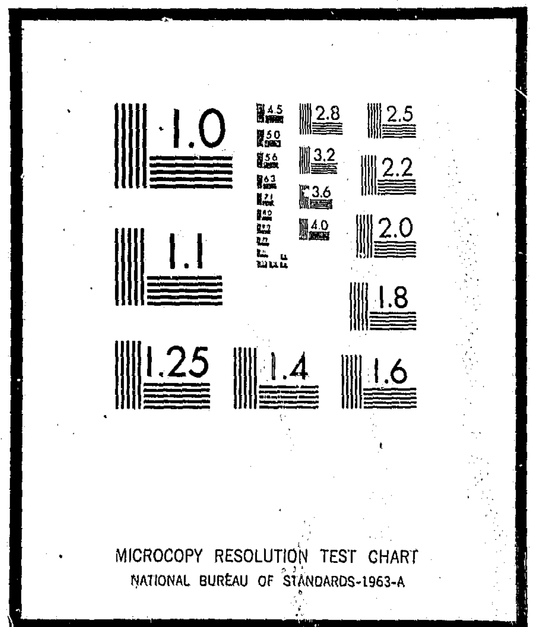

Report No.
ATR-75(7908)-3

EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

OPERATIONAL DESIGN OF A CARGO SECURITY SYSTEM

Law Enforcement Development Group
THE AEROSPACE CORPORATION
El Segundo, California

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EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

OPERATIONAL DESIGN OF A CARGO SECURITY SYSTEM

Approved

John O. Eylar, Jr., General Manager
Law Enforcement and
Telecommunications Division

ABSTRACT

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.

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SUMMARY

A survey and technical assessment effort[1] has examined the problems of cargo losses in the trucking industry, and has concluded that local pickup and delivery operations are the principal targets of the cargo thief. The concept of an automatic vehicle surveillance system that incorporates location and status sensors on the vehicle and the reporting of these sensor data to the fleet dispatcher has been developed, and its technical requirements and economic bounds established. In this report, the environment in which the system must function is described, and the operational requirements and constraints that the system must satisfy are defined.

The major effort in the present study was to establish operational design criteria based on an analysis of requirements and constraints that the cargo security system must satisfy. The following conclusions regarding these considerations were drawn from this study:

- In order to achieve system cost goals, the cargo security system must be capable of operation by existing dispatcher personnel. To meet this requirement, the cargo security and dispatching systems must be integrated and in such a manner that the dispatcher's workload is not increased.
- Specific information features of the cargo security system include:
  - Vehicle locations should be displayed in terms of street intersections and zones.

- Automatic or manual selection of a close surveillance mode should provide vehicle and driver identification to supplement vehicle status data.
- Route history should be available on demand.
- Area polling, i.e., the identification of all fleet vehicles in the vicinity of a specified location, should be possible.

• A record of all vehicle and dispatcher transactions with the system must be maintained to assist in investigations of theft incidents. Access to the recorder should be limited to security personnel in order to protect dispatcher/driver cooperation, which is essential to fleet efficiency.

• The base station computer program must be protected from access through dispatcher controls or the computer console, and the source program should be stored in a secure area to safeguard the information within the system.

• There is no standard set of environmental design criteria applicable to the trucking environment. However, three basic environmental categories have been established and worst-case design criteria identified.

• Operating characteristics of the communications and vehicle location subsystems of the cargo security system are subject to Federal Communications Commission regulations.

- Electrical and mechanical design of the system are governed by federal and local regulations pertaining to the safety of vehicles and personnel.
- A new procedure is required in the compilation of load schedules to ensure system compatibility of vehicle and route data.

The vehicle-mounted and ground support units of the system will be exposed to a wide variety of environmental conditions, and these conditions must be factored into the system design. Moreover, the constraints imposed by the regulations of the Federal Communications Commission governing use of the radio frequency spectrum and by other federal and local agencies pertaining to vehicle and personnel safety are important design factors. The design of equipment capable of operating within these constraints is well within the state of the art. No requirements for special legislation have been identified.

CHAPTER I. INTRODUCTION

Cargo theft has become a highly organized multibillion dollar business with a network of intelligence agents, drivers and freight handlers, and an efficient distribution system for the stolen goods. Although the direct dollar loss of stolen goods in the trucking industry is substantial (more than $1.6 billion dollars in 1972), there are greater indirect losses that must be considered in evaluating the real loss to the national economy. Specifically, the motor carrier, whose high insurance deductible makes him virtually self-insured, incurs an indirect cost of processing loss claims by the shipper of between $2 and $5 for each $1 of direct loss. The ever-increasing loss rate and growing evidence of highly organized theft rings have brought attention to the problem at the highest government levels. In FY 1974, under a Law Enforcement Assistance Administration (LEAA)-sponsored task, The Aerospace Corporation initiated a Cargo Security System Program aimed at developing a low cost, reliable security system to alert security officers of unauthorized access to cargo-carrying road vehicles.

A survey and technical assessment report[1] examined the cargo theft problem in the trucking industry and found that the majority of losses were incurred in local pickup and delivery operations. In performing the system study, Aerospace investigated the loss characteristics and reviewed theft prevention concepts with officers of the national and state trucking associations as well as with the Association of Transportation Security Officers.

It was determined that more than one-half of the total theft losses are vehicle related and that the most effective (but most expensive) preventive measure was the use of armed escorts or roving security officers to spot-check vehicles and loads. These findings together with considerations of available hardware and development capabilities led to the conclusion that a low cost security system that would provide protection equivalent to direct surveillance by security personnel was both desirable and feasible. A value analysis indicated that the system would be considered cost effective by the trucking industry if system operating costs did not exceed $1000 per vehicle per year.

Performance requirements were established and the concept of a cargo security system was developed (Figure 1). Technical studies and analyses established the design requirements[2] and the technical feasibility of the system.[3]

The purpose of this operational design report is to describe the environment in which the cargo security system must operate and to identify any operational constraints that might affect the design of the system or limit its effectiveness. In compiling this report, The Aerospace Corporation has reviewed the dispatching methods of a local pickup and delivery operation and the procedures employed by the dispatcher and security personnel following a theft incident. Environmental conditions in which the various system elements must operate as well as the impact of federal and local regulations on the system design have been examined. The findings are organized as follows: the operational environment of a typical pickup and

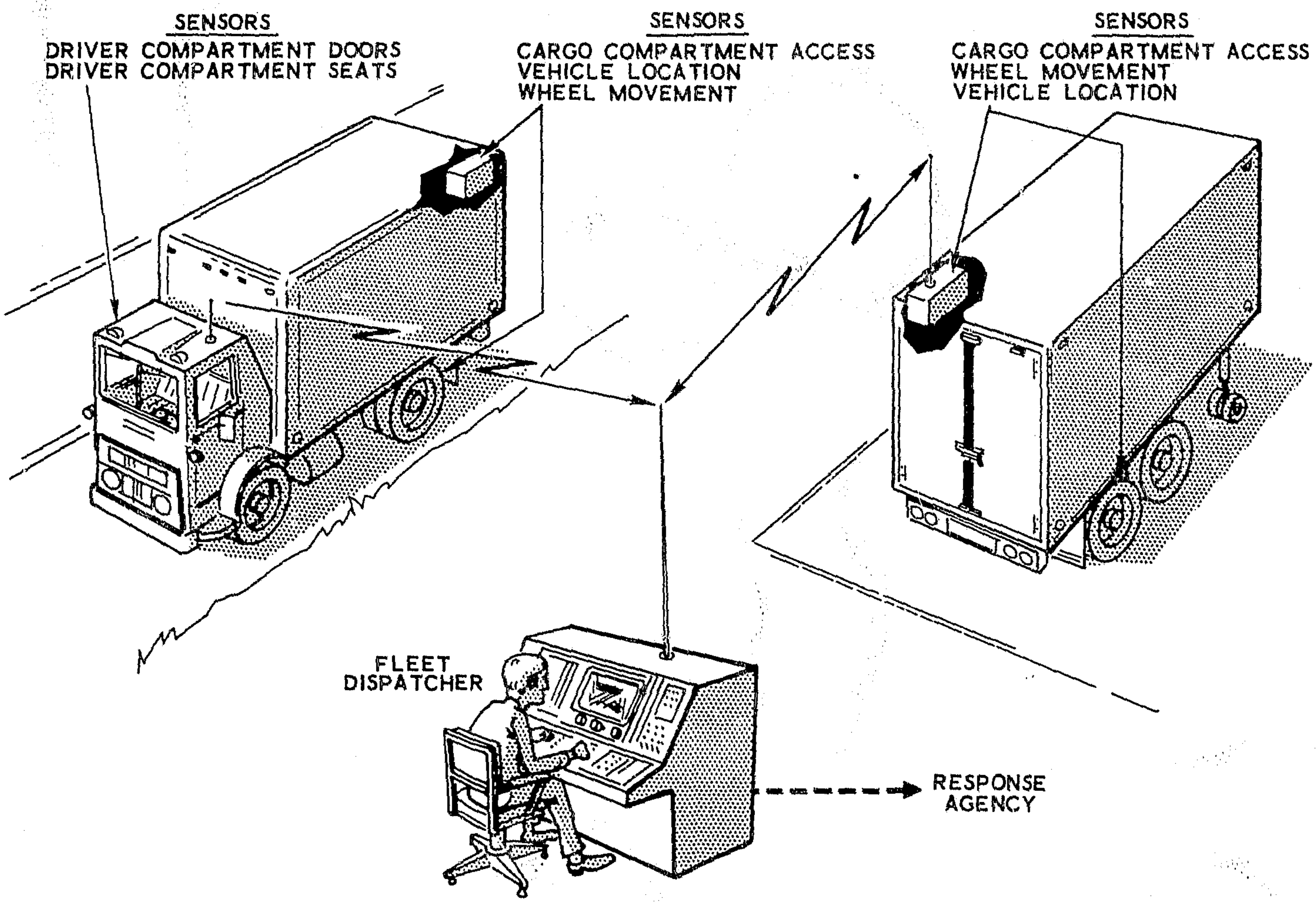

Figure 1. Cargo Security System Concept

delivery service is examined in Chapter II, and design requirements imposed by this environment are established; in Chapter III the physical environment to which the system will be exposed is reviewed and worst-case design requirements are summarized; the constraints imposed by federal and other regulations are summarized in Chapter IV; and operating procedures and training requirements for integration of the cargo security system into trucking operations are discussed in Chapter V.

CHAPTER II. OPERATIONAL REQUIREMENTS

A. Introduction

The operational environment of pickup and delivery services is examined in this chapter, and requirements imposed on the cargo security system by this environment are delineated. Organization of the material corresponds to the four elements of the cargo security system, namely: the vehicle unit, the location support units, communications, and the dispatcher station.

B. Vehicle Unit

The vehicle unit is comprised of the various status and location sensors and their interface with existing communications equipment. This unit is subject to the shock, vibration, and temperature environment of a road vehicle (reviewed in Chapter III) as well as to its interface with the operations personnel (driver, loader, etc.).

Except for those vehicles equipped with an optional driver-actuated alarm switch, the unit should be fully automatic, requiring no active interfaces with operations personnel. The principal operating requirements are imposed by the need to protect the unit from accidental or deliberate disablement.

1. Power. The vehicle system, which is composed of the cargo security vehicle unit and the vehicle communications unit, should be supplied with a backup power source so that disconnection of the vehicle battery cannot disable the system. In addition, the communications unit power switch

should not be accessible to operations personnel. Overvoltage protection is also desirable.

2. Communications. Misuse of the communications unit controls by the driver should not jeopardize system operation. Provision should be made in the system design for inhibiting or override of driver accessible controls by the vehicle unit.

3. Interconnect cables. System interconnect wiring should be routed in such a manner as to avoid accidental disconnection or severance under normal operations. In addition, the system should monitor the integrity of all interconnects and provide data on their status to the base station.

4. Physical protection. System elements located in the cargo compartment should be protected from physical damage from loading or unloading operations. Moreover, elements in the driver's cab should be sealed for protection against spilled liquids.

Where the optional driver alarm unit is installed, the actuation of this unit must be deliberate, e.g., a seal should be broken, to avoid accidental operation. In addition, the vehicle unit logic must provide protection against deliberate misuse of the switch in an attempt to disable the system.

C. Location Support Units

Location support elements in the form of proximity units are subject to natural environmental extremes and government regulatory constraints. (These subjects are reviewed in subsequent chapters.) Fully automatic in operation, these units have no active interface with the operations personnel

of the trucking fleets. However, because of their exposed installation, the system design should provide for protection against vandalism.

D. Communications

To minimize system costs, the cargo security system will utilize the land-mobile communications system of the host vehicle, and the use of this communications system will be governed by the regulations of the Federal Communications Commission as reviewed in Chapter IV. The addition of vehicle location and status data will impose an additional communications channel load, and the system design must ensure that the total load does not exceed channel capacity. It has been determined from a study of communications traffic of a typical pickup and delivery fleet operation that up to 40 percent of the current voice traffic pertains to the location of fleet vehicles. In addition, an analysis of radio traffic[2] has shown that the automatic reporting of vehicle location and status could actually result in a reduction of communications channel loading. To achieve this reduction, however, the design of the dispatcher interface with the system must provide for the display of dispatch related data in addition to the security data.

E. Dispatcher Station

Central monitoring and control of the cargo security system will be provided by the dispatcher station. Economic factors dictate that no additional operations personnel may be employed for this control function, and the system design must provide for the integration of dispatching and security operations so that both tasks can be performed by existing dispatcher personnel. The role of the dispatcher in typical pickup and delivery operations and his responsibilities in ensuring efficient fleet operations are discussed in the following sections. In addition, the security procedures employed in the event of vehicle-related theft and operational requirements of the integrated dispatch/cargo security system are described.

1. Dispatch operations. The dispatcher has the responsibility of ensuring that the vehicle fleet operates at high efficiency and, in effect, exercises real-time command and control operations from his office. The typical dispatch office will contain a status board and radio control and telephone communications facilities, with each dispatcher controlling up to 50 vehicles. The manual status board will generally be arranged in columns corresponding to routes, each column containing multiple slots into which data pertaining to vehicle stops are manually inserted. Its construction and operation is similar to that of a Federal Aviation Authority manual air traffic control board. Vehicle stops are typically color-coded for three categories of customer as follows:

- Established - daily stop at regular customer
- Established - scheduled or call-in stop at regular customer
- Casual - scheduled or call-in stop at new customer

An overview of the dispatcher procedures is shown in Figure 2. At the start of a working day, documentation pertaining to each vehicle and route is used to compile the status board and for distribution to the assigned drivers.

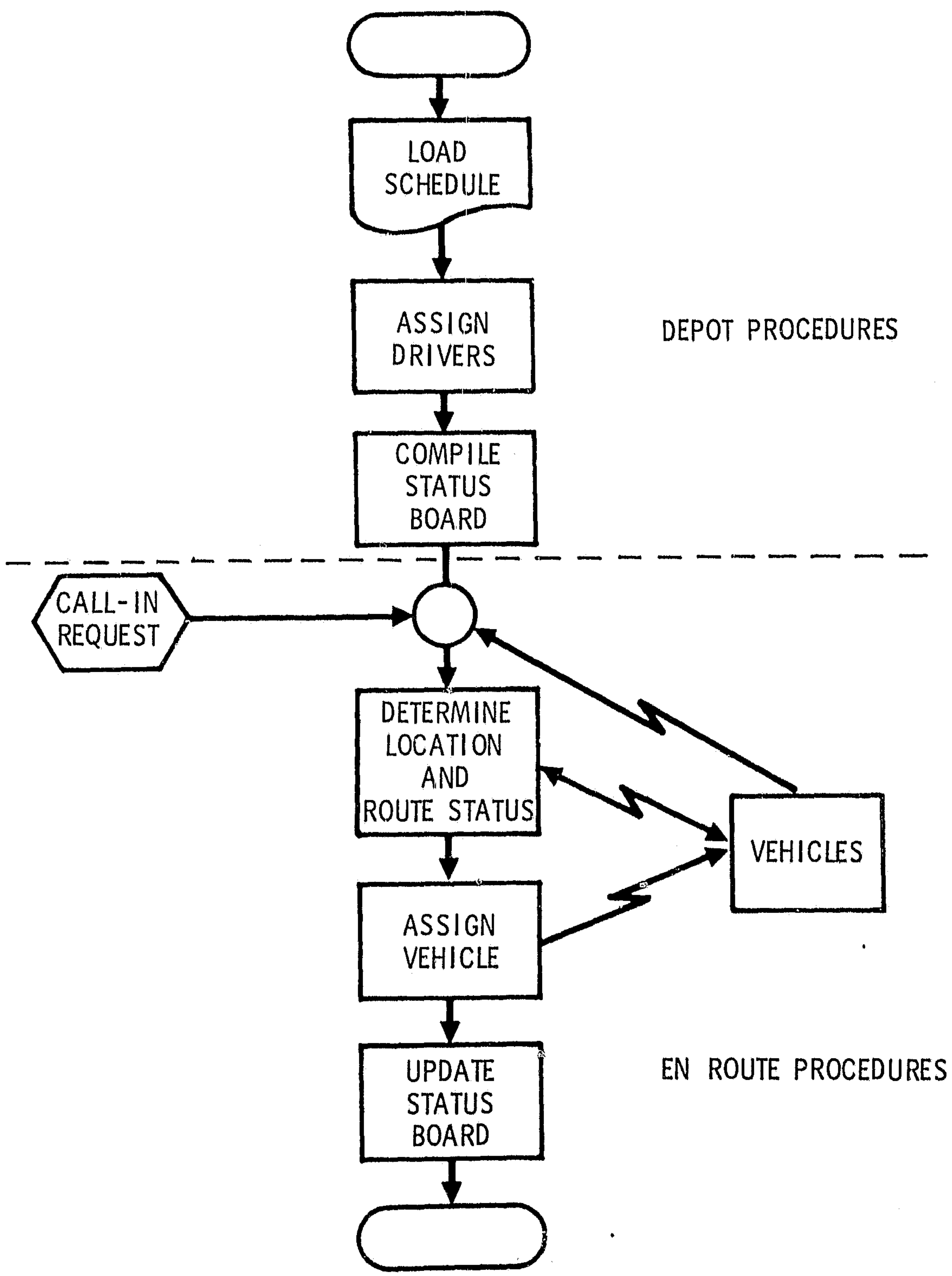

Figure 2. Dispatcher Procedures

The loading procedure which precedes daily operations consists of the routing of cargo received from long-haul, interline, and rail operations to the appropriate local delivery trucks. Incoming cargo is directed to specific loading dock locations corresponding to specific routes. As vehicles become available, they are loaded with this route cargo. In general, a route is serviced by a single unit ("route vehicle"), but where the cargo exceeds vehicle capacity (volume or weight), the surplus is loaded into a relief vehicle. The route for this relief vehicle that is to carry surplus cargo from several "route vehicles" is treated as a special case ("shag route"). As each loading operation is completed, the load documentation is forwarded to the dispatcher. This documentation includes:

- Route identification
- Vehicle identification
- Bills of lading
  - Consignee name and address
  - Number of items
  - Weight
  - Description
- Invoices for any C.O.D. items
- Load summary
  - Loading arrangement
  - Bills of lading numbers
  - Number of delivery stops
  - Weight summary

A copy of this documentation is provided to the driver assigned to the vehicle, and a duplicate is filed in the dispatch office.

Calls for pickup service received prior to departure of the vehicles from the depot are routed to the dispatcher who records:

- Customer name and address
- Number of items
- Weight
- Description
- Latest time for pickup

The dispatcher assigns these pickups to the appropriate "route vehicles," redefining the pickup routes as required to keep the individual loads within vehicle capacity and within the capability of the driver to handle during his regular work shift.

Customer requests for service received after the vehicles are en route are given to the dispatcher who must determine how the requests will be met. He then issues instructions via the radio communications system to the appropriate vehicles. In determining which vehicle is to be rerouted, the dispatcher must maintain an awareness of the general location of the vehicles, their load status, and their adherence to the schedule. His knowledge, obtained through experience with the drivers' work patterns and the nature of the loads, is supplemented by voice communication with the vehicles. Should a driver, because of traffic delays or vehicle problems, report that he will be unable to meet his pickup schedule, the dispatcher must balance the proximity of other vehicles against the added driver workload in determining the possible options. As these new assignments are made and existing schedules modified, the status board is updated accordingly.

A further factor — that of dispatcher/driver relationship — must be considered. Successful fleet operations are highly dependent on good working relationships between the drivers and the dispatchers as the latter effectively provide the only management of the daily en route operations.

To summarize, the design of the cargo security system must take into consideration the:

- Dispatcher workload - The task of operating the system will impose an additional workload on the dispatcher. Integration of common security/dispatch functions to the system computer is essential to relieve this problem.
- Dispatcher/driver relationships - In order to maintain good working relationships between the dispatcher and the drivers, the cargo security system must be designed so that detection of theft activities by the system can be attributed to the operation of equipment that is not under the control of the dispatcher.

2. Security procedures. The preponderance of vehicle-related thefts consists of one or more cartons. These thefts can be divided into the following two categories.

a. Short deliveries. In this category of theft the customer reports that fewer cartons were delivered to him than were listed on the invoice. Although loading records may show that the correct number of cartons were loaded on the vehicle, both driver and customer counts show a shortage at the time of unloading at the customer's facility. There are no methods of determining whether the theft took place at the loading depot or from the vehicle. The only weapons against this type of theft are increased surveillance or, with the sanction of the labor union, polygraph tests of suspect personnel.

b. Thefts from vehicles. The second category of theft is comprised of thefts of cartons from parked vehicles, either overnight at the depot or during the absence of the driver while en route. In cases of this type, security personnel are required to identify the nature and value of the goods stolen when advising the appropriate law enforcement authorities of the theft. Where theft occurs from a vehicle parked in the depot overnight following a loading operation, cargo data are obtainable from the load documentation and a physical inventory of the load.

When a theft takes place during a vehicle's scheduled run, the information must be determined from a calculation of cargo movements prior to the time of the theft. This requires a knowledge of: the original load (load documentation); customer stops completed (driver); the number, content, and value of cartons loaded or unloaded at each stop (driver documentation and phone contact with customers); and a physical inventory of the goods remaining in the vehicle after the theft. Although the driver can notify authorities of the occurrence of the theft, little or no action can be taken until this load information is available.

When a parked vehicle is stolen, the security officer must provide vehicle identification data to supplement that provided at the scene by the driver who may only know the vehicle make and radio identification code. In the case of unit body vehicles ("straights") the vehicle make, type, year, license plate number, and rooftop identification number are available. For semitrailer vehicles, identification data for both units are compiled on a daily basis for use by the security officer. Following preliminary notification of the police, a "theft alert" may be broadcast to all other company vehicles in the general vicinity. A computation of the stolen vehicle's load is made from the shipping documents and customer contacts. In the case of a vehicle hijacking where the driver has no opportunity to notify authorities of the theft, the first notification of a potential hijack situation is usually received from a customer whose cargo has not been delivered or picked up. If no radio contact can be made with the vehicle, the procedure, depicted in Figure 3, is as follows: From the current route schedule, the preceding stops are determined and phone contacts made to ascertain the last known stop and time of vehicle departure from that stop. From a knowledge of the route, typical traffic conditions, and the driver's propensity for meal or coffee breaks, the dispatcher must determine whether the delay is normal or due to a potential hijack condition. If the former, he will advise the customer of the probable time of arrival and place a followup call at that time to verify that the vehicle has arrived. Should the dispatcher and the security

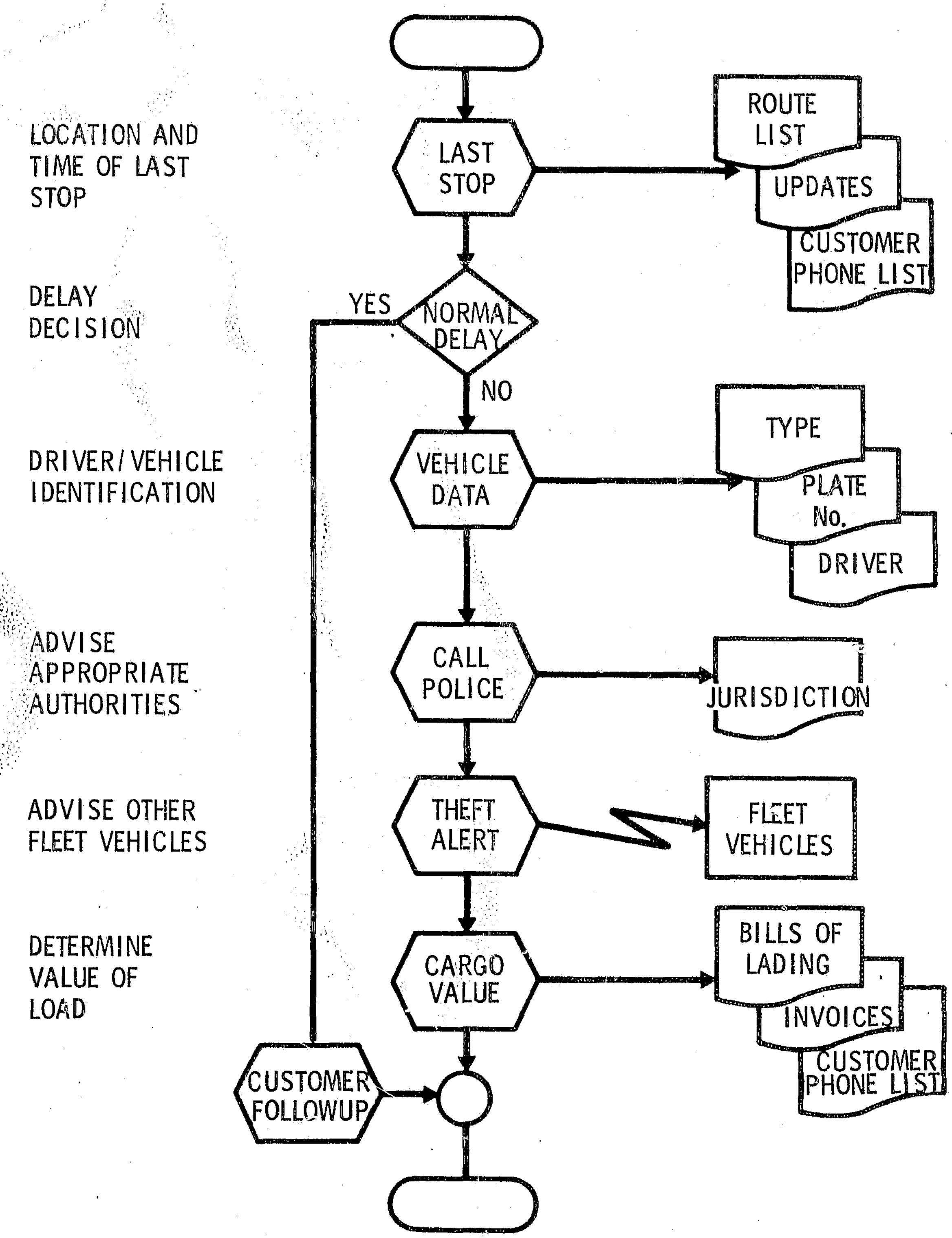

Figure 3. Security Procedure for a Missing Vehicle

officer determine that a hijack situation exists, the police agency within whose jurisdiction the hijack has occurred is notified of the crime and provided with vehicle and driver identification data. In addition, a theft alert may be broadcast to other fleet vehicles. The cargo load and its value are then computed for notification of the authorities.

The cargo security system must interface with these procedures in such a manner that the dispatcher's efficiency in responding to a theft situation is increased. In addition to providing the location and status data of each vehicle, the system should be capable of displaying the following information:

- Current route list
- Customer stops completed (identification and time)
- Vehicle and driver identification data
- Identity of other fleet vehicles in the area

3. Operational requirements. Integration of the cargo security system with the capability to display the location of each vehicle can relieve the dispatchers' communications workload and improve dispatch efficiency to a level where the additional tasks imposed by the system may be accomplished by existing personnel. The establishment of operational design requirements, therefore, must take into account this integration of the dispatch and security functions.

a. Data display. The alarm/alert functions of the cargo security system may be categorized in two groups:

- Group I — Route/vehicle independent - This group alerts the dispatcher to a change of status in the vehicle, e.g., changes in driver cab occupancy, intrusion into a parked trailer, lack of communication with a parked trailer, etc.
- Group II — Route/vehicle dependent - This group alerts the dispatcher to en route problems, e.g., the cargo door is open at an unauthorized stop, lack of communication with a vehicle, location of a vehicle outside zone limits, etc.

For both groups, the location and status of the vehicle must be displayed on a demand basis by the dispatcher and when the alert/alarm logic determines that suspicious activity is occurring. It is recommended that the alert/alarm logic be given priority over routine surveillance requests, and that a blinking feature together with an audible alarm be incorporated into the display station to alert the dispatcher to the situation.

For the display of location data, it is considered essential that the location coordinates be in a format readily understood by the dispatcher. Without recourse to maps or code books, he should be able to ascertain immediately the current location of a vehicle. In smaller communities, two street names may be sufficient to identify an intersection. However, in large metropolitan areas such as Los Angeles, a zone or municipality identifier will be required, not only for unambiguous location data, but also to determine which law enforcement agency has jurisdiction over a particular area. Abbreviations of street names for the purpose of reducing data storage should be selected carefully so that no misinterpretation is possible. A preliminary analysis indicates that a minimum of 8 characters should be allocated to each street name and zone, i.e., a minimum of 24 characters will be required to define an intersection.

Similarly, the condition that initiated the alert/alarm status should be presented to the dispatcher in a legible format together with the make, type, and license number of the vehicle and the name of the driver. A candidate format is shown in Figure 4. In this display, the location and status of each vehicle in the fleet is presented in the upper area of the screen. An alert condition for Vehicle 081 is indicated by a blinking symbol in this upper area, and the sensor status and other relevant data are presented in the lower area of the screen.

b. Data entry. The Group II functions require that the system contains data relating each vehicle to a sequence of authorized pickup and delivery stops. As described earlier, each route zone has three categories of stops:

- Established - routine stop
- Established - demand stop
- Casual - demand stop

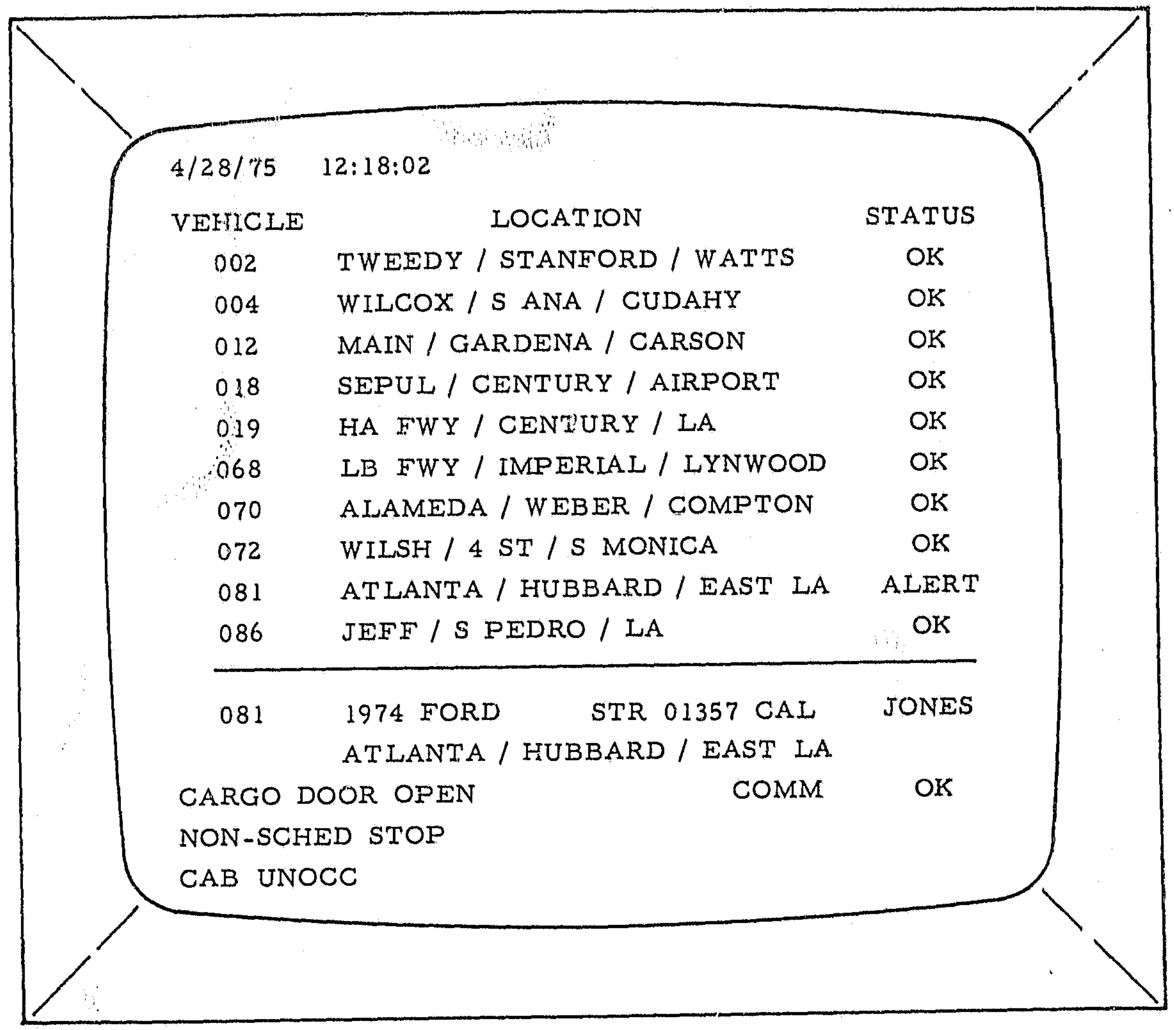

Figure 4. Candidate Format for Security Status Display

When the dispatcher receives the load plan for the day, he must enter data describing the stops assigned to each vehicle together with related information such as the name of the driver and vehicle identification code. As requests for service are received subsequent to the departure of the vehicles, the dispatcher assigns a vehicle to the request and enters the appropriate data into the system. A capability must also be provided that will allow the dispatcher to enter changes to the previously entered data. This capability will enable the dispatcher to transfer an assigned pickup operation from one vehicle to another.

Because of the large number of data entries involved, means must be provided within the system to assist the dispatcher in this task. Much of the information is of a permanent nature (vehicle/type/license plate number, route/established stops/location of stops) and, consequently, lends itself to storage within the base station computer in the form of library files.

Figure 5 is a system flow diagram of a routine for the compilation of a daily operations file. Selection by route identification presents a display of the established stops for that route. Modifications, e.g., demand stops, casual stops, etc., may be entered through the keyboard. This modified route data together with the vehicle/driver assignment is stored in the operations file that forms the daily operations data base for the main system program. En route changes would be entered by a subset of this program, which would be established at a lower priority than the alert/alarm logic routines.

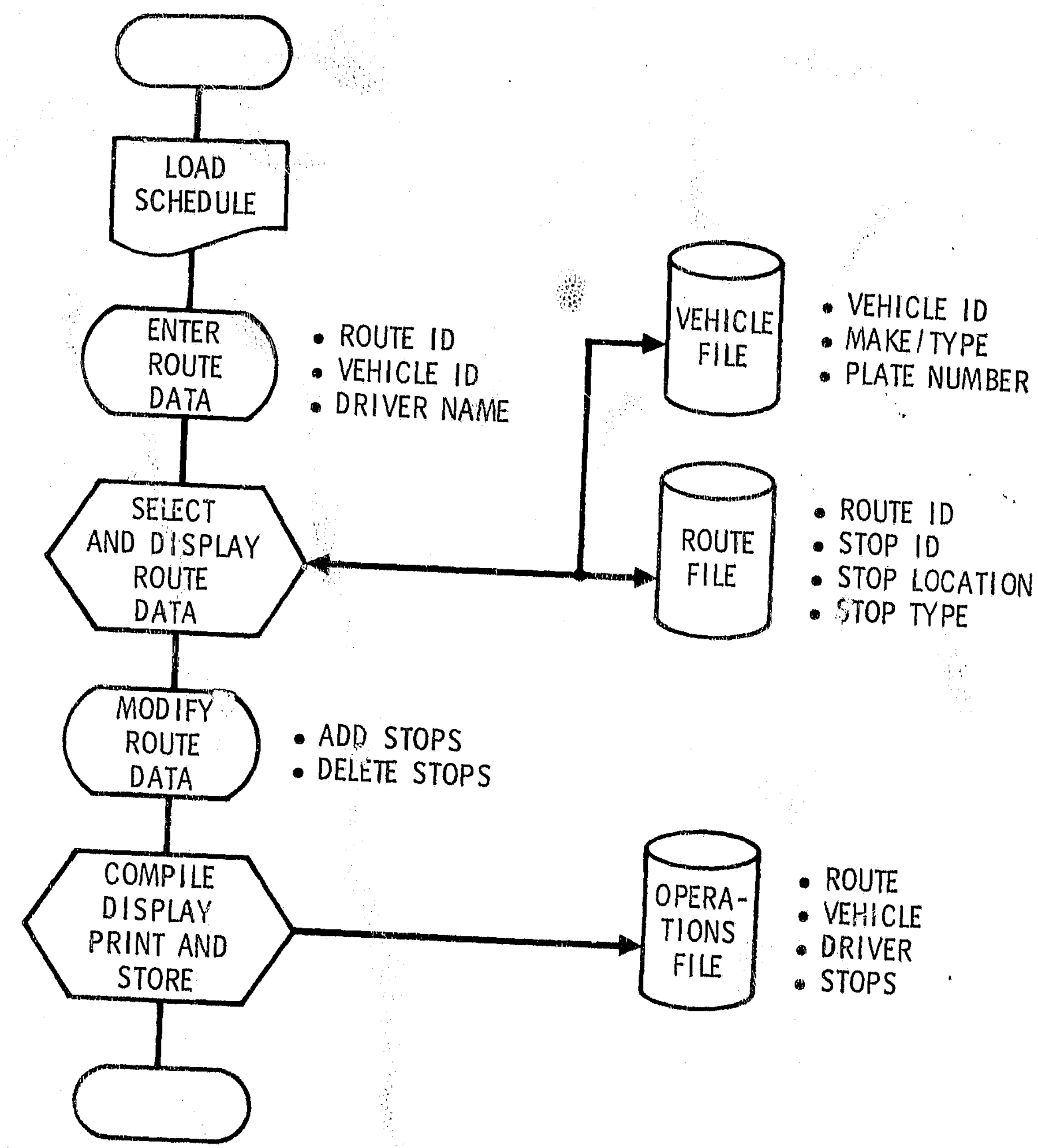

Figure 5. System Flow Diagram of Daily Operations File Compilation

Although the route/established stop relationship is relatively static, provisions must be made for reassignment, addition, and deletion of established stops within a route. This function is essentially that of library file maintenance and should be considered as an off-line utility program. Implementation of the on-line file operation will require changes in procedures for generation of the load plan and the establishment of new manual procedures by the dispatcher. These procedures are reviewed in Chapter VI. Route and vehicle identification codes are currently employed in the dispatch system and may be readily adapted to interface with the cargo security system. However, in those load planning operations which do not employ automatic data processing equipment, identification of customer stops may not be compatible with computer formats and word lengths. In these cases, a set of symbols must be created for compatibility purposes. The location of new customer stops must be defined in terms of street names and zones, and a manual operation will be required on the part of the dispatcher to convert street addresses into system compatible terms, i.e., intersection identifiers.

c. Operations control. Following compilation of the daily operations file, the operation of the system should be automatic, providing for routine surveillance of all vehicles, detection of alert/alarm conditions, and close surveillance of a vehicle reporting such conditions. In addition, provisions should be made for operator override or modification of certain parameters as the operational situation changes.

(1) Sensor masking. In the event that a faulty sensor or actuator (e.g., a cargo door that will not latch) causes a false alert/alarm condition to be generated, the dispatcher should have the capability to mask out the alarm logic associated with that sensor. However, this feature will compromise the protection afforded by the system, and security precautions must be invoked if sensor masking is employed.

(2) Route changes. As the overall situation changes, provisions must be made for modification of the operations file to reflect current conditions. The addition or deletion of stops as a result of service calls, the rerouting of vehicles, and the transfer of a load from a disabled vehicle to a relief vehicle are typical conditions that would require the use of this feature.

(3) Route status. When a vehicle is stolen, it is desirable that the security personnel have a knowledge of the current schedule of the vehicle in order to assess the magnitude of the theft. For this purpose, the dispatcher should have the capability to display the route status of each vehicle, i.e., the authorized stops completed and the current location. A candidate display for this status information is shown in Figure 6.

(4) Area polling. When a vehicle has been hijacked or stolen, it is desirable that other fleet vehicles in the vicinity of the incident be alerted to watch for the vehicle and to report its location if it is seen. (The cargo security system of the missing vehicle may have been deliberately disabled.)

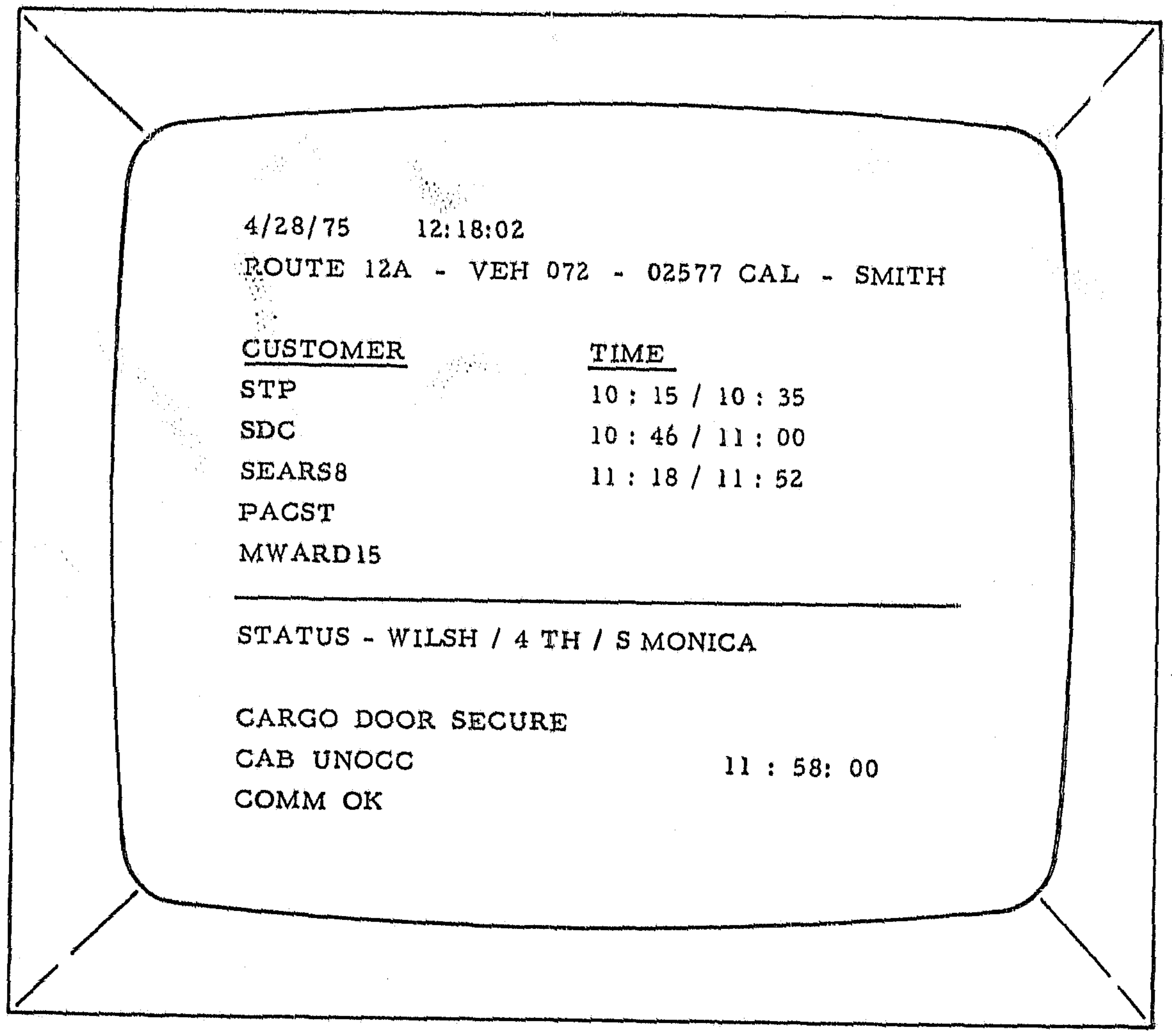

Figure 6. Candidate Display Format for Route Status Information

Area polling, which is the automatic identification of all fleet vehicles in the area of the incident, would enable the dispatcher to alert the drivers of these vehicles to the theft situation. Figure 7 is a candidate display for this feature. Area polling also provides a means for the dispatcher to ascertain the position of vehicles in the area of a call-in service request, thereby reducing his workload and relieving communications loading.

d. Data logging. A recording of system status is mandatory to assist in the investigations of thefts of or from vehicles and to provide documentary evidence of driver activities for use by security officers and the drivers' union in determining driver involvement. The recording should include the daily operations file, all changes entered by the dispatcher, and the location/sensor status data of all vehicles in an alert/alarm condition or under selective surveillance, together with a date/time tag for each log entry.

e. Security. Successful operation of the system is dependent on the integrity of its input data, and security precautions must be employed to ensure that key parameters are not suppressed or false data entered. Such precautions include the following features:

- The operational program must be secure against unauthorized modifications. The use of read-only storage and/or routine audits against a master program securely stored outside the confines of the dispatcher area could provide this security.

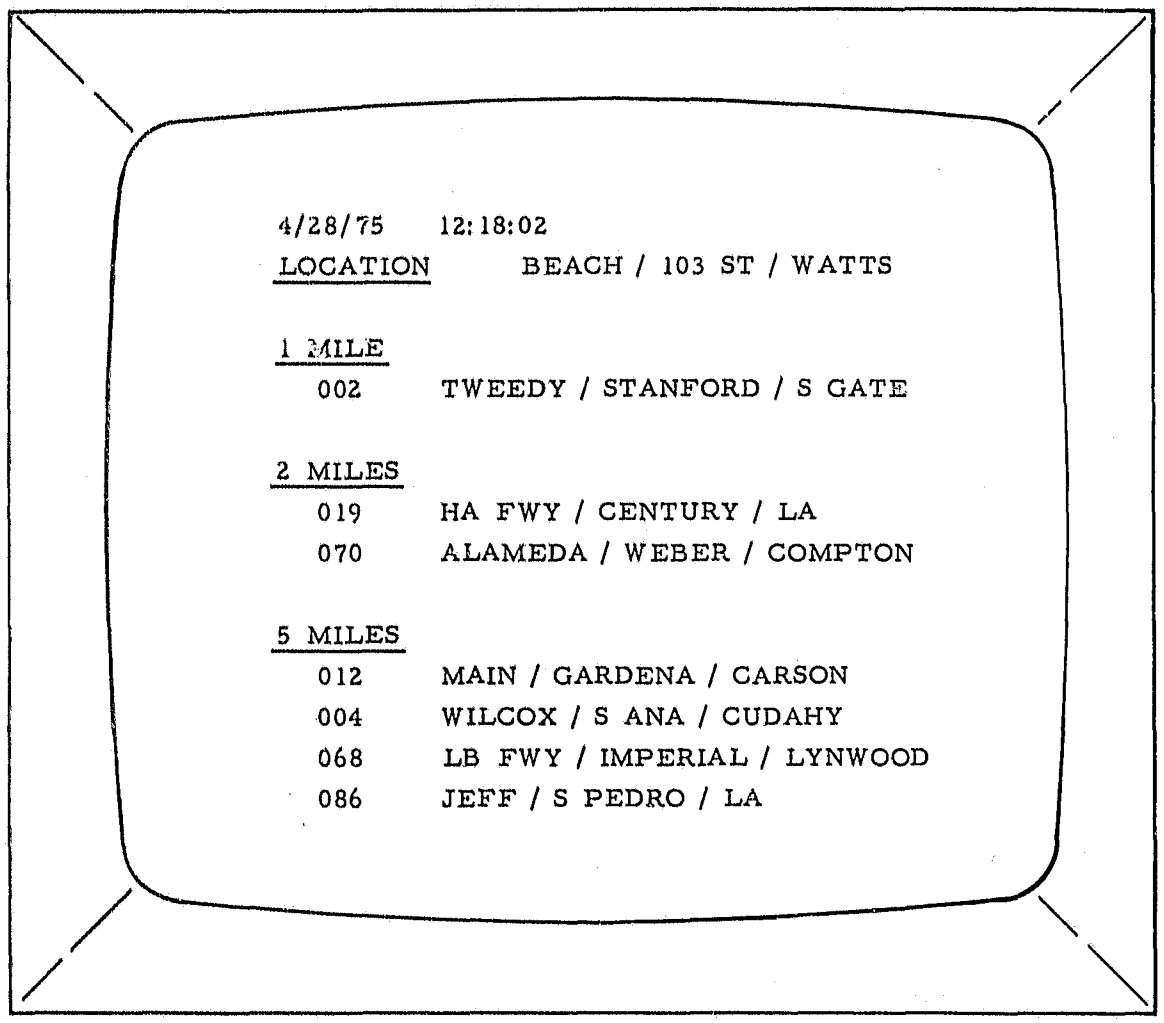

Figure 7. Candidate Display Format for Area Polling

- Use of the sensor masking routine should automatically initiate close surveillance of the vehicle whose sensor condition requires the use of this routine.
- The data log must be protected from tampering or erasure. Should access to the tagging mechanism be required to replenish the recording medium, sufficient storage must be provided in the system computer to ensure that no data are lost. Procedures must be initiated for the secure storage of the data logs.

It is highly desirable that the recording mechanism be located remotely from the dispatcher position, e.g., in the security officer's area, in order that the drivers do not associate the dispatcher with the recording of events that may lead to discplinary action.

CHAPTER III. ENVIRONMENTAL REQUIREMENTS

A. Introduction

The environment in which the cargo security system must operate encompasses a wide range of natural and manmade conditions including shock, vibration, temperature, pressure, and humidity. The locations where the various system elements are deployed will govern the severity of the environmental conditions to which they are exposed. In this chapter, the four principal installation location categories are identified and the worst-case design criteria for each type of environmental condition are defined.

B. Installation Location Categories

The locations at which the various elements of the cargo security system will be installed may be categorized as follows.

- Group 1 - External (Fixed). This group encompasses the nonvehicle system elements that will be exposed to extremes of natural temperature, pressure, humidity, etc. Included are proximity units, fixed communications antennas, and exposed interconnecting cables.
- Group 2 - External (Mobile). In addition to the environmental extremes to which the Group 1 system elements will be exposed, all elements mounted external to the vehicle's cab and compartment will also be subjected to shock and vibration

induced by vehicle motion. Included in this group are vehicle-mounted antennas, externally mounted sensors, and exposed cabling and disconnects.

- Group 3 - Internal (Mobile). Those system elements that will be mounted in the vehicle cab or cargo compartment will be subjected to the same vehicular shock and vibration as is encountered by Group 2 elements. However, Group 3 system elements will be protected from the extremes of environmental conditions to which Groups 1 and 2 will be exposed.
- Group 4 - Internal (Static). The base station elements (computer, displays, recorder, remote alarm unit, etc.) will be installed in the controlled environmental conditions of a typical business office.

C. Physical Environment

The physical environment to which the cargo security system will be exposed is examined in the following discussion. In addition, requirements for each category of equipment are established.

1. Shock. All elements of the system will be subjected to the physical shock induced by shipping, handling, and installation. In addition, all vehicle-mounted equipment will be exposed to shock induced by vehicle motion, parking, freight handling, etc.

a. Shipping. There are no established standards relating to the design of equipment for protection from damage by shipping shock.

In general, equipment is designed for a specific operating environment, with any additional protection designed into the shipping carton. Typical shock test criteria employed for packaged electronic equipment include a drop test (48 inches to a cement floor) and a jarring test (3 foot-pound impact).

b. Vehicle induced. Vehicle-mounted equipment will be subjected to road shocks and shocks resulting from freight loading (fork lift operations and parking at the freight dock). It is recommended that all vehicle-mounted equipment in Groups 2 and 3 be designed to meet a shock environment of 20 g.

2. Vibration. The vibration conditions to which the vehicle-mounted equipment will be subjected are governed by the shock environment and the damping effects of tires, springs, and shock absorbers. The vibration power spectral density will vary as a function of equipment location. To meet worst-case conditions, however, all Group 2 and 3 equipment should be designed for the following environment:

- Peak Acceleration
  - 5 to 100 Hz — 0.1 g^2/Hz
  - 100 to 2000 Hz — 0.0006 g^2/Hz

3. Temperature. This environmental factor has the greatest variation as a function of equipment location and geographical area of operation. The criteria presented in Table 1 have been developed based on measured temperature and test criteria for commercial equipment designed for vehicular use.

Table 1. Temperature Design Criteria

Group	Operating		Nonoperating (min, °F)
	Min (°F)	Max (°F)	
1	-40	+250	-60
2	-40	+250	-60
3	-40	+180	-60
4	+20	+ 95	-40

4. Atmospheric pressure. Variations in atmospheric pressure may result in leaking seals, arcing, and changes in chemical properties. The design should provide for satisfactory operation of the equipment system at altitudes ranging from sea level to 10,000 feet.

5. Relative humidity. Humidity will influence the properties of materials used in components by the absorption and diffusion of moisture vapor. Vapor pressure variations result in the migration of moisture and its penetration of materials, causing physical strength loss and insulation degradation. Requirements for the cargo security equipment have been determined from an evaluation of typical conditions for commercial installations. These requirements are presented in Table 2.

Table 2. Relative Humidity Design Requirements

Group	Relative Humidity	
	Max	Min
1 2 3	100	20
4	95	50

CHAPTER IV. REGULATORY CONSTRAINTS

A. Introduction

Use of the cargo security system will be confined to individual trucking fleets, with each fleet dispatcher or security officer providing the interface with law enforcement agencies. As such, the system can be considered as a private alarm system, subject only to those regulations that govern safety and the licensing of radio transmissions. Regulations pertaining to safety are promulgated at all levels of government whereas the use of radio transmitting equipment is regulated by a single agency, the Federal Communications Commission (FCC). In this chapter, an assessment is made of the impact of both these categories of regulation on the operational design of the cargo security system.

B. Safety

The safety of vehicles on the public highways and the safety of personnel who will work in the vicinity of the equipment must be considered in the design of the cargo security system.

1. Vehicle safety. Installation of the system must not compromise the safety of the vehicle operations. In addition to obviating any hazard to the driver, any interfaces with the vehicle's systems (power, lighting, steering, and braking) must be designed for fail-safe operation, and access to the vehicle's controls by the driver under normal or emergency conditions must not be constrained by the system installation.

2. Personnel safety. Requirements for personnel safety are delineated by federal, state, and local regulations.

a. Federal requirements. The Occupational Safety and Health Act (OSHA) requires that the safety of operating personnel be factored into the system and equipment design.

For vehicle-mounted equipment, the design must provide for protection of the driver or cargo loaders from physical injury. The equipment units should have rounded corners, and the physical mountings should be capable of withstanding the shock of a vehicle collision. The chassis of vehicle-mounted electrical equipment must be grounded to the vehicle frame, and protection must be provided against electrical shock in all equipment using electrical potentials exceeding 24 volts.

For ground support equipment (base station and location support units), all electrical equipment connected to 60-Hz power must incorporate three-prong power plugs with the third prong connected to chassis ground. Protection from electrical shock must be provided in all equipment using voltages in excess of 24 volts. Personnel hazards such as equipment corners, cabinet weight distribution, etc. must be considered in the mechanical design. Where equipment is to be mounted on lighting or utility poles, the equipment must be located at least 10 feet away from exposed wires carrying a potential greater than 300 volts.

b. Other requirements. The design of pole-mounted proximity units will be affected by state, county, and municipal codes and by the regulations of utility companies. State and local laws, regulations, and building codes governing the use of utility-powered devices may require utilization of armored conduit and the installation of a watt-hour meter at each proximity unit location. Many utility companies require that pole-mounted units in the direct line of access to the upper part of the pole be capable of supporting the weight of a lineman, and mounting brackets for such installations must be designed for this loading.

C. Radio Transmission

The cargo security system will employ a land-mobile communications link for the purpose of transmitting data between the vehicles and the base station. In addition, the system may employ radio transmissions for vehicle location purposes. System design of these elements must adhere to FCC regulations.

1. Land-mobile communications. Transmission of data between vehicle and base may be accomplished by one of the following two methods.

a. Combined voice/data link. Location and status data are transmitted over channels assigned by the FCC for voice communications. This technique, which provides the most cost-effective approach for the trucking industry, is authorized by the FCC under Section 89.120 (c)(3), Section 91-120 (c)(3) and Section 93-120 (c)(3) of Chapter I of Title 47 of the Code of Federal Regulations. Trucking fleets not currently equipped with communications links may request channel assignments for this dual purpose.

b. Dedicated data link. Where existing voice channels cannot be used, location and status data may be transmitted over a channel specifically allocated for this purpose. Parts 89, 91, and 93 of the FCC regulations specify the minimum number of vehicles to be served by each assigned frequency channel as well as the methods to be employed to reduce voice traffic interference.

2. Vehicle location systems. The Federal Communications Commissions Report and Order Docket 18302 relating to automotive vehicle locator systems sets tentative standards for the development of such systems. This Report and Order exempts vehicle location stations from the identification requirements of Section 89.153, and prescribes the number of vehicles to be served by a dedicated frequency channel. (See Table 3.)

The Report and Order, Section 89-120 (e)(3), Section 91.120 (e)(3), and Section 93.120 (e)(3), recognizes the use of proximity devices ("signposts") for the purpose of vehicle location and specifies power output and cochannel interference parameters.

Employment of LORAN-C signals for vehicle location purposes is recognized by the FCC in its Report and Order. However, the FCC will not authorize nongovernment operations in this band. Sections 91.604 (a) and 91.604 (b)(1a) and footnote US 104, Section 2-106 deal with this subject.

Should the use of phase-locked AM (amplitude modulated) broadcast signals be employed for vehicle location purposes, an advance ruling must

Table 3. Minimum Vehicle Assignment for Dedicated Frequency Channels

Required Bandwidth	8 MHz	1 MHz	25 kHz
Frequency Band	904-912 MHz or 918-926 MHz	903-904 MHz 926-927 MHz	25-50 MHz 150-170 MHz 450-512 MHz
Min. No. of Vehicles per Assigned Frequency	500	Not Specified	200[a]

[a]Note: Section 89.120(c)(3)(i) specifies that a showing must be made that 50 percent of these minimum vehicles must be in operation by the end of the second year of the license and 70 percent by the end of the initial license term. Otherwise, assignments will be made on a secondary, noninterference basis to any authorized radio telephony operation.

be obtained from the FCC as to the "type approval" of radio transmitters that incorporate phase-lock units. Use of the units provides a frequency stability several orders of magnitude better than that required by Section 73.59 of the Commission's regulations. Operational experience has been gained during concept feasibility testing of the AM phase-lock system,[3] with the stations operating under a Special Temporary Authority issued by the Commission.

CHAPTER V. PROCEDURAL AND TRAINING REQUIREMENTS

A. Introduction

The impact of the cargo security system on the operating procedures of a typical cargo pickup and delivery operation is examined in this chapter. New procedures are outlined, and suggestions are made for the modification of existing procedures. Personnel training requirements are also discussed.

B. Procedures

1. <u>Load documentation</u>. The principal procedure that will be impacted by introduction of the cargo security system into trucking operations will be that of preparing the load schedule and documenting pickup operations. As reviewed in Chapter II, the load documentation prepared prior to the departure of the vehicle from the depot consists of bills of lading and a load summary describing the:

- Names of customers
- Addresses of customers
- Number of cartons and shipment weight of each pickup
- Latest acceptable time for pickup

These documents are used by the dispatcher for scheduling and driver assignments and for the compilation of his status board. Calls for pickup service received after the vehicle is en route are directed to the dispatcher, who logs the data listed above prior to assigning the call to a specific vehicle.

The cargo security system requires that, for each vehicle, the identity and location of all stops on that vehicle's route be entered into the base station computer. To be compatible with the system and to minimize computer storage requirements, these data must be entered in the following formats:

- Identity - mnemonic or code number
- Location - street intersection and zone in abbreviated format

For example, consignee data currently recorded as

The ABC Widget Corporation
8605 West Olympic
Los Angeles

would be entered as follows:

ABCWID/OLYMPIC/CARSON/WEST LA

To accomplish this format conversion, a new procedure must be introduced into the load scheduling process. A mnemonic or identification number must be assigned to each consignee and to each customer for pickup service. The location of these customers is then converted to the intersection/zone format.

As described in Chapter II, vehicle stops fall into two broad categories, established and casual. For established customers, the data would be created and stored in the system computer library file, and a customer reference index would be generated as part of the system installation procedure. The library file and index would be updated on a periodic basis by means of an

off-line file maintenance routine. For these established customers, the load documentation procedure would be limited to entering the customer mnemonics or identification numbers on the load summary. The cross reference index would be utilized by the shipping clerks for this purpose. For casual customers, a temporary identification number must be assigned and location data created.

Sequential numbers must be maintained for identification codes, and the base station computer can be programmed to provide this sequence. Conversion of the street address to intersection/zone format would be performed with the use of a street map or by simply requesting the customer to identify the nearest intersection to his place of business. The actual address would be retained for the purpose of briefing the driver. This new load documentation procedure is illustrated in Figure 8.

2. <u>Dispatch procedures</u>. Integration of the cargo security system with the dispatch operations will result in a modification of the dispatcher's procedures. Basically, the dispatcher will replace his manual status board compilation with keyboard procedures, and reduce his use of the communications system by observation of the location and status displays.

As discussed in Chapter II, the dispatcher provides real-time control of the system. Prior to departure of the vehicles from the depot, the load documentation will be distributed to the drivers. The dispatcher's copy will be used for compilation of the status board. During the period that the vehicles are en route, service calls are documented and vehicles assigned, with vehicle availability determined by the use of the communications system. Following vehicle assignment, the manual status board is updated.

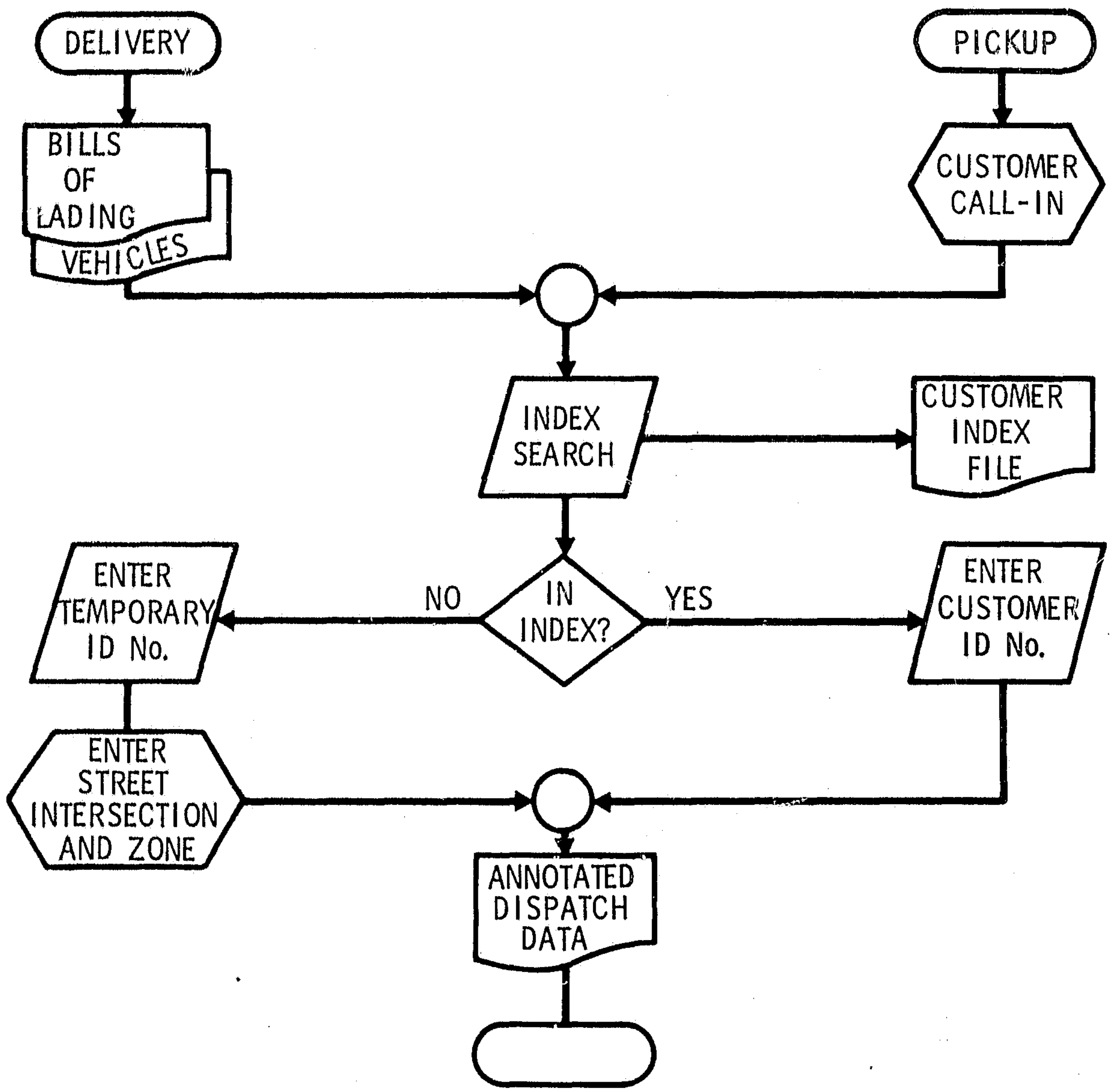

Figure 8. Flow Diagram of Load Documentation Procedure

The features offered by the cargo security system base station will eliminate the need for a manual status board as well as the communications loading associated with determination of vehicle location and availability. However, voice communications will continue to be used for assignment of call-in service requests. The revised dispatcher procedure is shown in Figure 9. For load scheduling activities conducted prior to the vehicle's departure from the depot, annotated dispatch data resulting from the load documentation procedure described above together with the identification of vehicles assigned to call-in requests for pickup service will be entered directly into the system via the keyboard. Use of the area or single vehicle status displays will enable the dispatcher to determine vehicle location and availability without the use of the communications system. Once this determination has been made and the details of the service call transmitted to the assigned vehicle, the identification of this vehicle and the annotated dispatch data will be entered via the system keyboard.

3. Security procedures. Since the operation of the cargo security system is automatic, no new procedures will be required on the part of the dispatcher in operating the equipment for security purposes. However, as discussed in Chapter III, the system data available to the dispatcher and security officer, particularly that of vehicle location, can significantly reduce the time required to initiate recovery of the missing cargo or vehicle. Because of the capability to determine the current location of a moving vehicle, procedures previously established with local law enforcement agencies for the reporting of vehicle-related theft incidents must be changed to provide for the reporting of this real-time location data. The majority of law enforcement

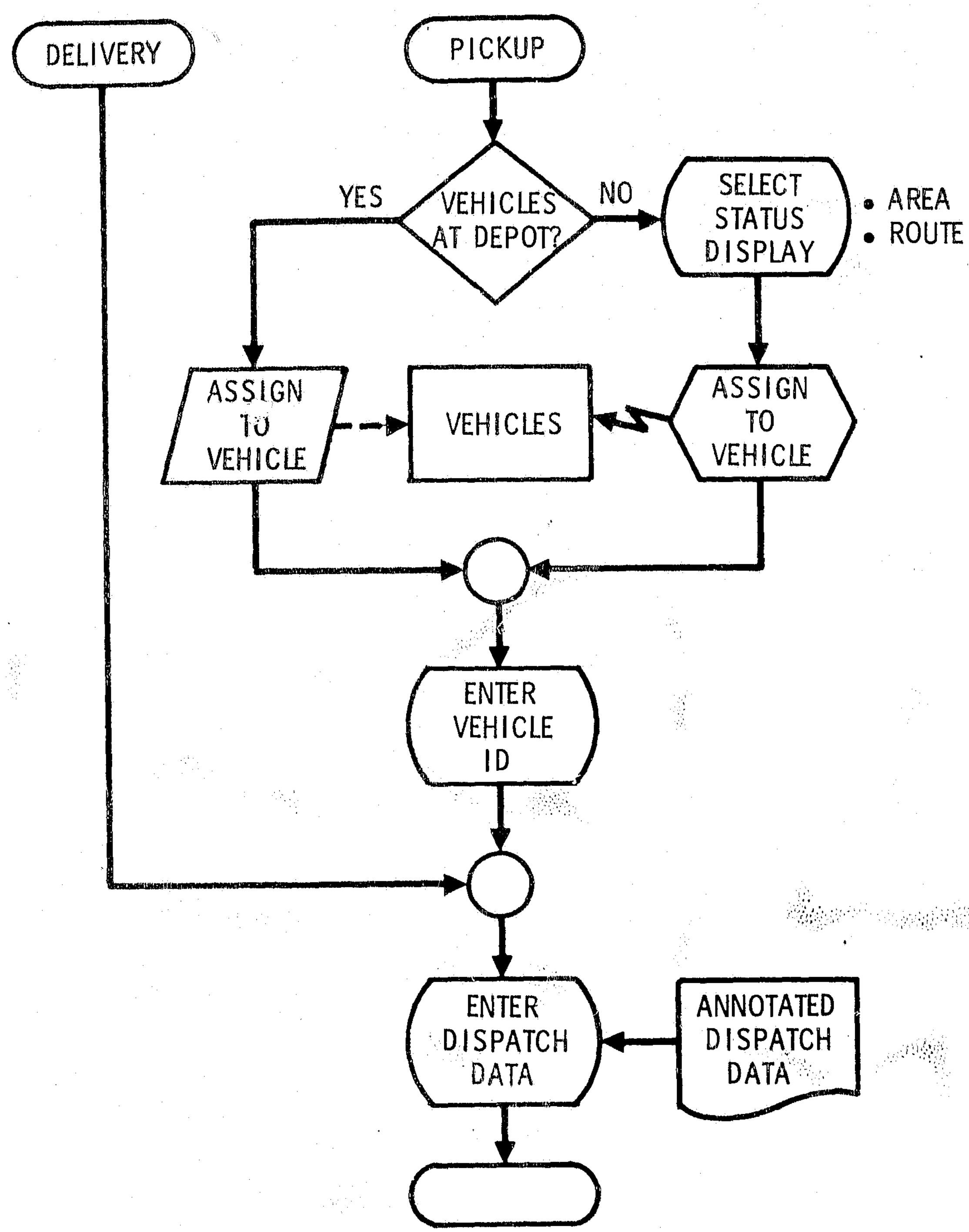

Figure 9. Flow Diagram of Data Entry Procedure

agencies have established systems, such as link operators or complaint operator bypass keys, for receipt of "open-line" data pertaining to crimes in progress, and these systems may be directly employed for the reporting of vehicle location. The fleet dispatchers and security officers should familiarize themselves with the methods of access to these open-line systems, and the law enforcement agencies within the operating area of the trucking company should be made aware of the type of data that will be reported by the fleet dispatchers.

C. Training Requirements

New and revised procedures will necessitate the training of clerical and dispatcher personnel in the operation of the cargo security system. Since it is the practice of the trucking industry to contract for equipment maintenance, no requirement for maintenance training is anticipated.

1. Load documentation. The load scheduling clerk or the dispatch clerk will require training in the use of the customer index file and in the derivation of location data in terms of street intersections and zones. In addition, training will be needed in the use of the system keyboard for data entry and maintenance of the library file.

2. Dispatch operations. The principal training requirement in this activity will be that of dispatcher personnel. To acquire the skills necessary to operate the system, the employment of classroom or programmed instruction in addition to hands-on training will be required. The training course should include the following subjects:

- System description
- Data requirements
- Data input formats
- Display and control options
- Display formats
- Turn-on and initialization procedures
- Alphameric and function keyboard operations

In addition, dispatcher personnel should receive familiarization training in the security procedures generated for their company's operations.

3. Security operations. Depot guards should receive familiarization training in the use of the remote alarm unit and in the new security procedures that result from introduction of the cargo security system into the company's security organization.

NOTES

1. "Survey and Technical Assessment," ATR-75(7908)-1, El Segundo, The Aerospace Corp. (July 1974).

2. "Design Requirements Report, Cargo Security System Program," Ft. Worth, Texas, Hoffman Information Identification, Inc. (April 1975).

3. "Cargo Security System, Feasibility Analysis Report – Hybrid Dead Reckoning and Hyperbolic Grid Location," ATR-75(7908)-2, El Segundo, The Aerospace Corp. (April 1975).

END