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AEROSPACE REPORT NO.
ATR-79(7922)-1

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

CARGO SECURITY FIELD TEST PROGRAM

TASK CLOSEOUT REPORT

December 1978

DEVELOPMENT

Prepared for

National Institute of Law Enforcement and Criminal Justice
LAW ENFORCEMENT ASSISTANCE ADMINISTRATION
U.S. DEPARTMENT OF JUSTICE

The Aerospace Corporation

13738

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ATR-79(7922)-1

Equipment Systems Improvement Program

CARGO SECURITY FIELD TEST PROGRAM

TASK CLOSEOUT REPORT

Prepared by

Eastern Technical Division
Government Support Operations
THE AEROSPACE CORPORATION
Washington, D.C.

December 1978

Prepared for

National Institute of Law Enforcement and Criminal Justice
Law Enforcement Assistance Administration
U.S. DEPARTMENT OF JUSTICE
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EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM
CARGO SECURITY FIELD TEST PROGRAM

TASK CLOSEOUT REPORT

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ACKNOWLEDGMENTS

The Cargo Security Field Test System program represented the first wide-area deployment of an automatic vehicle monitoring system and, as such, required the cooperation and participation of a large and diverse group of private and government organizations to support the program management and its technical subcontractor teams.

The trucks and dispatch facilities used in the program were made available by G.I. Trucking and Transcon Lines, and the enthusiastic assistance and support of the managements of these organizations, in particular E. Blyar and J. Cavin of Transcon, and T. Schlauch and T. Perumian of G.I. Trucking, was particularly appreciated.

In the acquisition of control data on cargo losses, excellent cooperation was provided by R. Matzenbacher of Brake-Meier Trucking and L. Pitz of IML Trucking, by the national and state trucking associations, and by various government and private organizations.

The phase stabilization of the three AM broadcast stations for vehicle location purposes was achieved through the cooperation of the chief engineers of KFI, KNX, and KPOL and the Broadcast Bureau of the Federal Communications Commission.

The installation of proximity transmitters on lighting standards throughout the 400-square-mile test area necessitated authorization and/or licensing, and valuable assistance in the acquisition of these installation permits was provided by the cognizant personnel of the following Los Angeles area municipalities:

Alhambra	El Segundo	Lynwood	Santa Fe Springs
Bell	Gardena	Manhattan Beach	Signal Hill
Bellflower	Hawthorne	Maywood	South El Monte
Bell Gardens	Hermosa Beach	Montebello	South Gate
Buena Park	Huntington Park	Monterey Park	Torrance
Carson	Inglewood	Norwalk	Vernon
Cerritos	Lakewood	Palos Verdes Estates	Whittier
Commerce	La Mirada	Paramount	
Compton	Lawndale	Pico Rivera	
Cudahy	Lomita	Redondo Beach	
Downey	Long Beach	Rolling Hills Estates	
El Monte	Los Angeles	Rosemead	

The Department of Transportation, State of California, provided installation facilities in its area of jurisdiction.

The support of Mr. J. Crotty of the Teamsters Union in ensuring the cooperation of the union drivers was invaluable in ensuring program success.

The law enforcement community played an active part in the program in recommending response strategies and in participating in the field surveys. These agencies included the California

Highway Patrol, the Los Angeles County Sheriff's Department, and the following municipal police departments:

Alhambra
Bell
Bell Gardens
Buena Park
Compton
Cudahy
Downey
El Monte
El Segundo
Gardena
Hawthorne
Hermosa Beach
Huntington Park
Inglewood
Long Beach
Los Angeles
Manhattan Beach
Maywood
Montebello
Monterey Park
Palos Verdes Estates
Pico Rivera
Redondo Beach
Signal Hill
South Gate
Torrance
Vernon
Whittier

SUMMARY

This report summarizes the activities which were completed under Task Element 7922 in the field test program for the Cargo Security System.

The predecessor Cargo Security System Development Program (Task Element 7908) had identified the nature of the theft problem, established that the pickup and delivery segment of the industry was the principal target of cargo crime, evaluated the cost benefits that would accrue to the industry as a result of deploying a cargo protection system, and determined the technical feasibiity of monitoring the location and status of cargo vehicles.

The Field Test Program had as its principal objective the evaluation of the impact of the system on the incidence of cargo theft. Subcontracts were awarded to Hoffman NavCom for the design development, fabrication, installation, and maintenance of a multivehicle system and the J.H. Wiggins Company for the planning and conduct of the field test.

The system was successfully deployed in 40 trucks operating over a 400-square-mile area of the Los Angeles basin. During the early phases of the system acceptance tests (completion of which would have initiated the formal field evaluation), communications interference with other local users of the assigned frequency channel resulted in a decision to cease testing, pending a resolution of this problem. Candidate solutions were identified, but a reappraisal of the program by the Law Enforcement Assistance Administration resulted in a decision to terminate the task.

The system design materially advanced the state-of-the-art in automatic vehicle monitoring and provided an active demonstration of the practicability of an economic, wide-area, monitoring system capable of being shared by multiple users without compromise of individual data integrity. A new concept in the distribution of data processing in the vehicle units and the individual trucking companies was proven feasible and enabled the use of a common radio communications link for all vehicles. The system hardware and software design have been documented, and design modifications to further enhance system performance have been identified.

CHAPTER 1. INTRODUCTION AND CHRONOLOGY

Cargo theft is a highly organized, multi-billion-dollar business and is most prevalent in the pickup and delivery segment of the trucking industry. To aid the industry in reducing the theft losses and to improve the security of the cargo carrier, a truck antihijacking project was initiated under National Institute of Law Enforcement and Criminal Justice sponsorship (Task Element 7908) in FY 1973. The FY 1973 and subsequent FY 1974 efforts addressed the problem of vehicle hijackings and the theft of cargo trailers. A demonstration antihijacking system was fabricated for the purpose of eliciting industry comments. As a result of these demonstrations and a thorough analysis of theft loss statistics, the scope of the program was broadened during FY 1974 to encompass more critical areas of cargo theft from the motor carriers.

With the assistance of security officers in the industry, the concept of remote surveillance of vehicle status and location was developed (Figure 1). Value analyses established an upper cost bound of $1000 per year per truck, and a survey and technical assessment found that the major barrier to system implementation was the lack of a low-cost automatic vehicle location technology. To rectify this situation, feasibility studies were initiated during FY 1974 on two location concepts: hybrid deadreckoning and a hyperbolic system based on AM broadcast signals. It was found that the latter concept had the potential capability of meeting system requirements.

In the latter part of FY 1974, a competitive procurement was initiated for the design and development of a brassboard system to be pilot-tested to determine technical feasibility, and a subcontract was initiated with Hoffman NavCom in mid FY 1975. Pilot test planning was initiated in FY 1976, and the system was installed in a dispatcher's office and in six commercial vehicles operating in a 24-square-mile area of Los Angeles, California. Pilot testing was conducted over a 3-month period. It established the technical feasibility of the concept and identified the changes required to meet the operational needs of the industry.

To acquaint potential users with the capabilities of the concept, a competitive procurement for an orientation movie resulted in a fixed-price award to The Elliot Concern.

The 7908 Task Element was concluded in FY 1976 with the delivery of a final technical report, the orientation movie, and a task closeout report.

The Cargo Security Field Test Program (Task Element 7922) was initiated in FY 1977. The technical and operational changes identified during the pilot test program were factored into the system specification, test objectives were defined, and test planning analysis established the test parameters and criteria required to meet these objectives. It was determined that a total of 40 truck-years of operation was necessary for a comprehensive field evaluation of the system and, from test operations planning, that the minimum area required to encompass 40 truck routes in the Los Angeles area was on the order of 400 square miles.

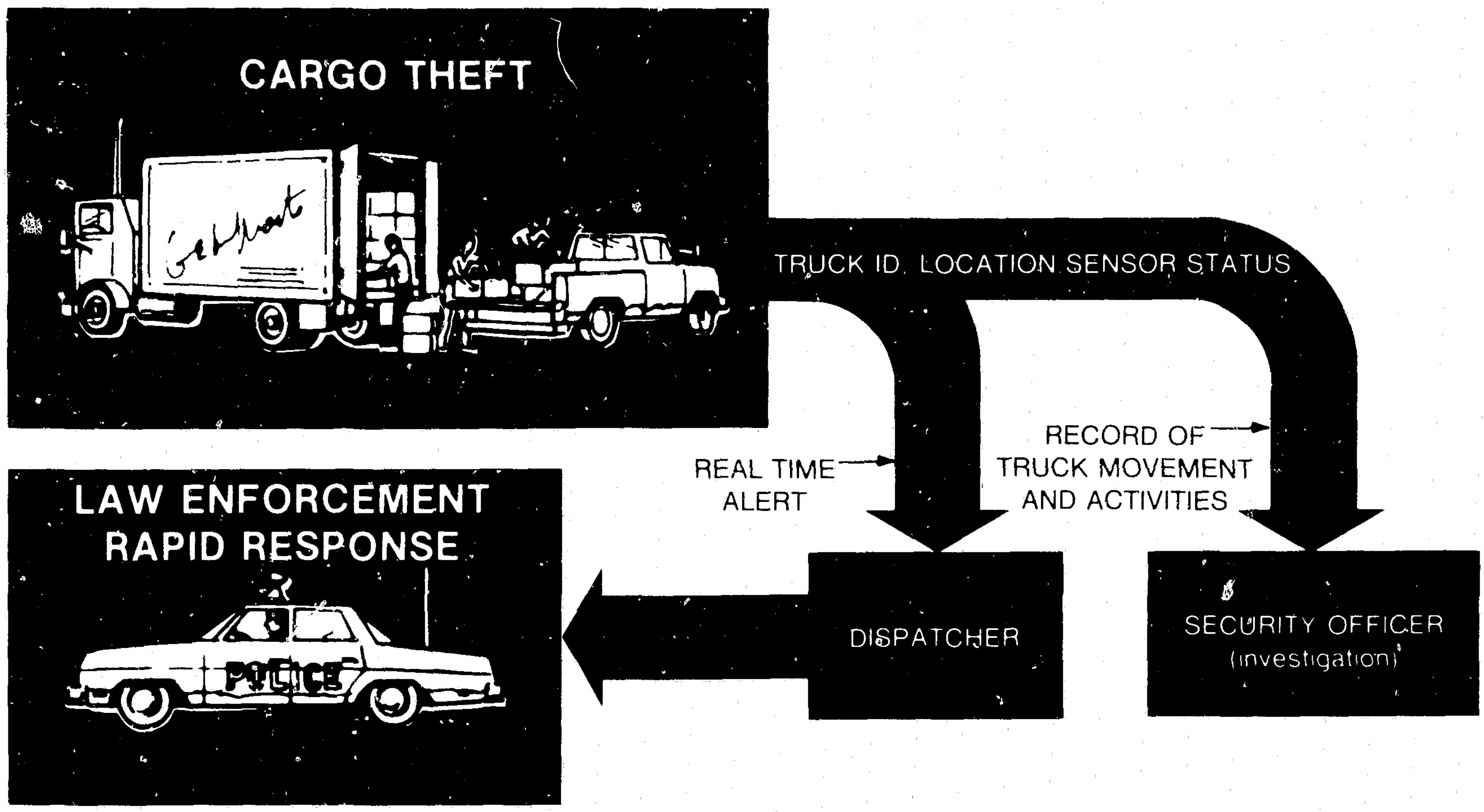


Figure 1. Cargo Security System Concept

A sole-source subcontract was awarded to Hoffman NavCom in February 1977 for the design, development, installation, and maintenance of the field test system. A competitive procurement for the conduct of the field test program and the analysis of the test data resulted in the award of a subcontract to the J.H. Wiggins Company, also in February 1977.

The system was deployed and checked out in the 40 cargo vehicles and 2 dispatch terminals during the third quarter of FY 1978. System acceptance testing, completion of which would have initiated the formal field phase of the program, was commenced but was halted as a consequence of radio communications interference. Solutions to the problem were identified, and the cost/schedule impact of their implementation was evaluated. A reappraisal of the situation led to a decision by the Law Enforcement Assistance Administration (LEAA) to terminate the program, and the task was concluded in early FY 1979 with the delivery of a technical report on the system and the results of system checkout testing.

CHAPTER II. PROBLEM DEFINITION AND SYSTEM REQUIREMENTS

One of the most serious problems confronting the transportation industry is the theft of cargo in transit. The Select Committee on Small Business, U.S. Senate, estimated that these losses, with the attendent cost of claim processing and the indirect cost of losses in the competitive market position of manufacturers and retailers, posed an annual $10 billion burden to the national economy.

Of all modes of transportation, it is the trucking industry (shippers, carriers, consignees) that incurs the highest theft-related losses--more than 60 percent of the national total--with direct losses (the wholesale value of the goods stolen) amounting to $1 billion in 1970 and increasing at a rate of approximately 10 percent per year. Within the trucking industry, it is the motor carriers that incur the heaviest losses. The carriers accept full responsibility for the cargo during its transfer from shipper to consignee and are liable for all losses. The cost to the carrier occasioned by cargo theft is comprised of two elements: direct value of the goods and indirect costs associated with the processing of claims by the shipper or consignee. It has been estimated by the American Trucking Association that these indirect costs amount to $2 to $5 for each $1 of the actual value of the stolen goods.

Of the various classes of motor freight carriers, it is the local pickup and delivery operations (which account for more than 50 percent of carrier revenues) which are the principal victims of the cargo thief.

The theft distribution pattern shows that 5 percent of theft losses are the result of after-hours break-and-enter burgleries, 10 percent are caused by armed hijackings or theft of entire vehicles or containers, with the remaining 85 percent resulting (1) from individual thefts during the course of normal operating procedures and (2) from thefts by persons with authorized access to the cargo handling areas, the stolen goods being carried out of the freight terminals during regular working hours in vehicles or by persons authorized to be in the terminal area. It has been estimated that more than 60 percent of thefts involve collusion of the driver and that up to 80 percent involve collusion of some employee.

Conventional security measures at the freight terminals are effective against after-hours break-ins and the surreptitious removal of stolen goods in private vehicles or concealed in terminal garbage containers, etc. However, such measures cannot prevent the use of the authorized pickup and delivery vehicle for transporting stolen goods out of the terminal area. Further, pickup and delivery vehicle operations are particularly susceptible to theft of authorized cargo by thieves operating independently or in collusion with some trucking company employee.

Surveillance of vehicle movements by security officers using trail vehicles has long been recognized as the most effective theft countermeasure, but the cost of such surveillance precluded its general use except in special circumstances, such as high-value cargo movements or in the gathering of evidence against an employee suspected of cargo theft.

To counter vehicle-related cargo theft, a means of conducting surveillance on all pickup and delivery vehicles, at a cost commensurate with industry losses, was required. Cost analyses indicated that to be cost-effective, the total annual operating costs should not exceed $1000 per year per truck for a system capable of reducing carrier theft-related losses by 20 percent. Further, to provide an incentive to operations management for the use of such a system, it should provide tangible benefits in operational efficiency.

The pilot test findings and the operational analyses conducted during the predecessor program had established the technical and operational requirements of the system to be developed for the field test program. These requirements included:

- Location accuracy: 600 ft at the 95th percentile
- Location designation: nearest street intersection
- Communications
  - Coverage: 90 percent of the test area
  - Service probability: 95 percent
- System capacity: 256 vehicles
- System availability: 94 percent
- False reports: ≤ 1 per vehicle-year
- Missed reports: ≤ 1 per vehicle-year
- Alarm/alert logic: programmable combinations of vehicle sensor actuations and vehicle location/route comparisons
- Data recording: up to 3 days of individual vehicle transaction activities

CHAPTER III. TEST PLANNING

The overall objective for the field test program was to quantitatively assess the usefulness of a cargo security system to the trucking industry. In support of this overall objective, the following assessments and evaluations were established.

- Impact of the system on the incidence of cargo theft
- Performance and reliability of the system
- Cost benefits of the system
- Acceptibility of the system to the industry and the law enforcement community

A general test plan outlined the principal program objectives and further defined these objectives in terms of quantifiable goals to be achieved through the collection, reduction, and analyses of operational and cost data.

To bound and define the field test, a sample size analysis was conducted to determine the number of truck-years required to accumulate meaningful statistical data on the system's effect on cargo theft. Based on the theft statistics and value analyses performed during the predecessor program, it was found that 35 to 40 truck-years would be required to demonstrate a 50-percent system effectiveness with a 90-percent confidence factor (Figure 2). The general test plan and the sample size analysis formed the basis for defining the tasks for the field test conductor subcontractor (J.H. Wiggins Company).

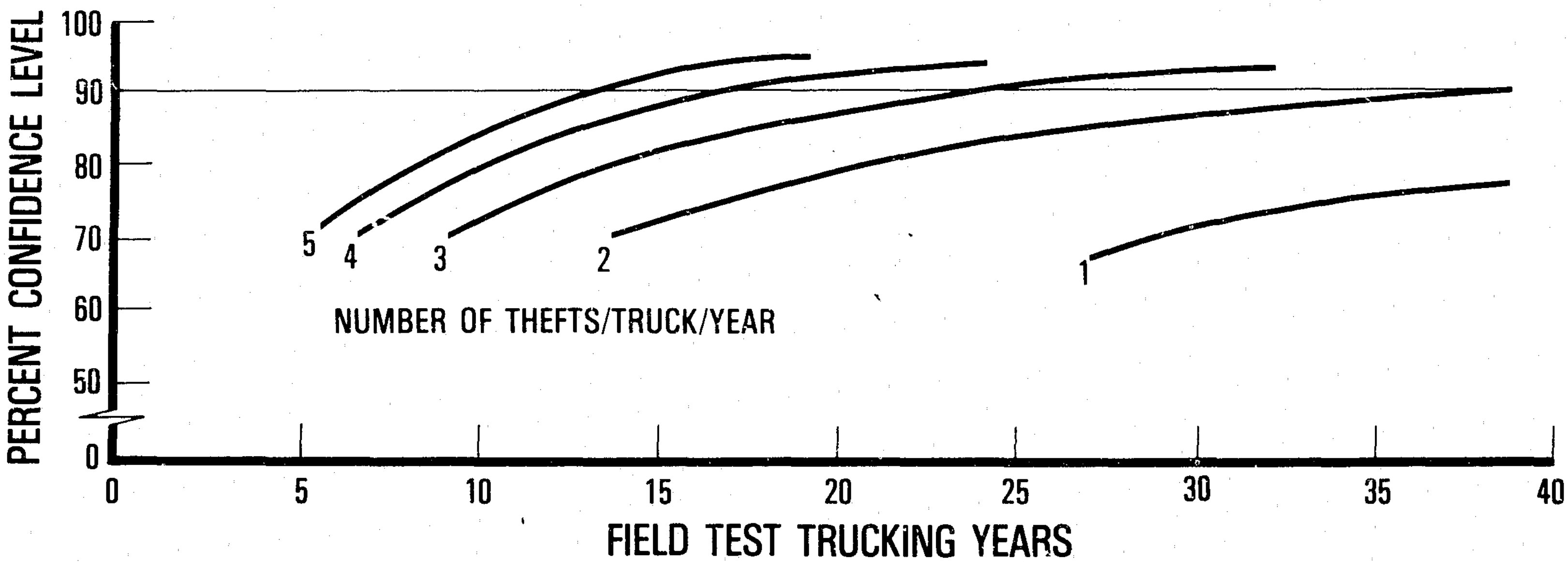
Selection of the test participants was made following a series of program briefings to the trucking industry and was based on a willingness to participate in furnishing facilities and cargo theft statistics, as well as on commonality of route structures, an important factor in minimizing the size of the test area. Two Los Angeles based trucking companies, Transcon Lines (which had participated in the pilot test) and G.I. Trucking, were selected for equipment installation. Two other companies, Brake-Meier and IML Trucking, expressed a willingness to furnish control data for the program.

A review of the route structures of Transcon and G.I. Trucking showed that the operations of 40 trucks would be within a 397-square-mile area of the Los Angeles basin, and this area (Figure 3) was selected as the test site. With the test area defined, selection of installation sites for the proximity transmitters was made, and the task of acquiring the licenses and other authorization documents for the use of these sites (utility poles) was initiated.

Most of the utility poles in the test area were owned by the Southern California Edison (SCE) Company, but the restrictions and conditions required by this organization (such as SCE control over the release of all program data) were considered unacceptable. Resolution of this problem required that alternate sites be identified and individual authorizations be sought from the 43 State, county, and municipal authorities having jurisdiction over these non-SCE sites.

GIVEN

- THEFT LOSS PER VEHICLE IS $2000 PER YEAR
- SYSTEM COST IS $1000 PER TRUCK PER YEAR
- FOUR VEHICLE-RELATED THEFTS PER TRUCK PER YEAR (G.I. Trucking Data)
- SYSTEM MUST BE 50% EFFECTIVE TO BE COST EFFECTIVE



CONCLUSION

- 17 TRUCK YEARS ARE REQUIRED TO DEMONSTRATE 50% SYSTEM EFFECTIVENESS WITH 90% CONFIDENCE

Figure 2. Cargo Security Field Test--Sample Size Analysis Summary

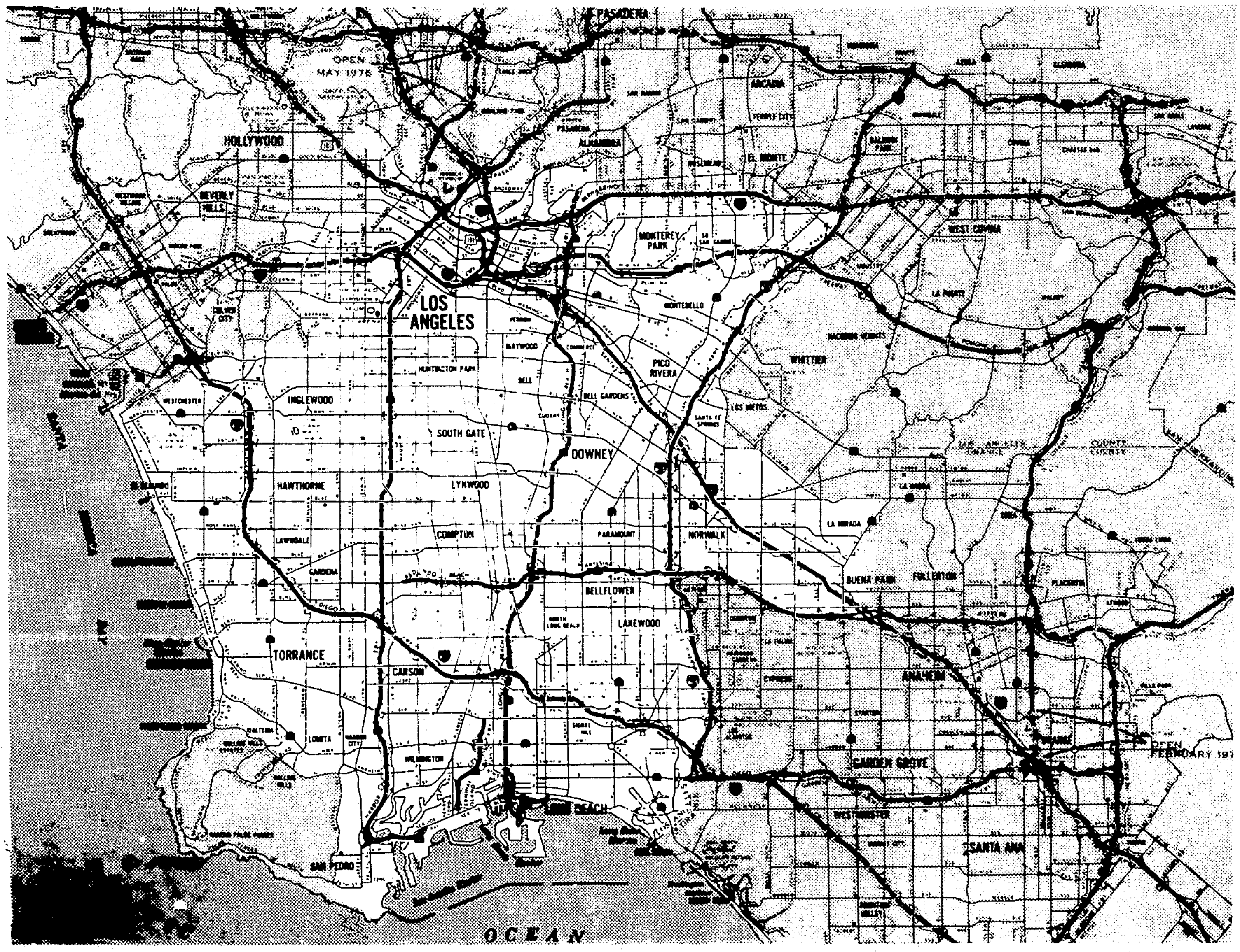


Figure 3. Los Angeles and Vicinity Cargo Security System Test Area

Liaison was established with the Broadcast Bureau of the Federal Communications Commission to acquire the authority to maintain phase-stabilized operation of the three commercial broadcast transmitters. Permanent authority was given for the use of the rubidium standard in station KFI, and Special Temporary Authority was granted for the slave operation of stations KNX and KPOL.

CHAPTER IV. SYSTEM DESCRIPTION

The Cargo Security System developed for the field test program is depicted in Figure 4 and comprises vehicle units, a base station, a communications link, a dispatcher station, and location support units.

The vehicle unit contains sensors to detect intrusion into the cargo compartment, vehicle movement, driver cab activity, driver alarm actuation, and any attempts to tamper with the system. These sensor data are then filtered by a programmable processor to select predetermined sequences or combinations of sensor actuations and to eliminate false sensor information. A second vehicle subsystem receives electromagnetic signals from the location support element and preprocesses these signals for subsequent determination of vehicle location. The filtered sensor data and preprocessed location data are then transmitted via a dedicated radio communications channel to the base station. The vehicle unit also contains provisions for the processing and execution of system commands transmitted from the base station.

The base station consists of a radio communications system and a computer system which are shared by all vehicles and dispatch stations and provides for overall system control. Its computer performs the balance of t[illegible]ation processing for each vehicle, the conversion of location data to the nearest street intersection, the determination of alert or alarm conditions of individual vehicles, the recording of vehicle transaction histories, and the routing of vehicle data to the appropriate dispatch terminal in response to commands from that terminal or as a consequence of vehicle events. Base station operation is normally automatic and continuous, but provisions are made for any necessary supervisory monitoring and system diagnostic procedures.

Each dispatch terminal, linked to the base station via commercial land lines, contains a central terminal unit and local peripheral devices. Each central terminal unit incorporates a microprocessor for local control of its satellite terminal and printer and for communication with the base station. The microprocessor memory ensures that data traffic between the central terminal and the base station is reduced to a level commensurate with the characteristics of the land-line connection.

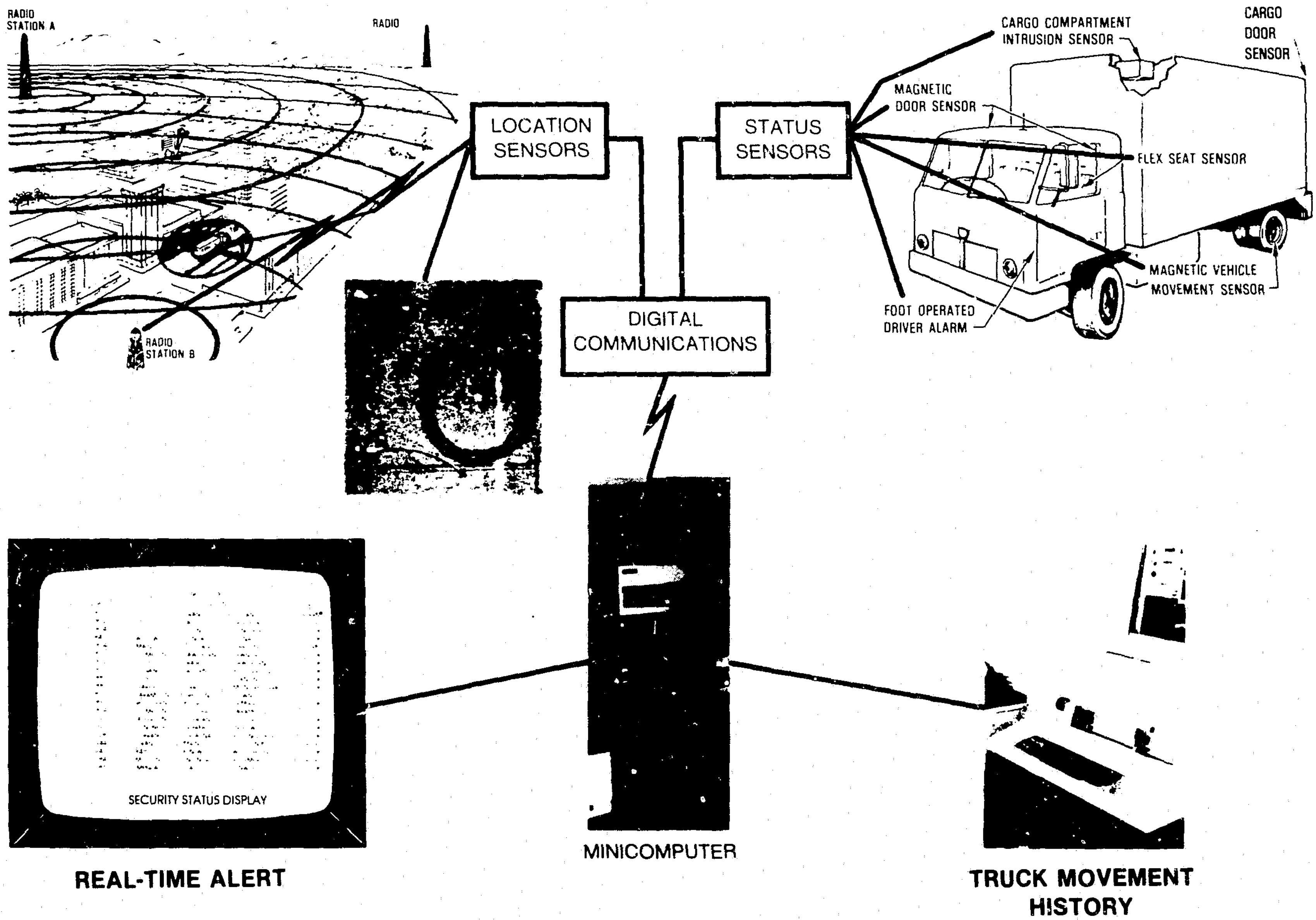


Figure 4. Cargo Security System

CHAPTER V. SYSTEM INSTALLATION AND TEST

In conformance with the field test plan, the system was installed in 40 pickup and delivery trucks (20 trucks from Transcon Lines and 20 from G.I. Trucking) the operational routes of which were encompassed by the designated 400-square-mile test area of the Los Angeles basin. The dispatch terminals were installed in the two trucking company depots, located in Sante Fe Springs and La Mirada, and the base station was located in the United California Bank building in central Los Angeles, a site which had been selected for its excellent communications coverage of the test area. The AM phase stabilization units that had been employed for the pilot test program were recalibrated and modified as necessary to interface with the transmitters at stations KFI, KNX, and KPOL. A total of 256 proximity transmitter units were installed at approximately 2-mile intervals on utility poles which had been selected and authorized during the test planning phase of the program. An experimental radio frequency channel was allocated by the Federal Communications Commission (FCC) for the program.

System integration and checkout was initiated with an instrumented test vehicle to determine system performance characteristics in the operational environment, and to identify and diagnose system problems. Operational vehicle units were then incrementally brought on line to assess system performance under multiunit loading conditions. Problems identified and rectified during this period were characteristic of complex real-time control systems and included:

- Inadequacy of the central computer to handle the processing load in real time,
- Data timing contention in the vehicle master control units, and
- Data timing contention in the central terminal processors.

In December 1977, a complaint of communications interference was received from the San Diego municipal transit authorities (a permanent licensee of the radio frequency assigned by the FCC to the cargo security program). A series of tests established that the base station was the source of interference, and the transmitted power level was attentuated to a level where the interference with San Diego was eliminated.

During this system checkout phase, the system demonstrated the capability to monitor and report the operational movements of equipped vehicles and to correctly partition vehicle data between the two trucking companies.

Three sections comprised the system acceptance test: location, inspection, and system operations. Successful completion of this test would have inaugurated the formal field test. Location testing was conducted with the instrumented test vehicle, and the results showed that while good accuracy could be obtained in many areas of the city, large position offsets were introduced by signal warpages in the vicinity of high-voltage power lines and freeway underpasses with the consequence that system specifications were not met for the selected test route. The inspection phase of the test, an inventory of installed equipment, was satisfactorily completed.

As a prelude to the system operation test, 38 trucks were put on line. The heavy communications traffic engendered by this vehicular load on the system resulted in a high level of communications interference with San Diego. Tests showed the source to be the vehicle transmitters, and the tests were terminated so as not to violate the conditions of the experimental FCC license issued for the program.

CHAPTER VI. FIELD EVALUATION

Because the field test program was terminated before the formal test period was initiated, the activities of the test conductor, the J.H. Wiggins Company, were limited to the acquisition of pretest data and planning for the field test.

System briefings followed by attitudinal surveys were made of participating drivers, Teamster Union personnel, and the law enforcement community. The survey data were analyzed and a partial evaluation was made.

Where possible, historical loss data from the participating active and control trucking companies were researched. Dispatch, claims, and security procedures were defined for Transcon, G.I. Trucking, and Brake-Meier.

Forms for the collection of data were designed. Notebooks for dispatachers and security personnel were assembled, and instructions were provided to assist in completing forms and noting the necessary data and comments. The form for logging law enforcement response characteristics was designed and reviewed with the Los Angeles Sheriff's Department.

The software statistical packages required for test analyses were acquired, and special programs to reduce and tabulate data were designed and checked out. A program to extract system performance characteristics from the system log tape was designed.

CHAPTER VII. PROGRAM FINDINGS

Although the field test program was terminated prior to its completion, sufficient test data were acquired to enable an assessment to be made of the technical and operational viability of the cargo security system developed for the program. From the techinical viewpoint, the system design advanced the state-of-the-art in automatic vehicle monitoring technology and will have a significant impact on the design of such systems for government, law enforcement, and private sector vehicle management and security operations. Of particular note was the concept of using a distributed network to perform local data filtering and processing and thus enable the use of low-speed communications links while maintaining real-time monitoring operations. Only one significant technical problem, that of location accuracy in the immediate vicinity of strong reradiating sources, was not rectified at the time of program termination. However, the problem is not insurmountable, and several candidate solutions have been identified.

The operational capability of the system to automatically monitor the daily movements of the equipped vehicles was demonstrated during the system checkout period. The ability to share a mobile radio communications channel and yet maintain the privacy of individual user data illustrated the potential for an economic multiuser system to serve major population centers. Further, the system demonstrated that the low-cost AM broadcast signal location technology was capable of determining the position of vehicles within a large operational area. (The 400-square-mile area of the field test program was more than double that of any other area previously used in a vehicle monitoring program.)

The technical and limited operational experience resulting from the system activities has led to the following recommendations for design improvement:

- Improve location accuracy in the vicinity of strong signal reradiation sources.
- Incorporate a microprocessor in the vehicle unit to improve location accuracy and to further reduce communications channel loading.
- Improve human factors design to simplify the system interfaces with the end users of the data.
- For commercial trucking operations, further harden the vulnerable system elements against malicious and accidental damage.
- Reduce the number of proximity transmitters and improve their economies of operation (installation and maintenance).

CHAPTER VIII. CONCLUSIONS AND RECOMMENDATIONS

The Cargo Security Field Test Program resulted in the design of an automatic vehicle location system for multiuser operation with a potential for reducing cargo theft and for improving the efficiency of vehicle resource management in government and private sectors of the national economy.

The system had a capability to reliably monitor the daily activities of cargo trucks and also demonstrated that very wide operational coverage could be achieved economically using the AM broadcast signal location technology and a low-speed radio communications link. The capability of the system to serve multiple users with this common communications link while maintaining user data privacy is of particular economic significance in the deployment of automatic vehicle monitoring systems.

No quantitative data on the system's impact on the incidence of cargo theft was acquired during the program; however, the initial reaction of participants indicated that they believed that monitoring represents a very effective approach to countering cargo crime. The dual-capability nature of the system (cargo theft prevention/investigation plus improved resource management control) was very attractive to management.

In summary, the program resulted in the design of a system which has application to a broad segment of the economy. Its capability to serve multiple users with diverse needs is particularly significant.

To ensure that maximum advantage is taken of the investment made in the development of the system, and to establish the economies of shared system operation, it is recommended that a wide-area multiuser demonstration program involving law enforcement agencies and selected commercial users be undertaken by the Law Enforcement Assistance Administration.

APPENDIX. DOCUMENTATION AND HARDWARE PRODUCED

1. Documentation

a. Cargo Security System - Development Program (Task Element 7908)

Feasibility Demonstration of A Truck Anti-Hijacking System, Aerospace Report TOR-0073(3658-02)-1, July 1973.
A truck anti-hijacking system was designed, assembled, and demonstrated that satisfies the case of an urban deslivery truck operating over any prescribed route. The system employs a simply calibrated odometer supported by capabilities for hijack detection, engine disabling, and aural and visual beacons. The design uses no direct driver interaction and operates autonomously in the case of a hijack event. The base, or dispatcher, station equipment requirements are simple and economical.

Evaluation of An Automatic Direction Finder for Hijacked Truck Location, Aerospace Report TOR-0073(3658-02)-2, July 1973.
The capability of an automatic direction finder, tuned to local communications broadcast stations to determine the location of a hijacked truck in an urban environment is evaluated. Buildings, power lines, and other potential re-radiators of the transmitted signals strongly influence the electromagnetic field and result in unacceptable errors in computed location.

Concept Definition For The Truck Anti-Hijack and Trailer Security System, Aerospace Report ATR-74(7908)-1, January 1974.
The concept of a truck anti-hijack and trailer security system is defined. Low-cost sensors and vehicle location technology is employed to provide the dispatcher with a remote surveillance capability.

Survey and Technical Assessment - Cargo Security System, Aerospace Report ATR-75(7908)-1, July 1974.
Theft of truck cargo in transit is causing a multi-billion dollar loss to the trucking industry. An examination of the theft problem is made to determine the make-up of the industry losses, the theft prevention systems in existence, and the most cost effective means to counter theft and reduce the losses.

It is found that there are no existing theft prevention systems which meet all performance requirements identified by the trucking industry. While direct surveillance of vehicles by security forces provides the most effective tool, it is expensive and consequently is currently limited to vehicles carrying high value cargo.

A two-step cargo protection program for reducing losses from cargo theft is proposed: a cargo security program with its major goal a reduction in thefts from cargo trucks and a companion cargo accountability program aimed at developing systems for the tagging of cargo to provide traceability of shipments. Technical concepts for a cargo security system are developed and a development plan defined. (Description of the cargo accountability program is limited to basic concepts and to the way it interfaces with the Cargo Security System.)

Cargo Security System Feasibility Analysis Report - Hybrid Deadreckoning and Hyperbolic Grid Location, Aerospace Report ATR-75(7908)-2, April 1975.
Thefts of cargo in transit from the manufacturer to the consumer represent a multi-billion dolar drain on the national economy. The motor trucking industry is the principal victim of the cargo theft, and a Cargo Security System is needed for the timely detection of the crime and for determining the location of the vehicle in order that appropriate action can be initiated.

The availability of a low-cost vehicle location system is essential to the implementation of a cost-effective Cargo Security System. An examination is made of two candidate systems to determine their feasibility and to identify potential problem areas.

It is found that the concept of hybrid deadreckoning, using inertial components, is technically feasible but that the annual maintenance costs of currently available directional gyroscopes preclude its use by the trucking industry.

The concept of using AM phase-locked signals for vehicle location purposes is found to be technically sound, and implementation costs are within the bounds established for the Cargo Security System.

Design Requirements Report - Cargo Security System Program, Hoffman Information Identification, Inc., April 1975
Technical studies and analyses of a Cargo Security System establish its environmental, regulatory, and operational requirements, and define an electronic system to meet these requirements. Ten candidate automatic vehicle location technologies are reviewed, and three are subjected to a detailed technical, operational, and cost analysis.

Operational Design of A Cargo Security System, Aerospace Report ATR-76(7908)-3, June 1975.
An examination is made of the operational requirements and constraints that will influence the design of a Cargo Security System whose major goal is the reduction of thefts from cargo vehicles.

In order to avoid an increase in operating costs beyond the bounds established from a survey of theft losses in the trucking industry, the system design must allow integration of fleet dispatch and security data so that existing dispatcher personnel can manage the system.

A system design approach is described that considers factors such as the cargo vehicle environment, federal and other regulations governing radio spectrum usage, and vehicle and personnel safety. Minimum operational changes are required to integrate the proposed Cargo Security System into fleet operations.

Cargo Security System Pilot Test Plan, Aerospace Report ATR-76(7908)-1, March 1976.
The objectives, scope, schedule, locations, equipment, and personnel requirements for the pilot testing of the Cargo Security System are defined.

Cargo Security System Development - Final Report, Hoffman Information Identification, Inc., June 1976.
A technical description of the hardware and software elements of the Cargo Security System utilized in the pilot test program is documented in detail. Methods employed and data collected during the pilot test phase are described. The results of the data analyses are presented and recommendations for design changes are made.

Cargo Security System Movie, The Elliott Concern, June 1976.
A 20-minute movie depicts the background, development, and testing of the Cargo Security System. It covers theft loss data, the national importance of the problem, concept description, systems development features, and pilot test results.

b. Cargo Security System - Field Test Program (Task Element 7922)

Cargo Security System - General Field Test Plan, Aerospace Report ATR-77(7922)-1, February 1977.
The cargo security system, evaluated over a period of 17 months within a 400-square-mile region of the Los Angeles basin is described. The major test objectives center on measuring cargo theft reductions, establishing system reliability, determining cost/benefit ratios, and evaluating user acceptance. Each objective is further defined by a set of quantifiable goals that will be evaluated through the collection, reduction, and analysis of operational and cost data.

Interim Report For the Cargo Security System Field Evaluation, J.H. Wiggins Company, Technical Report 77-1295-3, 1977.
The results of the pretest planning, surveys, collection of claims data and familiarization activities conducted between February and September 1977 are documented.

Final Report Cargo Security System Field Evaluation Test Conductor, J.H. Wiggins Company, Technical Report 1295-4.
The final pretest results and survey data including all program documentation.

Cargo Security Field Test - Final Report, Gould/Information Identification Inc. (To be issued)
A technical description of the hardware and software elements of the system is presented. The methods employed and the data acquired during the installation and system checkout phases of the program are described, and recommendations for system improvements are made.

c. Additional Papers

Cargo Security System, by Geoffrey D. Wilson, The Aerospace Corporation, 1975 Carnahan Conference on Crime Countermeasures, University of Kentucky.
This paper outlines general problems, requirements and potential technical solutions for development of cargo security systems.

Selection Factors for Police Automatic Vehicle Location Systems, by Geoffrey D. Willson, The Aerospace Corporation, 1977 Carnahan Conference on Crime Countermeasures, University of Kentucky.
This paper reviews the interfacing of the technology with law enforcement dispatch operations, summarizes the three categories of available systems, identifies the operational paramters that influence system performance, and outlines the technical and administrative factors that must be considered in the selection and deployment of an operational system.

2. Hardware Produced

331 Proximity units*
1 Rubidium standard*
2 AM slave/exciter units*
40 Vehicle units
- AM unit
- Data control unit
- Radio transceiver
- Sensors

1 Base station
- PDP 11/05 computer (2)*
- Radio transceiver
- VT50AA DecScope*
- LA 36 DecWriter*
- RX11BA disk and controller*
- RK11 disk and controller*
- Interface units*

2 Dispatch stations
- ADM3A CRT display
- 8001 CRT display
- Keyboard unit
- SILENT 700 printer

1 System simulator
1 Sensor test unit
1 Installation test unit
1 Card test unit
1 Test readout unit
1 Lot Electronic spare parts

*Originally procured for development (Task Element 7908) program.

END