment on the Island of Maui.

Table 43. Position and OOC Reports by 10-Mile Road Segment on the Island of Maui

State Route	Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
31	0-10	1	0	0%
31	10-20	0	0	N/A
31	20-30	0	0	N/A
31	30-40	0	0	N/A
31	40-50	0	0	N/A
31	50-60	0	0	N/A
340	0-10	49	0	N/A
340	10-20	0	0	N/A
340	20-30	0	0	N/A
36	0-10	7	0	0%
36	10-20	666	0	0%
360	0-10	0	0	N/A
360	10-20	0	0	N/A
360	20-30	0	0	N/A
360	30-40	0	0	N/A
37	0-10	0	0	N/A
37	10-20	67	0	0%
37	20-30	72	0	0%
380	0-10	321	0	0%

Routes on the Island of Kauai

Figure 61 highlights the state routes on the Island of Kauai—Routes 50, 56, and 550. SR 50 is 33 miles long and begins in the town of Lihue at the junction with SR 56. It extends around the southwestern part of the island and ends in Kekaha. SR 56 is 38 miles long and begins in the town of Lihue at the junction with SR 50. SR 56 extends around the eastern and northern edges of Kaui and ends near Princeville on the northern shore of the island. SR 550 is 19 miles long and begins at the junction with SR 50 near Waimea. It extends north and ends near Kokee.

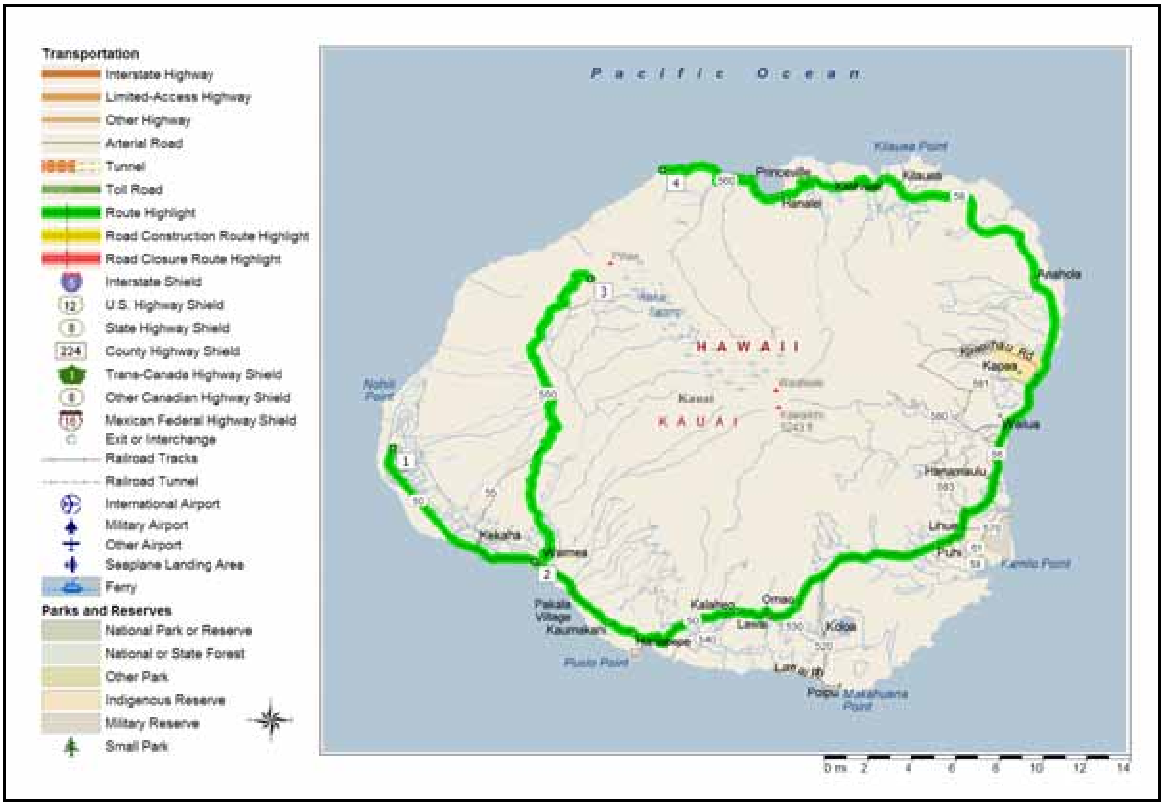


Figure 61. Map of Routes on the Island of Kauai

Source: Data: Microsoft MapPoint North America, 2004.

Position Reports on the Island of Kauai

One vehicle with the ESCT system generated a total of 605 position location reports during the pilot test on Kauai. Figure 62 shows the location of these position location reports recorded during the test period.

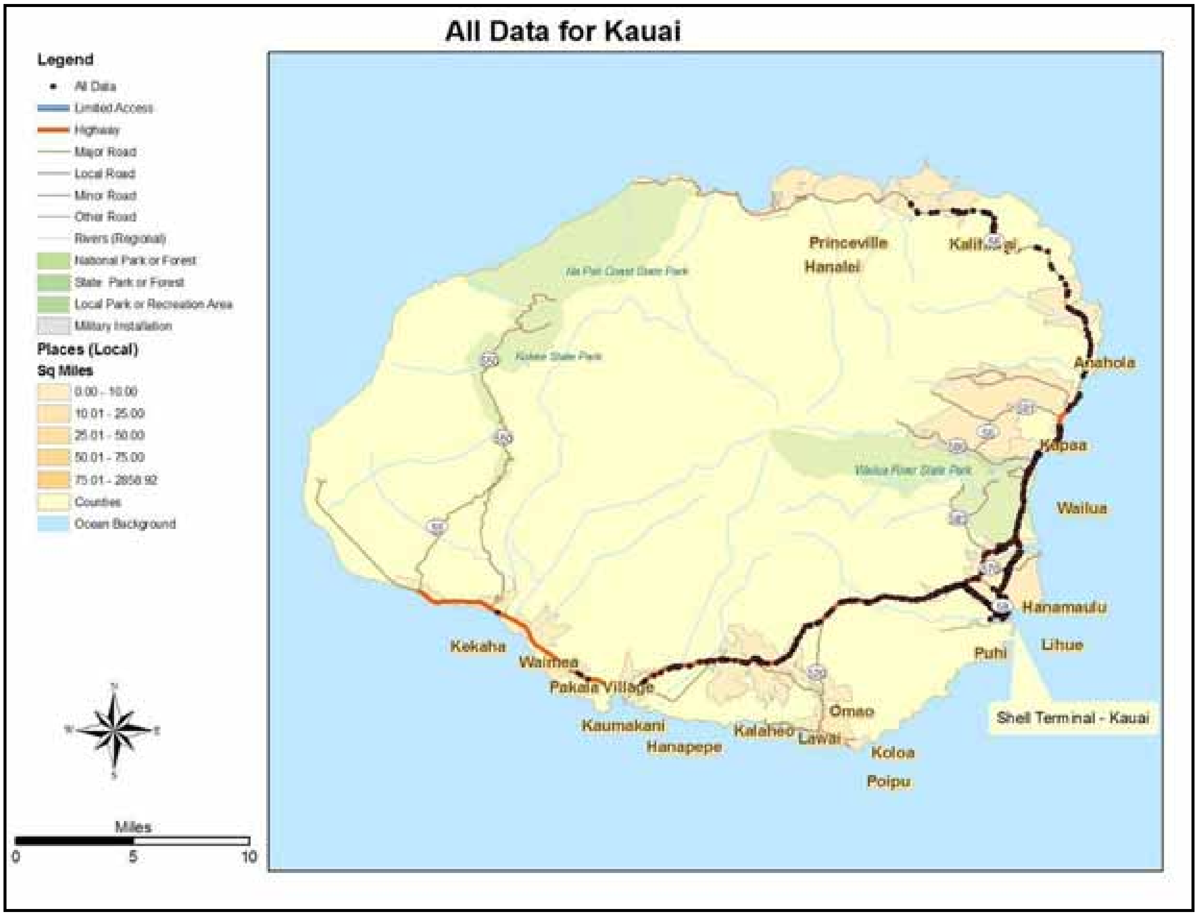


Figure 62. Position Location Reports on the Island of Kauai

Source: Roadway Data: ESRI Street Map.

Out-of-Coverage Reports on the Island of Kauai

A total of 24 OOC reports (less than 4 percent of total position reports) were sent by the ESCT systems in Kauai during the pilot test. Table 44 presents the summary of the position reports and OOC reports for each 10-mile segment on the Island of Kauai.

Figure 63 shows the position of the OOC reports recorded during the test. Because of the small number of OOC reports, it was difficult to determine any trend in these data. The participating carrier indicated that the small concentration of OOC reports in the Lihue city area was near their fuel delivery facility, which has overhead structures in the area. In addition, this area of the city is in a small valley.

Table 44. Position and OOC Reports by 10-Mile Road Segment on the Island of Kauai

State Route	Milepost Range	Total Position Reports	Total OOC Reports	OOC Percentage of Total
Route 50	0-10	162	10	6%
Route 50	10-20	72	3	4%
Route 50	20-30	0	0	N/A
Route 50	30-40	0	0	N/A
Route 550	0-10	0	0	N/A
Route 550	10-20	0	0	N/A
Route 56	0-10	0	0	N/A
Route 56	10-20	32	0	0%
Route 56	20-30	47	0	0%
Route 56	30-40	292	11	4%

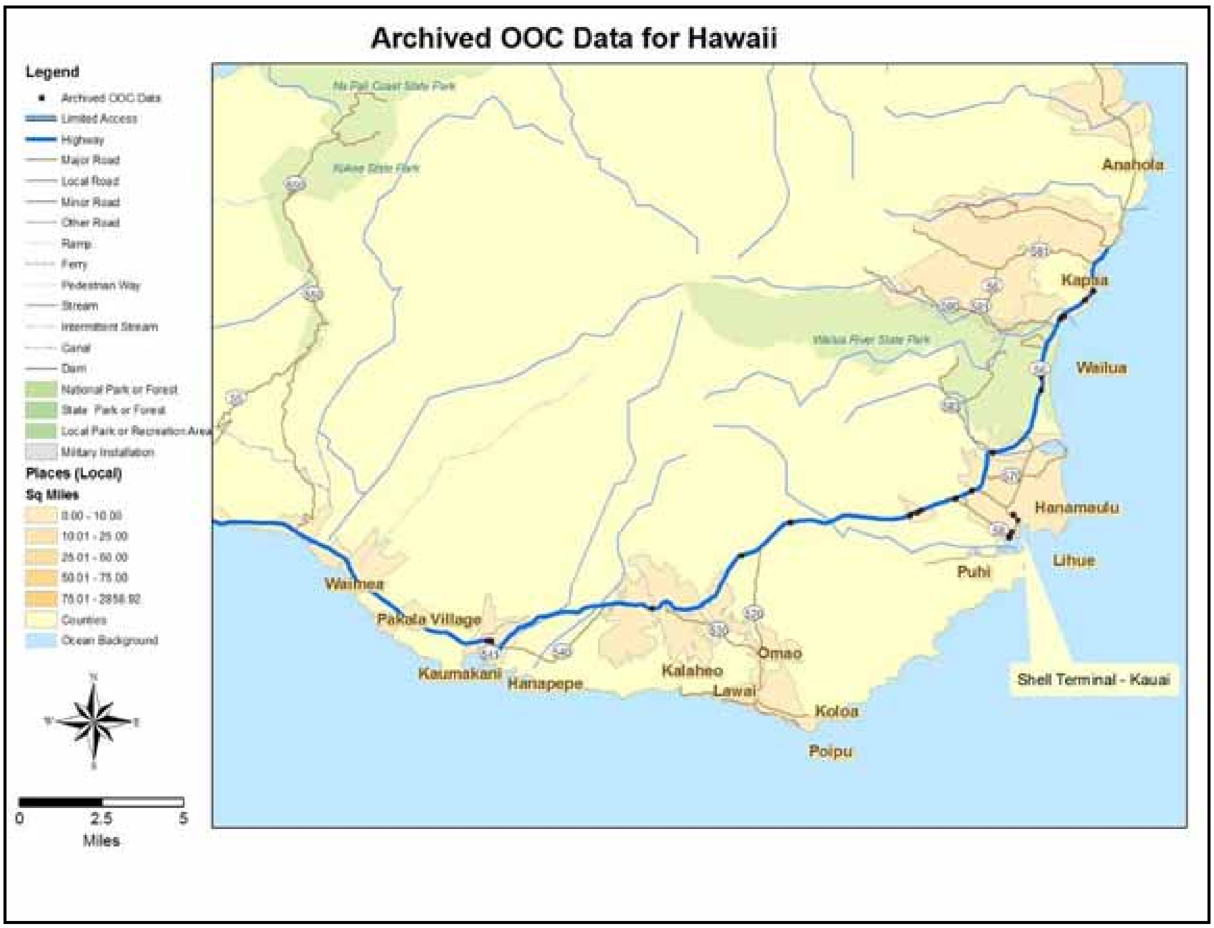


Figure 63. OOC Reports on the Island of Kauai

Source: Roadway Data: ESRI Street Map.

7.2 PANIC ALERTS AND TETHERED TRAILER TRACKING TESTS

During the pilot test, drivers could use panic buttons to send high-priority distress and/or panic messages, and dispatchers could receive notifications about trailer connections and disconnections. Since major security-related incidents did not occur during the pilot test, this technology was primarily tested during staged events in Alaska and Hawaii, as described in the following sections.

7.2.1 Panic Button Testing

Panic buttons in commercial vehicles carrying hazardous materials have the potential to provide improved security by enabling a driver to send a panic message in the event of a hijacking or other security-related event in which it is critical that the driver immediately contact dispatch or emergency response personnel.

During the pilot test, 51 panic alert messages were generated by carriers in Alaska, and three were generated by the carrier in Hawaii. Of the 51 panic messages in Alaska, 21 were part of the staged testing and five were conducted as remote technology exercises. The remaining 25 were generated as part of the carrier's daily operations. All three panic alert messages generated by the Hawaiian carrier were part of the staged testing in Hawaii.

Prior to the commencement of the pilot test, each carrier prepared an escalation procedure and protocol for using panic buttons. This escalation procedure provided the names and contact information for a prioritized list of carrier personnel who would be contacted when a driver sends a panic alert message. When a driver pressed a panic button, the ESCT system terminal sent a priority alert message over the satellite link to the NMC. When the NMC received a panic alert, a text message was generated and forwarded to the identified carrier personnel. Also, the NMC personnel called the first person listed on the carrier's escalation procedure. If that person could not be reached, they continued to call listed carrier personnel identified on the escalation procedure until they succeeded in making person-to-person contact.

During each site visit, the functionality of panic buttons was tested. The driver pressed the panic button and checks were made to ensure that the carrier received the panic alert message on the dispatcher screen, and that the appropriate person was contacted. Figure 64 presents a screen capture of one of the panic alert messages received at the dispatcher station as part of these staged tests.

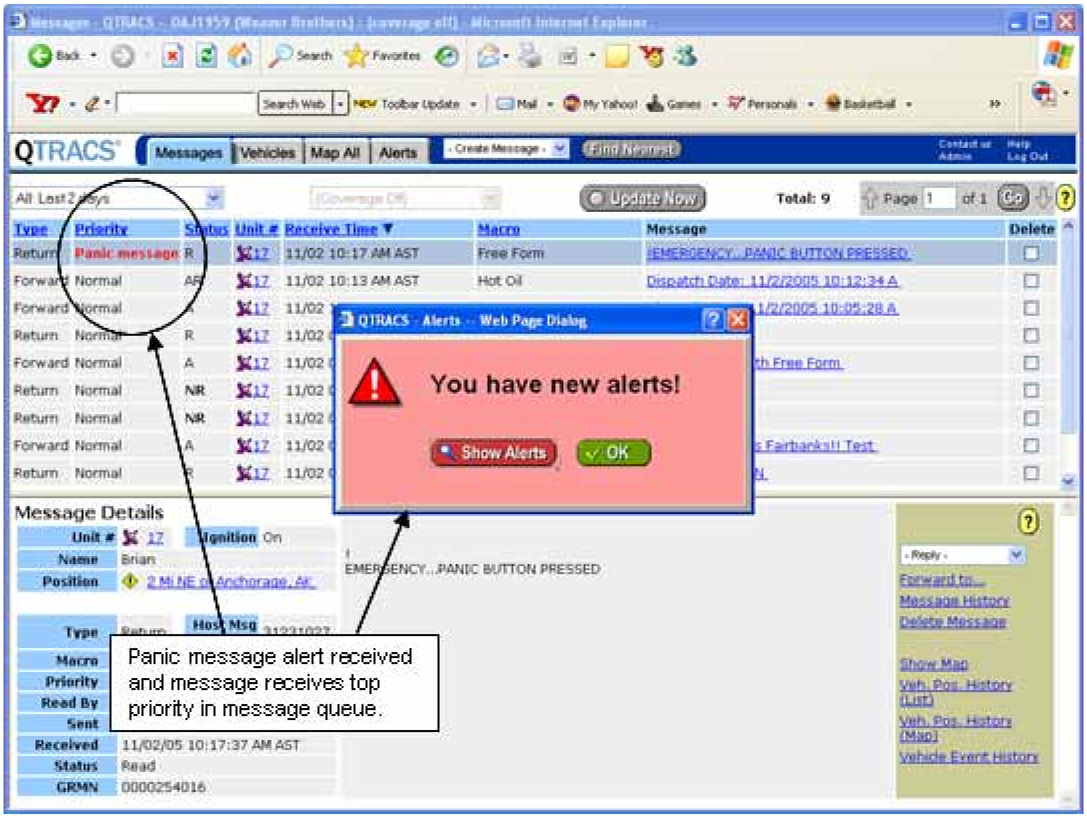


Figure 64. Panic Alert Message Forwarded Immediately to Identified Carrier Personnel

Source: Data: QUALCOMM QTRACS, 2006.

During one staged test of the panic alert, the carrier did not receive the follow-up telephone call, since the NMC was not provided with notice about the staged testing. Because drivers sometimes push the panic button multiple times, the NMC will not place a second call if the panic button is pressed a second time from the same vehicle at the same location shortly after the button has been pressed the first time.

Several false positive panic alerts (panic message sent when there was no actual emergency) were recorded during the pilot test; however, the dispatchers and carrier management personnel did not view the false positive alerts as an issue. Some of the reasons cited by dispatchers for the false positive alerts included:

- Driver Curiosity—Despite initial training, some drivers were curious about what would happen if the button were pushed.
- Accidental Alarms—Dispatchers indicated they received several panic alert messages when a driver accidentally pressed the button.

During the field testing, the panic button alerts were used in actual safety alert situations, such as vehicle breakdowns. Figure 65 provides a record of the messaging conversation (formatted for presentation but not edited) from a vehicle break-down on the James Dalton Highway.

Panic Message Between Driver and Dispatcher
!EMERGENCY…PANIC BUTTON PRESSED
problems???
YES LOST A CYLINDER AT ARCTIC CIRCLE DID YOU RECEIVE?
Should I send Brandon back with step to haul you home, and do some load swapping and turn Howard around w/ scotty's load. Howard @ coldfoot
TURN HOWARD BOBTAIL HOME
Trying to reach howard, got to coldfoot @ 5:45 do you have # to coldfoot
678 3500
WILL FIND HOWARD AND BOBTAIL HOME
Scotty take ec6085a, howard take MEG
OK WILL BOBTAIL HOME

Figure 65. Example of a Panic Message

Source: Data: QUALCOMM, 2006.

In another incident, an Alaska West Express truck had a serious mechanical failure (three "U Joints" broke) in the middle of a very mountainous section of the James Dalton Highway while hauling a modular container weighing approximately 240,000 pounds. In addition, the Alaska West Express dispatcher was contacted regarding the incident. The dispatcher was able to communicate (via the two-way text messaging capability of the ESCT system) with the driver to determine the extent of the problem, plan a response, and instruct the driver on "next steps."

On these two occasions, the dispatchers documented in their manual logs that the drivers used the panic alert feature after regular business hours, because they could not reach a dispatcher. Both dispatchers noted that the NMC did place the required telephone call to the appropriate person identified in the escalation procedure.

7.2.2 Tethered Trailer Tracking Technology Testing

For the pilot test, 20 tethered trailer tracking units were installed on Carlile Transportation Systems trailers operating out of their Anchorage, Alaska terminal. When a trailer was connected to a tractor equipped with the ESCT system, the tethered trailer tracking unit received power via the tractor's power supply and reported a unique trailer identification number to the ESCT system. The on-board system was configured to receive this trailer identification number which triggered a connection event to be sent over the ESCT system. When the trailer and tractor were connected, the trailer could be tracked by tracking the location and status of the tractor. When the trailer and tractor were disconnected, the trailer tracking unit could no longer send the identification number to the on-board system which triggered a disconnect event.

Due to the terrain, weather, and roadway infrastructure, false reports from the tether trailer tracking technology of either connections or disconnections between the tractor and trailer may result from a loose connection on the seven-way connector. As a result, a 60-second delay was designed into the on-board ESCT system before an event was generated. After this delay time was exceeded and the signal status did not change, a connection or disconnection alert was generated and forwarded through the ESCT system to the dispatcher.

The tether trailer tracking technology was tested seven times during staged-event testing at Carlile. The driver connected and disconnected the tractor and trailer and checks were made to ensure that Carlile's dispatcher received the appropriate alert. Figure 66 presents a screen capture of one of the disconnection messages showing the tractor and trailer identification numbers, date and time stamp, event description (D indicates disconnect), and a relative location to the nearest landmark. The host software, TrailerTracs, provided a view of this information on a map as well as the table form.

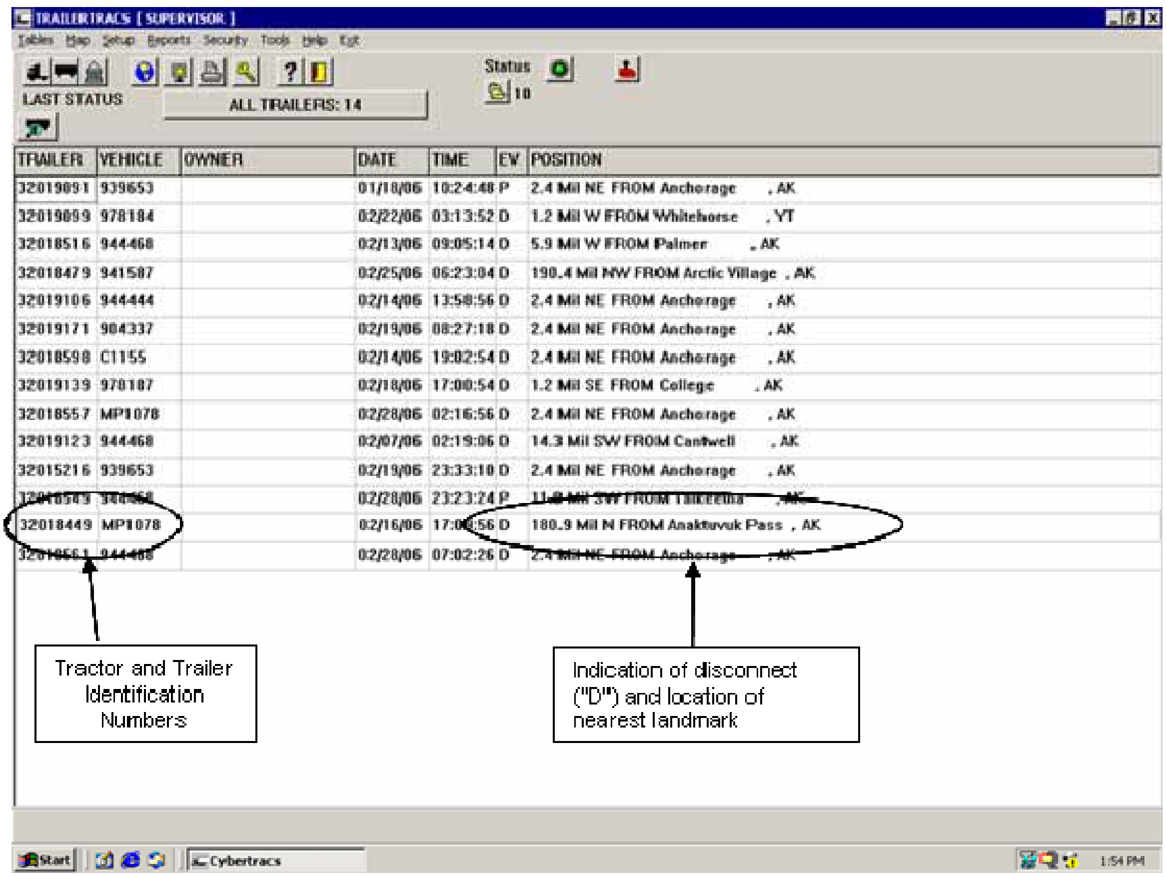


Figure 66. TrailerTracs Screen Capture Indicating Trailer Disconnect

Source: Data: QUALCOMM, TrailerTracs, 2006

During the first site visit to Carlile, the planned staged testing could not be accomplished due to a software problem with the host TrailerTracs application. This problem was corrected during the second site visit. During the pilot test, Carlile dispatch and management personnel used the trailer tracking technology to track the location and status of their trailers. Since only 20 trailers were equipped with the technology, and tracking those trailers was possible only if they were connected to one of the 25 Carlile tractors equipped with the ESCT system, their operational impact during the pilot test was very limited.

7.3 SYSTEM LATENCY

System latency for this test was defined as the time elapsed between the time that the message was sent by the satellite-based mobile communications terminal (SMCT) and the time that it was received by the dispatcher's host system (or from the host system to the SMCT). Latency was tested only during the staged tests in which the send-and-receive times were manually recorded in order to calculate the system latency for each message type; therefore, limited data were available about system latency. Table 45 presents the latency times calculated during each site visit in Alaska and Hawaii. For send and receive messages, latency times ranged from 21 to 109 seconds in Alaska and 22 to 634 seconds in Hawaii. Appendix F contains a summary of all the individual data collected at each site visit.

To be effective, the panic buttons were dependent on the availability of the satellite-based, two-way communication between the vehicle and the dispatcher/emergency response personnel. If the ESCT terminal could not establish communications with the satellite, an immediate alert from the panic buttons would not occur. Instead, the panic message would be stored locally and not sent until the vehicle re-established satellite communication coverage. For panic alerts, latency times ranged from 30 to 109 seconds in Alaska and 125 to 145 seconds in Hawaii.

Acceptability of these latency times is dependent upon carrier expectations. According to the carriers in Alaska, use of the panic buttons could reduce the notification time for emergencies. When breakdowns occurred prior to this pilot test, they would rely on driver-to-driver relays of information until someone reached an area where either a cell phone or a RF radio system would work, and from which the message could be forwarded to the appropriate dispatchers. Carriers indicated that this process could often take hours. With the harsh weather conditions in Alaska, drivers could experience significant risks due to the delay in emergency assistance. With one exception, all panic alerts were generated and forwarded to the dispatcher station, and the appropriate carrier personnel received a call notifying them of the alert.

Table 45. Latency Measurements (in seconds) for Alaska and Hawaii

Function	Alaska Total (seconds) AWE	Alaska Total (seconds) WB	Alaska Total (seconds) LYN	Alaska Total (seconds) CRL	Range	AVG	Hawaii Total (seconds) SM	Range	AVG
Send and Receive Messages	39 31 66 62 63 78 43	34 70 106 40 24 21 41	77 31 63 109 30 51	21 134 106 77 55 59	21-109	58.9	634 308 108 189 22	22-634	252.2
Send and Receive Macros	65 46 86	50 89 67 29	64 21 31 67 54 79	14 265 154 70 43	29-265	71.9	30 34	30-34	32
In-Cab Panic Button	52 43	48 35	57 33 109	55 58 30	30-109	52	145 25	25-145	85
Wireless Panic Button	58 52 56	66 51	47	46 57	51-57	54.1	37	37	37
Tethered Tracking Connect (Trailer to Mobile Unit)				70 15	15-70	42.5			
Tethered Tracking Connect (Mobile Unit to Host)				267	267	267			
Tethered Tracking Disconnect (Trailer to Mobile Unit)				137 131	131-137	134			
Tethered Tracking Disconnect (Mobile Unit to Host)				126 391	126-391	258.5			

Carriers: **AWE** = Alaska West Express, **WB** = Weaver Brothers, **LYN** = Lynden Transport, **CRL** = Carlile Transportation, **SM** = Shell Motiva

7.4 EXPANDED SATELLITE-BASED MOBILE COMMUNICATIONS TRACKING SYSTEMS MAINTENANCE AND OPERATIONS

The ESCT systems used in the pilot test were all new units. Because of this, and because of the relatively short (3-month) duration of the pilot test, hardware issues were minimal. QUALCOMM tracks hardware problems through its Return Material Authorization (RMA) requests. Figure 67 is a screen capture showing an example of one of the three RMAs for the pilot test systems. This RMA was for a “customer-damaged enhanced display unit.” Two other display units were damaged during the pilot test. The only other equipment-related issue recorded during the pilot test was a panic button malfunction in which the unit kept sending the panic alert messages after the button was accidentally pressed. A faulty cable had caused the panic button to stick and the keyboard “locked up.”

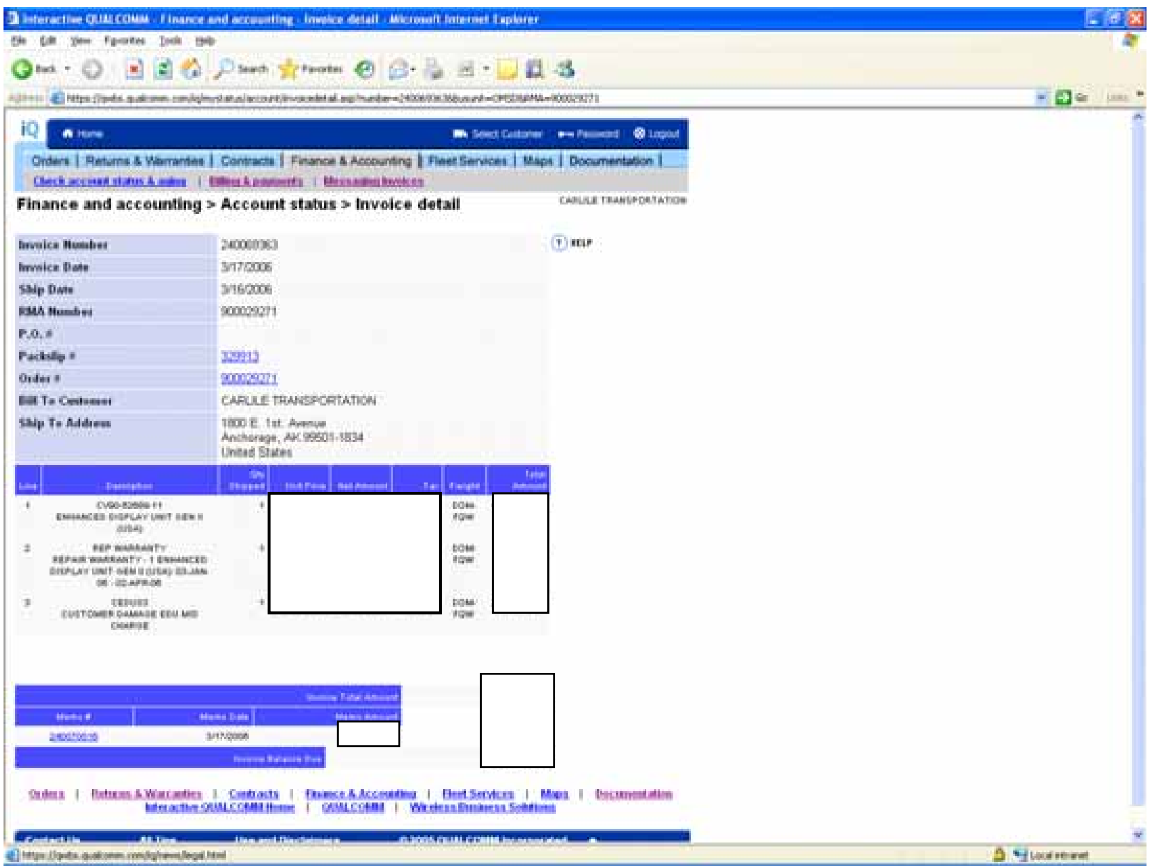


Figure 67. Sample RMA Received from Carlile for Damaged Display Unit

7.4.1 Participating Carrier Interviews

A series of 15 interviews with drivers, dispatchers, and management personnel was conducted to gauge the participating carriers' perceptions of improvements brought about by using the ESCT system. As shown in the interview guide in Appendix D, the drivers, dispatchers, and management personnel were asked to rate their perceptions using a 5-point preference scale in which 5 was "agree" and 1 was "disagree." The interview responses are provided in Table 46 along with summary remarks attributed to each carrier. A range of individual opinions was provided to many of the questions; however, most of the opinions were positive about the use and benefits of the ESCT system.

Carriers made several observations and comments about the use of the ESCT systems and the impact these systems had on their operational activities. The majority of the carriers indicated that they experienced better communication coverage with their vehicles during the three months of the pilot test. This improved communication coverage gave them the ability to respond more quickly to emergency situations and maintenance issues with their vehicles.

One of the main benefits the carriers identified from the use of the ESCT systems, and in its impact on their customers' (shippers and consignees') satisfaction was that use of the system provided better "visibility" into their loads. In the past (especially on the James Dalton Highway), carriers had to rely on spotty cellular coverage, and relayed messages from one driver to another to discover the status of a shipment.

One carrier stated that their customers prefer to know where the vehicle carrying their shipment is at all times, and an accurate estimated arrival time. In the past, the carrier used the phone to track the status of a load. With the ESCT system, the carrier had improved visibility into the status of the load and provided customers with limited access to the web-based host system so the customers could track a specific load.

Several carriers indicated that the ESCT systems provided a benefit related to load and crew planning. One carrier implemented this process in their Prudhoe Bay area operations. With the system, they knew a truck's arrival time with greater certainty, making it easier to arrange for temporary crew to help with the loading and unloading. If weather problems caused delays in vehicle arrival times, the drivers could communicate with the dispatchers, who adjusted the load assignments as needed and informed the customer in advance.

From the carrier's perspective, panic buttons and near-real-time communications from the ESCT system provided significant operational benefits. During the field testing, when drivers experienced major mechanical breakdowns, the panic buttons were used to inform their dispatchers of the breakdown and to receive assistance. In the past, when drivers had such problems, they had to wait for another truck to pass them to get help. At that time, the help from the other truck would be limited to either giving the driver a ride or relaying a message on to others until it reached a dispatcher. The driver did not know when dispatch personnel received his or her message or when he or she could expect assistance. The panic and two-way communication feature of the ESCT systems provided near-real-time notification of incidents and hence the ability to analyze the problem remotely, to determine the resources necessary to fix the problem, and to communicate and coordinate the response with the carriers. Efficiency of operations can be improved through quicker notification and communication to correct the problem and continue the shipment process without potentially extensive delays.

7.5 BENEFITS OF THE EXPANDED SATELLITE-BASED COMMUNICATON TRACKING SYSTEM

The pilot test focused on providing satellite-based, two-way communication throughout the states of Alaska and Hawaii. Table 47 provides a mapping of the technologies deployed as part of this pilot test of the operational steps in a typical commercial vehicle operation and to the anticipated security, efficiency, and system features and benefits.

Alaska carriers were able to track the progress of their shipments and maintain positive contact (hourly and on-demand messaging) with their drivers using the ESCT systems. Although the coverage using the ESCT system in Alaska was not 100 percent, the ESCT systems enhanced the ability to communicate between drivers and dispatchers, according to the interviewees. Prior to the pilot test, drivers and carriers indicated that they did not have communication capabilities along considerable portions of the routes. When drivers and dispatchers needed to communicate, they relied on relaying messages from one truck to another along the route, a process which could result in lengthy delays and unproductive down-time. Due to the size of Alaska, and the remoteness of parts of the state, down-time awaiting the arrival on-scene of actual emergency assistance could also occur with the use of the ESCT system; however, notification time would be improved.

Prior to installation of the ESCT systems for the pilot test, the Hawaii carrier relied on cell phones and email for communicating with their drivers. Use of the ESCT system technologies gave the carrier the ability to maintain contact (hourly and on-demand messaging) with their drivers. Dispatchers had the ability to view the location history of the vehicle on a map and determine the driver's progress delivering fuel. The drivers could send update messages to dispatch if problems occurred along their route, they were delayed, or they needed assistance. Before the pilot test, communication was limited to areas in which cell phone coverage was adequate. While the metropolitan areas had relatively complete terrestrial communication covered, as the drivers traveled between routes, they indicated that they experienced "dead spots" where they could not use their cell phones.

From a security perspective, the panic buttons provided the drivers with the capability to send a priority alert to their dispatchers and know (via a return confirmation) that "help was on the way," which was particularly important when mechanical problems occurred late at night or in remote locations. While no mechanical and/or personal emergencies were encountered during the pilot test by the Hawaii carrier, the drivers understood the benefits of the panic buttons.

Table 46. Summary of Responses from On-site Interviews

Questions	Alaska West Express (AWE)	Weaver Brothers (WB)	Lynden (LYN)	Carlile (CRL)	Shell Motiva (SM)	Remarks
1. The ESCT system improved your existing operations.	4, 4, 3, 5	1, 5, –, 5, 3	4, 3	5, 5, 5	4	Dispatch and management personnel indicated they have experienced better communication coverage and response to breakdowns. (AWE) One carrier noted that the system has helped in load and crew planning. (AWE)
2. The ESCT is used on a regular basis.	4, 4, 4, 5	1, 2, 2, 3, 2	3, 2	5, 5, 3	2	One carrier stated that this depends on the route they take. Line haul has more potential. (WB) Some drivers are still undergoing training, and they feel that the usage will increase over time. (WB)
3. The ESCT on-board features created distractions for drivers.	2, 1, 2, 5	1, 1, 1, 1, 5	2, 1	2, 3, 1	–	One carrier stated that the drivers pull over to read “global messages.” The carrier would like a feature which allows the driver to identify and view messages which need immediate response. (CRL) One carrier indicated the ESCT systems created some “driver curiosity” which could be a potential distraction. (WB)
4. The drivers feel safer with ESCT communication and security features.	4, 4, 4, 5	4, 4, 2, –, 4	4, 1	5, 4, 4	–	One carrier indicated that this system is critical for some of the loads that they carry, such as munitions shipments for DoD. (CRL) One dispatcher indicated that they have seen “increased” usage of the systems as the drivers get more “comfortable” with the system. They believe this increase in usage will continue. (WB) When drivers had personal emergencies but did not have a truck that had the ESCT system, they recognized the value of having the system in their truck. (WB) One carrier stated that the drivers were getting used to the system in general. (CRL)

Questions	Alaska West Express (AWE)	Weaver Brothers (WB)	Lynden (LYN)	Carlile (CRL)	Shell Motiva (SM)	Remarks
5. The dispatcher responded positively to ESCT system.	4, 4, 5	4, 3, –, –, 3	5, 5	5, 5, –	4	One carrier stated that problems were slow Internet access to the host and differences in training different dispatchers. (WB)
6. The ESCT host system is easy to use.	3, 5, 4, –	2, 4, –, –, 5	4, 2	5, 5, –	5	One carrier stated that landmarks in the host system mapping database need improvement, since there are insufficient "relevant" landmarks throughout Alaska. (AWE) Mapping clarity in general can be improved. (General comment received from several carriers) One carrier stated that there are some benefits for determining on-time performance. (WB) One carrier stated that they had some issues with the host system requiring and working only on Internet Explorer version 5.6—MAC OS does not support that. (AWE) The proximity database needs improvement. (AWE and LYN)
7. The ESCT on-board system is easy to use.	4, –, –, 5	2, –, 4, –, 4	5, 5	4, 5, 4	4	No comments.
8. The use of ESCT improved response to vehicle emergency.	5, 5, 3, 5	–, –, –, –, 5	5, –	5, 5, –	–	One carrier stated that they had little exposure; one driver had a breakdown. (WB)

Questions	Alaska West Express (AWE)	Weaver Brothers (WB)	Lynden (LYN)	Carlile (CRL)	Shell Motiva (SM)	Remarks
9. The use of ESCT allows better service to the shippers and receivers.	1, 5, 3, 5	5, 4, –, 5, 3	4, 3	5, 5, 5	–	Carriers had not used the system to provide information to their customers. (AWE) This system was especially useful for carriers who have terminals and operations in the Fairbanks and Prudhoe Bay areas. (CRL) This system provided the carriers with better visibility and status. (LYN) One carrier had not provided information to customers. Integration was still under discussion and they saw the potential benefit in the future with integration. (WB) This system provided the carriers with an Estimated Time of Arrival, which they could provide to their customers. (WB)
10. The use of ESCT allows better fleet management.	3, 3, 4, 5	3, 5, –, –, 4	4, 4	5, 5, –	–	Most carriers were using other fleet managements systems like in conjunction with the ESCT system and hoped that it would allow for better fleet management. (AWE and SM) One carrier indicated that the ESCT system is “another tool” that they can use. (WB)

Note: 1 = Disagree

5 = Agree

Before the pilot test, Carlile trailers were stolen on two occasions. Using the tethered trailer tracking system, connection and disconnection events could be monitored and matched with planned stops. A trailer disconnection at an unplanned or unknown location could alert dispatch and management personnel of a potential security concern, and the appropriate actions, such as trying to contact the driver or even notifying appropriate emergency response personnel, could be initiated.

A second operational impact of the tethered trailer tracking technology was related to trailer retention at their customer locations. Carlile's agreements with their customers sometimes call for Carlile to unhook and leave a trailer at a customer's location for the customer to unload. The customer typically has an agreed-to time limit for unloading the trailer. Carlile indicated that with the enhanced visibility provided by the ESCT system into exactly when and where their trailers were disconnected at a customer's site, they have better information to document the time that a trailer is left at a customer's facility and a greater chance of recouping costs if a customer does not unload a trailer within the agreed-to time period.

One constraint encountered by carriers in both Alaska and Hawaii related to the limited deployment of the ESCT systems within their fleets. The portion of their fleets not equipped with the ESCT systems were managed and operated differently than the portion of their fleet with ESCT systems.

Table 47. Mapping Pilot Test Technologies to Security and Efficiency Benefits

SMCT	Panic Buttons	Tethered Trailer Tracking	Operational Step	Description	Security Issues	Inefficiencies	Technology Features/Benefits
•			**Load Assignment**	Dispatcher informs driver of load pickup location and time.	Misplaced tractors and trailers vulnerable to unauthorized access.	Inability to notify driver of load and inability to locate available trucks. Missed loads and revenue.	QTRACS and TrailerTracs host applications provided carriers the ability to view tractor/trailer locations on a map and identify closest available truck and trailer. Text messaging capability allowed dispatchers and drivers to remotely communicate regarding load assignments. ESCT systems provided the capability for improved load visibility (status, arrival time, etc.) to shippers and consignees and provided notification to shippers of which authorized tractor and driver to receive load.
•	•	•	**Trailer Pick-Up**	Driver/tractor arrives to take away loaded trailer.	Unauthorized, hijacked or unknown tractor/trailer attempts to pick up load. Sabotage to load/equipment.	Incorrect tractor hooked up to a trailer.	Tethered trailer tracking technology provided immediate notification of tractor connection to trailer and unique identification of tractor and trailer. Panic buttons and ESCT system provided notification to shipper of which tractor/driver was authorized to receive trailer.
•		•	**Haul**	On-road transit towards destination.	Unauthorized stops and trailer drops.	Out-of-route miles. Unbilled miles. Truck/trailer taken on roads unsuitable for trucks.	ESCT system position history provided notification of out-of-route trucks. Tethered trailer tracking technology provided notification of trailer connections as confirmation of “pick-up.” ESCT systems provided the ability to monitor locations of tractor/trailers.
•		•	**Rest Stop**	Drivers need to stop and rest every few hours, typically in public rest stops. Trucks are often left idling.	Theft of tractor and trailer while unattended. Switching trailer to another tractor. Potential to sabotage load/equipment.		Tethered trailer tracking technology provided notification of a trailer connection and disconnection.

SMCT	Panic Buttons	Tethered Trailer Tracking	Operational Step	Description	Security Issues	Inefficiencies	Technology Features/Benefits
•		•	**Trailer Swap**	When drivers reach their hours-of-service limit, carriers may use another truck to complete the trip. Often trailers are left unattended during this "swap."	Theft of trailer while left unattended. Potential to sabotage load/equipment.		Tethered trailer tracking technology provided notification of a trailer connection and disconnection.
•		•	**Load Delivery**	Driver delivers load to destination dock for unloading.	Theft of trailer/load after drop.	Underutilized tractors and trailers. Idle drivers.	Tethered trailer tracking technology provided notification of a trailer connection and disconnection. ESCT systems provided the capability of improved load visibility (status, arrival time, etc.) about deliveries.
•	•		**Driver Distress**	Driver encounters emergency situations, such as personal (health), mechanical, or security-related concerns (hijack, vandalism).	Attempted hijacking or theft of tractor and/or trailer. Driver encounters unauthorized personnel around vehicle when left unattended.	Driver experiences a personal health emergency (heart attack, seizure, etc.) while en route, away from other communications. Driver experiences mechanical breakdown while en route, away from other communications.	Use of panic buttons (both in-cab and wireless) provided alert notification to dispatcher via host system.

8.0 SUMMARY

The focus of this pilot test was to test the ESCT systems and the availability of satellite-based communication coverage in Alaska and Hawaii to determine impacts on safety, security, and efficiency relating to the tested technology.

8.1 COMMUNICATION COVERAGE

Communication coverage was improved in both Alaska and Hawaii as a result of this pilot test. Terrestrial-based communications existed in both states, but the coverage in these areas was limited to the major metropolitan areas. The project deployed a modified SMCT and supplemented the satellite coverage with a “regional beam” from a communication satellite (PanAmSat), which provided coverage in Hawaii (for the islands and routes tested) and Alaska. Table 48 and Table 49 provide a summary by route of the total number of position reports and OOC reports collected for the pilot test in Alaska and Hawaii.

Table 48. OOC Reports in Alaska

Route Name	Total Miles	Total Position Reports	Total OOC Reports	Percentage of OOC Reports
Dalton Hwy	412	61,945	15,000	24%
Route 1	531	26,808	1,466	5%
Route 2	373	23,337	2,604	11%
Route 3	323	22,005	2,733	12%
Route 4	268	2,255	128	6%
Route 6	142	295	16	5%
Route 8	133	8	0	0%
Route 9	37	124	3	2%
All Routes	**2,219**	**136,777**	**21,950**	**16%**

Table 49. OOC Reports in Hawaii

Route Name	Total Miles	Total Position Reports	Total OOC Reports	Percentage of OOC Reports
Route 11	155	920	0	0%
Route 19	56	1,247	0	0%
Route 190	39	48	0	0%
Route 31	53	1	0	0%
Route 36	16	673	0	0%
Route 37	24	139	0	0%
Route 340	22	49	0	0%
Route 360	33	0	0	N/A
Route 380	6	321	0	0%
Route 50	33	234	13	6%
Route 56	38	371	11	3%
Route 550	19	0	0	N/A
All Routes	**494**	**4,003**	**24**	**1%**

Based on the geographic characteristics of each route and discussions with the carriers and drivers in both Alaska and Hawaii, ESCT systems increased the quality and coverage of two-way communication capabilities. However, there were areas in which OOC reports were generated.

Alaska encompasses vast remote areas with large mountain ranges and difficult operating conditions. Because the QUALCOMM system utilized a communication satellite in a geosynchronous orbit, a low-look-angle antenna was required on the SMCT units installed in Alaska. If the "view" of this satellite were blocked (terrain, buildings, oversized loads, etc.), the SMCT units could not communicate, and OOC reports were generated.

Carriers indicated that their terminal areas, as well as loading and unloading facilities, caused communication problems, and a significant number of OOC reports were recorded in these terminal areas. Because satellite communications require a "line of sight" between the transceiver on the tractor and the satellite, buildings, overhead loading and unloading facilities, and "urban canyons" in downtown areas caused communications problems.

A greater percentage of OOC reports relative to the total number of position reports was generated in Alaska than in Hawaii. Alaskan routes were in mountainous regions, while the Hawaiian routes were in the major metropolitan areas around the islands. The routes used to deliver fuel in Hawaii did not run through the mountainous interiors of the islands. Since Alaska is much farther north than Hawaii, the line of sight to the satellite was blocked by geographic obstacles, such as mountains.

Alaska carriers indicated that the nature of their business contributed to the number of the OOC reports. The Hawaii carrier handled fuel delivery, making short trips with many stops and no oversized loads. Alaska carriers often transported oversized loads, such as drilling equipment for the North Slope oil fields. These oversized loads could block the line of sight of the ESCT system to the satellite in Alaska. However, OOC spikes appeared most frequently in areas of rugged mountainous terrain.

8.2 SAFETY AND SECURITY FEATURES

This project demonstrated that the ESCT system improved the safety and security of hazardous materials shipments in the uncovered regions of the United States. Providing effective two-way communication coverage to these regions increased the safety and security of shipments by giving drivers a means of communicating safety- and security-related matters to dispatchers.

Panic buttons were designed to improve the safety and security of drivers. Combined with the enhanced communication coverage, panic buttons provided drivers a quick and reliable way of sending a high-priority alert to their dispatch and/or management personnel, with the assurance that the message would be received. The carriers indicated that the ESCT systems provided a direct and noticeable benefit. During the pilot test, the participating carriers experienced several instances in which drivers had emergencies and used the panic button feature to alert their dispatch and management personnel. Drivers noted that they felt safer and more secure knowing this technology was on-board. Dispatchers indicated that if their drivers had a problem, the ESCT systems provided a fast and reliable way to send assistance to them.

Tethered trailer tracking technologies demonstrated the potential to improve safety and security through better tracking and visibility of trailers equipped with the technology. Unauthorized and unplanned trailer connections and disconnections were detected remotely by carrier dispatch personnel. By improving detection times, carrier dispatch and management personnel could respond quickly to potential safety and security events.

8.3 IMPACT ON OPERATIONAL EFFICIENCY AND CUSTOMER SATISFACTION

The technologies deployed as part of this pilot test had a positive impact on both carrier operations and the level of customer satisfaction that carriers could provide to their shippers. The technologies gave the carriers improved visibility into the status of their fleet, which allowed them to improve their on-time performance to their customers. One carrier provided their customers limited access to the web-based host system for customers to directly track the status of their shipments. Another carrier indicated that the technologies helped them improve their human resource management. The carrier was able to improve load and crew planning at terminal locations by having more accurate arrival time information on their shipments.

The carrier that tested the tethered trailer tracking technologies noted that implementation of trailer and truck tracking on their entire fleet would allow them to better manage both their trailer inventory and the dwell times when trailers are dropped at customer locations for later loading and unloading.

8.4 CONCLUSION

With enhanced tracking capabilities for both trucks and trailers, carriers were able to improve their operations and service to their customers. Better asset visibility allowed the carriers to give more accurate delivery-time estimates, leading to better utilization of their overall fleet assets. More reliable delivery-time estimates helped the carriers schedule necessary loading and personnel resources at their terminals. As a result, ESCT systems helped to improve the security and efficiency of carriers' operations in Alaska and Hawaii.

APPENDIX A

REQUIREMENTS DOCUMENTATION

The Expanded Satellite-based Mobile Communications Tracking System requirements specified the following five primary functional requirements:

- Messaging
- Location and Mapping of Tractors
- Location and Mapping of Tethered Trailers
- Accurate Times of Trailer Connect and Disconnect Activities
- Panic Alerts

A.1. MESSAGING FROM THE SATELLITE-BASED COMMUNICATIONS SYSTEM

A.1.2 The satellite-based communications system shall provide two-way text communications between driver and on-site carrier personnel in free-form text messages and macros (pre-formatted messages).

Two-way text communication between the driver and on-site carrier personnel (i.e., dispatcher) was provided as part of the basic functionality of the QUALCOMM (QC) SMCT. Figure 68 provides a screen capture of a test message received at the dispatcher console sent from unit #2122.

Figure 69 provides an "Arrived at Shipper" macro sent from an Alaska West Express driver operating unit #2116.

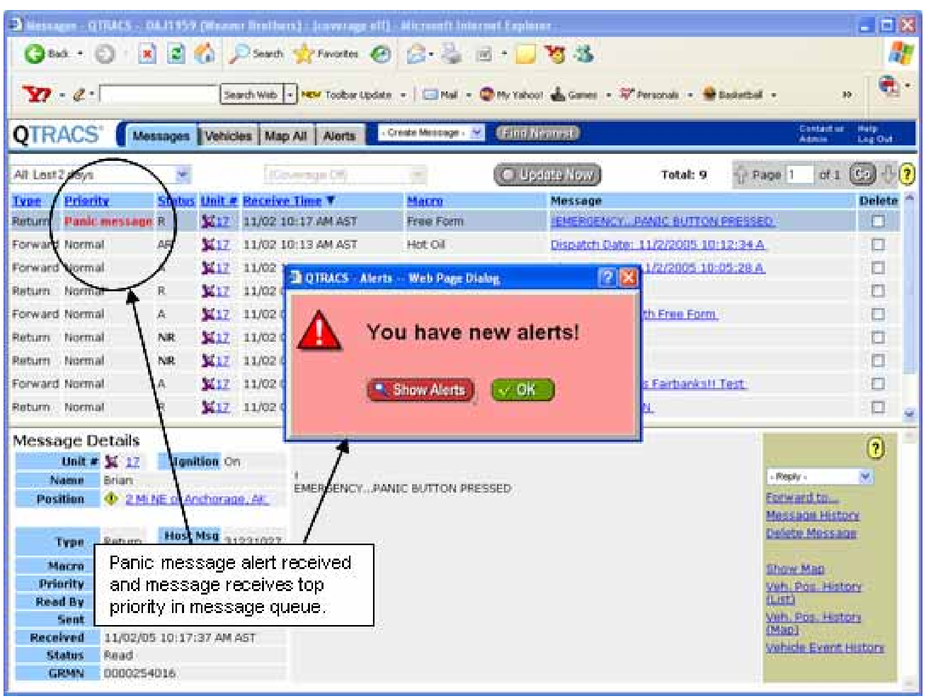


Figure 68. Free-Form Text Message Sent from Unit #2122 to Alaska West Express Dispatcher

Source: Data: QUALCOMM QTRACS, 2006.

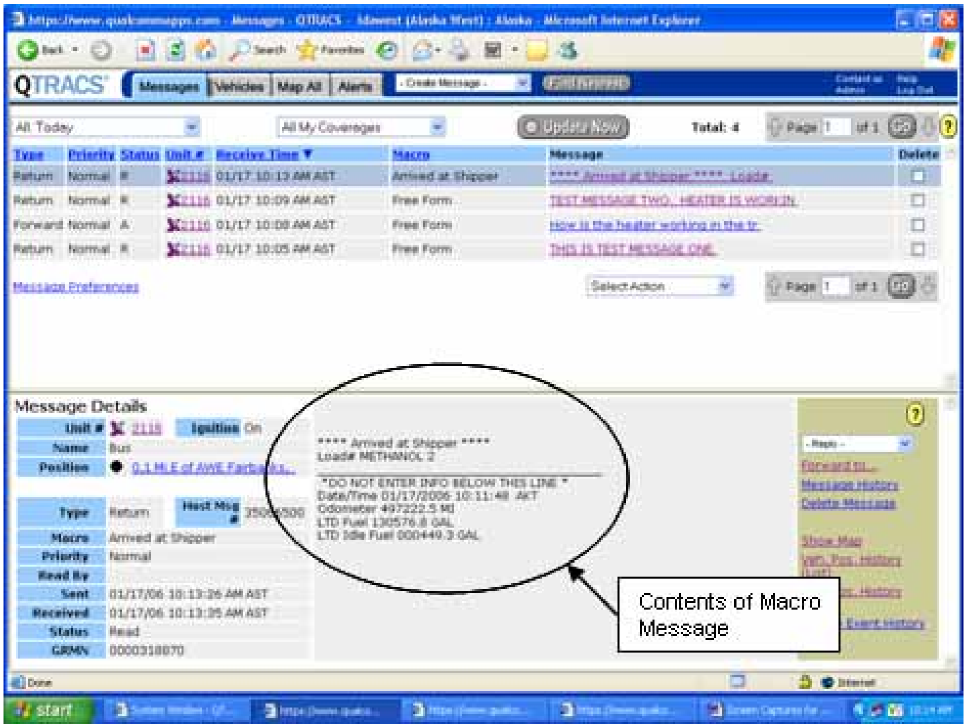


Figure 69. "Arrived at Shipper" Macro Sent from Alaska West Express Driver Operating Unit #2116

Source: Data: QUALCOMM QTRACS, 2006.

A.1.3 The satellite-based communications system shall include a driver interface unit which allows the driver to send and view messages to and from on-site carrier personnel.

Figure 70 provides a picture of the driver interface unit that was installed in the cab of the trucks. During the pilot test, this unit gave the drivers the ability to send and view messages to and from on-site carrier personnel.

Figure 70. QUALCOMM Driver Interface Unit

A.1.4 The satellite-based communications system shall allow users the ability to integrate data from the satellite-based communications system to the user's back office systems.

Integration with back office systems was included with only one carrier (Carlile) as an added feature, but it was not tested as part of the pilot test.

A.1.5 The satellite-based communications system shall provide a tractor position report with each message. The position report shall include the tractor's latitude and longitude, and the date and time that the message was sent from the tractor.

Providing tractor position reports with latitude, longitude, date, and time with each message was part of the basic functionality ESCT system. Figure 71 shows a simulated panic message sent from a Carlile truck during staged testing. This message contains the latitude, longitude, date, and time stamp.

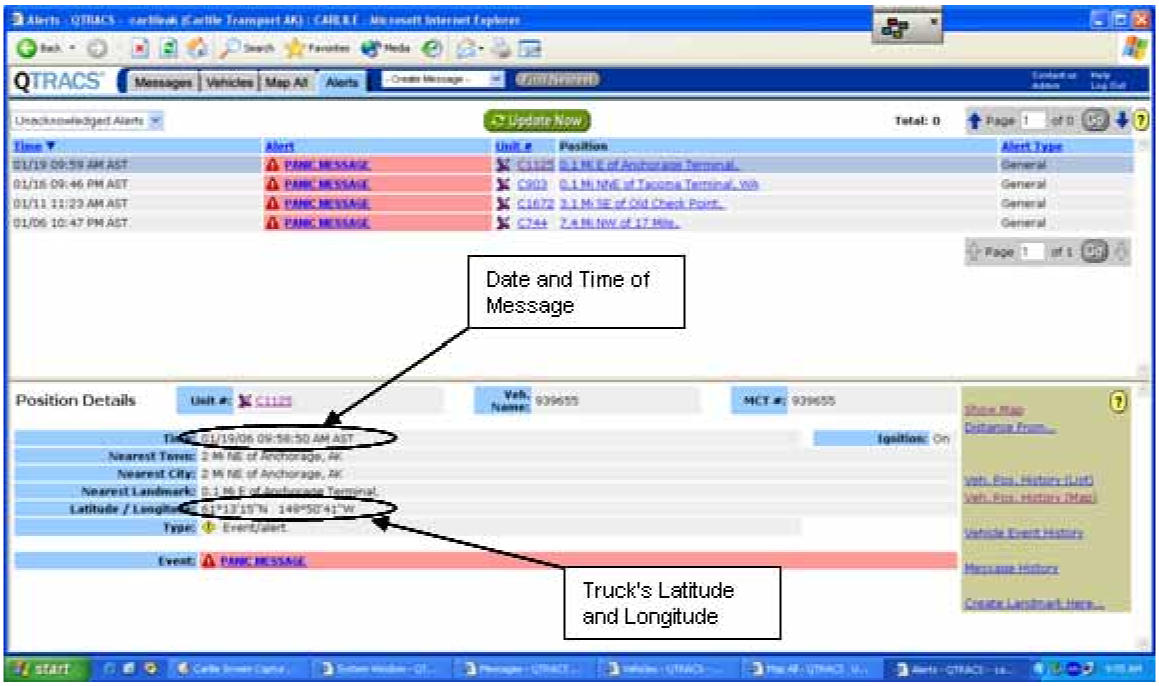


Figure 71. Detail of Panic Message Showing Latitude, Longitude, Date, and Time

Source: Data: QUALCOMM QTRACS, 2006.

A.1.6 The satellite-based communications system shall include a web-based host software application that displays all messages and tractor positions to the on-site carrier personnel.

The ESCT system installed for the test included a web-based host software application (QTRACS) that allowed carrier personnel to display all messages and tractor positions received. Figure 72 provides a screen capture showing the capability to “map all” vehicles in a fleet using the web-based host application.

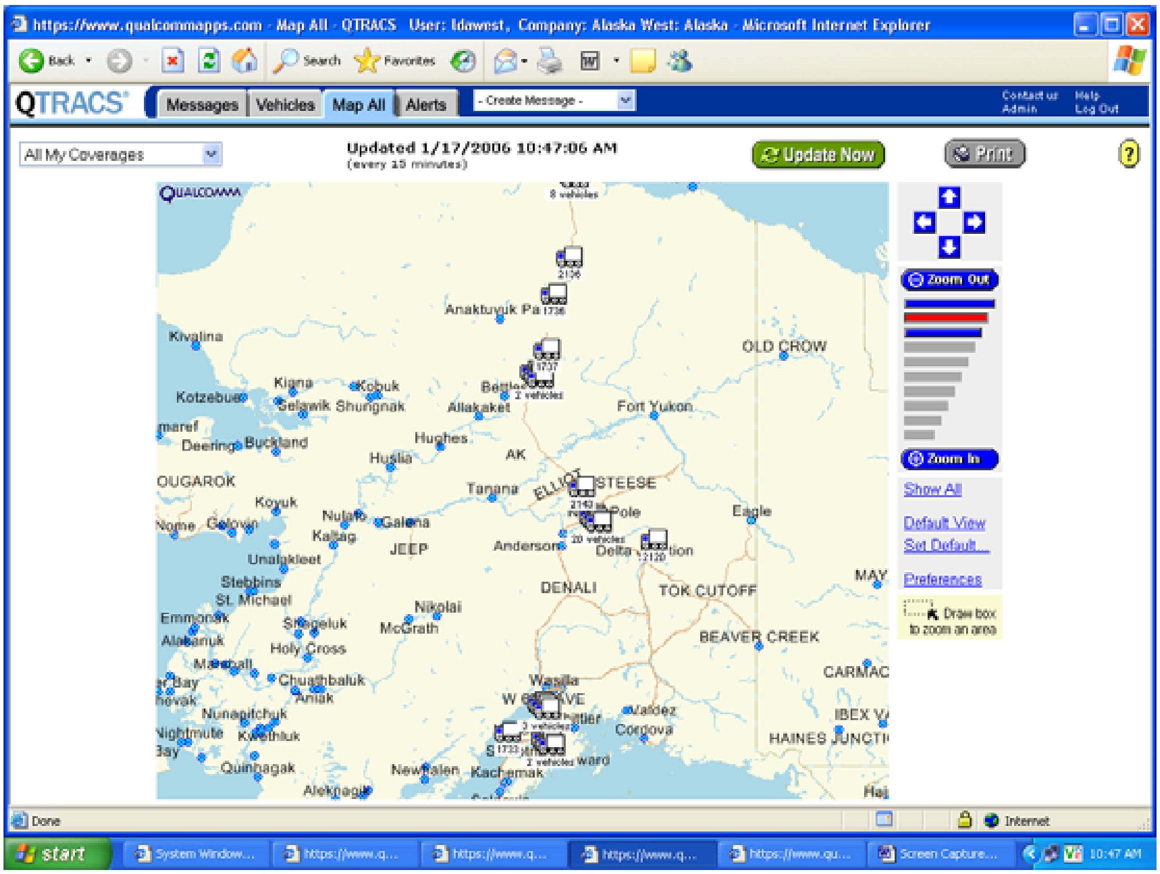


Figure 72. Screen Capture of QTRACS Application “Showing All” Alaska West Express Tractors on 1/17/06 at 11:18 am AST

Source: Data: QUALCOMM QTRACS, 2006.

A.2 MAPPING AND LOCATION OF TRACTORS WITH THE SATELLITE-BASED COMMUNICATIONS SYSTEM

A.2.1 The satellite-based communications system host software application provides tractor position information to enable on-site carrier personnel to track a tractor in "near-real-time." Tractor position information shall include, at a minimum, the tractor's latitude and longitude, and the date and time.

Through the QTRACS host application, carriers could adjust how frequently tractors reported their position. Though typically set to report once per hour, the application could be configured to report as frequently as every five minutes. Figure 73 shows the set-up screen for Lynden Transport where unit #148 position reporting interval was set. In this example, the Active Ping (how frequently position reports are submitted) is set to five minutes.

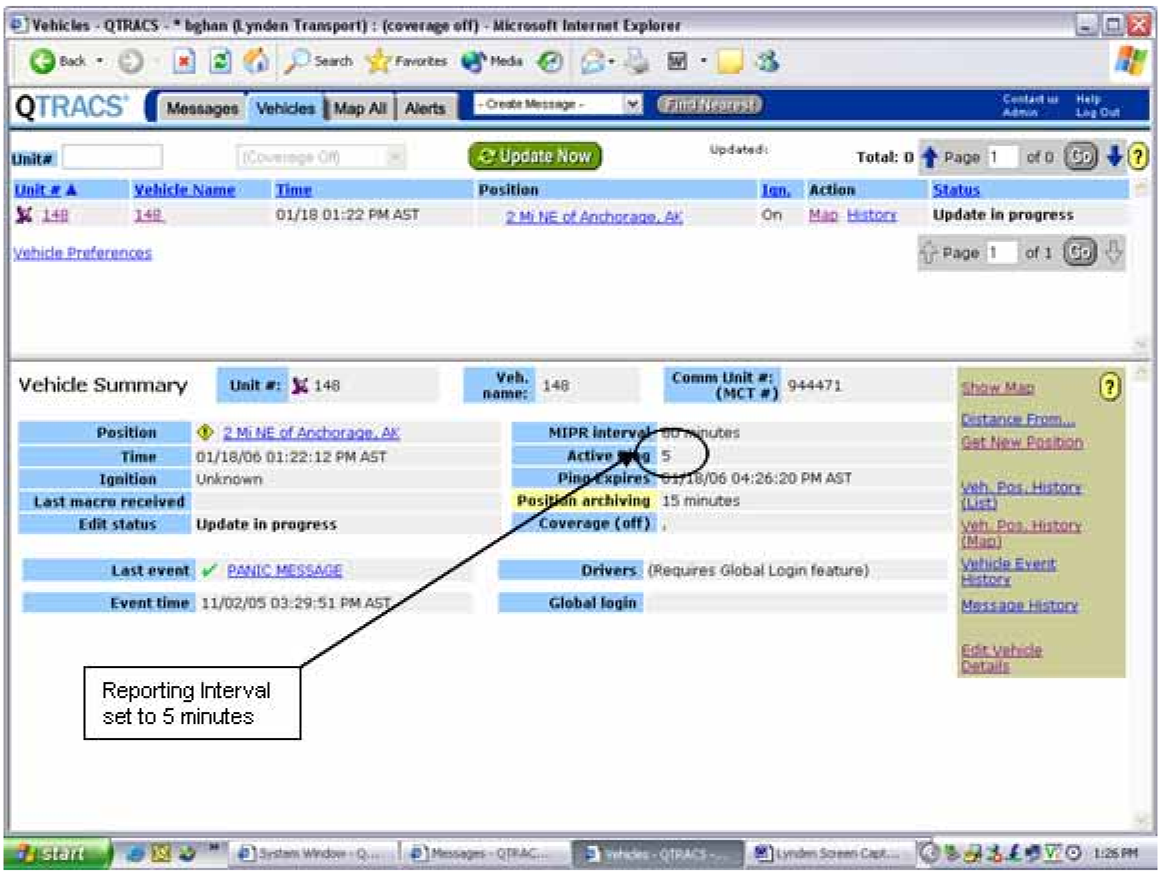


Figure 73. Weaver Brothers Unit #148 Position History Showing Position Reporting Every Five Minutes

Source: Data: QUALCOMM QTRACS, 2006.

A.2.2 The satellite-based communications system host software application shall provide views of a history of the tractor's positions. Tractor position history information shall include: tractor identification number (ID), tractor position (latitude and longitude), date, time, macro (i.e., a message that indicates that the load has been picked up, dropped, etc.), and nearest town and city to the tractor.

Through the QTRACS application, carriers could view the position history of all their trucks or a single truck. Figure 74 shows the vehicle position history of unit #2122. The positions are shown graphically on a map as well as a tabular listing for each position report. The latitude and longitude were included with each position report and could be displayed for any message. The "Position" information indicates where the vehicle is in relation to the nearest landmark included in the mapping database.

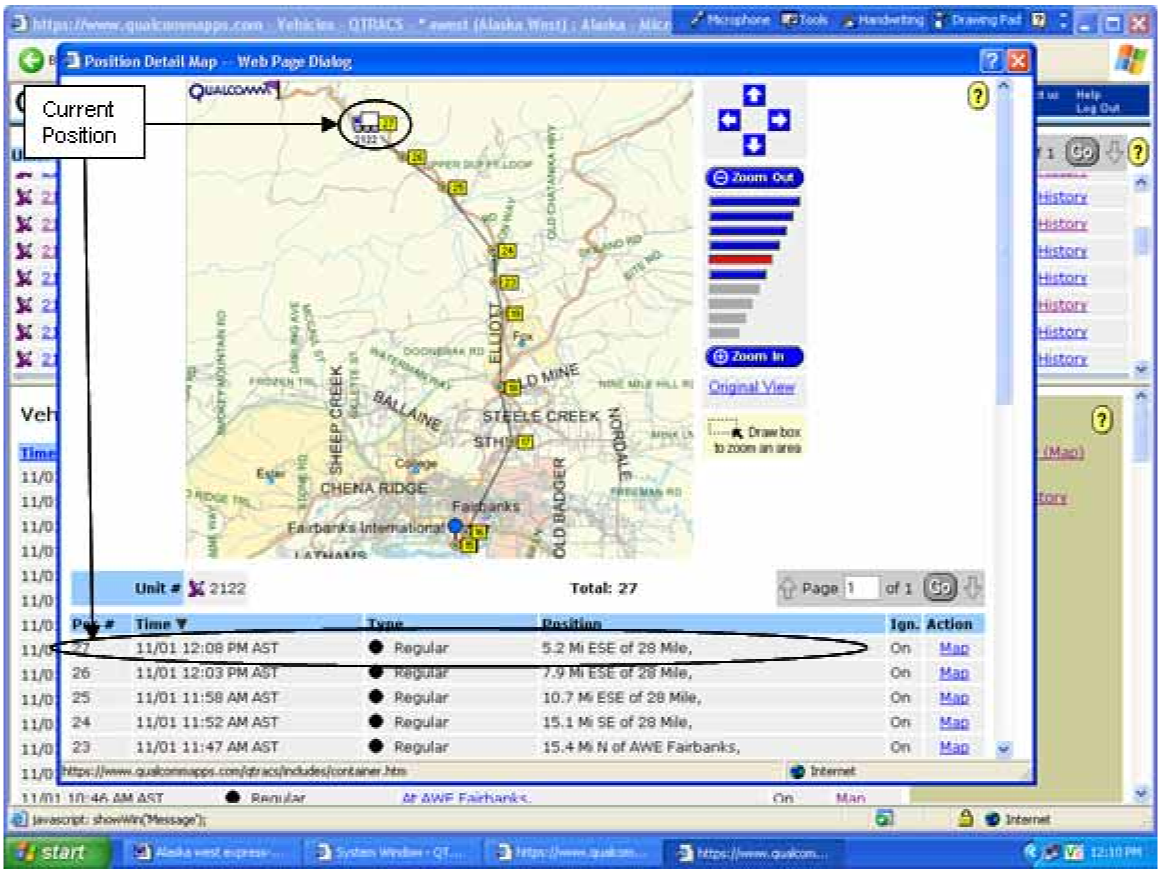


Figure 74. Position History of Alaska West Unit #2122 on 11/1/05

Source: Data: QUALCOMM QTRACS, 2006.

A.2.3 The satellite-based communications system shall provide tractor position information via the GPS.

The ESCT system used an externally mounted GPS antenna that calculated the vehicle position and sent that information with every message (e.g., position, macro, free-form text, panic). Figure 75 shows a picture of the external unit that contains the GPS receiver as well as the satellite transceiver.

Figure 75. External Antenna for SMCT System

A.2.4 The satellite-based communications system shall provide a default tractor position frequency of one hour. The tractor position frequency shall be configurable by the user if they desire another position frequency.

For the pilot test, the reporting interval was set at 15 minutes to increase the number of position reports received. This adjustment was done via the web-based host system and was shown earlier in Figure 73.

A.2.5 The satellite-based communications system host software application shall allow users to issue requests to check the position of the tractor in between the scheduled mobile initiated position reports.

The QTRACS system provided dispatcher personnel with the capability to “ping” a vehicle at any time and get the current location. Figure 76 shows the Vehicle Summary screen where the dispatcher can select the “Get New Position” function. Figure 77 shows how the vehicle position is shown graphically on a map, indicating the current position and scalable, road-level data.

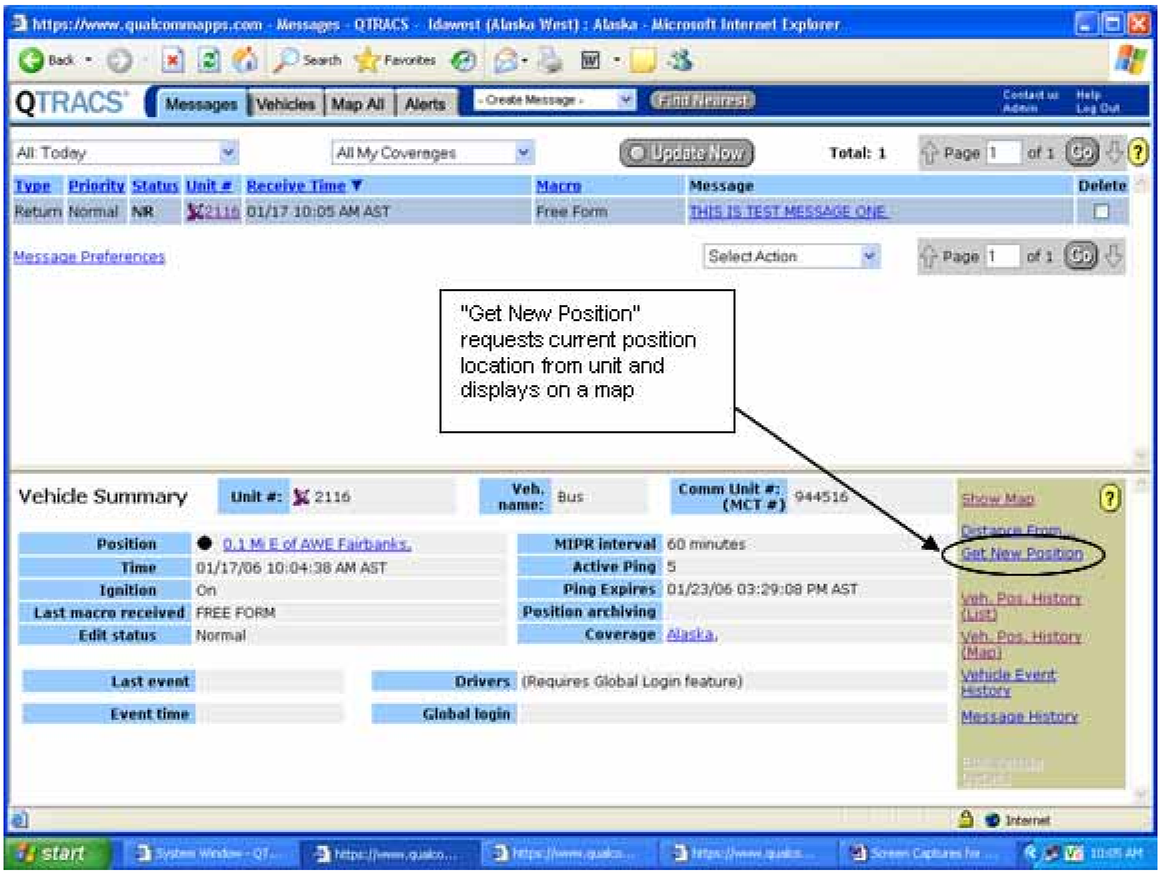


Figure 76. QTRACS System Provides Capability to Request Current Position of Any Unit

Source: Data: QUALCOMM QTRACS, 2006.

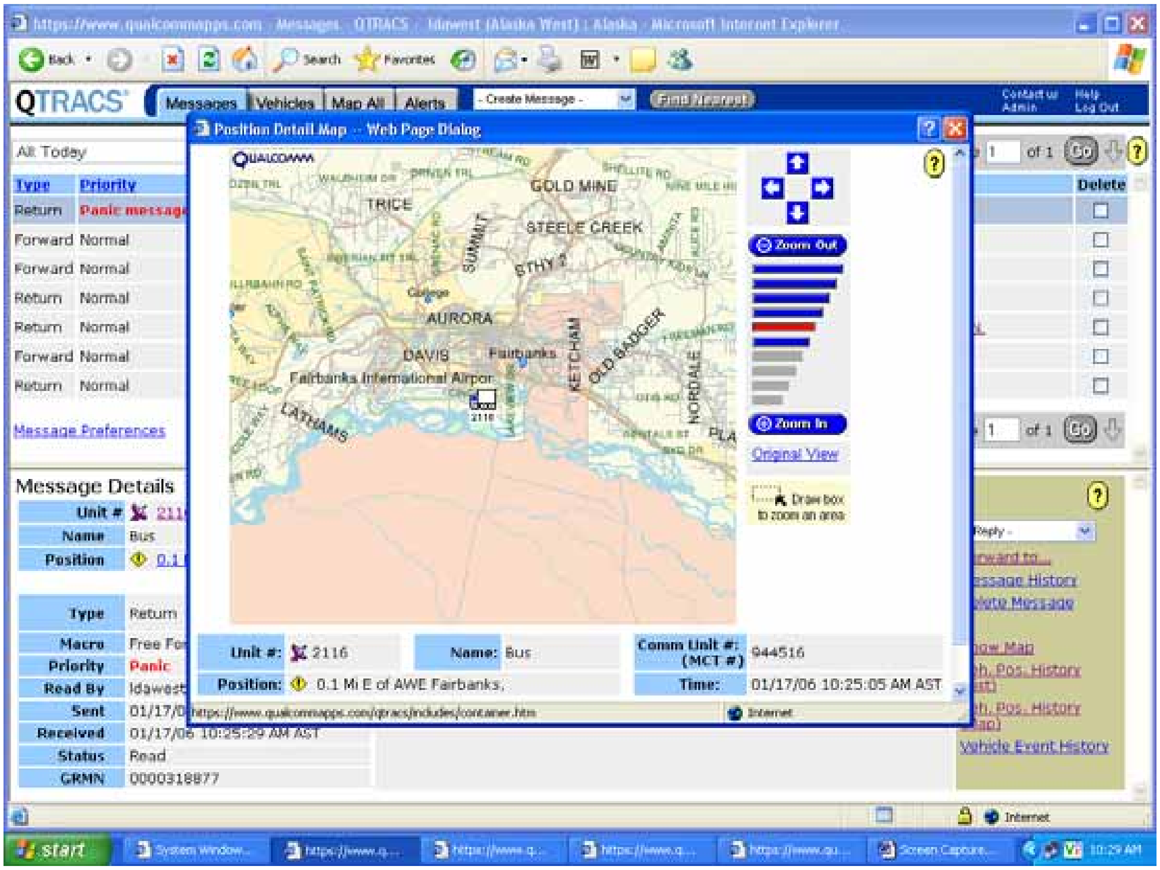


Figure 77. QTRACS Displays Unit's "Current" Position on a Map When Requested

Source: Data: QUALCOMM QTRACS, 2006.

A.2.6 The satellite-based communications system host software application shall include a mapping application that will display the position of one or more tractors on a map.

The QTRACS application allowed the user to display the position of one or more tractors on a map. Figure 77 provides an example of the ability to display multiple tractor locations on a single map.

A.2.7 The mapping application shall display a tractor's position history.

The QTRACS application allowed the user to display a tractor's current position or a tractor's position history for a selected (configurable) period of time. Figure 78 shows the position history (both graphically and in textual form) for Lynden Transport's unit #147 on 1/18/06.

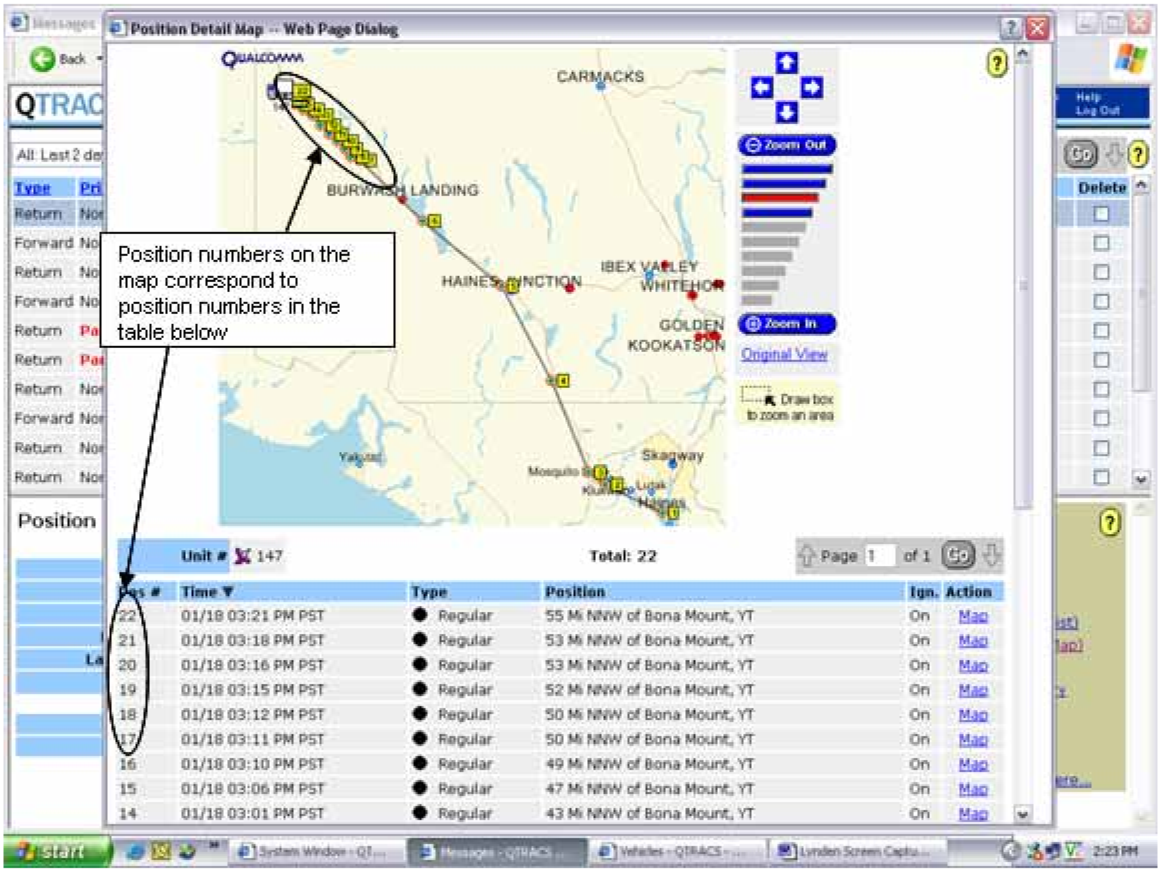


Figure 78. Lynden Transport Unit #147 Position History on 1/18/06

Source: Data: QUALCOMM QTRACS, 2006.

A.2.8 The satellite-based communications system mapping application shall provide street-level mapping.

The QTRACS system allowed users to display a vehicle's position on a map and zoom in to any level desired. At the lowest level, QTRACS provided street-level mapping. Figure 79 shows Lynden Transport's unit #148 on East 3rd Avenue in Anchorage, Alaska on 1/18/06.

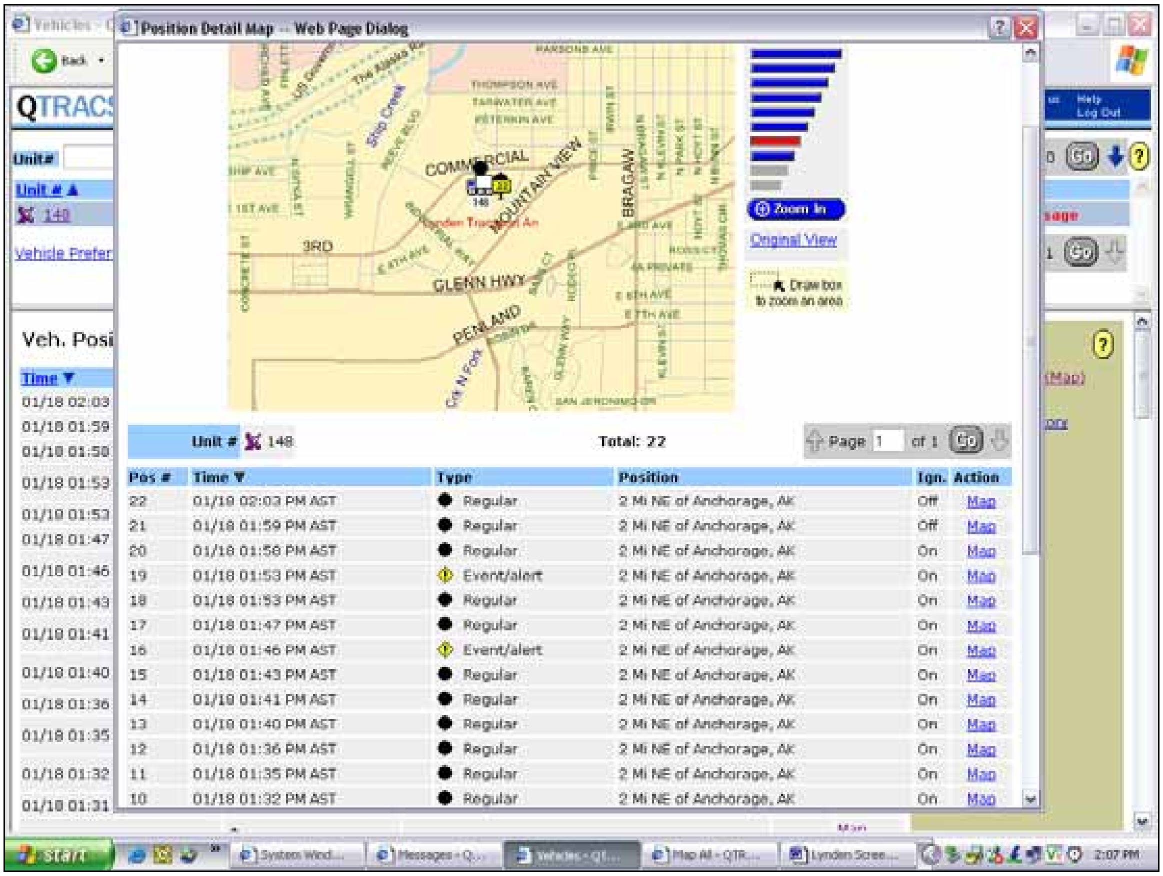


Figure 79. Lynden Transport Unit #148 Displayed on Street-Level Mapping

Source: Data: QUALCOMM QTRACS, 2006.

A.2.9 The satellite-based communications system host software application shall support the creation, modification, and deletion of custom landmarks by authorized users.

The QTRACS system had pre-defined landmarks established within the application. However, users could create custom landmarks or modify/delete existing landmarks. Figure 80 shows a landmark created at the Alaska West Express Terminal in Anchorage, Alaska.

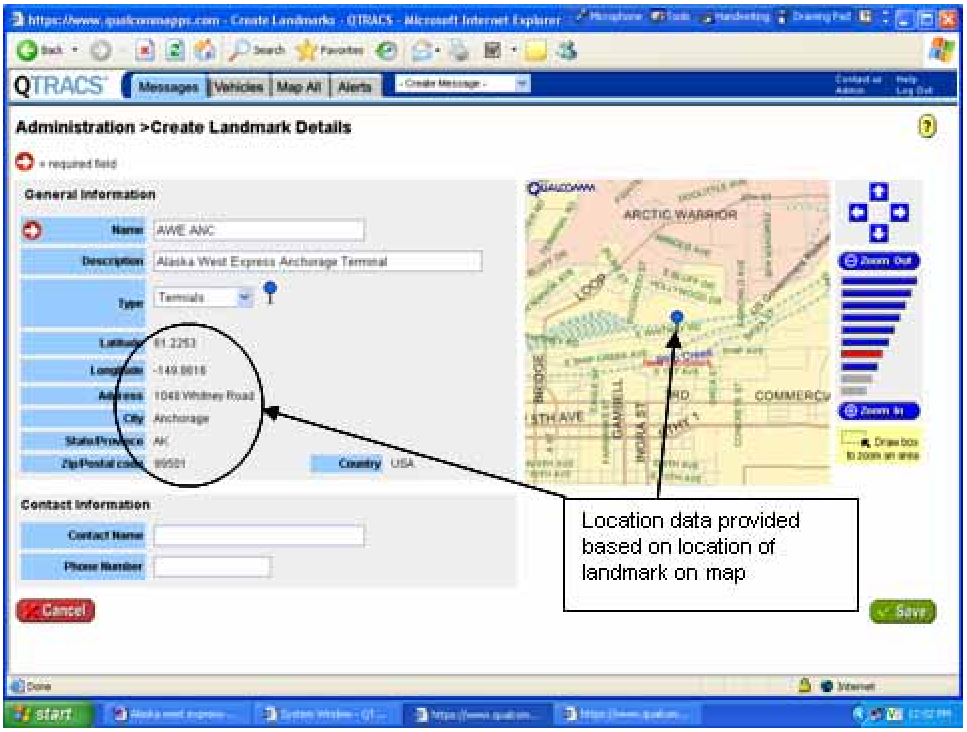


Figure 80. Landmark Created for Alaska West Express Terminal in Anchorage, Alaska

Source: Data: QUALCOMM QTRACS, 2006.

A.2.10 The satellite-based communications system host software shall support the display of tractor positions with proximity to the nearest pre-defined landmark, if configured as a user preference. (This allows the user to display all position reports in terms of the tractor's proximity to a landmark.)

The QTRACS application provided the capability to display tractor positions with proximity to the nearest pre-defined landmark. When a tractor's position was displayed, it automatically included a distance and directional indication from the "nearest" landmark. Figure 81 shows the position history for Weaver Brothers unit #86 on 1/18/06, including the distance to the nearest landmark.

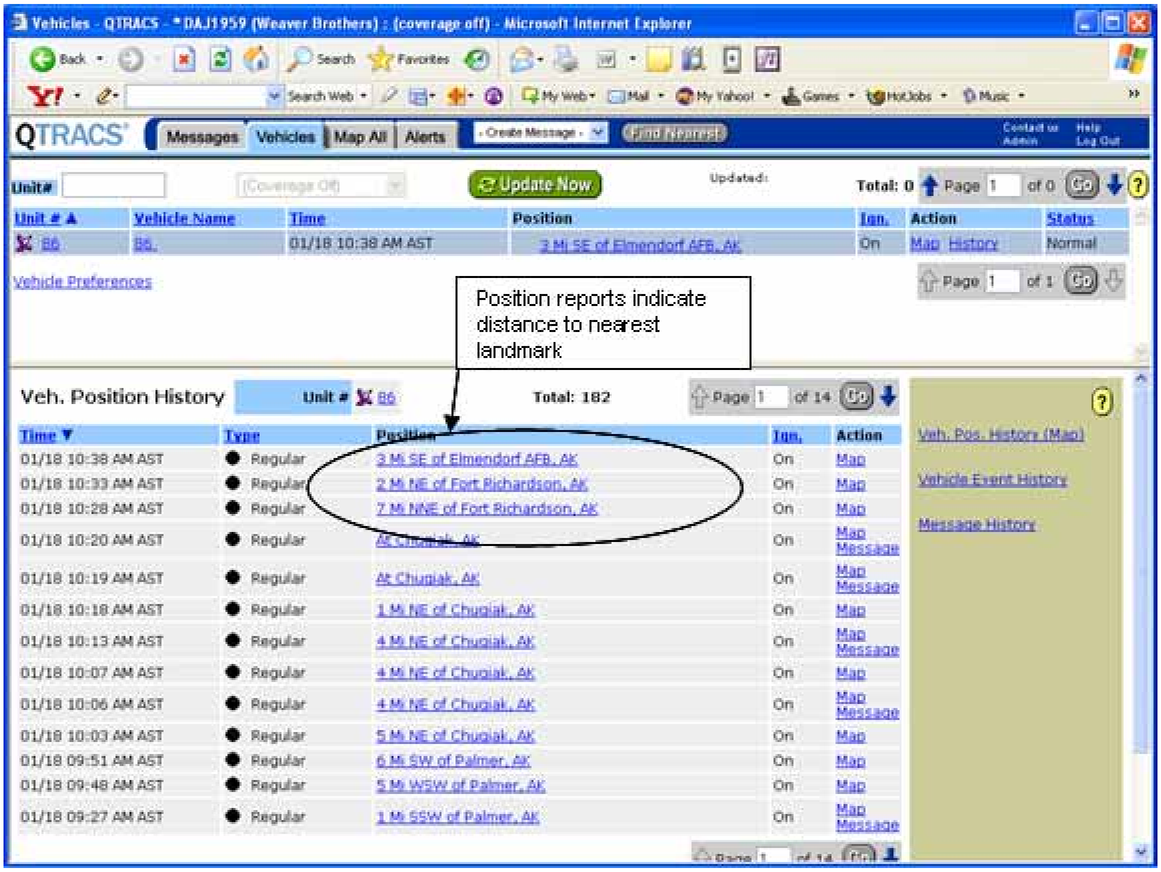


Figure 81. Weaver Brothers Unit #86 Position Reports Showing Distance to Nearest Landmark

Source: Data: QUALCOMM QTRACS, 2006.

A.2.11 The satellite-based communications system host software shall support the query for tractors near a specified landmark within a specified distance. (This allows the user to query for any tractor within a certain distance from a landmark.)

The QTRACS application provided the capability to query for tractors and their distances to selected landmarks. Figure 82 shows the search screen where the user selects the desired unit number and landmark. In this figure, the user is searching to find out how far unit #2122 is from the 0 Dalton landmark. Figure 83 provides the results of the search in numerical form and Figure 84 provides a plot of the search results on a map.

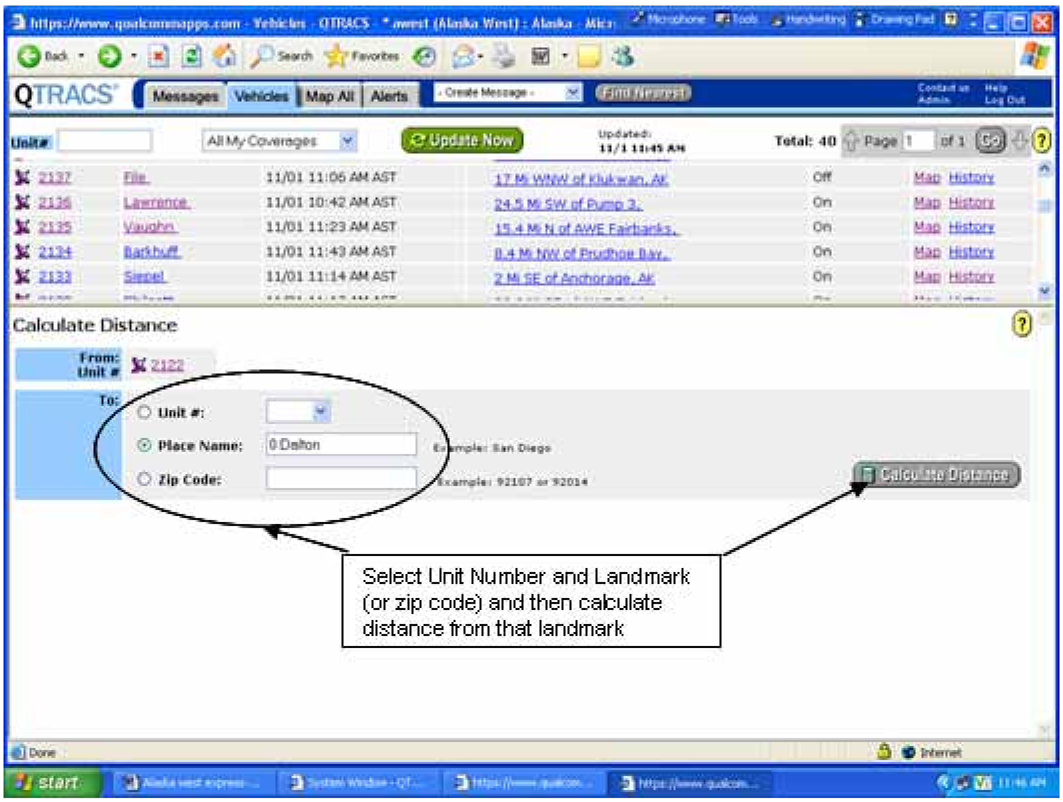


Figure 82. Search Screen for Determining an Alaska West Express Unit #2122's Distance from the 0 Dalton Landmark

Source: Data: QUALCOMM QTRACS, 2006.

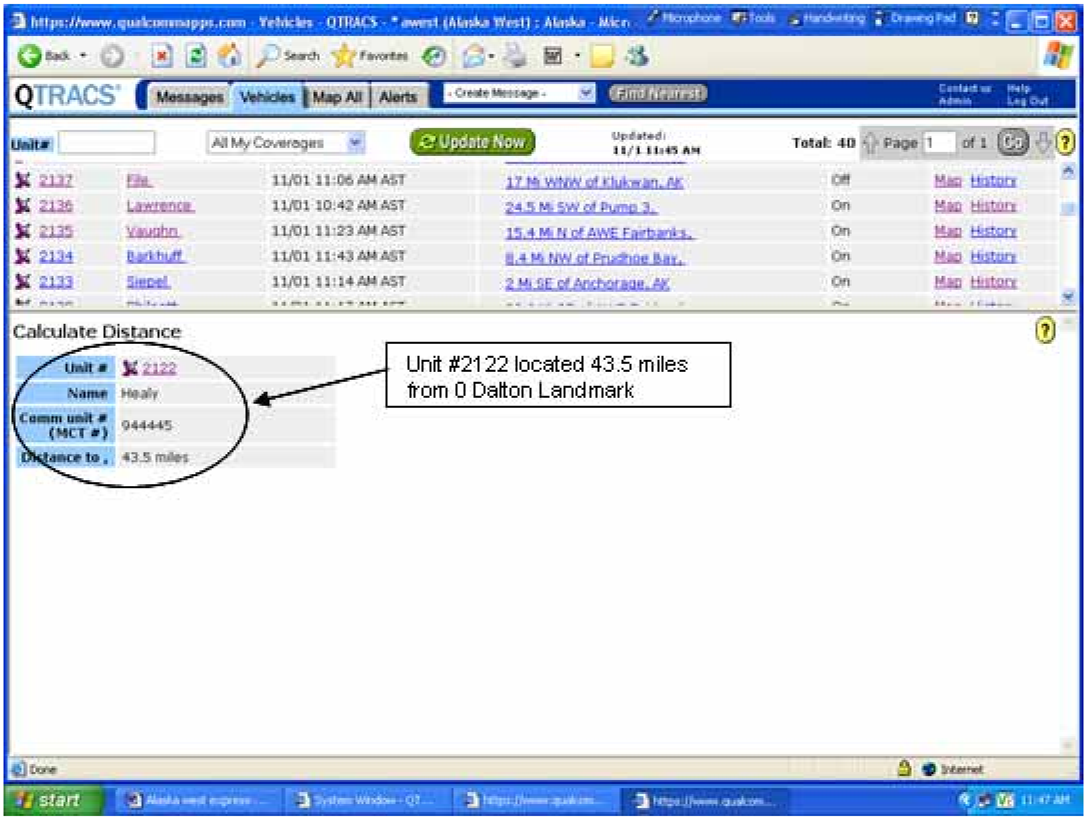


Figure 83. Search Results Displaying AWE Unit #2122's Distance from 0 Dalton Landmark

Source: Data: QUALCOMM QTRACS, 2006.

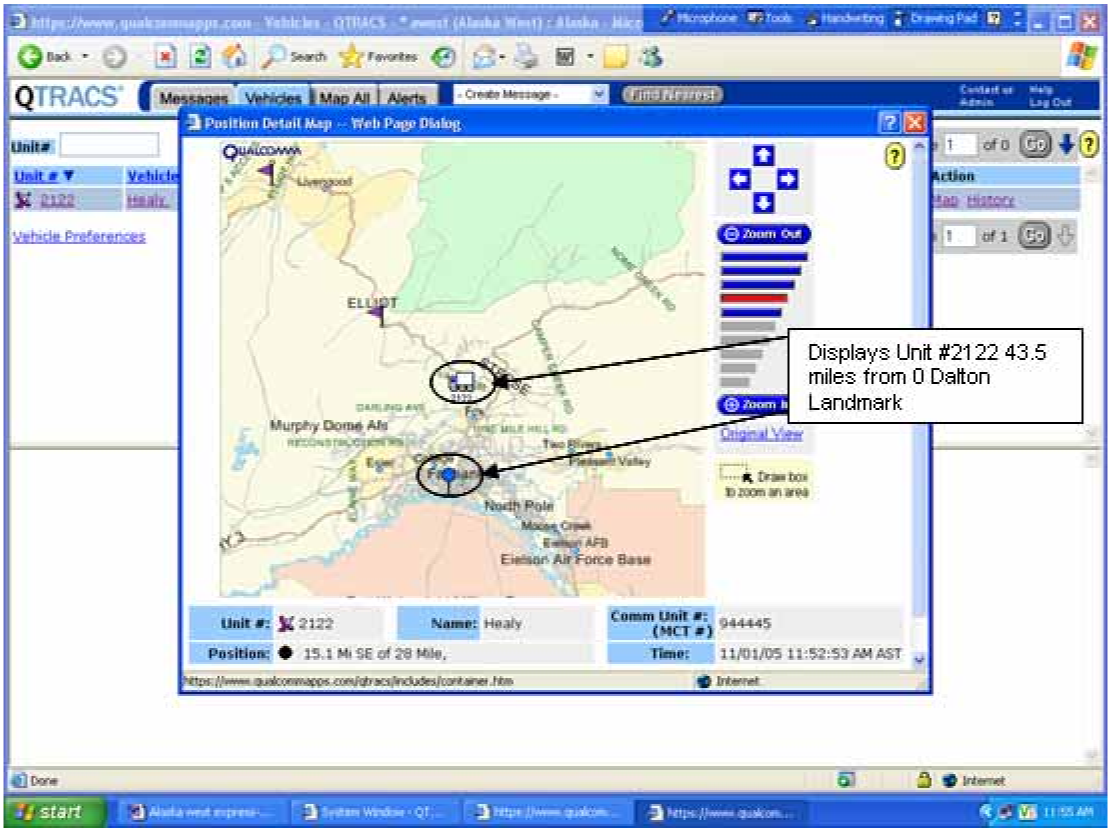


Figure 84. Map of Search Results Showing AWE Unit #2122's Distance from 0 Dalton Landmark

Source: Data: QUALCOMM QTRACS, 2006.

A.3 MAPPING AND LOCATION OF TETHERED TRAILERS WITH THE TETHERED TRAILER TRACKING SYSTEM

A.3.1 The tethered trailer tracking host software application shall store the last known position of each trailer equipped with a tethered trailer tracking unit. (These positions are updated when the system detects a connection or disconnection event from the tethered trailer tracking unit.)

The host operating system allowed the trailer tracking data to be stored in many ways. Figure 85 shows a screen capture identifying all trailers in the system.

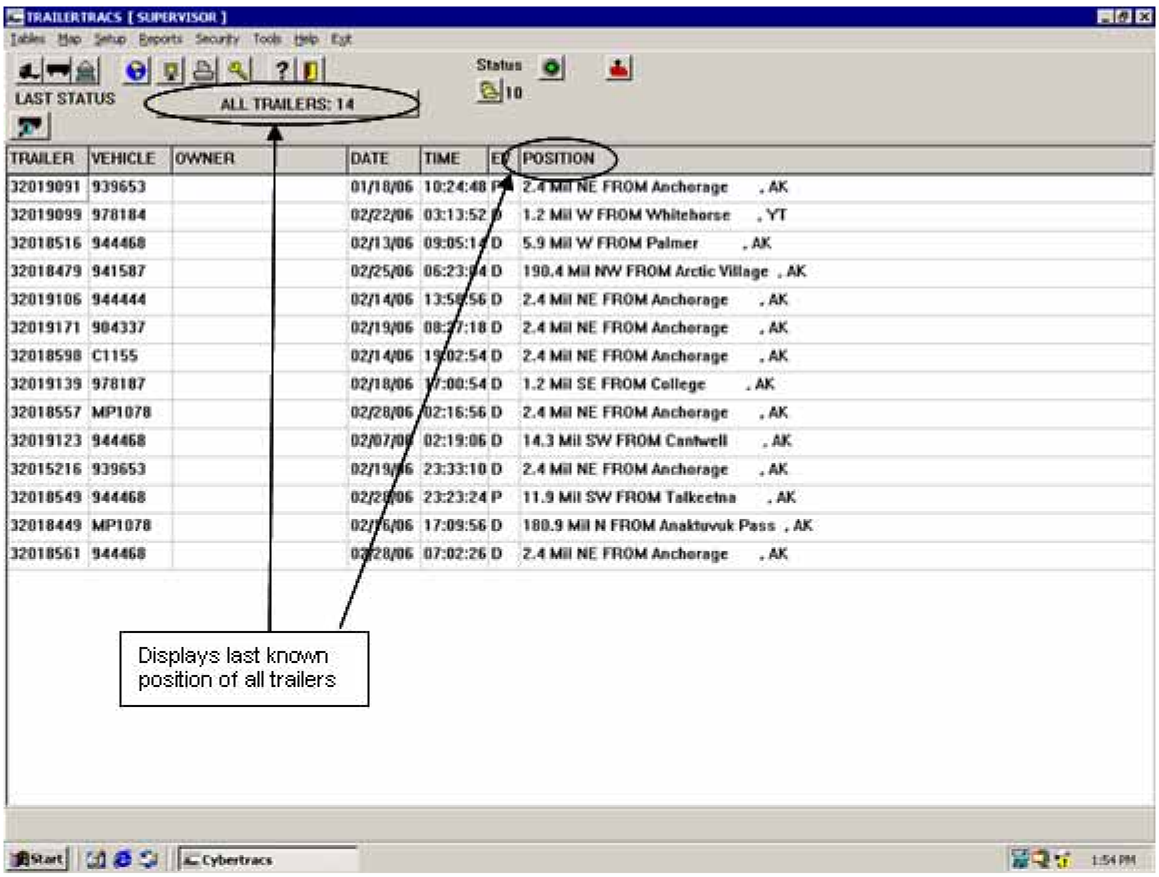
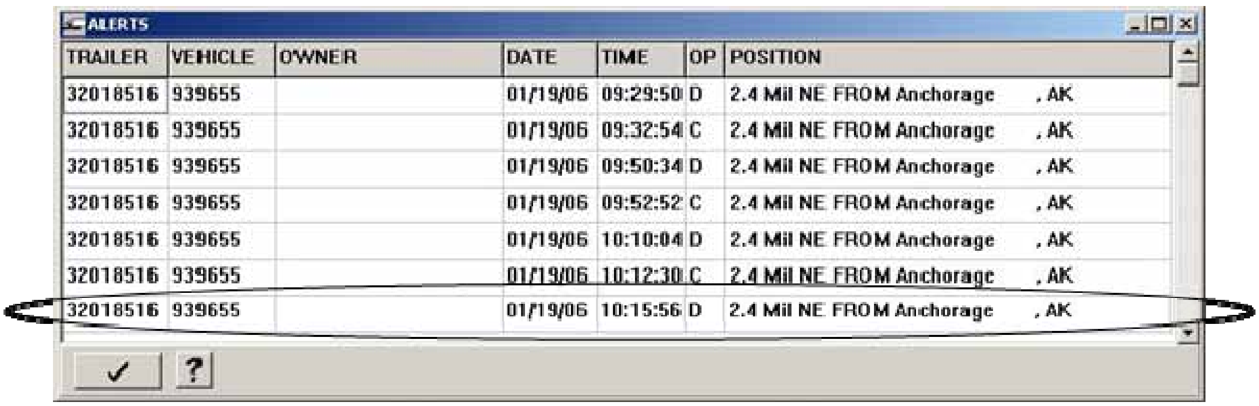


Figure 85. TrailerTracs Host System Screen Capture Showing the Status of All Trailers

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.2 The tethered trailer tracking system shall provide alerts notifying on-site carrier personnel of all tractor-trailer connections and disconnections.

Each time a trailer was connected or disconnected from a tractor, an alert was generated on the TrailerTracs host system. Figure 86 shows a screen capture with the alert screen generated when trailer #32018516 was disconnected from vehicle #939655 on January 19, 2006 at 10:15:56.


ALERTS

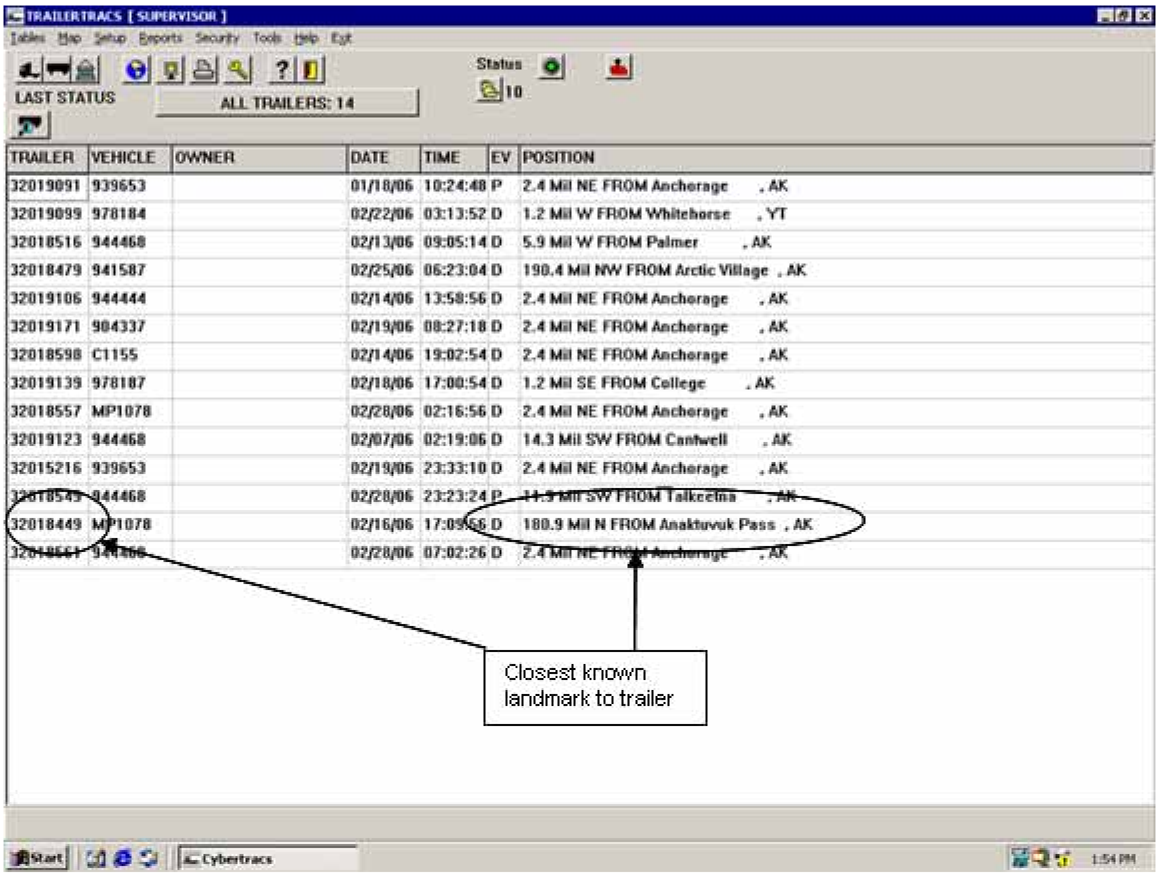
TRAILER	VEHICLE	OWNER	DATE	TIME	OP	POSITION
32018516	939655		01/19/06	09:29:50	D	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	09:32:54	C	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	09:50:34	D	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	09:52:52	C	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	10:10:04	D	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	10:12:30	C	2.4 Mil NE FROM Anchorage , AK
32018516	939655		01/19/06	10:15:56	D	2.4 Mil NE FROM Anchorage , AK

Figure 86. TrailerTracs Host System Screen Capture of Trailer Disconnection

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.3 The tethered trailer tracking host software application shall provide views of all trailers that are connected and disconnected from tractors with the satellite-based communications system terminal at or near a landmark.

Figure 87 provides a screen capture showing all trailers, their statuses, and their positions relative to the nearest landmark. Every time a trailer was connected (C) or disconnected (D) from a tractor, an event was generated. However, if a trailer was connected to a trailer for more than an hour, the trailer "event" was reported as P. In this figure, the EV column provides the last event status for each trailer.



TRAILER	VEHICLE	OWNER	DATE	TIME	EV	POSITION
32019091	939653		01/18/06	10:24:48	P	2.4 Mil NE FROM Anchorage , AK
32019099	978184		02/22/06	03:13:52	D	1.2 Mil W FROM Whitehorse , YT
32018516	944468		02/13/06	09:05:14	D	5.9 Mil W FROM Palmer , AK
32018479	941587		02/25/06	06:23:04	D	190.4 Mil NW FROM Arctic Village , AK
32019106	944444		02/14/06	13:58:56	D	2.4 Mil NE FROM Anchorage , AK
32019171	984337		02/19/06	08:27:18	D	2.4 Mil NE FROM Anchorage , AK
32018598	C1155		02/14/06	19:02:54	D	2.4 Mil NE FROM Anchorage , AK
32019139	978187		02/18/06	17:00:54	D	1.2 Mil SE FROM College , AK
32018557	MP1078		02/28/06	02:16:56	D	2.4 Mil NE FROM Anchorage , AK
32019123	944468		02/07/06	02:19:06	D	14.3 Mil SW FROM Cantwell , AK
32015216	939653		02/19/06	23:33:10	D	2.4 Mil NE FROM Anchorage , AK
32018549	944468		02/28/06	23:23:24	P	14.9 Mil SW FROM Talkeetna , AK
32018449	MP1078		02/16/06	17:09:56	D	180.9 Mil N FROM Anaktuvuk Pass , AK
32018561	944468		02/28/06	07:02:26	D	2.4 Mil NE FROM Anchorage , AK

Figure 87. TrailerTracs Screen Capture Indicating Status of All Trailers Used in Test

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.4 The tethered trailer tracking host software application shall display on a map the last known trailer positions and trailer position histories of trailers that are connected and disconnected from tractors with the satellite-based mobile communications tracking system terminal. The position information shall include latitude, longitude, date, and time.

The TrailerTracs host system allowed users to display the last known locations of trailers on a map. Each position report includes the latitude, longitude, date, and time. Figure 88 shows a map indicating the location of selected trailers.

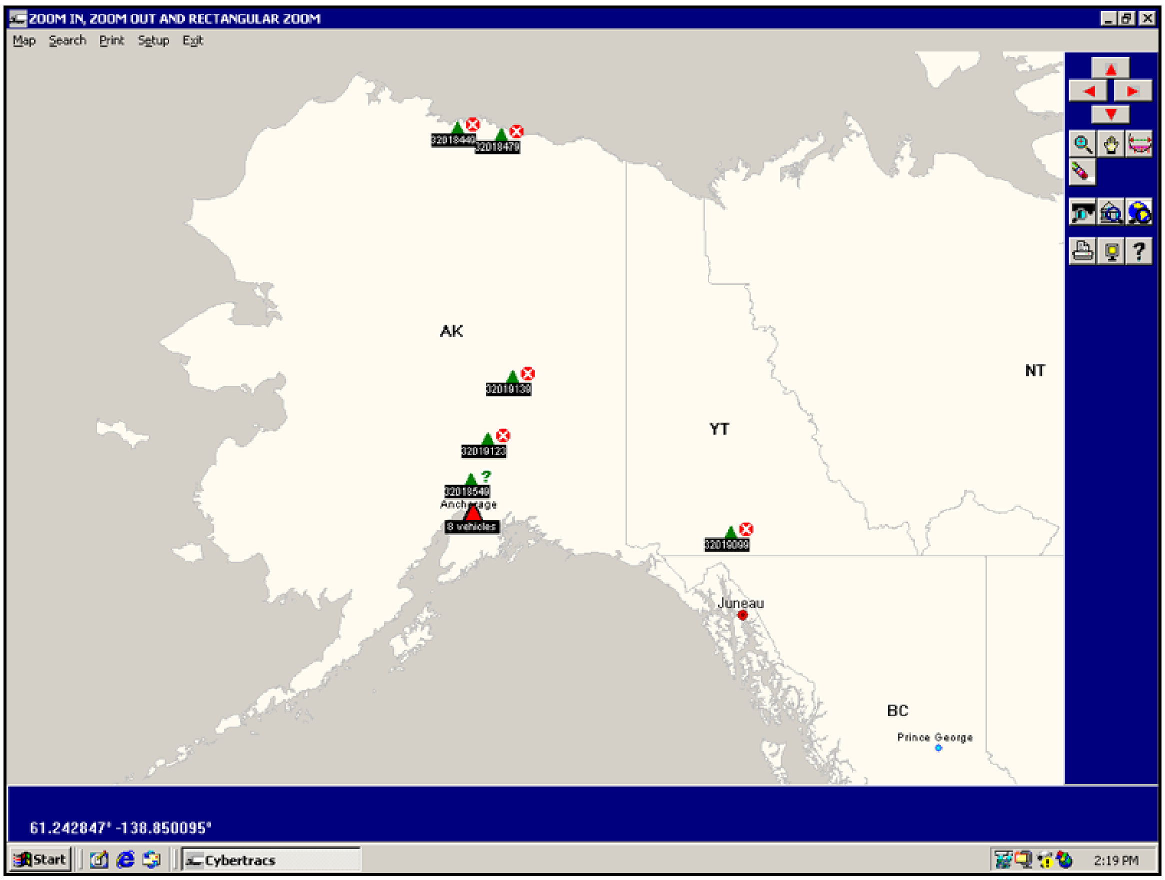


Figure 88. TrailerTracs Screen Capture Indicates Location of Selected Trailers

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.5 The tethered trailer tracking host software application shall provide a view of a position history of the tractor trailer's location at a particular time to enable the on-site carrier personnel to track the trailer connected to a tractor with the satellite-based mobile communications tracking system.

Figure 89 provides a screen capture of the host trailer tracking application showing the locations of a trailer over a period of time.

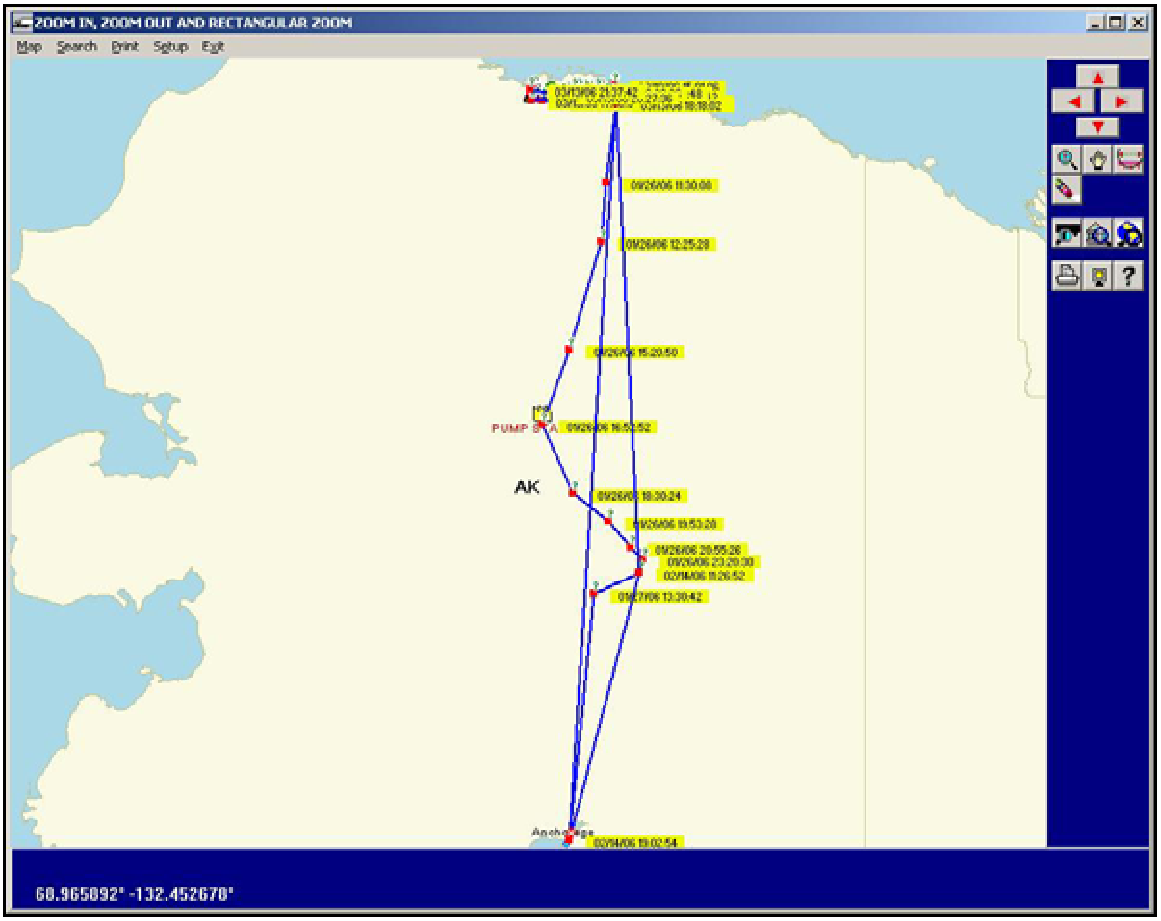


Figure 89. Position History of a Trailer in TrailerTracs Host Application

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.6 The tethered trailer tracking host software application shall allow the on-site carrier personnel to view only trailers connected to tractors with the satellite-based mobile communications tracking system.

Figure 90 shows the results of a request to display only those trailers that were connected at the time of the request.

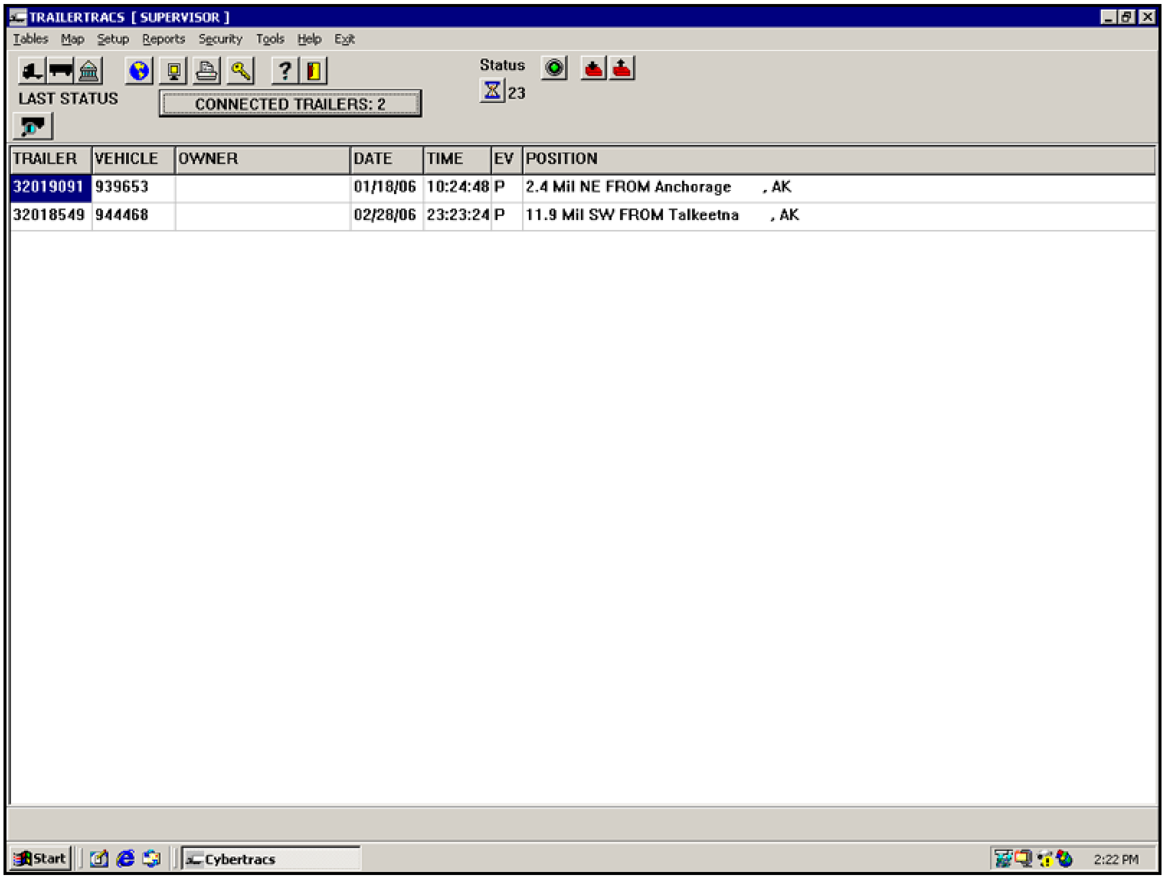


Figure 90. TrailerTracs Screen Capture Showing All Trailers Connected at Time of Request

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.3.7 The tethered trailer tracking host software application shall provide printable reports for the system user to view one or all trailer position histories, the last status report for a trailer, idle trailers, and trailers near a specific landmark that were connected or disconnected from a tractor with the satellite-based mobile communications tracking system.

Figure 91 provides a screen capture showing a printable report for a single trailer (#32018479) over time. It also depicts the last known status and its location in reference to the nearest landmark. Figure 92 shows this same information for multiple trailers, not just a single trailer.

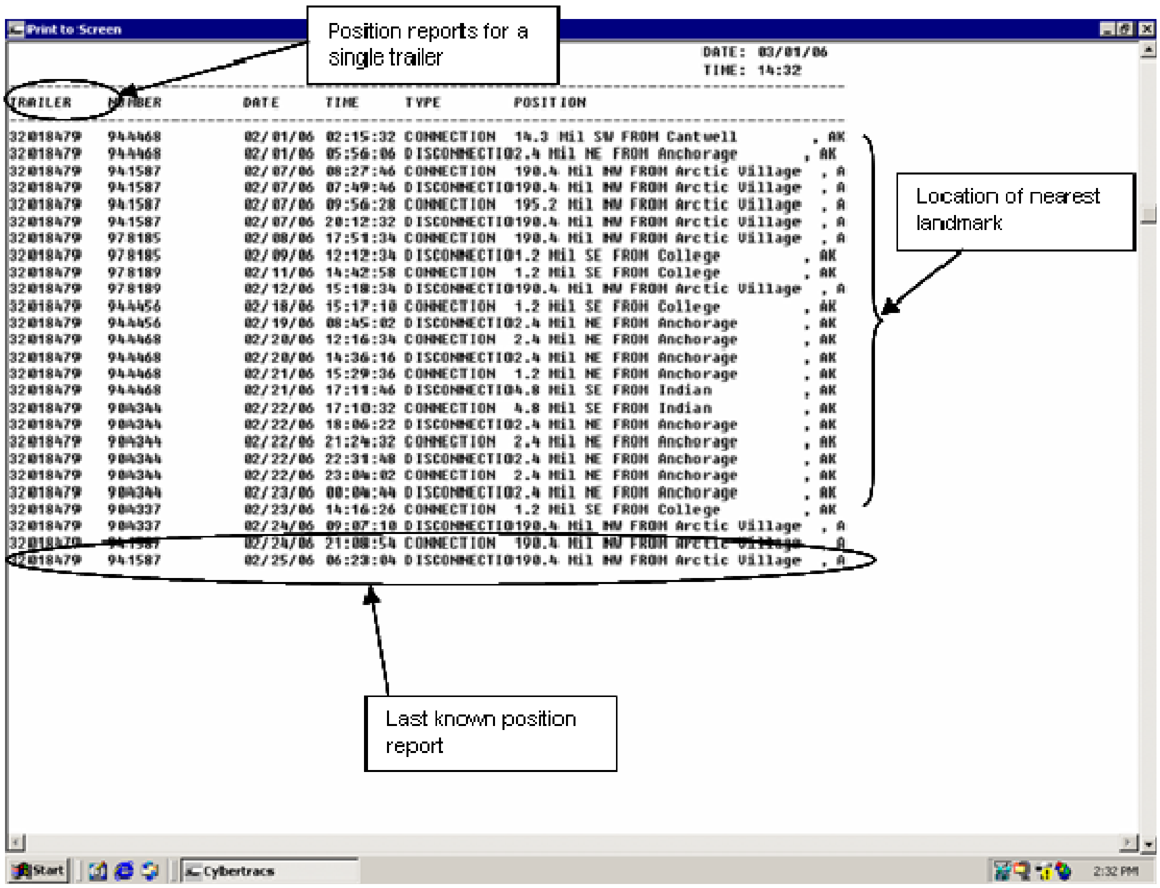
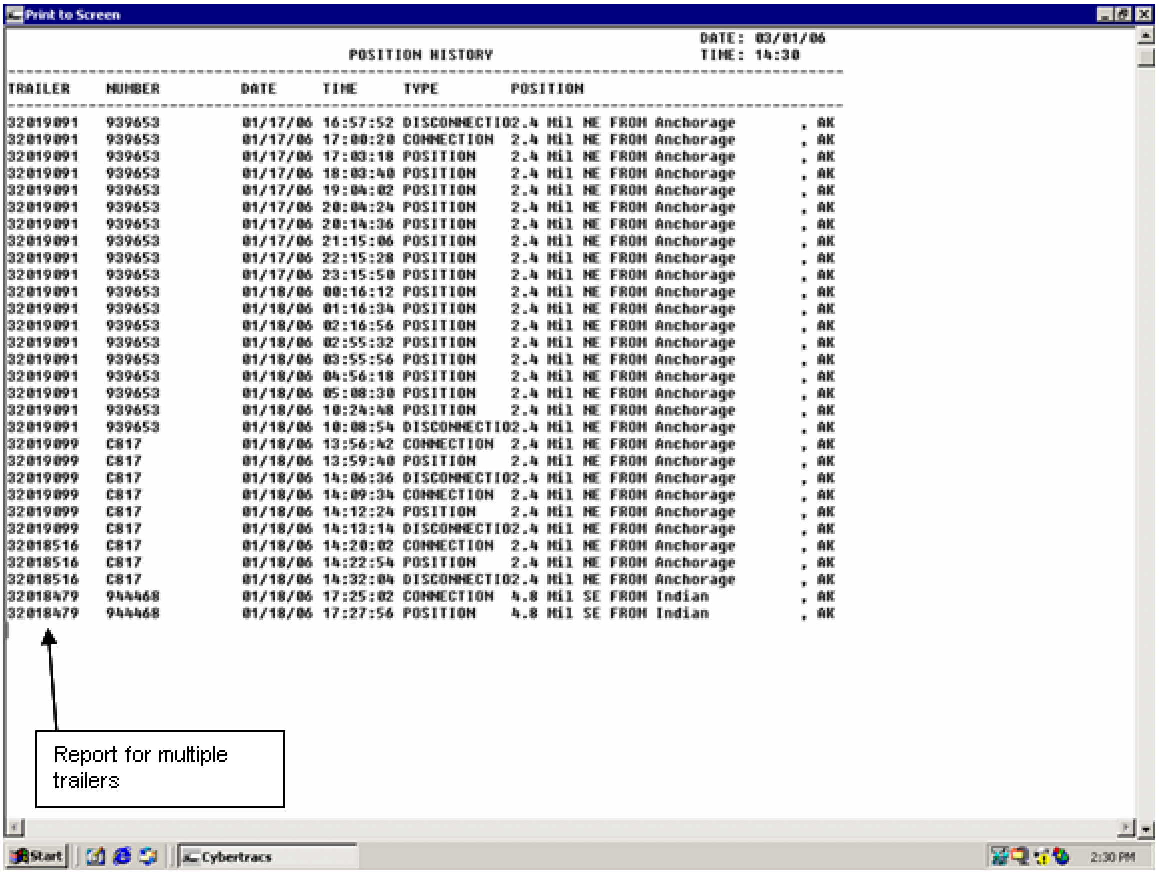


Figure 91. TrailerTracs Screen Capture Showing Printable Report for a Single Trailer

Source: Data: QUALCOMM, TrailerTracs, 2006.



Print to Screen

POSITION HISTORY

DATE: 03/01/06
TIME: 14:30

TRAILER	NUMBER	DATE	TIME	TYPE	POSITION
32019091	939653	01/17/06	16:57:52	DISCONNECTIO	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	17:00:20	CONNECTION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	17:03:18	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	18:03:40	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	19:04:02	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	20:04:24	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	20:14:36	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	21:15:06	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	22:15:28	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/17/06	23:15:50	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	00:16:12	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	01:16:34	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	02:16:56	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	02:55:32	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	03:55:56	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	04:56:18	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	05:08:30	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	10:24:48	POSITION	2.4 Mil NE FROM Anchorage , AK
32019091	939653	01/18/06	10:08:54	DISCONNECTIO	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	13:56:42	CONNECTION	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	13:59:40	POSITION	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	14:06:36	DISCONNECTIO	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	14:09:34	CONNECTION	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	14:12:24	POSITION	2.4 Mil NE FROM Anchorage , AK
32019099	C817	01/18/06	14:13:14	DISCONNECTIO	2.4 Mil NE FROM Anchorage , AK
32018516	C817	01/18/06	14:20:02	CONNECTION	2.4 Mil NE FROM Anchorage , AK
32018516	C817	01/18/06	14:22:54	POSITION	2.4 Mil NE FROM Anchorage , AK
32018516	C817	01/18/06	14:32:04	DISCONNECTIO	2.4 Mil NE FROM Anchorage , AK
32018479	944468	01/18/06	17:25:02	CONNECTION	4.8 Mil SE FROM Indian , AK
32018479	944468	01/18/06	17:27:56	POSITION	4.8 Mil SE FROM Indian , AK

Figure 92. TrailerTracs Screen Capture Showing Printable Report for Multiple Trailers

Source: Data: QUALCOMM, TrailerTracs, 2006

A.3.8 The tethered trailer tracking host software application shall provide views of trailer inventory counts by landmark using the last known trailer position of a trailer connected or disconnected from a tractor with the satellite-based mobile communications tracking system.

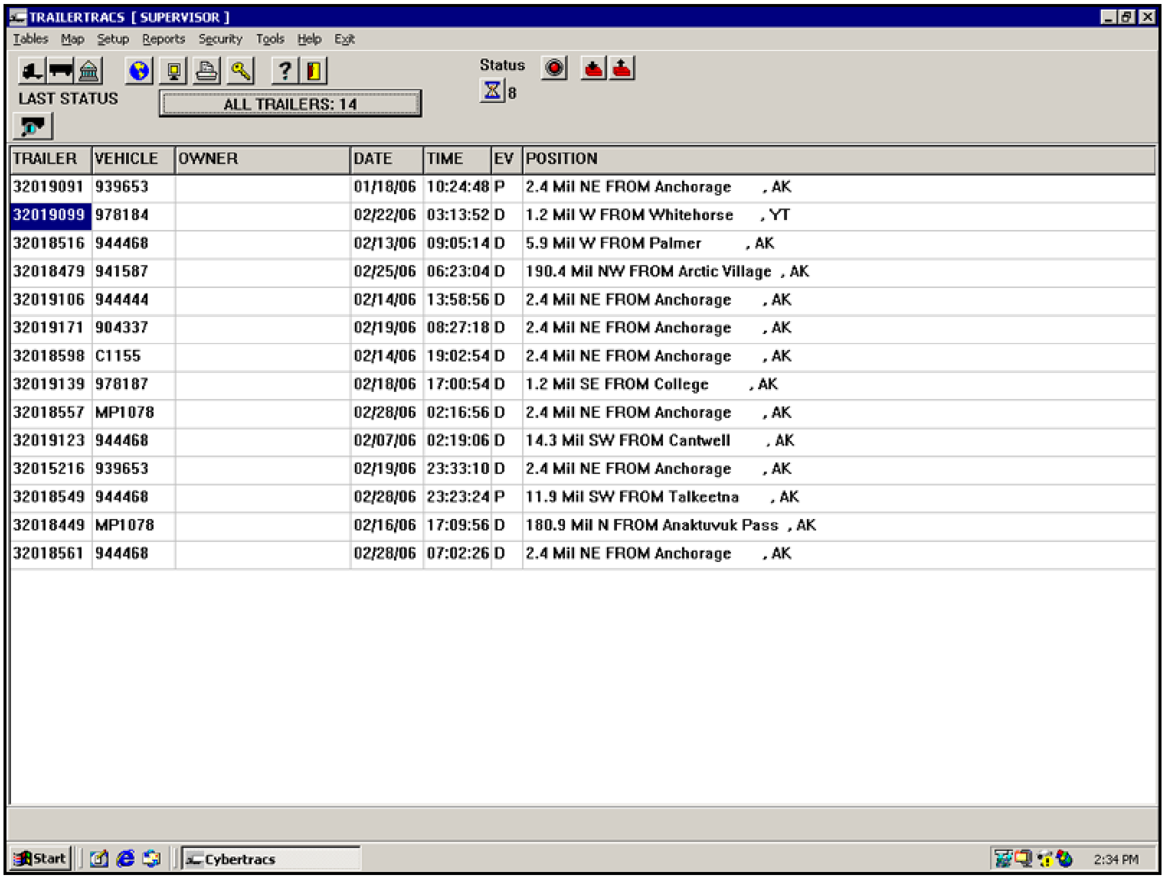
Figure 92 shows the location of trailers and the landmarks (indicated under column titled "position") closest to that trailer.

A.3.9 The tethered trailer tracking system shall detect and record the time and position of all tractor-trailer connections and disconnections where the accuracy shall be 100 percent within two minutes of the event.

As shown in the figure above, the TrailerTracs host system provided the functionality to record the time and position of all tractor-trailer connections and disconnections. The capability to record this information was tested as part of the on-site, staged-event testing during the two field visits to Carlile Transportation in Anchorage, AK.

A.3.10 The tethered trailer tracking system shall relay tractor-trailer identification numbers (IDs) with every connection and disconnection event, as well as position, date, and time.

As shown in Figure 93, a standard feature of the TrailerTracs system was relaying the tractor-trailer identification numbers with each event (connection, disconnection, and position).



TRAILER	VEHICLE	OWNER	DATE	TIME	EV	POSITION
32019091	939653		01/18/06	10:24:48	P	2.4 Mil NE FROM Anchorage , AK
32019099	978184		02/22/06	03:13:52	D	1.2 Mil W FROM Whitehorse , YT
32018516	944468		02/13/06	09:05:14	D	5.9 Mil W FROM Palmer , AK
32018479	941587		02/25/06	06:23:04	D	190.4 Mil NW FROM Arctic Village , AK
32019106	944444		02/14/06	13:58:56	D	2.4 Mil NE FROM Anchorage , AK
32019171	904337		02/19/06	08:27:18	D	2.4 Mil NE FROM Anchorage , AK
32018598	C1155		02/14/06	19:02:54	D	2.4 Mil NE FROM Anchorage , AK
32019139	978187		02/18/06	17:00:54	D	1.2 Mil SE FROM College , AK
32018557	MP1078		02/28/06	02:16:56	D	2.4 Mil NE FROM Anchorage , AK
32019123	944468		02/07/06	02:19:06	D	14.3 Mil SW FROM Cantwell , AK
32015216	939653		02/19/06	23:33:10	D	2.4 Mil NE FROM Anchorage , AK
32018549	944468		02/28/06	23:23:24	P	11.9 Mil SW FROM Talkeetna , AK
32018449	MP1078		02/16/06	17:09:56	D	180.9 Mil N FROM Anaktuvuk Pass , AK
32018561	944468		02/28/06	07:02:26	D	2.4 Mil NE FROM Anchorage , AK

Figure 93. TrailerTracs Relays Tractor-Trailer Identification Numbers with Each Event

Source: Data: QUALCOMM, TrailerTracs, 2006.

A.4. PANIC BUTTON ALERTS WITH THE SATELLITE-BASED TRACTOR COMMUNICATION SYSTEM

A.4.1 The on-board panic button shall be mounted in the tractor's dashboard of the tractor with the satellite-based communications system terminal.

Each tractor was equipped with an in-dash panic button. Figure 94 shows the installation of the wired panic button in one of Shell Motiva's vehicles.

Figure 94. Wired Panic Button Installation in Shell Motiva Vehicle

A.4.2 The wireless panic button shall operate within a maximum range of 150 feet from the satellite-based communications system terminal.

The wireless panic button was tested while on-site in both Alaska and Hawaii, and it was shown to have a minimal operating radius of 150 feet from the tractor.

A.4.3 The satellite-based communications system shall send an email and/or pager alert notification to a user when the panic button is activated.

During on-site testing in Alaska and Hawaii, email alerts were sent to the appropriate carrier personnel when the panic function (either wired or wireless) was activated. Figure 95 shows the alert generated on the dispatcher screen when a panic button is activated.

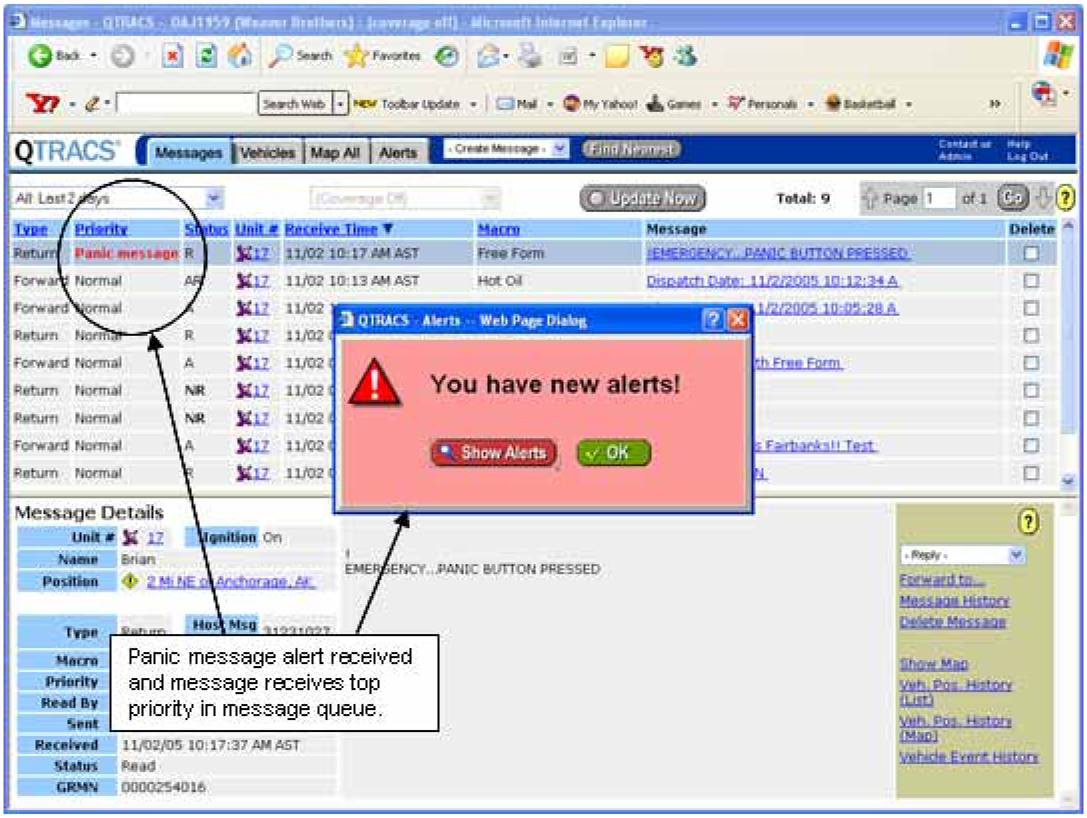


Figure 95. Screen Capture of Panic Alert Notification for Dispatcher

Source: Data: QUALCOMM QTRACS, 2006.

A.4.4 When a panic button is activated, the satellite-based communications system shall send the panic message notification to the web-based satellite-based communications system host software application within two minutes. This message shall have priority over any other queued messages.

The functionality and performance (time to deliver the alert) of the panic alert capability of the system was tested as part of the on-site, staged-event testing in both Alaska and Hawaii. Figure 95 shows the dispatcher screen where the panic messages received priority status and were placed at the top of the queue.

A.4.5 When the emergency message is received at the network management center (NMC), the NMC personnel shall place an emergency call to previously designated points of contact.

During the on-site testing with all participating carriers, the panic button feature was exercised where the NMC personnel placed an emergency call according to the carrier's previously defined escalation procedure.

APPENDIX B

DISPATCHER’S MANUAL LOG FORM

Figure 96 below shows the format of the manual data collection form. The actual forms provided to carriers will be formatted to allow sufficient space for handwritten inputs.

Company Name: ____

Log Book ______________________ of _______________________

Data Log Start Date: _____________ End Date: ______________

Entry No.	Date	Time	Tractor or Trailer No.	Type of Events (See Event Codes)	Successful (Y/N)	Explanation of Problems, if Any	Your Initials
1							
	Location of vehicle:						
2							
	Location of vehicle:						
3							
	Location of vehicle:						
4							
	Location of vehicle:						
5							
	Location of vehicle:						
6							
	Location of vehicle:						
7							
	Location of vehicle:						

Figure 96. Format of the Dispatcher Manual Data Collection Form

Definition of event codes:

1. Receiving and responding to panic alert messages
2. Assigning trailers to tractors and confirming a correct pick-up and the time
3. Location of a trailer
4. Loss of communication and inability to contact a driver

N When "N" is appended to any of the event codes (i.e., 2N), it will denote a time when sending/receiving the message provided a new capability that was not possible prior to installation of the technology. Dispatchers will be asked to annotate the circumstances around this new capability in the manual log.

Note: Receiving automatic vehicle location will not be logged as such events will occur at relatively short intervals.

APPENDIX C

SUMMARY OF MANUAL LOG RESPONSES RECEIVED DURING PILOT TEST

Table 50. Summary of Manual Log Responses Received During Pilot Tests, by Carrier

Carrier	Type of Log	Log Period	Event	Comments/Impacts
Alaska West Express	Regular	11/17/05	Panic Button	Truck broke down during after hours and the driver pushed the panic button to make his message noticed. Follow-up: After reviewing the manual log and the electronic data on this log, the project team member contacted the dispatcher to gather additional information on the problem. The dispatcher explained that the truck driver sent a message first to the dispatcher. When he did not receive a reply from the dispatcher, he realized that it was after hours and pressed the panic button. This triggered the escalation procedures and the answering service got in touch with the after-hours AWE dispatcher and helped the driver with the emergency situation. After this event, AWE has instructed their drivers to use the panic button after hours in emergency situations to reach a dispatcher immediately.
Alaska West Express	Remote	11/28/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Alaska West Express	Remote	11/29/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Alaska West Express	Remote	12/2/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Alaska West Express	Remote	12/20/05	Panic Button	Tested the panic button
Alaska West Express	Regular	12/20/05	Panic Button	Accidental push of the panic button during routine maintenance.
Alaska West Express	Regular	12/29/05	Panic Button	Driver pressed the panic button to ensure that he got help during after hours (approx 9 PM). Followed the procedures set forth by the carrier that if drivers had an emergency during after hours, and they are not able to reach a dispatcher, they should press the panic button.

Carrier	Type of Log	Log Period	Event	Comments/Impacts
Alaska West Express	Regular	1/4/06	Panic Button	3 Panic Alerts were sent from the same vehicle. The dispatcher contacted the driver and realized that all of them were false. Upon further investigation, it was realized that there was an equipment malfunction and a bad cable that triggered the panic button and locked up the key board of the mobile unit.
Alaska West Express	Regular	1/19/06	Panic Button	Driver pressed panic button after hours because his truck had equipment malfunction problems.
Weaver Brothers	Remote	11/14/06	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Weaver Brothers	Remote	11/24/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Lynden	Regular	11/5/05	Location of truck	Viewed the map to look at where the truck was and what time he switched the trailer.
Lynden	Regular	11/27/05	Panic Button	Truck broke down and the driver pressed the panic button to get in touch with the dispatcher.
Lynden	Regular	11/28/05	Location of truck	Viewed the map to track the location of the truck.
Lynden	Regular	11/30/05	Location of truck	Viewed the map to track the location of the truck.
Lynden	Remote	12/20/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Lynden	Remote	12/27/05 and 12/28/05	Messages	Performed send and receive messages and documented the time. This was performed so that additional data could be collected on these events.
Lynden	Remote	12/28/05 and 12/29/05	Panic Button	Tested the panic button.
Carlile	Regular	12/20/05	Panic Button	Driver pressed panic button.
Carlile	Regular	12/20/05	Messages	Communicating with the driver.
Carlile	Regular	12/21/05	Panic Button	Truck broke down—SOS panic from the driver to reach dispatcher after hours (7:25 PM).
Carlile	Remote	12/27/05	Panic Button	Tested the panic button.
Carlile	Remote	1/5/06	Panic Button	Tested the panic button.
Carlile	Regular	1/6/06	Panic Button	Truck broke down on Haul Road. Driver pressed panic button.

APPENDIX D

INTERVIEW GUIDE FOR SITE VISITS

The on-site interviews with carriers collected general comments concerning such various ESCT functions as:

- Effectiveness of communication coverage
- Use of Mobile Communication Terminal for messaging
- Use of panic button
- Use of tethered trailer tracking
- Use of host software in dispatch operations
- Reliability of host system
- Reliability and maintenance issues regarding on-board instruments
- Logistical issues in using ESCT
- Training-related issues

The interview guide contained a set of structured questions intended to assess the carrier's perceptions on various ESCT functionalities (see Figure 97). Interviewees were asked to rate their perceptions using a 5-point preference scale in which 5 is "agree" and 1 is "disagree."

Questions	Disagree				Agree	Remarks
1. The ESCT system improved your existing operations.	1	2	3	4	5	Specific improvements
2. The ESCT is used on a regular basis.	1	2	3	4	5	Reasons preventing it being used more often
3. The ESCT on-board features created distractions for drivers.	1	2	3	4	5	Suggestion for improvement
4. The drivers feel safer with ESCT communication and security features.	1	2	3	4	5	Perceived safety improvements
5. The dispatcher responded positively to ESCT system.	1	2	3	4	5	Testimony
6. The ESCT host system is easy to use.	1	2	3	4	5	Suggestion for improvement
7. The ESCT on-board system is easy to use.	1	2	3	4	5	Suggestion for improvement
8. The use of ESCT improved response to vehicle emergency.	1	2	3	4	5	Specific experiences
9. The use of ESCT allows better service to the shippers and receivers.	1	2	3	4	5	Feedback received from customers
10. The use of ESCT allows better fleet management.	1	2	3	4	5	Testimony

Figure 97. Interview Guide for Site Visits with 5-Point Preference Scale

APPENDIX E

STAGED-EVENT TESTING SCRIPT

Table 51. Staged Event Testing Script—Functional Requirements 3.2.1-1 to 3.2.1-5: Send/Receive Free-Form Text Message, Send/Receive Macro Message.

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Send/Receive Free-Form Text Message	Send free-form text message from tractor to dispatcher	• The driver enters the vehicle, starts the engine, and logs into the system • The driver sends a free- form text message to the dispatcher requesting confirmation.	• Verify the driver can complete the free- form text message and send it to dispatcher. • Verify the dispatcher receives the free-form text message.	• Time stamp,[28] • Message Text • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		Note: Get a screen capture of the dispatcher screen when this message is received.
Send/Receive Free-Form Text Message	Dispatcher reply to free-form text message	• The dispatcher receives free-form text message from driver • The dispatcher replies to driver with confirmation message	• Verify the dispatcher can complete and send the reply to the driver's free-form text message.	• Time stamp, • Message Text • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		
Send/Receive Macro Message	Request Load Assignment	• The driver enters the vehicle and starts the engine at the carrier terminal. • The driver sends a message to the dispatcher requesting a load assignment.	• Verify the driver can complete the load assignment request macro and send it to dispatcher. • Verify the return macro is received by dispatcher and can be read.	• Time stamp, • Return macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		

[28] For each message sent from the on-board SMCT as part of the staged-event testing, the time stamp will be the time displayed on the SMCT when the message is sent from the tractor. This will be compared against the time posted at the host (dispatcher) to determine system latency/response.

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Send/Receive Macro Message	Load Assignment	• The dispatcher determines the load assignment for the driver. • The dispatcher enters the load assignment and sends it the driver, including the ID of the trailer to be picked up.	• Verify the dispatcher can complete and send the load assignment macro to the mobile unit.	• Time stamp, • forward macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		
Send/Receive Macro Message	Load Assignment Acceptance	• The driver receives the load assignment macro and reviews it. • The driver sends an accept load macro message to the dispatcher.	• Verify the driver can read the load assignment macro on the mobile unit and it contains the ID of the trailer to be picked up. • Verify the driver can send an accept load macro message back to dispatcher.	• Time stamp, • Return macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		

Table 52. Staged Event Testing Script—Functional Requirements 3.2.3-1 to 3.2.3-10: Tethered Trailer Tracking via Load Assignment

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Tethered Trailer Tracking via Load Assignment	Load Assignment	• The dispatcher determines the load assignment for the driver. • The dispatcher enters the load assignment and sends it the driver.	• Verify the dispatcher can complete and send the load assignment macro to the mobile unit.	• Time stamp, • forward macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		Note: This test should be conducted in conjunction with the send/receive macro message test. In this case, the load assignment will be simulated with the driver connecting to a trailer at the carrier's facility.
Tethered Trailer Tracking via Load Assignment	Load Assignment Acceptance	• The driver receives the load assignment macro and reviews it. • The driver sends an accept load macro message to the dispatcher.	• Verify the driver can read the load assignment macro on the mobile unit and it contains the ID of the trailer to be picked up. • Verify the driver can send an accept load macro message back to dispatcher.	• Time stamp, • Return macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		
Tethered Trailer Tracking via Load Assignment	Connecting tractor to trailer	• The driver hooks the tractor to the trailer. • Tethered trailer unit transmits the tethered trailer track ID over the power bus to the mobile unit.	• Verify the driver can connect the tractor to the trailer cable.			

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Tethered Trailer Tracking via Load Assignment	Trailer Tracking Unit synchronizes with SMCT	• The mobile unit detects the trailer track ID message and auto connects the trailer. • The driver confirms the trailer ID to ensure the correct trailer was connected.	• Verify the trailer ID displays on the mobile unit confirming the correct trailer.			
Tethered Trailer Tracking via Load Assignment	Trailer Tracking Unit sends connection message to dispatcher	• The mobile unit sends an over-the-air message to the carrier to notify them of the connect event.	• Verify the connect message is generated by the TrailerTracs device and is received and displayed in TrailerTracs/Win	• Time stamp, • Origin (Vehicle), • Lat/Long, • Message length, type (connect)		Note: Get a screen capture of the dispatcher screen when this message is received.
Tethered Trailer Tracking via Load Assignment	Departing	• The driver prepares to depart once he has verified the trailer ID. • The driver sends a departing shipper macro message to the dispatcher.	• Verify driver can send the departing macro message. • Verify the dispatcher can view the departing macro message on host system.	• Time stamp, • return macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		

Table 53. Staged Event Testing Script—Functional Requirement 3.2.2: Positioning and Mapping of Tractors

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Positioning and Mapping of Tractors	Hourly positions are being sent from the tractor	• The driver enters the vehicle and starts the engine at the carrier terminal. • The driver continues the run and the mobile unit sends hourly position reports.	• Verify vehicle positions are received every hour.			
Positioning and Mapping of Tractors	Positions of the tractors displayed on a map	• The host application system displays the vehicle position every hour.	• Verify that the map is refreshed and the position is updated every hour			
Positioning and Mapping of Tractors	Find and display tractors closest to a specific location and/or landmark	• Using the host application, the dispatcher locates a specific tractor at a specific location. • Create landmarks for shipper, consignee, and carrier locations. Using the host application, the dispatcher locates a specific tractor at a specific landmark.	• Verify that the dispatcher can locate and display tractor position and location of the tractor on a map. • Verify that the dispatcher can create the landmarks. Verify that the dispatcher can locate and display tractor position and display it on a map based on a specified landmark.			
Positioning and Mapping of Tractors	Verify vehicle position reporting to every 15 minutes	• The mobile unit is modified to send mobile initiated position report every 15 minutes.	• Verify that vehicle position report is received every 15 minutes.			

Table 54. Staged Event Testing Script—Functional Requirements 3.2.4-1 to 3.2.4-5: Panic Button Alerts (Wired and Wireless)

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Panic Button Alerts (Wired)	Driver presses panic button in vehicle.	• The driver is in the vehicle and detects an emergency situation. • The driver depresses the wired panic button.	• Verify the driver is able to press the panic button.			
Panic Button Alerts (Wired)	Panic button message is received by host application	• Panic button sends a signal to the mobile unit. The mobile unit sends a panic message to the NMC.	• Verify a message is queued on the mobile unit with the text “panic message.”			
Panic Button Alerts (Wired)	Panic Alert Escalation procedures are followed	• The NMC forwards the panic message to the carrier. • NMC personal use the call procedure to notify the carrier of the emergency situation. This could include a call to Law Enforcement, if indicated by the call process.	• Verify the panic message displays in the Host system message list in red. • Verify the panic message is copied to the Laws Enforcement system via QMASS. • Verify the call is received at the correct phone number. The NMC should identify the vehicle from which panic message was sent.	• Time stamp, • Panic Message, • Lat/Long		Get "screen capture" of the message from the host application.
Panic Button Alerts (Wired)	Tractor position at the time of panic	• The host application system displays the vehicle position at the time of the panic.	• Verify that the tractor position is displayed at the time of the panic message.			

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Panic Button Alerts (Wireless)	Driver presses panic button in vehicle or outside vehicle or when detecting emergency situation.	• The driver depresses the red panic button on the wireless panic button (WPB) transmitter.	• Verify the driver is able to press the red panic button on the WPB transmitter.			
Panic Button Alerts (Wireless)	Panic button message is received by host application	• The wireless panic button receiver sends a signal to the mobile unit. • • The mobile unit sends a message to the NMC.	• Verify a message is queued on the mobile unit with the text “panic message."			
Panic Button Alerts (Wireless)	Panic Alert Escalation procedures are followed	• The NMC forwards the panic message to the carrier. • • NMC personal use the call procedure to notify the carrier of the emergency situation. This could include a call to Law Enforcement, if indicated by the call process.	• Verify the panic message displays in the Host system message list in red. • Verify the panic message is copied to the Laws Enforcement system via QMASS. Verify the call is received at the correct phone number. The NMC should identify the vehicle from which panic message was sent.	Time stamp, Panic Message, Lat/Long		
Panic Button Alerts (Wireless)	Tractor position at the time of panic	• The host application system displays the vehicle position at the time of the panic.	• Verify that the tractor position is displayed at the time of the panic message.			

Table 55. Staged Event Testing Script—Functional Requirements 3.2.7-1 to 3.2.7-5: Connect/Disconnect Monitoring

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Connect/Disconnect Monitoring	Driver connects to the right trailer	• Once the driver receives the load assignment and accepts it, the driver hooks the tractor to the trailer. • Tethered trailer unit transmits the tethered TrailerTracs ID over the power bus to the mobile unit.	• Verify the driver can connect the tractor to the trailer cable.	• Time stamp, • Return macro#, • Origin (Vehicle), • Lat/Long, • Message length, type (text/binary), user fields		
Connect/Disconnect Monitoring	Connect Notification message to dispatcher	• The mobile unit detects the TrailerTracs ID message and auto connects the trailer. • The driver confirms the trailer ID to ensure the correct trailer was connected. • The mobile unit sends an over-the-air message to the carrier to notify them of the connect event.	• Verify the trailer ID displays on the mobile unit confirming the correct trailer. • Verify the connect message is generated by the TrailerTracs device and is received and displayed in TrailerTracs/Win application.	• Time stamp, • Origin (Vehicle), • Lat/Long, • Message length, type (connect)		

Function Group	Function	Test Steps	Expected Result	Data Fields	Test Time	Comments
Connect/Disconnect Monitoring	Trailer Tracking Disconnect	• The driver disconnects the trailer and leaves it at the consignee. • The mobile unit detects the lack of a TrailerTracs ID and sends a disconnect event.	• Verify the trailer ID no longer displays on the unit. • Verify a disconnect event is sent and displayed on the TrailerTracs/Win application.			
Connect/Disconnect Monitoring	Disconnect Notification	• The dispatcher verifies that the disconnection of the trailer occurred at the proper location.	• Verify the position of the disconnect event is at the expected location.	• Time stamp, • Origin (vehicle) • Lat/Long • Message length, Type (disconnect) **Position**		

APPENDIX F

STAGED-EVENT FIELD TEST DATA

FIELD TEST 1—ALASKA

Table 56. Field Test 1—Alaska

Function	Alaska West	Weaver	Lynden	Carlile
Free-Form Messages—Driver to Dispatcher	**Free-Form 1** Driver sent Message: 9.53.06 Dispatcher received Message: 9.53.45 Total Time: 39 seconds **Free-Form 2** Driver sent Message: 10.15.39 Dispatcher received Message: 10.16.10 Total Time: 31 seconds	**Free-Form 1** Driver sent Message: 9.42.20 Dispatcher received Message: 9.42.54 Total Time: 34 seconds	**Free-Form 1** Driver sent Message: 2.19.50 Dispatcher received Message: 2.21.07 Total Time: 1 minute and 17 seconds **Free-Form 2** Driver sent Message: 2.22.40 Dispatcher received Message: 2.23.11 Total Time: 31 seconds	**Free-Form 1** Driver sent Message: 10.15.44 Dispatcher received Message: 10.16.05 Total Time: 21 seconds
Free-Form Messages—Dispatcher to Driver	**Free-Form 1** Dispatcher sent Message: 9.55.00 Driver received Message: 9.56.06 Total Time: 1 minute and 06 seconds **Free-Form 2** Dispatcher sent Message: 10.13.00 Driver received Message: 10.14.02 Total Time: 1 minute and 02 seconds	**Free-Form 1** Dispatcher sent Message: 9.46.19 Driver received Message: 9.47.29 Total Time: 1 minute and 10 seconds **Free-Form 2** Dispatcher sent Message: 9.54.16 Driver received Message: 9.56.02 Total Time: 1 minute 46 seconds	**Free-Form 1** Dispatcher sent Message: 2.26.14 Driver received Message: 2.27.17 Total Time: 1 minute and 3 seconds	**Free-Form 1** Dispatcher sent Message: 10.16.17 Driver received Message: 10.18.31 Total Time: 2 minutes and 14 seconds **Free-Form 2** Dispatcher sent Message: 10.20.32 Driver received Message: 10.22.18 Total Time: 1 minute 46 seconds
Macro Messages—Driver to Dispatcher	There were no macros in the system–we could not test it.	**Macro 1** Driver sent Macro: 9.58.18 Dispatcher received Macro: 9.59.08 Total Time: 50 seconds	**Macro 1** Driver sent Macro: 2.28.55 Dispatcher received Macro: 2.29.59 Total Time: 1 minute and 4 seconds	**Macro 1** Driver sent Macro: 10.28.25 Dispatcher received Macro: 10.28.39 Total Time: 14 seconds

Function	Alaska West	Weaver	Lynden	Carlile
Macro Messages—Dispatcher to Driver	There were no macros in the system–we could not test it.	**Macro 1** Dispatcher sent Macro: 10.05.28 Driver received Macro: 10.06.57 Total Time: 1 minute and 29 seconds	**Macro 1** Dispatcher sent Macro: 2.32.59 Driver received Macro: 2.33.20 Total Time: 21 seconds **Macro 2** Dispatcher sent Macro: 2.35.44 Driver received Macro: 2.36.15 Total Time: 31 seconds	**Macro 1** Dispatcher sent Macro: 10.22.30 Driver received Macro: 10.26.55 Total Time: 4 minutes 25 seconds
Wired Panic Button	**Test 1** Driver presses the panic button: 10.20.30 Dispatcher receives Alert: 10.21.22 NMC calls Carrier: 10.21.30 Answering Service Calls Carrier: 10.24.00 Total Time: 52 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 10.16.49 Dispatcher receives Alert:10.17.37 NMC calls Carrier: 10.18.12 Total Time: 48 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 2.37.30 Dispatcher receives Alert: 2.38.27 NMC calls Carrier: No escalation procedures were set up Total Time: 57 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 10.33.15 Dispatcher receives Alert: 10.34.10 NMC calls Carrier: Correct escalation procedures were not set up the first time Total Time: 55 seconds (Driver to Dispatcher) **Test 2** Driver presses the panic button: 11.21.45 Dispatcher receives Alert: 11.22.43 NMC calls Carrier: 11.22.59 Total Time: 58 seconds (Driver to Dispatcher)

Function	Alaska West	Weaver	Lynden	Carlile
Wireless Panic Button	**<u>Test 1</u>** Driver presses the panic button: 10.40.50 Dispatcher receives Alert: 10.41.48 NMC calls Carrier: 10.43.00 Answering Service Calls Carrier: 10.45.00 Total Time: 58 seconds (Driver to Dispatcher)	**<u>Test 1</u>** Driver presses the panic button: 10.25.38 Dispatcher receives Alert: 10.26.44 NMC calls Carrier: 10.27.03 Total Time: 1 minute and 6 seconds (Driver to Dispatcher)	**<u>Test 1</u>** Driver presses the panic button: 2.44.00 Dispatcher receives Alert: 2.44.47 NMC calls Carrier: No escalation procedures were set up Total Time: 47 seconds (Driver to Dispatcher)	**<u>Test 1</u>** Driver presses the panic button: 10.58.30 Dispatcher receives Alert: 10.59.16 NMC calls Carrier: 10.59.36 Total Time: 46 seconds (Driver to Dispatcher)
Trailer Tracking Connect/ Disconnect Monitoring—Driver Connects and Disconnects				The host application was not set up and configured properly. Testing was not conducted during this time on this function.

FIELD TEST 2—ALASKA

Table 57. Field Test 2—Alaska

Function	Alaska West	Weaver	Lynden	Carlile
Send/Receive Free-Form Messages—Driver to Dispatcher	**Free-Form 1** Driver sent Message: 10.04.03 Dispatcher received Message: 10.05.06 Total Time: 1 minute 3 seconds **Free-Form 2** Driver sent Message: 10.08.28 Dispatcher received Message: 10.09.46 Total Time: 1 minute and 18 seconds	**Free-Form 1** Driver sent Message: 9.58.53 Dispatcher received Message: 9.59.33 Total Time: 40 seconds **Free-Form 2** Driver sent Message: 10.02.15 Dispatcher received Message: 10.02.39 Total Time: 24 seconds	**Free-Form 1** Driver sent Message: 1.26.40 Dispatcher received Message: 1.28.29 Total Time: 1 minute and 49 seconds **Free-Form 2** Driver sent Message: 1.32.36 Dispatcher received Message: 1.33.06 Total Time: 30 seconds	**Free-Form 1** Driver sent Message: 9.34.49 Dispatcher received Message: 9.36.06 Total Time: 1 minute and 17 seconds **Free-Form 2** Driver sent Message: 9.39.56 Dispatcher received Message: 9.40.51 Total Time: 55 seconds
Send/Receive Free-Form Messages—Dispatcher to Driver	**Free-Form 1** Dispatcher sent Message: 10.08.00 Driver received Message: 10.08.43 Total Time: 43 seconds	**Free-Form 1** Dispatcher sent Message: 10.01.54 Driver received Message: 10.02.15 Total Time: 21 seconds **Free-Form 2** Dispatcher sent Message: 10.05.05 Driver received Message: 10.05.46 Total Time: 41 seconds	**Free-Form 1** Dispatcher sent Message: 1.30.01 Driver received Message: 1.30.52 Total Time: 51 seconds	**Free-Form 1** Dispatcher sent Message: 9.33.28 Driver received Message: 9.34.27 Total Time: 59 seconds
Send/Receive Macro Messages—Driver to Dispatcher	**Macro 1** Driver sent Macro: 10.12.30 Dispatcher received Macro: 10.13.35 Total Time: 1 minute 5 seconds	**Macro 1** Driver sent Macro: 10.11.36 Dispatcher received Macro: 10.12.43 Total Time: 1 minute 7 seconds	**Macro 1** Driver sent Macro: 1.34.58 Dispatcher received Macro: 1.36.05 Total Time: 1 minute and 7 seconds **Macro 2** Driver sent Macro: 1.41.27 Dispatcher received Macro: 1.42.21 Total Time: 54 seconds	**Macro 1** Driver sent Macro: 9.42.58 Dispatcher received Macro: 9.45.32 Total Time: 2 minutes and 34 seconds **Macro 2** Driver sent Macro: 9.50.42 Dispatcher received Macro: 9.51.52 Total Time: 1 minute and 10 seconds

Function	Alaska West	Weaver	Lynden	Carlile
Send/Receive Macro Messages—Dispatcher to Driver	**Macro 1** Dispatcher sent Macro: 10.16.57 Driver received Macro: 10.17.43 Total Time: 46 seconds **Macro 2** Dispatcher sent Macro: 10.20.25 Driver received Macro: 10.21.51 Total Time: 1 minute 26 seconds	**Macro 1** Dispatcher sent Macro: 10.16.12 Driver received Macro: 10.16.41 Total Time: 29 seconds	**Macro 1** Dispatcher sent Macro: 1.38.53 Driver received Macro: 1.40.12 Total Time: 1 minute 19 seconds	**Macro 1** Dispatcher sent Macro: 9.43.54 Driver received Macro: 9.44.37 Total Time: 43 seconds
Wired Panic Button	**Test 1** Driver presses the panic button: 10.25.29 Dispatcher receives Alert: 10.10.26.12 NMC calls Carrier: 10.26.59 Total Time: 43 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 10.27.40 Dispatcher receives Alert: 10.28.15 NMC calls Carrier: 10.29.04 Total Time: 35 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 1.46.10 Dispatcher receives Alert: 1.46.43 NMC calls Carrier: No escalation procedures were set up Total Time: 33 seconds (Driver to Dispatcher) **Test 2** Driver presses the panic button: 1.53.05 Dispatcher receives Alert: 1.54.54 NMC calls Carrier: No escalation procedures were set up Total Time: 1 minute 49 seconds (Driver to Dispatcher)	**Test 1** Driver presses the panic button: 9.58.27 Dispatcher receives Alert: 9.58.57 NMC calls Carrier: 10.01.16 Total Time: 30 seconds (Driver to Dispatcher)

Function	Alaska West	Weaver	Lynden	Carlile
Wireless Panic Button	**<u>Test 1</u>** Driver presses the panic button: 10.29.15 Dispatcher receives Alert: 10.30.07 NMC calls Carrier: NMC did not call because it was too close to the first panic button. Total Time: 52 seconds (Driver to Dispatcher) **<u>Test 2</u>** Driver presses the panic button: 10.37.40 Dispatcher receives Alert: 10.38.36 NMC calls Carrier: 10.39.09 Total Time: 56 seconds (Driver to Dispatcher)	**<u>Test 1</u>** Driver presses the panic button: 10.22.18 Dispatcher receives Alert: 10.23.09 NMC calls Carrier: 10.24.19 Total Time: 51 seconds (Driver to Dispatcher)	**<u>Wireless panic button was not available.</u>**	**<u>Test 1</u>** Driver presses the panic button: 10.03.14 Dispatcher receives Alert: 10.04.11 NMC calls Carrier: 10.05.14 Total Time: 57 seconds (Driver to Dispatcher)

Function	Alaska West	Weaver	Lynden	Carlile
Trailer Tracking Connect/ Disconnect Monitoring—Driver Disconnects and Connects				**Disconnect Event 1** Driver disconnects trailer: 10.11.33 Mobile Unit detects trailer disconnect: 10.13.50 TrailerTracs Window Displays Disconnect: 10.15.56 Latency time from trailer to mobile unit: 2 minutes 17 seconds Latency time from mobile unit to host: 2 minutes 6 seconds **Connect Event 1** Driver connects trailer: 10.12.35 Mobile Unit Displays Trailer ID: 10.13.45 TrailerTracs Window Displays Connect: 10.18.12 Latency time from trailer to mobile unit: 1 minute 10 seconds Latency time from mobile unit to host: 4 minutes 27 seconds **Disconnect Event 2** Driver disconnects trailer: 10.17.26 Mobile Unit detects trailer disconnect: 10.19.37 TrailerTracs Window Displays Disconnect: 10.26.08 Latency time from trailer to mobile unit: 2 minutes 11 seconds Latency time from mobile unit to host: 6 minutes 31 seconds **Connect Event 1** Driver connects trailer: 10.18.10 Mobile Unit Displays Trailer ID: 10.18.25 TrailerTracs Window Displays Connect: no data Latency time from trailer to mobile unit: 15 seconds

FIELD TEST 1—HAWAII

Table 58. Field Test 1—Hawaii

Function	Hawaii
Send/ Receive Messages— Free-Form—Driver to Dispatcher	**Free-Form 1** Driver sent Message: 10.14.00 Dispatcher received Message: 10.24.34 Total Time: 10 minutes 34 seconds **Free-Form 2** Driver sent Message: 10.28.00 Dispatcher received Message: 10.33.08 Total Time: 5 minutes and 8 seconds **Realized that there was an issue with the location of the truck—moved the truck, reset the mobile unit.** **Free-Form 3** Driver sent Message: 10.44.00 Dispatcher received Message: 10.45.48 Total Time: 1 minute and 48 seconds
Send/ Receive Messages— Free-Form—Dispatcher to Driver	**Free-Form 1** Dispatcher sent Message: 10.35.10 Driver received Message: 10.38.19 Total Time: 3 minutes and 9 seconds **Had the same problem—moved the truck and reset the mobile unit.** **Free- Form 2** Dispatcher Sent Message: 10.47.20 Driver Received Message: 10.47.42 Total Time: 22 seconds

Function	Hawaii
Macro Messages— From Driver to Dispatcher	**<u>Macro 1</u>** Driver sent Macro: 10.41.00 Dispatcher received Macro: 10.41.30 Total Time: 30 seconds
Macro Messages— From Dispatcher to Driver	**<u>Macro 1</u>** Dispatcher sent Macro: 10.47.21 Driver received Macro: 10.47.55 Total Time: 34 seconds
Panic Buttons— Wired Panic Button	**<u>Test 1</u>** Driver presses the panic button: 10.57.00 Dispatcher receives Alert: 10.59.25 NMC calls Carrier: 11.01.00 Total Time: 2 minutes 25 seconds (Driver to Dispatcher) **<u>Test 1</u>** Driver presses the panic button: 11.05.00 Dispatcher receives Alert: 11.05.25 NMC calls Carrier: 11.07.32 Total Time: 25 seconds (Driver to Dispatcher)
Panic Buttons— Wireless Panic Button	**<u>Test 1</u>** Driver presses the panic button: 11.01.00 Dispatcher receives Alert: 11.01.37 Total Time: 37 seconds (Driver to Dispatcher)