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Report 2232

MICRO-MARKER PARTICIPATION IN J-LOTS

by
Harry H. Ellis, Jr.

February 1978

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<p>The microwave system of automatic identification for containers, called MICRO-Marker, was incorporated in the Joint Logistics Over the Shore (J-LOTS) Test Program during August 1977 in order to demonstrate its capabilities and to gain operational experience in a realistic environment. MICRO-Marker stands for Microwave Identification of Containers by Remotely Operated Markers. MICRO-Marker provides for instant identification of intermodal cargo containers at critical points in the supply distribution system. The equipment deployed to participate in J-LOTS at Fort Story was designed to demonstrate the ability of an automatic identification</p> <p>(Continued)</p>		

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system, linked to a small data base, to provide verification of container arrivals and departures and real-time truck location and utilization information.

The participation in J-LOTS was an extremely useful learning experience. Many system problems were uncovered and to a large extent corrected during the course of the exercise. The system showed its ability to rapidly output data descriptive of ongoing operations. The high correspondence between automatic and manual data taken during a selected period of the test showed the system capable of excellent accuracy.

PREFACE

This effort was performed under Project 1L763726DG1409, "Control and Identification Equipment and Techniques," at the request of COL William Danzeisen, Project Manager, Army Container Oriented Distribution Systems. The primary coordination of data requirements and interaction with the Army Standard Port System operations was accomplished through Buckley Smith, Transportation School, Fort Eustis, Virginia.

The MICRO-Marker hardware was developed by the Mobility Equipment Research and Development Command (MERADCOM), Fort Belvoir, Virginia, via a contract with the Fairchild Space and Electronics Company, Germantown, Maryland. System software was designed and developed by MERADCOM personnel with coding and debugging assistance by Robert D. Gholston III, Digital Equipment Company, the data terminal equipment manufacturer.

The equipment at Fort Story, Virginia was operated by Harry H. Ellis, Jr., Project Engineer, and Michael A. Mando, both of MERADCOM. Administrative support was provided by CPT Harold Barclay, S 2/3, Fort Story.

Major contributions to this report were made by Mr. Mando, who collated and analyzed the raw data and assembled much of the example material presented.

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MICRO-MARKER PARTICIPATION IN J-LOTS

I. INTRODUCTION

1. **Summary.** The microwave system of automatic identification for containers, called MICRO-Marker, was incorporated in the Joint Logistics Over the Shore (J-LOTS) Test Program during August 1977 in order to demonstrate its capabilities and to gain operational experience in a realistic environment. MICRO-Marker stands for Microwave Identification of Containers by Remotely Operated Markers. MICRO-Marker provides for instant identification of intermodal cargo containers at critical points in the supply distribution system.

One such critical point in a Military distribution system is represented by a LOTS operation. This operation involves the many physical difficulties attendant to the offshore discharge of cargo containers from a non-self-sustaining containership, and their movement through a hastily established shoreline facility. A LOTS operation will also have to deal with critical cargo accounting and control problems. In a situation which would justify a LOTS undertaking, all cargo will be critical and shipment diversions will be commonplace.

The MICRO-Marker System deployed to participate in J-LOTS at Fort Story was designed to demonstrate the ability of an automatic identification system, linked to a small data base, to provide verification of container arrivals and departures as well as real-time truck location and utilization information. In addition, the ability to generate Army Standard Port System documentation was incorporated.

The participation in J-LOTS was an extremely useful learning experience. Many system problems were uncovered and to a large extent corrected during the course of the exercise. Such discoveries during the evaluation of prototypes are of great benefit since the problems can be eliminated, in many cases without significant cost, during subsequent stages of development. The system showed its ability to rapidly output data descriptive of ongoing operations. The high correspondence between automatic and manual data taken during a selected period of the test showed the system to be accurate. Unfortunately, a number of minor technical problems and several unplanned operational conditions precluded comprehensive data collection during the entire operation.

2. **Background.** The MICRO-Marker program was initiated in 1973 by the Project Manager for Container Systems (PM-ACODS) in response to an apparent need to improve the accuracy and speed of the reporting of cargo container movements. The program's primary objective was to devise an automatic identification system which

could acquire container movement data and make it available to applicable logistics systems, eliminating extensive manual operations. It was recognized that such a system could play a major role in achieving timely inventory-in-motion. MERADCOM was tasked to develop hardware responsive to this objective. The early results of this development was a labeling technique using microwave passive transponders attached to the cargo containers which overcame many of the deficiencies of then state-of-the-art optical identification systems. Subsequently, advanced development of the microwave system was undertaken with continued positive results.

The chartering of the J-LOTS test in September 1975 overlapped the MICRO-Marker development. The purpose of the J-LOTS test was to evaluate the capabilities of the services to deploy LOTS units and equipment to handle container ships and bargeships and the cargo they deliver in an over-the-shore environment. Initially, MICRO-Marker participation was limited to a minor demonstration in one of the pre-tests. However, in a meeting at MERADCOM during December 1976 attended by the PM-ACODS and Transportation School personnel, it was decided to expand participation. The expanded participation included the labeling of all trucks and containers in the exercise and monitoring their movement through a small-scale, mini-computer-based operating system.

The demonstration of MICRO-Marker at J-LOTS required a dramatic increase in the quantity of hardware in a short time frame, with only modest funding. Almost 15 times the number of labels then in existence were required. The existing data terminal capabilities had to expand from simple raw data output to a system for monitoring, storing, and interpreting the movements of trucks and containers. In addition, the data representing equipment movements had to be processed against a data base for structured output in the Army Standard Port System (SPS) format.

The rapid expansion forced a reliance on the best defined and most economical label design rather than a design with optimal characteristics. Rather than fabrication of sufficient interrogators of the advanced development design, early "brassboard" models were retrofitted with as many improvements as possible. The details of the data terminal software were tailored to anticipated J-LOTS requirements with little provision for general application. These factors notwithstanding, sufficient hardware and an adequate software operating system were available for deployment one week prior to the initiation of Phase I of J-LOTS.

II. INVESTIGATION

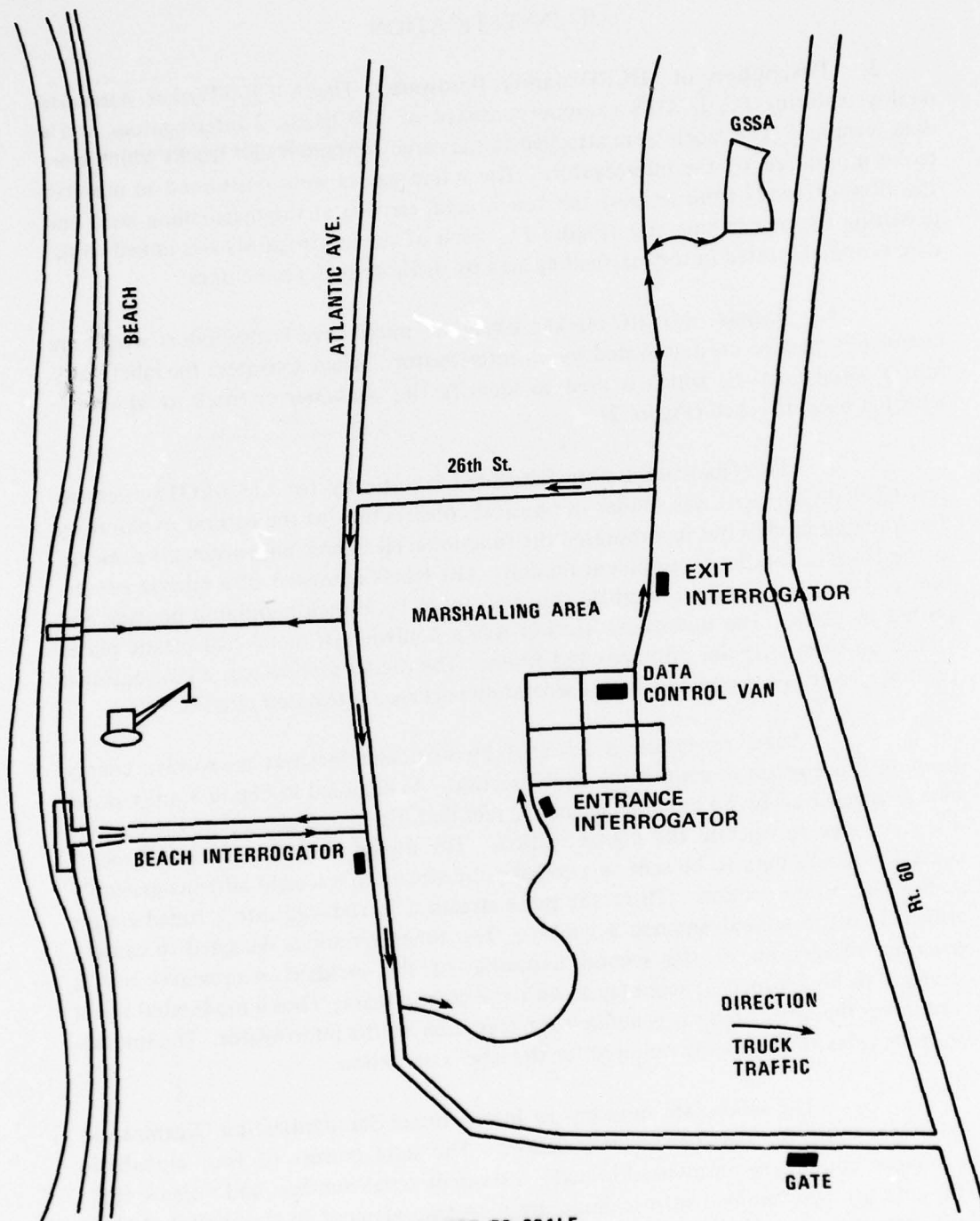
3. **Description of MICRO-Marker Hardware.** The MICRO-Marker hardware deployed during the J-LOTS exercise consisted of 720 labels, 3 interrogators, and a data terminal. The labels were attached to the cargo containers and trucks which were to be monitored by the interrogators. The interrogators were positioned to monitor the flow of assets from or past the beach area, arriving at the marshalling area, and departing the marshalling area (Figure 1). Each of the interrogators was linked to the data terminal located in the marshalling area by dedicated telephone lines.

a. **Labels.** MICRO-Marker labels are microwave transponders which are completely passive until activated by an interrogator. When activated, the label transmits a serial number, which is used to identify the container or truck to which the label has been attached (Figure 2).

The labels used were fabricated specifically for the J-LOTS exercise. The label design used was similar in physical construction to the earliest exploratory development models but incorporated the functional electronic improvements achieved in the latest advanced development models. The labels consisted of a microwave section and a digital section assembled into a 4- by 5- by 1/2-inch aluminum housing and potted in place. The microwave section was a sandwich of metal-clad plastic plates etched to form strip-line antennas and filters. The digital section was a conventional printed circuit board populated with separately packaged integrated circuits.

Label operation is initiated by sufficient incident microwave energy from an interrogator to actuate the digital section. As depicted in Figure 3, microwave energy is received by an antenna assembly, rectified, filtered, and regulated to provide a d.c. voltage to operate the digital section. The digital section's control elements cause the label's data to be sent as a coded pulse stream to a second antenna assembly in the microwave section. There the pulse stream is introduced into a tuned circuit attached to the second antenna assembly. The tuned circuit is designed to cause a generous reradiation of the second harmonic of the incident microwaves but is arranged to be detuned in accordance with the pulse stream. Thus a modulated signal containing the label's data is generated for reception by the interrogator. The interrogator provides all the energy required for the label's operation.

The label data conform to International Standardization Organization (ISO) standards for container identification. The data consist of four alphabetic characters, comprising an ownership code, a six-digit serial number, and a check digit. The data are programmed into a diode array storage element in the digital section. This programming occurred at the time of manufacture for labels used in J-LOTS. In general, however, the labels can be field-programmed. These factors are of extreme



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Figure 1. Marshalling Area.



Figure 2. MICRO-Marker Label.

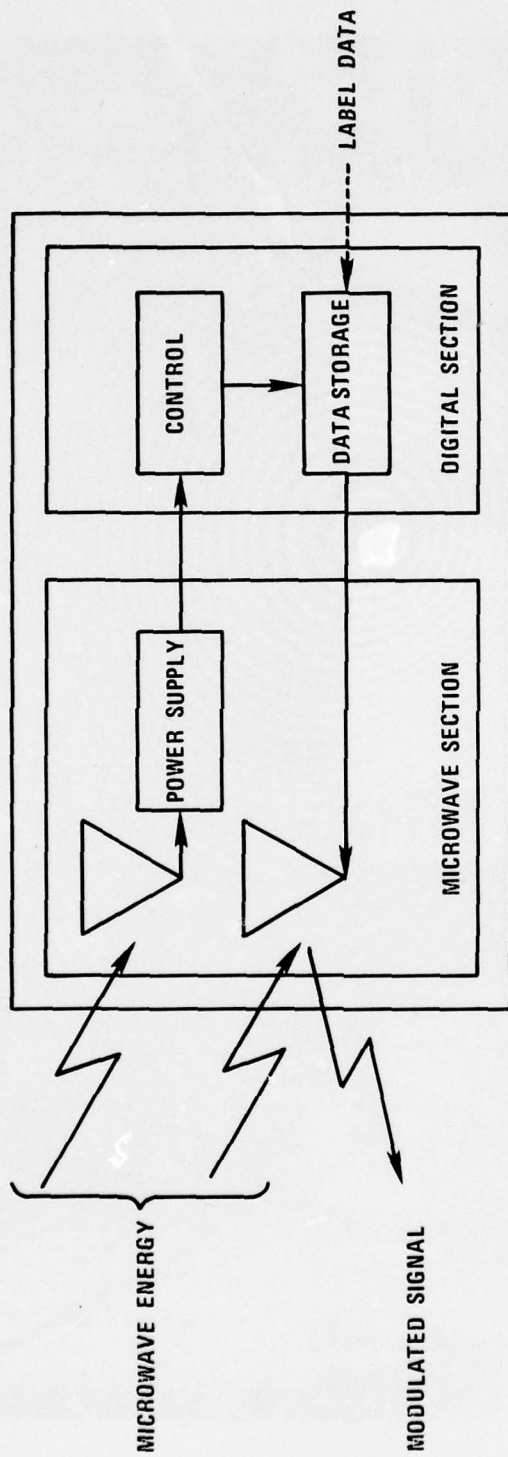


Figure 3. Schematic of Label.

importance in the general use of commercial containers for Military transport. The ISO serial number provides a common element with commercial practice since this number is used exclusively by commercial shippers in their data processing systems for control and identification of their assets. It will be present in the same location on every commercial container delivered for Military use. Field programability will allow "blank" labels to be stockpiled and rapidly applied to containers when needed.

b. **Interrogators.** The MICRO-Marker interrogator reads the label's serial number as the label moves into the interrogator's field of view and transmits the label information to a central data terminal. The interrogators are positioned at key points along the routes taken by trucks and containers; thus, the identity of the passing assets becomes available to the central location as the movement is taking place (Figure 4).

Positioning of the interrogator at key points is to some extent restricted by its zone of interrogation. For operational purposes, this zone can be thought of as extending from 4 to 20 feet from the face of the interrogator and from the top of the trailer or chassis wheels to half way up the side of the container. This allows the use of this type of interrogator on all standard two-lane roads. There was no difficulty in establishing viable interrogation points at Fort Story, since all of the traffic was constrained to hard-surface roads which conformed to the design limits of the interrogators.

Two types of functionally equivalent interrogators were deployed in J-LOTS. Two of the three interrogators were exploratory development models upgraded for this exercise. The third interrogator was the advanced development model. While their physical construction was somewhat different, both types were approximately the size of an Army foot locker and mounted on heavy-duty camera tripods.

Both types of interrogators incorporated an inclosed antenna assembly with transmit and receive arrays composed of horizontally arranged slots machined in rectangular wave guides. The antenna assemblies are attached to electronics packages. Internally, these are composed of modular microwave inclosures for the transmitter and receiver, printed circuit cards in a guide assembly for the signal processor, data processor and modem, and power supplies which are the heaviest components in the interrogator (Figure 5).

The interrogator normally operates in a search mode transmitting a relatively low level of microwave energy for label detection. When a label enters the antenna's field of view, its presence is detected by reception of the second harmonic reflected from the label. At this point, the energy transmission is increased to power the label. This interrogate mode continues until a read has been validated, a false alarm determined, or a time default occurs. A read is validated when two identical bit

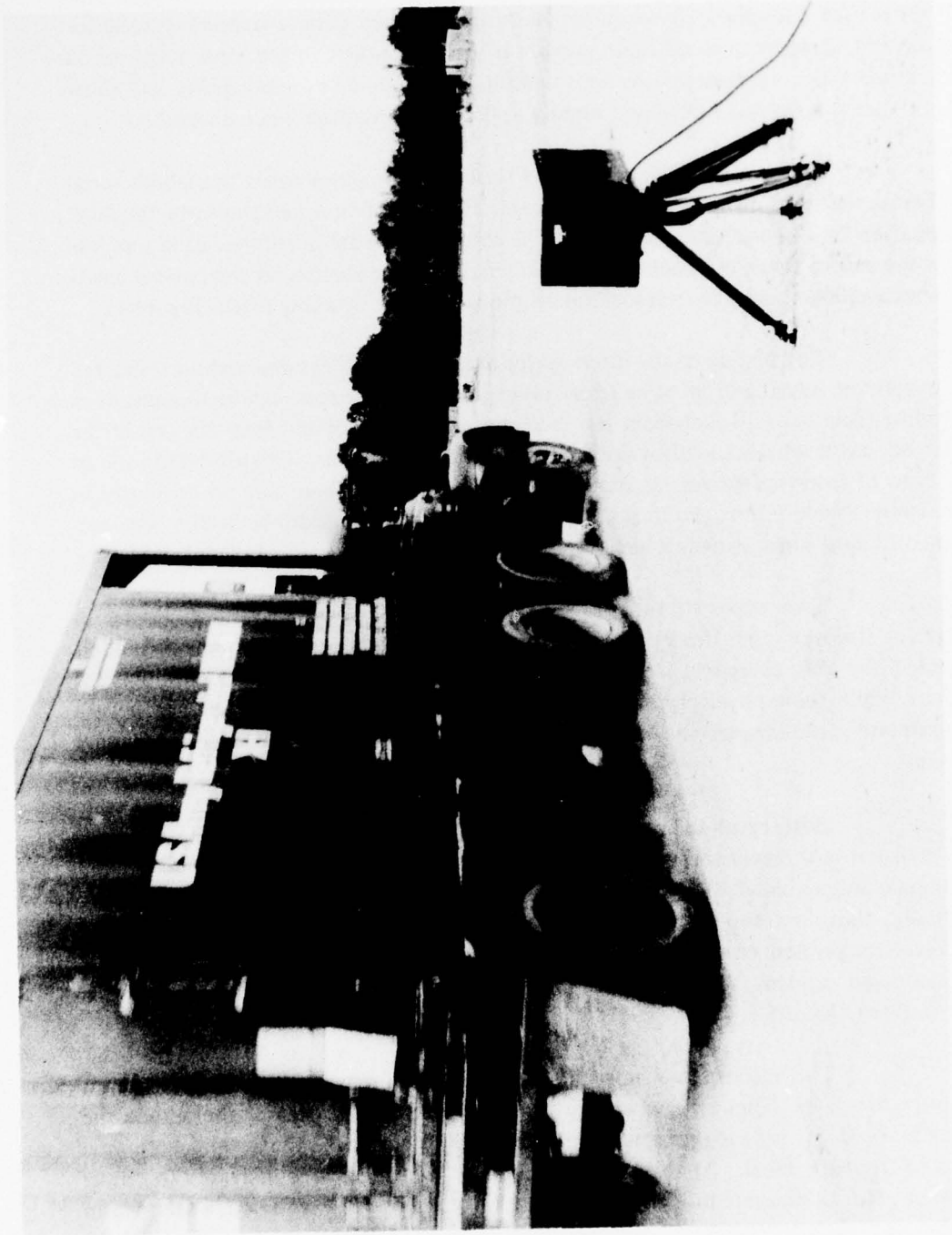


Figure 4. MICRO-Marker Interrogator.

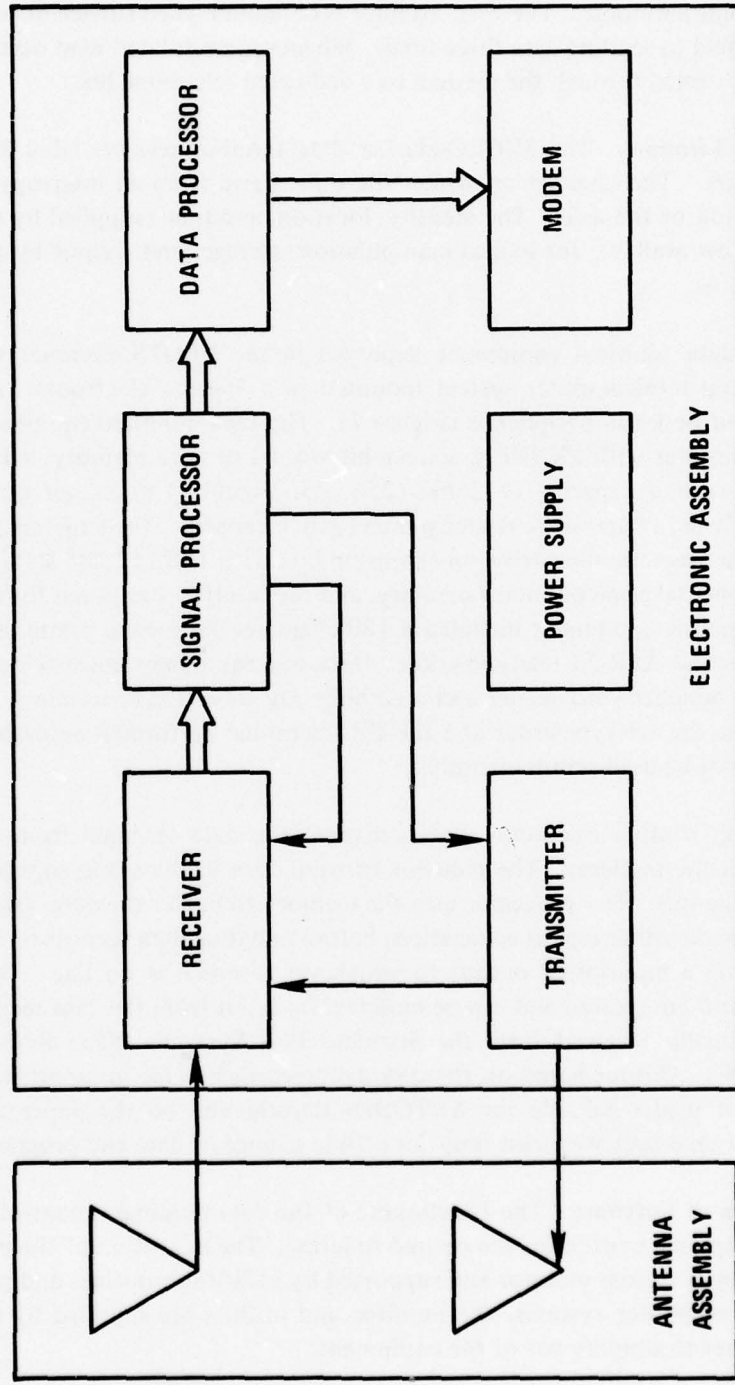


Figure 5. Schematic of Interrogator.

streams have been received from the label. False alarms are identified by the absence of pulses in the second harmonic. The read attempt is defaulted when sufficient time has elapsed for the label to send its data three times. Whenever a validated read occurs, the label data are forwarded through the modem to a dedicated telephone line.

c. **Data Terminal.** The MICRO-Marker data terminal receives label data from the interrogators. The channel on which the data arrive from an interrogator determines the location of the asset. The identity, location, and time (supplied by the data terminal) are now available for logical manipulation, storage, and output by the data terminal (Figure 6).

The data terminal equipment deployed in the J-LOTS exercise consisted of a commercial minicomputer system mounted in a 19-inch electronics rack with free-standing and desk-top peripherals (Figure 7). The rack-mounted equipment included the minicomputer with 8K (8192 sixteen-bit words) of core memory; a dual "floppy" disk unit with a capacity of 256K (256, 256 eight-bit) bytes per drive; three 2400-baud modems; a paper-tape reader/punch (punch capacity 50 characters per second); dual cassette magnetic tape drive; an extension box with 12K (12,288 sixteen-bit words) of supplemental semiconductor memory; and the interfaces required for the peripherals. Free-standing equipment included a 180-character per second printer and a 10-character per second ASR-33 teletypewriter. Desk-top equipment consisted of a 285-card-per-minute punched-card reader and a cathode ray tube (CRT) terminal. It should be noted that the teletypewriter and the CRT terminal performed equivalent functions but could not be used simultaneously.

During routine operation, data arrive at the data terminal from the interrogators through the modems. The modems forward data to the minicomputer's processing unit via the bus. The processor uses the memory to buffer the data, attach date and time, and make other logical associations before updating data records on the disk unit and making a monitoring output to whichever terminal is on line. Data records on the disk unit are created and can be modified by input from the card reader. The cards were normally received from the Standard Port System's (SPS) Remote Process Facility (RPF). Output based on the disk data records is made in report form via the printer or in media suitable for AUTODIN transmission on the paper-tape punch. The cassette tape unit was used only for offline storage of data and programs.

4. **Description of Software.** The functioning of the data terminal is controlled by minicomputer programs written for the desired function. The execution of the programs is controlled by a system monitor and supported by utility subroutines and programs. As in most computer systems, the monitor and utilities are supplied by the hardware manufacturer to simplify use of the equipment.

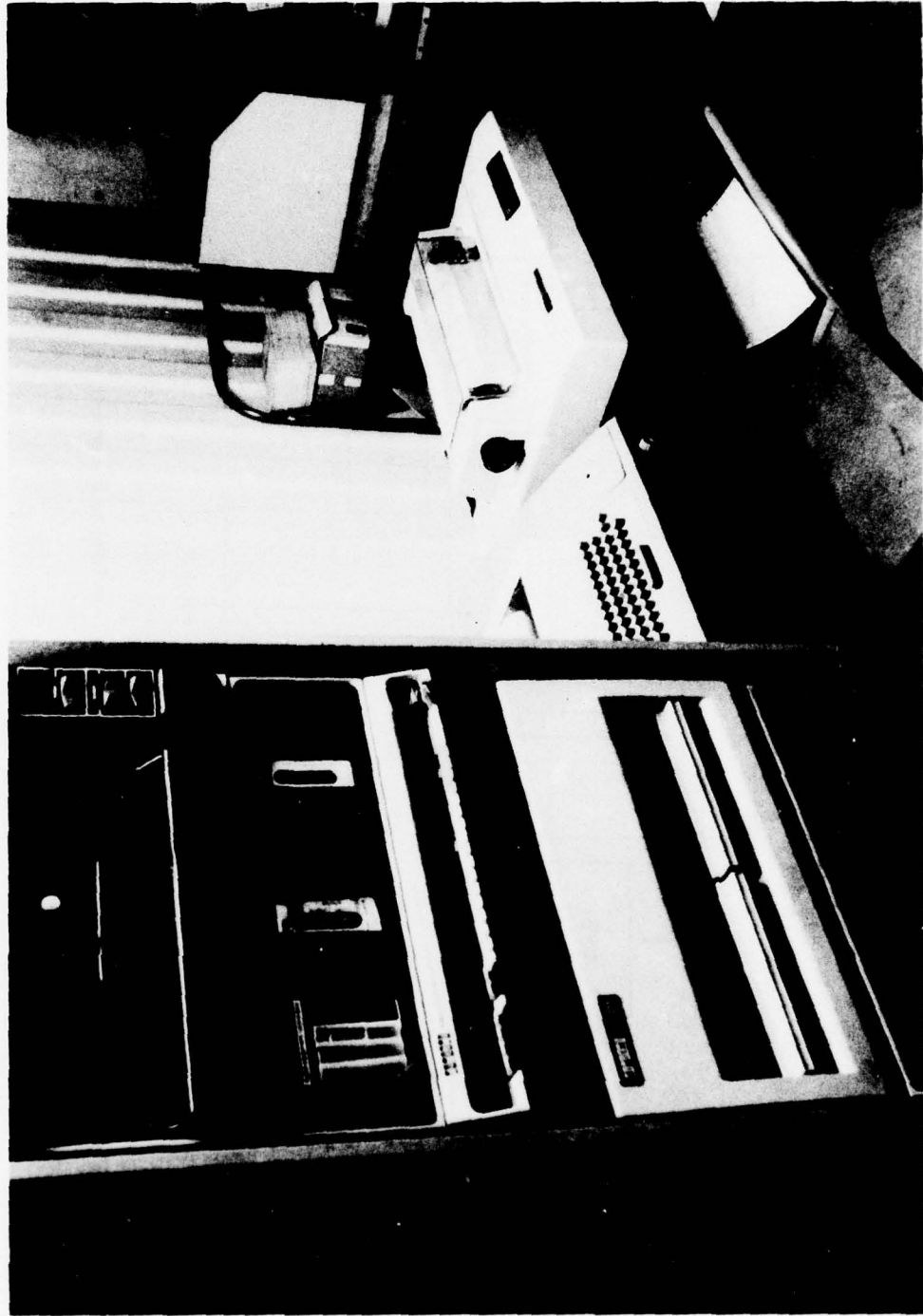


Figure 6. MICRO-Marker Data Terminal Equipment.

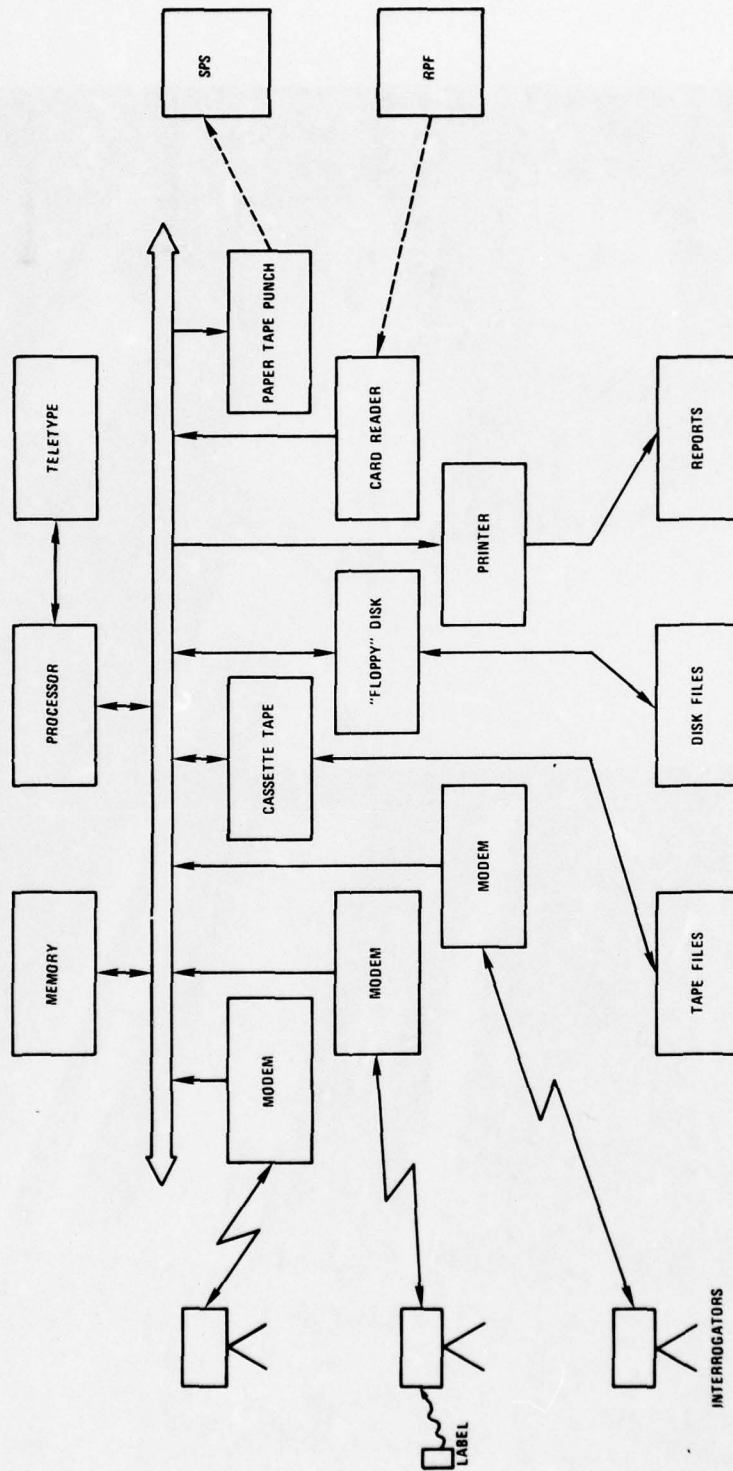


Figure 7. MICRO-Marker Data Terminal Equipment.

The software system used in the data terminal during the LOTS exercise allows three priorities of processing to take place: interrupt handling, foreground processing, and background programs. Although these three levels of processing are scheduled to take place in accordance with their priority, the speed at which the computer performs the processes allows them to be thought of as being executed simultaneously. Each of the levels is processed independently; therefore, two interface buffers are required to establish communication. The first buffer is the input queue which links the interrupt handlers to the foreground processing. The second is the data files which hold the results of foreground processing for one of the background programs (Figure 8).

Interrupt handling is the highest priority level of processing. Whatever processing is taking place when data arrive in a modem is interrupted by hardware incorporated in the minicomputer. The data element present at the modem interface when an interrupt occurs is a character. This character is subjected to several validity checks and moved to a buffer where it is held until all the characters of a particular label have arrived. After each character has arrived, the processing in progress at the time of the interrupt is resumed. After the last character in a label has arrived, the entire label data are moved to the input queue for foreground processing. Since the time required for character and label data movement is short compared to the time it takes for a full character to arrive at the modem, foreground processing or whatever background program may be in progress can continue with little retardation due to interrupt handling.

Foreground processing is the second highest priority level. This processing searches the input queue for label data, identifies the label as a particular truck or container, links truck and container labels which arrive consecutively on the same channel within 20 seconds, links the current time and date with the truck/container pair, and updates the data files accordingly. In addition, based on coding in the data files, an appropriate message is selected and a descriptive output is sent to the terminal (Figure 9). The purpose of the descriptive output is to verify correct system operation and give the operator a feel for ongoing operations. This output can be suppressed by keyboard commands. When the foreground processing finds no label data in the input queue it yields processing time to any background program which may be in progress.

Since background programs normally involve outputting data from the files to the printer or the paper-tape punch through a buffer arrangement similar to input interrupt handling, operation is effectively interleaved. The data terminal appears to be simultaneously outputting a message on the teletype, listing a report on the printer, and accepting data from interrogators.

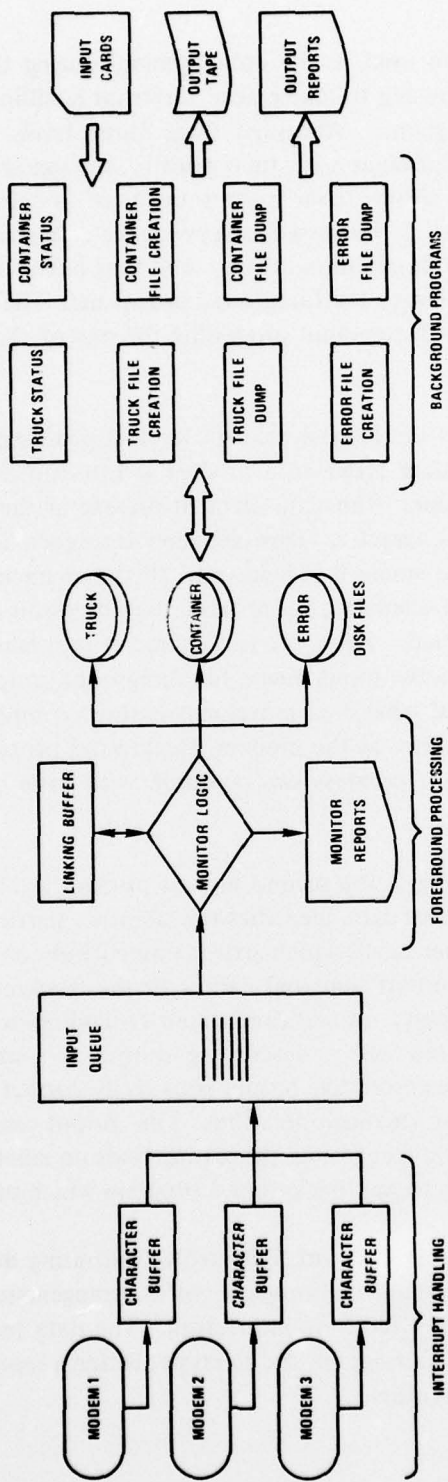


Figure 8. MICRO-Marker Data Terminal Processing.

```

@ 2043 TRUCK 19MC365435 DEP TERM FOR BEACH WITH CONTAINER 04131
@ 2051 TRUCK 19MC371755 ARR AREA FROM BEACH EMPTY
@ 2101 TRUCK 19MC365316 ARR AREA FROM BEACH EMPTY
@ 2104 TRUCK 19MC365448 ARR AREA FROM BEACH EMPTY
@ 2115 TRUCK 19MC365366 DEP TERM FOR BEACH WITH CONTAINER 04851
@ 2116 TRUCK 19MC365316 DEP TERM FOR BEACH WITH CONTAINER 06522
@ 2117 TRUCK 19MC365440 ARR AREA FROM BEACH EMPTY
@ 2118 TRUCK 19MC371755 DEP TERM FOR BEACH EMPTY ✓
@ 2120 TRUCK 19MC365440 DEP TERM FOR BEACH EMPTY
@ 2121 TRUCK 19MC365300 ARR AREA FROM BEACH EMPTY
@ 2123 TRUCK 19MC365447 DEP TERM FOR BEACH WITH CONTAINER 03889
@ 2124 TRUCK 19MC365358 ARR AREA FROM BEACH EMPTY
@ 2126 TRUCK 19MC365448 DEP TERM FOR BEACH EMPTY ✓
@ 2130 TRUCK 19MC365445 DEP TERM FOR BEACH EMPTY ✓
@ 2134 TRUCK 19MC365300 DEP TERM FOR BEACH WITH CONTAINER 07002 ♦
@ 2140 TRUCK 19MC365440 ARR AREA FROM BEACH EMPTY
@ 2143 TRUCK 19MC365435 ARR AREA FROM BEACH EMPTY
@ 2148 TRUCK 19MC365440 DEP TERM FOR BEACH WITH CONTAINER 04398
@ 2149 TRUCK 19MC365316 ARR AREA FROM BEACH EMPTY
@ 2151 TRUCK 19MC365435 DEP TERM FOR BEACH WITH CONTAINER 09745
@ 2156 TRUCK 19MC365448 ARR AREA FROM BEACH EMPTY
@ 2201 TRUCK 19MC365300 ARR AREA FROM BEACH EMPTY
@ 2205 TRUCK 19MC365316 DEP TERM FOR BEACH WITH CONTAINER 04304
@ 2208 TRUCK 19MC365440 ARR AREA FROM BEACH EMPTY
@ 2209 TRUCK 19MC365300 DEP TERM FOR BEACH WITH CONTAINER 04451 ○
@ 2210 TRUCK 19MC365448 DEP TERM FOR BEACH WITH CONTAINER 04833
@ 2210 TRUCK 19MC365358 DEP TERM FOR BEACH EMPTY
@ 2215 TRUCK 19MC365440 DEP TERM FOR BEACH WITH CONTAINER 06678
@ 2224 TRUCK 19MC371726 ARR AREA FROM BEACH EMPTY
@ 2226 TRUCK 19MC371720 ARR AREA FROM BEACH EMPTY
@ 2228 TRUCK 19MC365435 DEP TERM FOR BEACH WITH CONTAINER 03953
@ 2228 ERROR ON CHANNEL 2 = 10SAC007458
@ 2228 TRUCK 19MC365300 ARR AREA FROM BEACH EMPTY
@ 2232 TRUCK 19MC365366 ARR AREA FROM BEACH EMPTY
@ 2235 TRUCK 19MC365316 ARR AREA FROM BEACH EMPTY
@ 2236 TRUCK 19MC371726 DEP TERM FOR BEACH WITH CONTAINER 04110 ■
@ 2237 TRUCK 19MC365300 DEP TERM FOR BEACH WITH CONTAINER 04853 ★
@ 2238 TRUCK 19MC371755 ARR AREA FROM BEACH EMPTY
@ 2241 TRUCK 19MC371720 DEP TERM FOR BEACH WITH CONTAINER 03682
@ 2243 TRUCK 19MC365316 DEP TERM FOR BEACH WITH CONTAINER 07510
@ 2246 TRUCK 19MC365447 ARR AREA FROM BEACH EMPTY
@ 2247 TRUCK 19MC365445 ARR AREA FROM BEACH EMPTY
@ 2250 TRUCK 19MC365366 DEP TERM FOR BEACH WITH CONTAINER 03805
@ 2259 TRUCK 19MC371755 DEP TERM FOR BEACH WITH CONTAINER 03791
@ 2259 TRUCK 19MC365440 ARR AREA FROM BEACH EMPTY
@ 2259 TRUCK 19MC365316 ARR AREA FROM BEACH EMPTY
@ 2306 TRUCK 19MC365435 ARR AREA FROM BEACH EMPTY
@ 2307 TRUCK 19MC365300 ARR AREA FROM BEACH EMPTY
@ 2308 TRUCK 19MC365440 DEP TERM FOR BEACH EMPTY
@ 2310 TRUCK 19MC365316 DEP TERM FOR BEACH EMPTY
@ 2310 TRUCK 19MC365447 DEP TERM FOR BEACH WITH CONTAINER 03831
@ 2312 TRUCK 19MC365445 DEP TERM FOR BEACH WITH CONTAINER 04271 ▲

```

Figure 9. Example of Terminal Messages.

The most important function of foreground processing is, however, the updating of the data file structure established for the J-LOTS exercise. This file structure contains three data files – a truck file, a container file, and an error file. Both the truck file and the container file contain item records which can be accessed directly based on the label number.

Each item record contains administrative data relative to the equipment to which the label is attached and has reserved space for the information acquired by the system. This acquired information includes date, time, location, and the truck/container association established by the foreground processing. The administrative data for truck records are limited to bumper number, unit identification, and route identification. The more extensive administrative data for containers consist of an 80-character zone for an image of an Army Standard Port System (SPS) discharge tally document (DIC U52). This document contains important transportation information such as the consignee, transportation control number, and container serial number. It can be altered to produce a variety of SPS documents. In addition to item records, the truck and container files both contain cross-reference sections which allow accessing the asset records based on truck bumper number or container serial number.

The third data file, the error file, contains all interrogator inputs which could not be identified as a truck or a container. Typically, the data accumulated in this file consist of labels which are not in the truck or container files or data which have become garbled in transmission.

The MICRO-Marker Data Terminal accumulated data for J-LOTS in several ways. Whenever the system was functioning, monitor output was produced by the teletypewriter as in Figure 9. Data were allowed to accumulate in the file structure until the end of each J-LOTS phase when the files were zeroed. At the end of each shift, however, the current file data were output. Examples of these outputs are shown in Figure 10 for the truck file and in Figure 11 for the container file. Examination of these examples shows the different ways the data were accumulated. The truck file can be used conveniently to generate utilization reports. The container file is set up to produce reports concerning containers and the associated transportation documentation. Note that the container records contain a complete SPS DIC U52 image. The three outputs have been cross-referenced with chart symbols to show their accumulation of data relative to the same event.

To trace the transaction identified by the diamond (◆), first note that in Figure 9 the monitor reports that Marine Corps truck number 365300 departed the terminal for the beach with container 7002 at 2134 hours. Next observe that in Figure 10, the truck file, the same information appears. The truck in question was identified by label number 745 and passed location 3 (the exit) in direction 1 (towards

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TRUCK NO. 743 TRUCK I.D. 19MC321224 READ COUNT 20

DATES	TIMES	LOCATIONS	DIRECTIONS	CONTAINERS
7225	1710	2	1	0
7225	1717	3	1	372 5339
7225	1809	2	1	550 3978
7225	1846	3	1	188
7225	1928	2	1	188 4729
7225	1934	3	1	188
7225	2224	2	1	0
7225	2236	3	1	569 4110 m
7225	318	2	1	0
7225	325	3	1	618 7488
7225	421	2	1	0
7225	430	3	1	592 4568
7225	819	2	1	0
7225	840	3	1	227 3882
7225	851	2	1	227
7225	930	3	1	398 3511
7225	1021	2	1	0
7225	1208	2	1	0
7225	1314	2	1	0
7225	1448	2	1	0

TRUCK NO. 744 TRUCK I.D. 1724119051 READ COUNT 5

DATES	TIMES	LOCATIONS	DIRECTIONS	CONTAINERS
7225	1910	3	1	0
7225	1930	3	1	0
7225	1955	2	1	0
7225	2002	3	1	0
7225	1125	2	1	0

TRUCK NO. 745 TRUCK I.D. 19MC365300 READ COUNT 24

DATES	TIMES	LOCATIONS	DIRECTIONS	CONTAINERS
7225	1655	2	1	0
7225	1700	3	1	127 4570
7225	1725	2	1	0
7225	1733	3	1	379 4495
7225	1810	2	1	0
7225	1832	2	1	0
7225	1847	3	1	491 5372
7225	2121	2	1	0
7225	2134	3	1	585 7002 ♦
7225	2201	2	1	0
7225	2209	3	1	171 4451 ○
7225	2228	2	1	0
7225	2237	3	1	28 4853 *
7225	2307	2	1	0
7225	2324	3	1	573 4837
7225	318	2	1	0
7225	330	3	1	598 4559
7225	806	2	1	0
7225	836	3	1	489 4142
7225	920	2	1	0
7225	1041	3	1	312 4010
7225	1125	2	1	0
7225	1245	2	1	0
7225	1426	2	1	0

TRUCK NO. 746 TRUCK I.D. 1LABEL:746 READ COUNT 0

Figure 10. Example of Truck File Data.

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LABEL NO. 28 COUNT 1
 * U52 CARD
 U52 04853 W26RKL 757 HN 9994 1M9 ZC SM310071A0V249KXX 383
 0001 12052 1280

COUNT STATUS BEACH AREA DEF
 1 (110: 0) 0: 0/ 0 7224: 402/ 63 7225:2237/ 45

LABEL NO. 171 COUNT 1
 o U52 CARD
 U52 04451 999000 694 9N 9994 1M9 ZZ A26TAM71A0V821KXX 062
 0001 05740 1280

COUNT STATUS BEACH AREA DEF
 1 (110: 0) 0: 0/ 0 7224: 251/ 13 7225:2209/ 45

LABEL NO. 549 COUNT 1
 ■ U52 CARD
 U52 04110 W26RKL 576 JN 9994 1M9 ZC SM040071A0V643KXX 097
 0001 40000 1280

COUNT STATUS BEACH AREA DEF
 1 (110: 0) 0: 0/ 0 7224: 628/ 65 7225:2236/ 43

LABEL NO. 585 COUNT 1
 ♦ U52 CARD
 U52 07002 999000 694 9N 9994 1M9 ZZ A26TAM71A0V800KXX 071
 0001 05740 1280

COUNT STATUS BEACH AREA DEF
 1 (110: 0) 0: 0/ 0 7224:1003/ 43 7225:2134/ 45

Figure 11. Example of Container File Data.

the beach) pulling the container identified by label 585. Note in passing that this file record contains 24 reads for truck 365300 or 12 round trips and has cross-reference numbers for 12 containers, although not all of these are shown in the figure. Finally, observe in Figure 11 that the container identified by label 585 is container 7002. Note that the container commodity code (694) indicates it was empty, the POD (1M9) is Fort Eustis and the Transportation Control Number (TCN) was A26TAM71A0V800KXX. It can also be observed that container 7002 arrived the previous day (7224) at 1003 hours pulled by the truck identified by label number 43 (USMC bumper number 371726). While this information is incoded for file storage, it is obvious that an appropriate background computer program can present the information desired by a particular user in a convenient format.

The file structure was used by background programs to generate system output. The background programs, stored on one of the disk units, were executed as desired by terminal keyboard commands. Various interactive user programs were written for the J-LOTS exercise. One typical program would output the last location of a truck and what it was transporting upon entry of the truck's bumper number. This program could also print a listing of all observations of the truck, including the containers moved. Another program could punch a paper tape in 80-column image of SPS documents. This tape was suitable for input to the AUTODIN network for forwarding the data to the SPS main computer. There were also programs to create or alter the file structure as well as output, or "dump," each file.

Although the framework of this operating system was suitable for any container terminal, the detail coding of the routines was tailored specifically to the J-LOTS exercise. This was done to save the time and expense of creating general programs when the only projected use was for this exercise. A completely generalized system, which can be set up rapidly for a particular location can be written during the next stage of development.

5. Conduct of Operations. The labels were attached to the containers (Figure 12) before they left the marshalling yard at Norfolk International Terminal. This operation took place from 13 July to 20 July 1977. Only one label was applied to each container, since all containers were to be placed upon the chassis with doors rearward to allow each container to be unloaded by ramp and forklift truck without being removed from its chassis. The label was located on the right side, facing the doors, 6 feet from the rear and 1½ feet from the bottom edge. The label was attached by 1/16-inch double-back foam tape to facilitate application and later removal. A label was attached to each truck on its curbside approximately 6½ feet from the ground during 3 through 6 August 1977. The container or truck number was recorded next to the electronic label number on a pretyped list to create a cross-reference table for both types of equipment. The cross-reference tables were then keypunched to provide input to the data terminal.

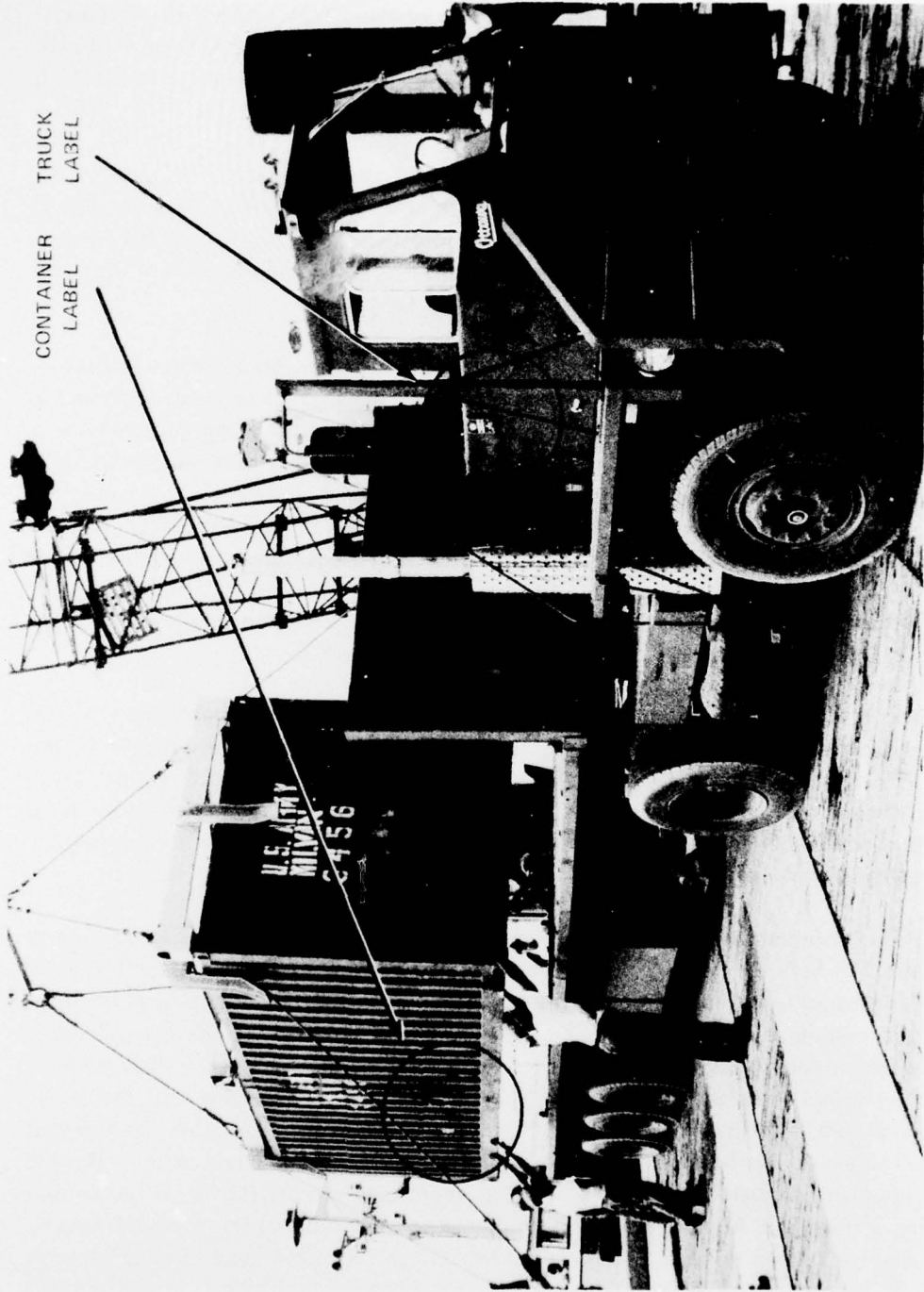


Figure 12. Position of Labels on Truck and Container.

The three interrogators and the data terminal were transported in the data van from the MERADCOM Testing Area at Fort Belvoir to Fort Story, on 26 July 1977. The data van is a 20-foot insulated refrigerator container converted for use as a shelter for the data terminal and necessary equipment. The van can accept either 110- to 220-Vac, single-phase or 220-Vac, three-phase power with minimal on-site changes. For J-LOTS, power supplied was 220-Vac, three-phase. The van was set up in the marshalling area (Figure 1). Interrogators were located on the right side of the road at points 1 (leaving the beach), 2 (entering the marshalling area) and 3 (departing the area) as indicated on the map. This was for the final traffic pattern which established one-way movement of containers along the route. All interrogators were powered from 110-Vac outlets. Data communication to the data terminal was via existing telephone lines which were available at all locations. Although, initially, one interrogator was located just inside the marshalling area with a field wire connection to the data terminal, this interrogator was moved to the location shown in Figure 1, since the movement of heavy equipment persisted in breaking the field wire.

J-LOTS was conducted over a 19-day period from 31 July 1977 to 18 August 1977 in three phases. There were two shifts per day. Day-to-day MICRO-Marker operation is described in the Chronology of Events (Appendix).

III. DISCUSSION

6. System Performance. The interrogators failed a number of times during the course of the exercise, although, one interrogator, serial number 001, operated throughout the exercise. Another, serial number 002, had a minor manufacturing problem which caused occasional failure of its digital processing circuit and a period of intermittent operation. After five failures, the problem was eventually diagnosed as a fleck of loose solder on one of the circuit boards. Although troublesome during field operations, this sort of problem can generally be expected in hand-built prototypes, with little burn-in time. Interrogators 001 and 002 were rebuilt for J-LOTS and had few operating hours prior to the exercise. The third interrogator, serial number 004, was the advanced development model which had performed well for over a year, throughout engineer design testing and quality testing of the labels being manufactured for J-LOTS. This interrogator's modem failed because of overheating and was replaced by a backup unit. Later, its microwave oscillator failed and was sent to the manufacturer twice before successful repair was accomplished. Both of these failures demonstrate weaknesses in the detail design of the subassemblies involved. The necessary redesign of temperature compensation circuits and other changes can be readily and economically accomplished in the final design of the interrogator. The required equipment characteristics are well within the state-of-the-art.

The data terminal also experienced occasional failures. The processor halted at random intervals. It could be restarted immediately and would continue to function correctly until the next random halt. Although it was impossible to determine the cause of these failures, the most likely reason was random electrical "noise" on the input data or power lines. This sort of problem is not unusual in the deployment of commercial minicomputers, although it had not occurred previously with this system. There are numerous solutions to this, and for a mobile-unit, electromagnetic interference (EMI) suppression measures would be applied routinely.

This problem did not occur during a 48-hour period of Phase II of the exercise. This was sufficient for a good comparison of manual and automatic data.

In order for the operator to obtain a feel for the accuracy obtainable by the system, the data acquired during a portion of Phase II were compared to data taken manually by the Marine Corps. Figure 13 is an example of the USMC data. The USMC times for departing the marshalling area, indicated by "DMP," and arrival at the beach, "BCH," were taken before and after the MICRO-Marker interrogator, respectively. The examples used have also been referenced here by corresponding symbols. The example using the diamond symbol shows container 7002 departing the marshalling area at 2130 hours and arriving the beach at 2137 hours. This corresponds to the automatically recorded time of 2134 hours. It should be noted that the MICRO-Marker system recorded a number of empty truck movements not recorded by the USMC.

An exhaustive comparison was carried out for the period 1130 hours, Friday, 12 August (Julian date 7224) to 1100 hours, Sunday, 14 August (Julian date 7226). The results of this comparison indicated a 99-percent correspondence between USMC and MICRO-Marker data for trucks. The correspondence for containers was 84 percent. If the USMC data are assumed to be highly accurate, it can be presumed that these percentages represent the approximate accuracies achieved by the developmental model system on its first operational exercise. The truck accuracy is about as anticipated. An analysis of the container errors will be made to establish corrective measures. A preliminary review indicates that most of the errors were due to operating conditions, typically either the container had been placed on the trailer backwards or the label had fallen off the container. These are the only conditions which differ appreciably from the truck reading conditions.

DATE	7225	CONT.#	4131	TRAC.#	365435	TRLR.#	377234	DMP	2039	BCH	2047
DATE	7225	CONT.#	4851	TRAC.#	365366	TRLR.#	5068	DMP	2108	BCH	2119
DATE	7225	CONT.#	6522	TRAC.#	365316	TRLR.#	377270	DMP	2110	BCH	2120
DATE	7225	CONT.#	3626	TRAC.#	371755	TRLR.#	377277	DMP	2112	BCH	2124
DATE	7225	CONT.#	3889	TRAC.#	365447	TRLR.#	364425	DMP	2117	BCH	2128
DATE	7225	CONT.#	3995	TRAC.#	365448	TRLR.#	377258	DMP	2120	BCH	2129
DATE	7225	CONT.#	3681	TRAC.#	365445	TRLR.#	388136	DMP	2126	BCH	2133
DATE	7225	CONT.#	7002	TRAC.#	365300	TRLR.#	377272	DMP	2130	BCH	2137
DATE	7225	CONT.#	4598	TRAC.#	365440	TRLR.#	330034	DMP	2143	BCH	2150
DATE	7225	CONT.#	9745	TRAC.#	365435	TRLR.#	377234	DMP	2146	BCH	2155
DATE	7225	CONT.#	4304	TRAC.#	365316	TRLR.#	377270	DMP	2200	BCH	2217
DATE	7225	CONT.#	4451	TRAC.#	365300	TRLR.#	377272	DMP	2203	BCH	2214
DATE	7225	CONT.#	4833	TRAC.#	365448	TRLR.#	377258	DMP	2205	BCH	2215
DATE	7225	CONT.#	6678	TRAC.#	365440	TRLR.#	330034	DMP	2206	BCH	2221
DATE	7225	CONT.#	3953	TRAC.#	365435	TRLR.#	377234	DMP	2223	BCH	2236
DATE	7225	CONT.#	4110	TRAC.#	371726	TRLR.#	364359	DMP	2230	BCH	2240
DATE	7225	CONT.#	4853	TRAC.#	365300	TRLR.#	377272	DMP	2231	BCH	2242
DATE	7225	CONT.#	3682	TRAC.#	371270	TRLR.#	364354	DMP	2236	BCH	2251
DATE	7225	CONT.#	7510	TRAC.#	365316	TRLR.#	377270	DMP	2238	BCH	2244
DATE	7225	CONT.#	3805	TRAC.#	365366	TRLR.#	5068	DMP	2244	BCH	2253
DATE	7225	CONT.#	4271	TRAC.#	365445	TRLR.#	388136	DMP	2249	BCH	2316
DATE	7225	CONT.#	3791	TRAC.#	371755	TRLR.#	377277	DMP	2253	BCH	2314
DATE	7225	CONT.#	3831	TRAC.#	365447	TRLR.#	364425	DMP	2302	BCH	2317

Figure 13. Example of Marine Corps Data Taken Manually.

IV. CONCLUSIONS

7. **Conclusions.** Although the MICRO-Marker System experienced hardware failures during the J-LOTS operation, it demonstrated the ability to rapidly output data descriptive of ongoing operations. The operation also showed that the technology base is satisfactory for accomplishing the task, although specific performance parameters are yet to be formulated.

The software interface between MICRO-Marker and existing reporting systems is critical in reaping the maximum benefit from the interrogating system.

APPENDIX

CHRONOLOGY OF EVENTS

Friday, 5 August 1977 – The interrogators were positioned and made operational. The modem on the beach interrogator (Serial 004) failed and was replaced with a back-up unit. Labels were attached to the trucks of the 119th Transportation Company. Data terminal reprogramming required by a last minute change in traffic pattern was undertaken. Reprogramming and attendant debugging were continued through Friday night until 0600 hours 6 August in an effort to be operational at the beginning of Phase I.

Saturday, 6 August 1977 – Phase I operations commenced. Although the bulk of the reprogramming effort was completed, minor flaws precluded correct operation. Labels were attached to the U.S. Marine Corps trucks. Several U52 cards, MICRO-Marker's input from SPS (Standard Port System), were not available at this time.

Sunday, 7 August 1977 – The foreground processing software was completed. This portion of the system appeared to function properly. The labeling of trucks was completed. The communication line to the marshalling area interrogator was knocked down, apparently by a 50K RT FLT. The data terminal teletypewriter malfunctioned, intermittently echoing the improper characters.

Monday, 8 August 1977 – A vendor field-service representative repaired the teletypewriter. The interrogator (Serial 002) which was located at the exit to the marshalling area failed because of a loose connector. Part of this day was used reprogramming background programs. During operational periods of the day the computer program halted on an irregular and seemingly random basis. This behavior was to continue throughout much of the operation.

Tuesday, 9 August 1977 – The data communication field wire to the marshalling area interrogator was again broken by heavy equipment. The interrogator (Serial 002) at the marshalling yard exit became inoperable because of malfunctioning of its digital circuitry. The beach interrogator (Serial 004) failed. Its symptom was extremely low microwave output. Part of the time during this day was spent debugging the background computer programs.

Wednesday, 10 August 1977 – The digital problem in the interrogator (Serial 002) was corrected by a manufacturer's representative, and the unit was returned to service. A few hours later, however, it malfunctioned again. The problem with the beach interrogator (Serial 004) was diagnosed as a faulty solid-state oscillator transistor.

The oscillator was returned to the manufacturer for repair. The background programs were finalized. The irregular program halts continued. The interrogator (Serial 002) at the marshalling area entrance was relocated to reduce the vulnerability of its communications lines.

Thursday, 11 August 1977 – Phase II operations commenced. The interrogator (Serial 002) at the marshalling area entrance malfunctioned intermittently, was repaired, and returned to service. The computer file record of the container and truck movements for Phase I were printed out. The computer files were cleared and reinitiated with a new deck of U52 cards for Phase II input. The problem with irregular halts became less prevalent.

Friday, 12 August 1977 – The beach interrogator oscillator (Serial 004) was reinstalled, and the interrogator was returned to service.

Saturday, 13 August 1977 – The beach interrogator (Serial 004) again failed (early Saturday morning). The symptoms were as before – no microwave output. The computer functioned without irregular halts and operated throughout the night. Phase II retrograde commenced at 1600 hours.

Sunday, 14 August 1977 – The marshalling area exit interrogator (Serial 002) failed at 1100 hours. The marshalling area entrance interrogator (Serial 001) was repositioned at the exit to gather retrograde container movements.

Monday, 15 August 1977 – The marshalling area interrogator (Serial 002) was repaired. (A tiny metal chip was responsible for the intermittent problems.)

Tuesday, 16 August 1977 – Phase III operations commenced. The records for Phase II were printed out and the files cleared. Two interrogators were operational, at the entrance and exit to the marshalling area. It was observed that at least 50 percent of the containers had been placed on the chassis backwards. Labels were removed from the containers at the GSSA area. The problem mentioned previously concerning irregular program halts began to recur.

Wednesday, 17 August 1977 – In the late afternoon, the ± 15 -Vdc terminal modem power supply failed during an electrical storm. Removal of labels from the containers in the marshalling area was begun.

Thursday, 18 August 1977 – The data van and equipment were secured for transportation. Removal of labels was largely completed.

Tuesday, 23 August 1977 – The system was retrograded to Fort Belvoir, Virginia.