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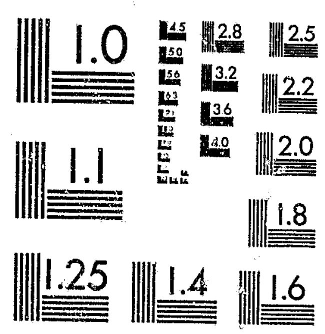

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National Institute of Justice
United States Department of Justice
Washington, D.C. 20531

MF-1

85156

METROPOLITAN POLICE DEPARTMENT
MAN-PORTABLE DIGITAL
COMPUTER TERMINAL STUDY

FINAL REPORT

GOALS

1. Demonstrate the feasibility of providing foot officers with inexpensive direct-access to computerized data banks.

2. Direct access was to be gained without the aid or intervention of a radio dispatcher.

3. Direct digital inquiries were to be fast, readable, in plain text so that the officer could use the device with a minimum of training.

4. Focus upon portability and versatility.

5. Radio channel congestion reduction.

ACCOMPLISHMENTS

1. Two distinctly different prototype computer terminals were engineered and built which would enable any police officer to access the WALES data base directly, from any location where the officer's radio would transmit and receive.

   The terminals, although larger than what might be considered optimum, are completely portable and capable of being carried anywhere the officer goes, by whatever means the officer used to travel.

2. Direct access to the WALES, MILES (Maryland Interagency Law Enforcement System), and NCIC, was accomplished with software developed for this project. Each mini-computer was programmed to reformat inquiries for acceptance into WALES and responses were edited to provide only that information necessary for the street officer to make a decision. For example, if a tag number entered by the officer turns out to be stolen, it isn't necessary for the officer to know at that time any additional information; the mere fact that the car is stolen is sufficient "probable cause" to enable the officer to take some action.

3. The direct digital inquiry for these systems is accomplished without any dispatcher intervention, thereby giving the radio dispatcher more time to devote his/her attention to emergency calls. Direct access means that the officer on the street can query the data base for non-critical information during busy hours without creating animosity with the radio dispatchers.

4. Monitors were built into the system which alert the radio dispatcher, by audible signal, whenever one of the terminals have made a hit on an inquiry. This allows the dispatcher to ascertain from the officer, by means of standard voice transmission, if any additional assistance or information is needed. No hit responses are returned to the requesting unit without alerting the dispatcher; however, all transmissions are displayed for the dispatcher's information.

5. The systems were designed to keep the usage as simple as possible. Software allows the inquiry to be made by simply identifying the file to be accessed with the first alpha character in the file name; i.e., the letter V would indicate that the inquiry is being made on a vehicle identification number. The normal WALES format requires that a four letter code be entered for any inquiry.

Additionally, where the WALES format required a slash after the initial file code, the digital system software supplies the slash along with the proper four letter alpha code.

6. All inquiries and responses to the terminals are in plain text. No coding or deciphering is required on the part of the user. With 30 minutes training and about 4 hours of actual use, any officer can become proficient with the terminal.

7. Both type of terminal was engineered and built with portability the uppermost consideration. The terminal can be operated in a scout car, from a motor scooter, on foot patrol, or from a fixed location which make it a far more versatile tool than existing computer hardware. Because this terminal uses a portable radio as its communications medium, it is as portable as the radio it plugs into.

8. Although radio channel congestion was not appreciably reduced during the test period, this experiment showed that a reduction could be achieved. For the test period of this grant, a voice overlay scheme was employed. In such an environment where digital is in contention with and must always be inferior in priority to voice, little reduction in air congestion was forthcoming. However, through a traffic analysis study it was determined that there would be substantial radio and dispatcher relief with a dedicated radio channel. (See Appendix A - Computer Sciences Report - Sec. 3).

REVIEW OF SPECIAL CONDITIONS FOR HAND-HELD TERMINAL PROJECT 3304

1. The Metropolitan Police Department agreed to adhere to reporting requirement established by LEAA, to administer finances according to the grant application, and to subject ourselves to standard conditions of the grant.

2. The Metropolitan Police Department has gathered documentation relating to the systems, and it will be made available upon request to any authorized user in the criminal justice community.

3. A complete set of documentation is available to the Systems Development Division, Office of Criminal Justice Assistance, LEAA, upon request.

4. The Metropolitan Police availed themselves of existing software where practicable and therefore its vendors needed only special modifications to handle the specialized tasks of this project.

5. This project utilized mini-computer interfaces with existing systems. Both vendors used existing software which was written primarily for the mini-computer used. Therefore, neither COBOL nor FORTRAN were used.

6. All reports submitted under this grant are original material. Where material from other sources was used, the appropriate notations have been made crediting the source.

7. All contracts entered into under this grant were awarded by means of the competitive bid process. All contracts received approval from LEAA prior to award.

8. The Metropolitan Police Department conducted field tests of the equipment developed under this grant in accordance with the original grant application. A copy of the complete results is appended to this report.

9. Requests for Proposal soliciting bids and the distribution list was submitted to LEAA for approval prior to release.

10. The contract to hire Computer Sciences Corporation to perform an analysis of the entire project, was submitted to, and approved by, LEAA.

REVIEW OF SPECIAL CONDITIONS FOR HAND-HELD TERMINAL PROJECT 3311

1. All of the special conditions enumerated here have been complied with as so stated in the preceding special conditions statement for grant 73-SS-99-3304.

2. The Metropolitan Police Department and the vendors involved in this grant did not use or reveal any criminal history information for any purpose other than the purpose for which it was intended. There was no criminal history information collected or stored in relation to this project. The criminal history information disseminated was done so by means of the terminals developed under this grant and only for law enforcement purposes. The hard copy terminal transactions are available upon request.

3. The special condition was satisfied in like manner to that of Special Condition No. 7 in grant 73-SS-99-3304. There was no sole source procurement in either grant.

4. A revised program schedule including significant milestones was submitted to LEAA within 60 days after the grant award, the duration of which was not to exceed sixteen months.

5. Special Condition No. 5 was waived by Grant Adjustment Notice No. 1, dated July 1, 1974.

6. Travel authorized under this grant was limited to less than first class, and per diem did not exceed $25 per day.

7. The Metropolitan Police Department applied the special conditions of grant 73-SS-99-3304 and 74-SS-99-3311 to each other on an equal basis.

FINAL REPORT TO LEAA

RE: 73-SS-99-3304
74-SS-99-3311

This will constitute the final report from the Metropolitan Police Department regarding the conclusion of LEAA grant 73-SS-99-3304 and supplemental grant 74-SS-99-3311 which were awarded for the development and field testing of a hand-held, man-portable, digital computer terminal.

In order to best present this report, it will be broken down into four major areas: A) Background, B) Development, C) Testing, D) Present System. In addition, there will be reports highlighting the pertinent developmental aspects with Burroughs and Electromagnetic Sciences, Inc., as well as the final comprehensive technical reports submitted in compliance with their contracts. Finally there will be an evaluation from M.P.D.C. based upon data gathered during the testing.

BACKGROUND

The Metropolitan Police Department for the District of Columbia, like many metropolitan police agencies throughout the United States, experiences considerable overcrowding of their existing radio voice communications network at peak hours. Air time during typical police busy periods is at a premium and only those messages of critical importance are given high priority. Much of the voice traffic now consists of a variety of inquiries to the Washington Area Law Enforcement System (WALES).

WALES is a very large, comprehensive computerized criminal justice system which was developed by M.P.D.C. and serves not only M.P.D.C., but the surrounding jurisdictions. Included in the data base are the standard criminal justice files such as, vehicle registration information, wanted persons information, and a multitude of other files not pertinent to this report. WALES also has direct communications with the NCIC System, the Maryland Interagency Law Enforcement System (MILES), and NLETS. Access to NCIC and MILES is accomplished automatically within the WALES software and requires no operator initiation other than the original request.

Direct access to the WALES system is accomplished through a large telecommunications network, a portion of which is installed at the various radio dispatch positions. This system provides officers on the street with computerized information through the radio dispatcher and at the latter's convenience. Normally this environment is adequate; however, during peak hours when the dispatchers are extremely busy, routine requests are not handled in as timely a fashion as might be desired. One solution to this problem was considered to be direct access digital terminals, on the street.

Direct Access systems were then available from several vendors and each system seemed to function adequately. The units were installed in the front of a scout car and associated equipment was installed in the trunk.

These systems allowed the officers on the street, in a car, to access the computer files direct without any dispatcher intervention. The technique was, and is, very acceptable in many environments. The one problem with such a setup is that in an all portable radio network there are no provisions for officers not assigned to scout cars and these large terminals are not versatile--scout car use is the only use. Consequently, M.P.D.C. personnel felt that something smaller, more versatile, even portable would better serve the needs of the policeman of the future. M.P.D.C., like many jurisdictions was moving toward a totally portable radio system which would give an officer communications regardless of the assignment, whether scout car, scooter patrol, or foot patrol. Therefore, some device was needed which would be small, durable, easy to operate, compatible with the portable radios, and be capable of digital communications.

DEVELOPMENT

After having presented this idea to the Law Enforcement Assistance Administration, and the idea having been accepted with the award of a grant, requests for proposals were distributed. Responses to this unique proposal were many and varied. The choice of a vender was narrowed to two--The Burroughs Corporation and Electromagnetic Sciences Incorporated. Both proposals were good, and both money bids were very close to each other; however, each presented a different concept of what the terminal should be like. A decision was made, because of the diverging engineering philosophies, to conduct parallel development and testing. This would enable M.P.D.C. to study several features simultaneously and at the conclusion of the test, select the best features for an optimum piece of equipment. The results follow:

BURROUGHS CORPORATION

The Burroughs Corporation submitted to the M.P.D.C. a proposal to design, develop and manufacture a compact, rugged, reliable and cost-effective hand-held, man-portable digital computer terminal. The system as proposed by Burroughs would consist of 5 engineering model terminals, an audio interface, an interface channel with M.P.D.C.'s data base and a dispatcher's display. The audio interface is designed to be handled by means of a Burroughs B700 mini-computer, the software for which will accept inputs, reformat them and forward them to M.P.D.C.'s data base (WALES). The mini-computer will receive WALES output, convert them for terminal acceptance and forward these responses to the appropriate terminal.

The design concept for the terminal to be developed was described as having a display of 32 characters, a keyboard, digital functions, modulator/demodulator, and a power converter. The display to be used

was Burroughs own plasma display 5 x 7 dot matrix model SSD0132-0040. The keyboard arrangement was proposed in several forms--1. 40 key, full alpha-numeric. 2. "Ouija-board" type with a slider to be moved. 3. 16 key full alpha-numeric with letter control keys to select alpha character. The final selection was a full 40 key alpha-numeric keyboard in straight alphabetic order as opposed to the standard typewriter keyboard arrangement. The case dimensions as originally conceived and in final form were very close. The terminal was box shaped with dimensions 9" x 4-3/8" h. x 2-1/2" w. and the final size was 9-1/2"l.x5-1/2" h. x 2-3/4" w. (136 in^3).

Software which was to be resident in the mini-computer was going to be designed to perform the following functions:

1. Handle input from the terminals.
2. Make error checks on received messages.
3. Creates "acknowledge" message, and sends it.
4. Buffers inquiries in a queue.
5. Reformats inquiry messages for WALES.
6. Display input messages, both as received and as reformatted, on dispatcher's display.
7. Handles input/output from 370/158 interface.
8. Display WALES messages on dispatcher's display.
9. Edits, makes "hit" decisions on received data according to criterion established.

10. Reformats data in 32 character form for terminal.
11. Transmits response to terminal.
12. Holds transmitted data until next inquiry received from that terminal.
13. Continues to collect WALES output.
14. Prints a record of each transaction; terminal number, operation code, type of response, time.

Contracts were signed September 1974 and initial talks began. A decision was made early to emulate an IBM Model 2740 communications terminal as opposed to the IBM 3270 display terminal, the latter of which constituted the preponderance of terminals in the WALES system. This decision was made on advice of M.P.D.C. technical staff who felt that the line discipline for the 2740 was simpler than for the 3270.

In retrospect, this may not have been such a wise choice. The decision was also made to interface with the 370/158 through a single input channel operating on a multipoint line in a pole/select mode. This too was made in the interest of simplicity as well as efficiency. At this same time an agreement was reached that for the field trial, only five files would be available to the hand-held terminal. The five files were: Vehicle license tag file, vehicle identification number (serial number) file, operator's license number file, wanted name file, and bicycle registration number file. These inquiries were called

respectively--Tag, Vin, Permit, Name, and Bike; and to access one of these files the operator merely had to enter the first alpha character in the file name, i.e. "B" for bike file.

From this point onward the entire system began to evolve and the terminal itself began to take shape. The system was to provide direct digital access to WALES, MILES and NCIC. A Burroughs B711 processor provides an interface between the existing audio network and the WALES data base. The B711 processor receives FSK modulated digital inputs from the hand-held terminals; reformats these inquiries for WALES acceptance, and forwards them on. The reverse process takes place for WALES responses which are scanned, edited, and compressed by the B711 for transmission to the HHT.

The hand-held terminals themselves were not designed with the capability to transmit data by other than conventional means such as a wire. The terminals are not communications devices, but merely input devices which use existing radio communications to transmit data. The M.P.D.C. utilizes the General Electric portable radio (Model PR-25) for a part of its communications system, which is primarily a UHF system using several satellite receivers to pick up the signal and transmit it via telephone lines to a communications center where the signal is amplified and retransmitted through a repeater system. The repeated signal is received through a monitor and is then fed to the dispatching consoles.

At the dispatching console there is a transmit and receive pair of lines which picks up signals for the B711 processor. When FSK tones, recognizable to the mini-computer, are sensed the processor allows the message to be stored in input buffer.

When a digital message is received in the buffer it must be reformatted for acceptance by the WALES system. The mini-computer software determines the type of inquiry being made, adds the proper format header, appends the correct identifier and forwards the request to WALES, the same as any other standard terminal inquiry is made. The mini-computer is configured to emulate an IBM Model 2740 terminal, and to the WALES it is just another terminal. Internally, in WALES inquiries are routed to NCIC and MILES when the request indicates these systems should be queried.

Responses to inquiries follow the same general route as inquiries, in reverse. However, when the typical WALES response is received in the mini-computer, there is a considerable amount of editing necessary. Very early in the project, M.P.D.C. decided that simplicity would be the key to making the experiment a success. Therefore, responses to terminal inquiries would only contain enough information to allow the officer on the street to make an intelligent decision and take positive action. For example, if an officer's license plate check reveals that

the auto is stolen, this information alone allows that officer to take positive action. It isn't necessary at that moment that the officer have all of the pertinent information contained in the WALES record. This information will be available at the station for the officer at any subsequent time. The theory was to utilize these terminals to augment and enhance the current system, not to replace existing equipment.

The Burroughs final report which is a part of this report (Appendix B), explains in detail the procedure and technique employed to achieve the results described above. This report gives an excellent description of the system in very clear terms.

<u>ELECTROMAGNETIC SCIENCES INCORPORATED</u>

On July 5, 1974, the Metropolitan Police Department entered into a contract with Electromagnetic Sciences Incorporated, Atlanta, Georgia, to develop and build 5 hand-held, man-portable computer terminals and a system to facilitate use of these terminals. This was a parallel project with the Burroughs Corporation, Paoli, Pennsylvania.

A proposal from E.M.S. was submitted to develop, install, and test a hand-held, man-portable digital computer terminal. E.M.S.' system was envisioned to:

1. Minimize energy requirement.
   Design goals were established for eight-hour operation.

2. Small size 8-1/2" h. x 3-1/2" w. x 1-3/4" d. (52 in^3) weight w/o battery 2 lbs.

3. Weatherproof terminal.

4. Simple interface between transceiver and terminal.

5. System capability with existing CPU.

The proposal design provided for a full alpha-numeric capability (12 keys) and 3 special character keys. The 12 data keys are arranged in a manner similar to a touch-tone telephone. The display used is a 5 x 7 dot matrix, 16 character display, plasma type manufactured specially by the Burroughs Corporation. The original design called for an on/off switch, but was discarded in favor of a normal condition of power off. When the officer wants to use the terminal, the clear button is depressed which activates the terminal and it automatically powers down after 15 seconds from the last keyboard entry. This technique was employed in an effort to conserve power and reduce battery drain.

The Central Electric Unit will contain the necessary circuitry to regulate message traffic and will contain a mini-computer. A Modular Computer Systems Model II/10 is incorporated in the system and will provide:

1. Interface with the WALES CPU.

2. Interface with control and display unit.

3. Means for editing messages from WALES.

4. Message cuing.

5. Buffer memory.

6. System functional flexibility.

The CEU is connected to WALES through a standard modem and appears as any remote terminal in the system.

In the initial phase of design considerations, M.P.D.C. staff and E.M.S. staff met in Atlanta and mutually agreed upon the design approach to be employed. At this time decisions affecting the final configuration of the system, and the makeup of the terminals, were made. "10 Code" labels were discarded because they are not used in M.P.D.C. communications extensively; however, the option for their use remains in the terminal. A decision was made to identify the inquiry type with an alpha character in lieu of the original numeric designation. This was in an effort to simplify the operation for the officer on the street. It is simpler for an officer to remember that for a VIN (Vehicle Identification Number) check the alpha character "V" is used instead of the number 8. The message switching capability originally planned was discarded in the interest of simplicity and because the system was going to share a voice channel. The capability exists for message switching if desired in future applications. An agreement was reached that keyboard operation would take precedence over any message emanating from the CEU. This means that when an officer started composing a message to be transmitted, the message would not be interrupted by incoming responses from previous transmissions. In the absence of an acknowledge message from the CEU, indicating reception of the transmission without error, the hand-held terminal (HHT) would automatically retransmit its message three times. If no acknowledgement is received at this juncture, the operator must recompose the message and initiate another transmission. A "fail safe" CEU operation was discussed which would provide minimal functioning of the CEU in the event the main system failed; however, design time and cost precluded this option from becoming a reality. The only indication that the officer on the street has that the system is not working is failure to receive responses to inquiries. If WALES is down, software in the mini-computer will automatically send a message to the terminal in response to an inquiry, but if the CEU is inoperative the terminal gets no response. A high speed paper tape reader was requested to be added to the system and provisions were made to exercise the purchase option in the original contract to facilitate timely loading of the systems software in the event of failure. The data rate between the CEU and WALES was agreed upon at 1200 baud.

The initial proposal submitted indicated that E.M.S. was considering

two display systems for the HHT. The first alternative was to employ 4 Hewlett-Packard Model 5082-7101, 5 x 7 dot matrix LED display units. Cost and power consumption exceeded desirable limits however, so an alternative display was considered better. An unique display system using light emitting film was developed by Signatron Corporation in Santa Barbara, California, which required only 80% of the Hewlett-Packard power and cost only one half as much. Unfortunately before the terminal was engineered, the LEF displays had to be abandoned because they could not be obtained by E.M.S. Hewlett-Packard displays were also rejected in favor of the Burroughs plasma type display which E.M.S. considered to be better suited for the project. The Burroughs display however, was larger and necessitated a physical change in the HHT from rectangular to its present "T" shape.

The system as it is currently installed was very clearly described in non-technical language by E.M.S. in technical bulletin 050175-6 which is attached to this report (Appendix C) and gives an excellent outline of the sytem's operation. The final report of this project submitted by E.M.S., although non-technical, does provide a further description and is also included in this report for clarity (Appendix D).

TESTING

The first system (EMS) was installed in June 1975 after several technical delay problems. Like all new systems there were many bugs to be ironed out and it was July before any of the terminals actually were tested on the street. Much of the initial street use was with personnel from Data Processing and there was a period of overcoming the toy value of the terminal. There were two problems which became immediately apparent to the terminal operator, one serious and the other not so serious.

After the terminals had been in use for about two days, it was obvious to all involved with the project that parasiting power from the PR-25 radio battery was going to produce disastrous results. With nominal terminal usage and a randomly selected fully charged nicad battery, power would be drained in 20 to 40 minutes. There would still be enough energy to operate the radio, but the terminal would not function. Under these conditions an officer on the street would have two choices during a tour of duty: 1. Operate the terminal only once or twice an hour or 2. Carry 8 batteries with him each tour of duty. The latter choice of course is out of the question, and the first option defeats the intended purpose of the equipment. As a result of these findings EMS engineers built a battery box which would hold two nickel cadmium batteries, of the type used in the PR-25, which quadrupled the operating time of the terminal. Although this is not what would ultimately be considered as ideal, it allowed a more realistic evaluation of the equipment on the street. The battery box is built to the dimensions of a PR-25 (3-3/8" w. x 1-11/16" d. x 8-7/16" h.) With this addition to the terminal (the battery box was built to fit where the PR-25 had previously been carried), it meant that the officer now had to carry the radio separately and actually added another piece of equipment. Needless to say, this design change was not met with overwhelming enthusiasm, however, the officers did not completely reject the equipment.

Another problem which was initially experienced with the EMS terminals was radio transmission bleed from the frequency used to other frequencies on the police network. Those officers using other voice networks would complain bitterly about the digital tones bleeding over into their channels. This phenomenon was caused by modulation inside the PR-25 produced by noise introduced on the battery terminals by the HHT. A power filter was designed and installed in each terminal and the problem is only sporadically experienced now, and is immediately cleared up by a freshly charged battery.

There have been minimal failures with the terminals and the only modification other than those pointed out before was the addition of a coil cord connection for the PR-25 radio which was necessitated by the battery box change.

Officers using the terminals on the street would quickly become frustrated with this terminal and tend to discontinue usage. Most of the frustration stemmed from their inability to be able to transmit a message when it had been composed because of voice traffic, and losing the message when the terminal powered down. This was an extremely frustrating experience. Due to F.C.C. regulations the terminals had to be designed so that they would wait for a clear channel to transmit, and when operating in conjunction with voice traffic, transmissions oftentimes were lost.

After the system had been installed, many software problems were encountered which kept the system down initially a good portion of the time. EMS support to correct these deficiencies however was good. Most of the problems are discussed in the EMS final report, Appendix D. The areas where most of the trouble occurred were isolated in that section of the program which handled the communications with WALES. During the test period the WALES control language was upgraded from FASTER M/T to CICS (Customer Information Control System), both standard IBM products; however, the line character stream is somewhat different between them. This caused some problems but software changes were made and the system now works well.

While officers were using the terminals on the street they found that it was possible to keep the terminal powered up while waiting for air-time by continuing to activate the "RECALL" button. What ultimately would happen however, is that battery life was shortened considerably; 8-9 watts of power is necessary when the unit is powered up.

The communications technique, while simple, caused some problems with terminal users. The operating instructions are attached as Appendix E. Basically what happens is the officer must depress the "CLEAR" button to power on the terminal; then the message is composed; at this point, if the channel is clear, the "INQ" button is depressed. This causes the message to be transmitted. Under optimum conditions the transmission will be accepted and an acknowledgement will be returned. If there are no messages waiting for that terminal the word "ACKNOWLEDGE" will be displayed, indicating to the officer that the inquiry is being processed. If there was a message waiting for the officer, that message would automatically be transmitted. Frequently one of two things would occur. Either the message would not be acceptable to the mini-computer or the acknowledge message would not be accepted by the terminal. If the first condition existed the terminal would automatically retransmit 3 times and then power off. The problem was that officers were never sure, because frequently the "ACK" message would be obliterated by voice indicating non-acceptance when in fact the inquiry was being processed. When the officer re-sent the same inquiry, response to the first message would be displayed, leaving the officer confused.

The most difficult operation to get accomplished was the acknowledgement from the terminal which was activated by the officer. This operation allowed the message to be deleted from the queue stack. If the officer failed to acknowledge, or if the acknowledge message did not get through, the terminal continued to receive the same message over and over. There is no automatic redundant transmission cycle of the acknowledge because of the possibility of inadvertently destroying answers not seen by the officer.

The majority of problems experienced during the street testing period stemmed from the radio communications and from the officer's failure to follow instructions on usage of the terminal. The radio communications accounted for about 75% of the problem and much of this would be eliminated with a dedicated digital frequency. Surely with additional familiarization the second problem would be overcome. It became obvious as the project grew older that officers were having less trouble getting responses to their inquiries as they used the terminals more.

Testing according to the grant was to be simultaneous. That is to say that EMS and The Burroughs systems were to be tested at the same time on the street using the terminals in a real environment.

A test of this type would allow officers to have an opportunity to use each type of terminal and decide which features of which terminal were most desirable.

Burroughs, due to some unforeseeable problems was unable to deliver their system until July 1975 and normal startup snafus delayed the field testing until August. As with the EMS system, Burroughs experienced unforeseen software bugs and some minor hardware problems.

Once the Burroughs terminals were delivered to officers in the field, an immediate reaction was forthcoming. Although the terminal was described as hand-held it was more realistically a man-portable terminal. Officers reaction was very strong that the terminal was too large and far too heavy. The unit is about the size of a standard 50-cigar box and weighs approximately 5 lbs. Of the several officers introduced to the terminal, only one felt that its size and weight was not intolerable; a female officer who stated that it was not so different from a handbag. The terminal comes with a strap attached which was designed to go around the officer's neck allowing the terminal to be supported by the left hand and resting against the officer's abdomen. This setup was rejected by the officers who used the terminal because they did not want to have such a piece of equipment hanging around their necks.

Like the EMS display, Burroughs used their own product line, the 5 x 7 dot matrix plasma display--32 character. The same problems were encountered with sunlight. In direct sunlight the displays would wash out even though the displays were mounted behind a polarized filter.

Officers assigned to foot patrol did not use these terminals because of the size and weight; however, scooter patrol officers were assigned the equipment. The scooter officers had no technical problems with the equipment; however, they did not want to carry the terminals because they were afraid of dropping one while operating the scooters. Officers remarked that the snaps on the shoulder strap did not appear strong enough. Although this opinion prevailed, no snap malfunctions were recorded during the test period. The results of these opinions caused the testing of the Burroughs terminal to be conducted primarily from scout car and tactical car patrol.

Because the Burroughs unit had its own power source, this unit was very effective in the scout car when the officer would place his PR-25 in the "in-car" charger and utilize the vehicle's additional transmit power and antenna system. Officers found that when operating the terminal in a car without a charger, reception was spotty. The test also revealed that by adding an external portable antenna to the PR-25 reception improved markedly.

The reception was a critical part of the entire communications technique with the Burroughs terminal the same as with EMS. If reception on the PR-25 was marginal the "ACK" "NACK" handshaking which was crucial would not occur and the message would not be completed. The Burroughs terminal is equipped with 3 LED's which aid the operator in transmission. These are most aptly described on pages 3-5 of Appendix B. What most commonly occurred with the terminal when in a marginal reception area was that the ACK coming back from the processor would not be received, causing an error condition to appear when in fact the message was to be handled. The operator, not realizing this, would re-enter the request and as a result several answers to several identical requests would be queued up which frustrated the user. A software change allowed suppression of responses to contiguous identical entries which alleviated the problem to some degree.

The officers were not as frustrated with the Burroughs terminal as with EMS because the inquiry remained in memory until cleared by the operator or until the terminal was turned off. The terminal was engineered so that in an idle state (no display) power consumption was minimal. This condition allowed for data to remain in the display buffer until erased by incoming traffic or cleared by the operator. Even though the display would go off in 15 seconds, the message was not lost and the operator merely had to depress the "XMT" key to transmit.

The "XMT" key also caused some problems until complete familiarization of the terminal was accomplished. It is best to explain the sequence of operation to illustrate how the "XMT" key became troublesome. When an inquiry is ready for transmission, the operator waits for a clear channel and depresses the "XMT" key, the LED alongside the "XMT" button will light briefly and go out indicating a clear transmission. When the response to an inquiry is ready, the mini-computer transmits an "ENQ"signal to the terminal which lights the LED marked "PRESS ACK TO RCV." When the operator presses the "ACK" button, the "STAND BY TO RCV" LED lights while the message is being transmitted. When the message is stored in the terminal display memory, the "MSG RCVD" LED lights up. At this point the operator, according to instructions, is supposed to depress the "ACK" button a second time which automatically displays the message while simultaneously transmitting the acknowledgement to the mini-computer facilitating deletion of that response from the queue. What apparently happened most frequently is that the operators would become oriented to the LED's to the extent that they were prompting the responses from the officers. Because the LED "MSG RCVD" is just below the "XMT" button, the natural tendency was to depress that button. In so doing the operator inadvertantly re-transmitted the last stored message. Consideration was given to making the "XMT" button inoperative once a transmission was completed, and not reactivate it until the message response had been properly displayed. This change was not made in the interest of expense and the problem was not debilitating to the system.

A complete set of operation instructions is attached as Appendices E (EMS) and F (Burroughs). Both final reports explain in detail the operation of the respective systems.

EVALUATION

The test period covered six months from the time which both systems were installed and operational. An evaluation of the two systems was conducted, under separate contract, by Computer Sciences Incorporated and a copy of the results of their finding is attached as Appendix A. It would be redundant for this report to reiterate the findings and recommendations reflected in Appendix A and therefore the following observations will be those made from personal contact with the equipment and from conversations with the various users.

Obviously to the casual observer of the two terminals, the EMS is superior to the Burroughs in one major respect--size. This is critical because on first sight the officers assigned to use the equipment would balk and make every effort to keep from having to take the equipment out. A terminal which must be in excess of two pounds and which is larger than a PR-25 radio, will not be acceptable to officers on the street. Size was the most criticized feature of either terminal.

Keyboard design was a feature that was not as controversial as expected. Although, the EMS, 16 character keyboard was cumbersome to use, the officers tolerated it without complaint. When asked which keyboard they preferred, the Burroughs 40 key was the first choice. Most officers would like to have seen the full alpha-numeric on the smaller terminal. With few exceptions a straight alphabetical keyboard arrangement was desired over the typewriter arrangement.

The 16 character display with column roll was described as satisfactory. Officers felt that 16 characters was enough display at one time as long as there was some additional storage capability. Most officers who used the 32 character terminal didn't see the necessity of 32 characters, however, in the event of a "hit," the information was instantaneous whereas with the 16 character display a program change was made to begin a "hit" message with an asterisk. A good compromise would employ the marqueing effect coupled with a 32 character display and buffer space.

Perhaps one of the most significant deficiencies with the EMS terminal was that there was no memory protect capabilities. We realize that power considerations were the reason behind this, however, had this feature been a part of the terminal, usage would have been greater. Inquiries for the terminals would run about three to one in favor of the Burroughs unit. There is no way to measure frustration, but in conversations with EMS users, it soon was obvious that loss of an inquiry through the power down feature was critical. An additional problem which caused the power down was the amount of voice traffic on the channel.

For the test a channel was selected which theoretically had no voice traffic except in emergency situations. Of prime consideration was the fact that the channel selected was available on every radio within the M.P.D.C. These two factors seemed to make an ideal environment in

which to test the terminals over a standard voice link. What was not anticipated was the frequency with which this channel was used for emergency transmissions. Also, each time maintenance was being performed on another channel, the emergency channel was used. With this inordinate amount of voice traffic, the terminals had great difficulty transmitting, consequently the displays would power off before the channel would clear and in the case of EMS, the message was lost. All too often the message was simply forgotten and never re-entered. Protected display memory would have surely solved this problem.

The normal WALES "hit" rate is between 8% and 9%. During intensified test usage periods with the digital terminals, the "hit" rate on the terminals was about 17%. The phenomenon is not easily explained and one can only assume that the hit percentage increased with the system availability and the fact that the type of inquiries lend themselves to be hits more than an average number of times. The overwhelming majority of terminal inquiries were vehicle registration information, whereas the normal WALES inquiries are spread among several different files. During this abbreviated intensified test period, based upon the "hits" made which included unpaid parking fines; a potentially recoverable amount of nearly $8,000 was revealed. In a jurisdiction which has a huge number of unpaid traffic violations, such a device would soon prove its worth.

The Metropolitan Police Department was able to conclude from this experiment that a device such as was developed and tested is a viable tool for law enforcement. Certainly it must be refined and redesigned but one should remember that 15 years ago calculators were larger than typewriters and could only perform basic math problems; today one can buy a wristwatch with a calculator built in which will do many mathematical calculations. Future terminals should be more versatile and provide extended capabilities for officers on the street.

Development of the technology employed in this experiment proved that the limits of such a device are bounded only by the imagination of the user. As an example, future terminals will probably be modular to the extent that the body of the terminal will be standard and the display medium will be flexible. A "plug in" type display medium would allow the foot patrol officer to use a small plasma display or a small printer (printers are available which are no larger than a pack of cigarettes and consume less power than the display used in the experiment); and would allow the unit to be used in a scout car with a larger display such as 256 character type available off-the-shelf. The potential is unlimited. This test has proven conclusively that technology has reached the capability of producing a hand-held, portable computer terminal inexpensively. Only the future can determine to what extent development will improve the product. The Metropolitan Police Department is grateful for having been

able to advance the cause of research in the field of law enforcement and we are certain that this worthwhile tool will someday become as familiar as the policeman's portable radio.

MAN-PORTABLE DIGITAL COMMUNICATIONS SYSTEM STUDY

FINAL REPORT

Prepared for
GOVERNMENT OF THE DISTRICT OF COLUMBIA
METROPOLITAN POLICE DEPARTMENT
Washington, D.C. 20001

MARCH 1976

COMPUTER SCIENCES CORPORATION

6565 Arlington Boulevard

Falls Church, Virginia 22046

Major Offices and Facilities Throughout the World

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SECTION 1

INTRODUCTION

Computer Sciences Corporation (CSC) is pleased to submit this Final Report on the Man-Portable Terminal Study for the Metropolitan Police Department (MPD) of Washington, D.C. (Contract No. 1048-AA-NS-0-5-FA). The purpose of the study was to test and evaluate the man-portable digital communication systems delivered to the MPD by the Burroughs Corporation and Electromagnetic Sciences, Inc. (EMS). The study was divided into two major parts:

1. Comparison of digital operation, using the pilot systems, with current voice operation

2. Comparison of the Burroughs and EMS systems.

As dictated by contract terms, the evaluation of the two systems did not include any cost considerations. All evaluations were purely technical and CSC's recommendations contained in this report are made on technical grounds only.

CSC wishes to thank Sergeant Charles Peacock and the other 39 MPD officers who participated in this study.

SECTION 2

SUMMARY OF RESULTS

The concept of a man-portable digital communication system is technically feasible. Digital operation with such a system is superior to current voice operation in terms of response time, radio channel loading, queuing time for access to a radio channel, and the number of WALES inquiry/response transactions per unit time. Implementation of a digital system would significantly increase officer productivity with respect to WALES inquiries, with an associated increase in the number of hits. Assuming that the relationship between hits and inquiries is similar for voice and digital operation, we predict an increase in the number of hits using the digital terminals of over 3 to 1 (see Paragraph 5.1). Thus, the digital systems will be of significant value to the MPD.

An important finding of this study is that a separate digital channel is mandatory for digital operation (Paragraph 5.2). The voice/data interference on a shared channel was judged intolerable by the CSC evaluators and most of the police officers who participated in the study. Besides eliminating voice/data interference, a separate digital channel allows a much larger number of transactions to be performed during busy periods. On shared channels, voice has a virtual monopoly of the channel and digital transactions are only possible between voice transmissions--an impractical method of operation. Our conclusion regarding the need for a separate digital channel confirms the pre-study opinion of the MPD.

The comparison between the Burroughs and EMS systems revealed that both were inadequate for the MPD in their present form. We believe that a practical system can be designed to incorporate the strengths and eliminate the weaknesses of both systems. A summary of a specification for such an "ideal" system is contained in Section 8. Overall, we have rated the Burroughs system slightly superior, mainly on the basis of its communications discipline and its ability not to lose messages after the unit "powers down". Section 6 contains the detailed comparison of the systems.

Results of the officer survey are shown in Section 7. The survey indicated that officers were generally negative in their evaluation of the digital systems. This was primarily due to the physical aspects of the digital terminals and voice/data interference on the radio channel. This interference prevented digital messages from "getting through" after repeated attempts--a great source of annoyance to frustrated police officers. We expect that modification of the physical characteristics of the terminals (Section 8) and the use of a separate digital channel will remove most of the officers' objections.

In summary, we recommend that the MPD continue in its program for the implementation of a digital communication system in Washington. Section 9 contains specific recommendations.

SECTION 3

DEFINITIONS

WALES - Washington Area Law Enforcement System.

NCIC - National Crime Information Center.

MILES - Maryland Inter-Agency Law Enforcement System.

TAG INQUIRY - Inquiry on motor vehicle license plate number.

Permit Inquiry - Inquiry on operator's permit number.

Bike Inquiry - Inquiry on bicycle registration number (D. C. requires mandatory bicycle registration).

VIN - Vehicle Identification Number.

Transaction - A WALES inquiry/response cycle originated by a police officer in the field. Transaction can also include NCIC and MILES responses.

Voice Transaction - A transaction in which the inquiry from the officer and the response to the officer is in the voice mode and only the dispatcher actually accesses the computer system.

Digital Transaction - A transaction originating at a digital terminal accessing WALES via a front-end minicomputer.

Type T Transaction - Transactions that can be originated at a digital terminal (e.g., TAG, NAME, VIN, PERMIT, and BIKE).

Voice Radio Channel - Current radio channel.

Digital Radio Channel - Radio channel dedicated to digital communications.

Voice Operation - Voice type T transaction on a voice radio channel.

Digital Operation - Digital type T transactions on a digital radio channel.

Radio Time of Transaction - Time that radio channel is occupied in the inquiry/response process associated with a transaction.

System Response Time - Time between end of an inquiry and beginning of associated response.

Duration of Transaction - Time between officer access to the radio channel to make an inquiry and end of associated response.

Queuing Time - Time spent by officer in waiting for access to the radio channel.

Busy Hour - Busiest hour during the day in terms of activity on current radio channels.

Radio Relief - Reduction in current voice radio channel loading due to transfer of Type T transaction to a separate channel.

Dispatcher Relief - Reduction in dispatcher workload due to conversion of Type T transactions to the digital mode.

Queuing Time Relief - Reduction in queuing time on current radio voice channels due to transfer of type T transactions to a separate channel.

Radio Channel Utilization - Fraction of time that radio channel is occupied.

Terminal Activity - Number of transactions per hour originating at a terminal.

Peaking Factor - Number of transactions during busy hour divided by average number of transactions per hour for the same day.

SECTION 4

DIGITAL SYSTEM DESCRIPTION

Each of the two systems evaluated by CSC consists of a man-portable terminal (Figures 4-1 and 4-2), a minicomputer, and the existing MPD Radio System. The man-portable terminal is used to enter TAG, NAME, VIN, PERMIT and BIKE inquiries and receive WALES responses and, if applicable, NCIC and MILES responses. Inquiries to NCIC and MILES are automatically made by WALES without operator involvement. The minicomputer acts as the interface between the terminals and the WALES system.

The operation of the digital system evaluation can be explained by referring to Figure 4-3. After the user has entered his inquiry, using the terminal keyboard, he pushes the TRANSMIT button. A modem in the terminal changes the data to audio frequency shift keying (FSK) tones and this signal is fed to the officer's radio, which broadcasts it on frequency F1. The satellite receivers scattered about the city receive the signal and send it over leased telephone lines to the GE Voting Logic, which selects and locks onto the strongest signal. This FSK audio signal is fed to the minicomputer and, as for voice operation, to the line amplifier input and dispatcher's speaker. The minicomputer is equipped with a modem which converts the FSK audio signal back to digital data form for processing. The minicomputer then sends an inquiry to the WALES computer.

When the WALES computer responds, the minicomputer interprets the response, selects the portion of the response to be sent out, encodes it for transmission and sends it to the associated modem. The modem changes the data signal to FSK audio form and sends it via the line amplifier to the base transmitter which broadcasts it as frequency F2. The patrolman's radio receives this response signal and supplies it to the terminal as an FSK audio tone. The terminal modem demodulates the FSK to derive the data and displays the response message on the alphanumeric display panel. In a similar series of exchanges, the user acknowledges the WALES response, the system sends the NCIC and MILES responses, and the user acknowledges again to conclude the transaction and remove the messages from minicomputer storage.

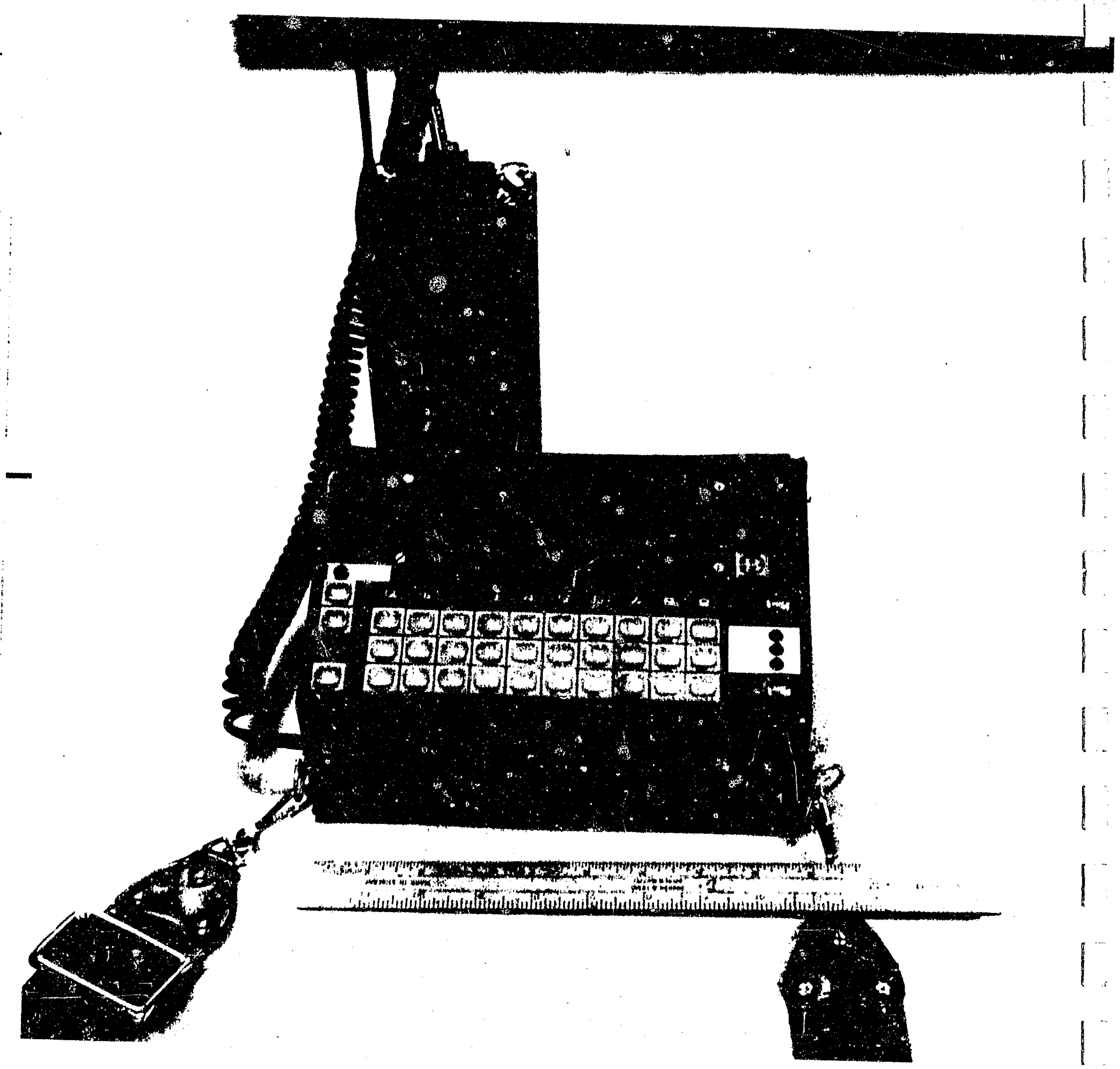


Figure 4-1. Burroughs Terminal

Figure 4-2. EMS Terminal

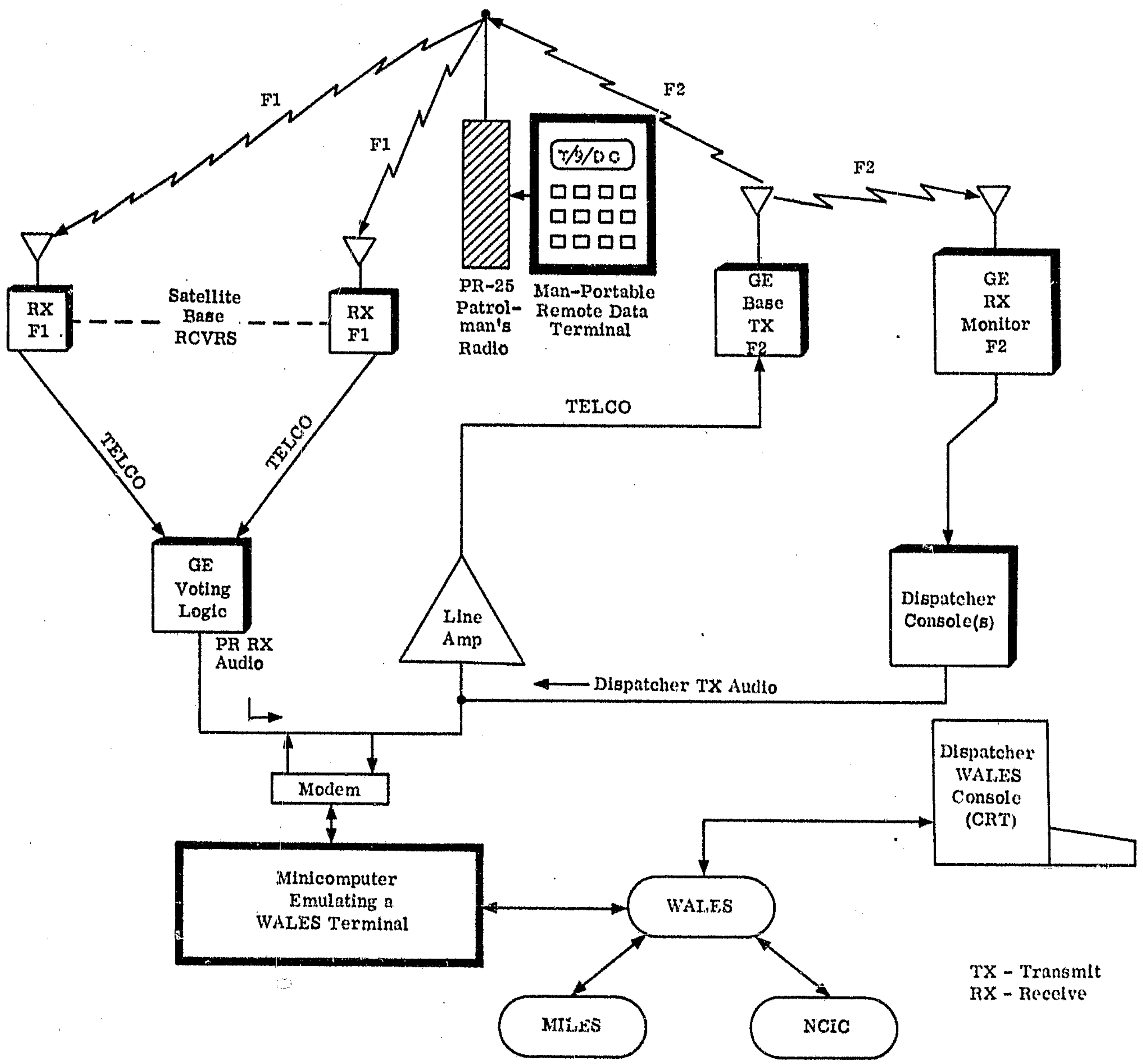


Figure 4-3. Digital System Layout

SECTION 5

COMPARISON OF VOICE AND DIGITAL MODES OF OPERATION

A comparison of voice and digital operation was one of the two major objectives of this study. As described in Paragraphs 5.1 through 5.4, our analysis revealed that digital operation is superior to voice operation for Type T transactions, in terms of radio system loading, queuing time for access to radio channels, number of transactions per hour, and security.

5.1 TRAFFIC ANALYSIS

The purpose of the traffic analysis was to compare voice and digital operation from the traffic viewpoint. Five measures of performance were used in this comparison:

- Average radio time per transaction
- Average system response time
- Average duration of transaction
- Average queuing time for access to radio channel
- Number of transactions during busy hour.

These terms are defined in Section 3.

In performing the comparison, we assumed that voice transactions take place over a typical existing voice radio channel using conventional officer-dispatcher voice inquiry/response; and that digital transactions were carried out using a dedicated digital radio channel and digital terminals. As stated earlier, we did not consider digital operation feasible without a separate channel dedicated to such operation.

As part of the traffic analysis, CSC assessed the reduction in the dispatcher's workload and the reduction in voice channels loading and queuing time resulting from the implementation of digital operation. The following variables are measures of these improvements:

- Dispatcher relief

- Radio relief
- Queuing time relief.

Thus, eight variables were used to measure the impact of digital operation - five to compare how quickly Type T transactions can be carried out under each mode of operation, and three to measure the voice system relief resulting from the use of digital terminals.

5.1.1 Summary of Results

The traffic analysis revealed that digital operation is clearly superior to voice operation for Type T transactions, as shown in Table 5-1. Improvement factors for the five performance variables ranged from 3.1 to 8.3, and result from two fundamental differences between the two modes of operation. First, the improvement in average radio time per transaction comes from short radio bursts between terminal and mini-computer replacing the relatively long voice interchanges between officer and dispatcher. Next, the average response time is drastically reduced in the digital mode because the transaction bypasses the dispatcher who is the major element of delay in voice operation during the busy hour. This delay is due to the large workload imposed on the dispatchers, not any inefficiencies on their part. It is this improvement in average radio time per transaction and average system response time that causes the improvements in the remaining three measurements of performance in Table 5-1. This will become evident as the study method is described in subsequent paragraphs.

Table 5-2 summarizes the relief in radio voice channels resulting from digital operation. The figures in this table are based on the assumption that all Type T transactions currently performed in the voice mode will be removed from the voice channel entirely and transferred to a digital channels. This assumption is not strictly true. However, as described in Paragraph 5.1.2.5, we have judged it to be close enough for a valid estimate of radio relief.

Consistent with the preceding assumption, the figures in the "With Digital Operation" column apply to non-type T voice transactions, since these are the only ones that would still be performed in the voice mode.

Table 5-1. Comparison of Voice and Digital Operation For Type T Transactions (1)

Measure of Performance	Voice	Digital	Improvement Factor (2)
Average Radio Time per Transaction (Sec.)	25.4 (Table A-1)	8.2 (Table 5-8)	3.1
Average System Response Time (Sec.)	113.7 (Table A-1)	25.0 (Text)	4.5
Average Duration of Transaction (Sec.)	139.1 (Table A-1)	39.9 (Table B-1)	3.5
Average Queuing Time for Access to Radio Channel (Sec.)	22.5 (Table 5-6)	2.7 (Text)	8.3
Average Number of Transactions During Busy Hour	80 (Table 5-5)	280 (Text)	3.5

(1) Quantities are from referenced tables. "Text" indicates that figure is derived in text of report.

(2) For example, improvement factor for Average Radio Time per Transaction = 25.4/8.2 = 3.1.

Table 5-2. Dispatcher/Radio Relief[1,2]

	Existing	With Digital Operation	Relief
Dispatcher Active Period During Busy Hour	60 min (Table 5-5)	54.9 min [3]	6.1 min (Table 5-5) (10.2%)
Radio Channel "In Use" During Busy Hour	36 min (Table 5-6)	29.9 min [3]	6.1 min (Table 5-5) (16.9%)
Queuing Time for Voice Channel During Busy Period (Table 5-5)	22.5 sec	15.0 sec	7.5 sec (33.3%)

(1) Quantities come from referenced tables. "Text" indicates that figure is derived in text of report.

(2) Figures apply to busiest existing channel (District 6/7).

(3) Figure is derived by subtracting figure in "Relief" column from that in "Existing" column.

The dispatcher and radio reliefs resulting from digital operation will be modest, approximately 6 minutes during the busy hour in the busiest channel, since the majority of transactions carried out on current voice channels are not Type T. Therefore, transfer of such transactions to a digital channel will only have the modest effect shown in the figure. Even this small impact will only be felt if terminals can be used in cars, since this is where the majority of Type T transactions currently originate.

The queuing time for access to the radio channel will be reduced by one-third even though the radio relief is only about one-tenth. This is due to the large sensitivity of queuing time to variations in radio channel loading. In summary, digital operation is markedly superior to current operation in the voice mode in terms of the five measurements of performance used in this study (Table 5-1). Voice system relief, although not substantial, is a positive byproduct of conversion to digital operation.

5.1.2 Study Method

As described earlier, the purpose of the traffic analysis was to compare voice and digital operation for Type T transactions, and assess voice system relief resulting from conversion to the digital mode. Since results of the analysis are contained in Tables 5-1 and 5-2, the study objectives can be viewed as the calculation of quantities required to prepare these two tables. Therefore, the study objectives can be summarized as the calculation of:

1. Average radio time per transaction - voice
2. Average system response time - voice
3. Average duration of transaction - voice
4. Average number of transactions during busy hour - voice
5. Radio relief
6. Dispatcher relief
7. Average queuing time for access to radio channel - voice
8. Average radio time per transaction - digital
9. Average system response time - digital
10. Average duration of transaction - digital

11. Average queuing time for access to radio channel - digital
12. Average number of transactions during busy hour - digital

Items 1 through 4 and 7 through 12 were required for the voice-digital comparison of Table 5-1. Items 5 through 7 were needed for the voice system relief assessment summarized in Table 5-2.

Figure 5-1 depicts the traffic analysis procedure. This figure shows how each of the 12 study objectives was achieved. Each box in the table represents a calculation process, and identifies the figure/table/appendix where the process has been carried out. The figure also shows the inputs/outputs associated with each process, and, in particular, states exactly where, in the string of processes, each of the 12 study objectives is achieved. For example, Objective 11, Average Queuing Time - Digital, is achieved by performing processes associated with Tables 5-7, 5-8, and 5-9 and Figures 5-2 and 5-3. Calculations associated with each objective are described in the following paragraphs.

5.1.2.1 Objective 1 - Average Radio Time/Transaction - Voice

The basic input for this objective, as well as for Objectives 2, 3, 6, and 7, is the raw traffic data shown in Appendix A. This data was obtained by monitoring radio channels for Districts 4 and 6/7, mostly during busy periods, until 100 complete Type T transactions could be pieced together. For this study, a voice Type T transaction was assumed to consist of three elements:

- Transmission of inquiry from officer to dispatcher
- Waiting time by officer (response time)
- Transmission of response from dispatcher to officer.

The sum of the times for inquiry and response transmissions is the radio time for a particular transaction. The officer's request for dispatcher attention, the dispatcher's acknowledgment of that request, and the officer's acknowledgment of the dispatcher's response are of negligible duration and have been disregarded.

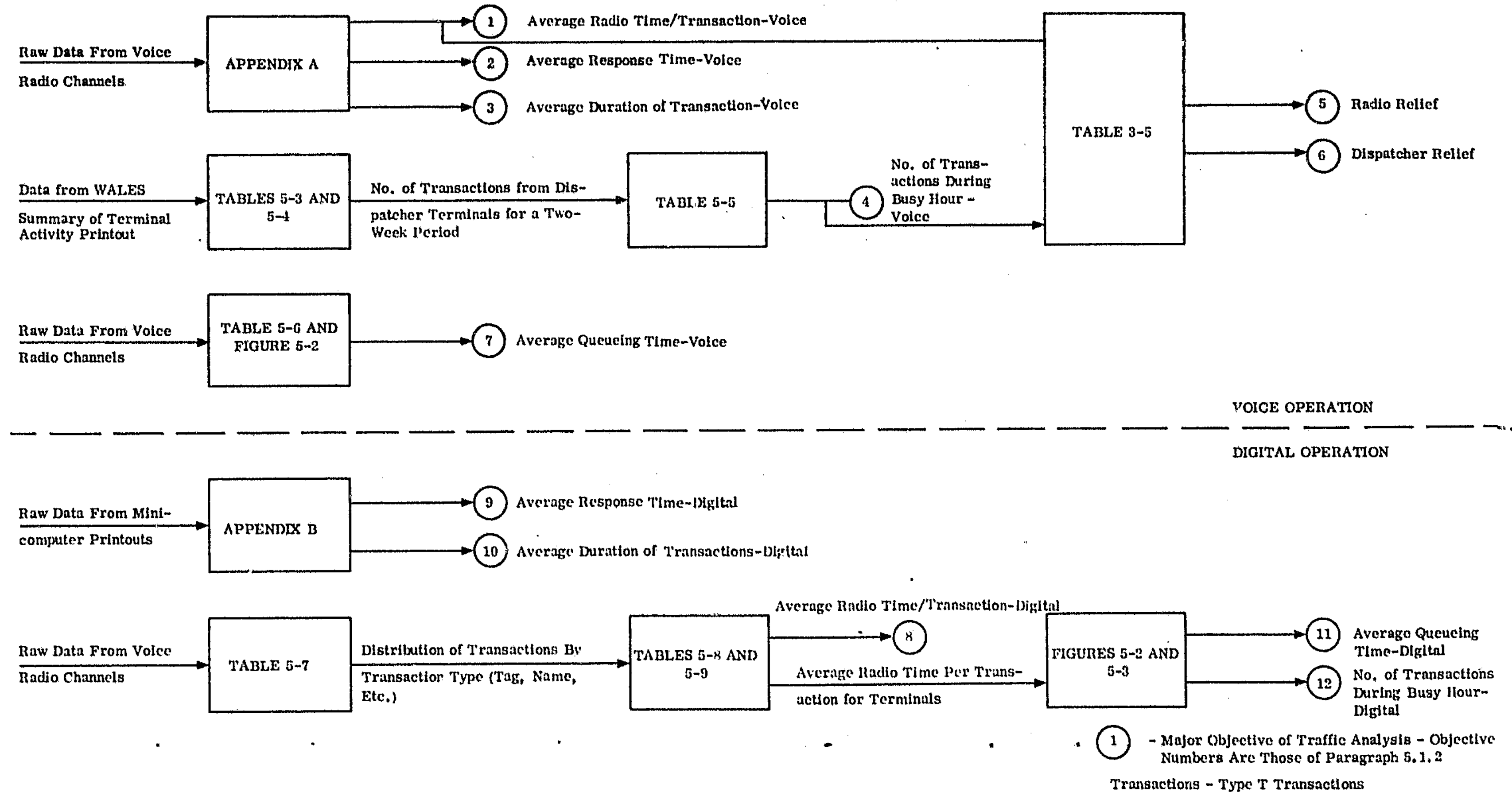


Figure 5-1. Traffic Analysis Procedure

In selecting transactions to be included in Table A-1, we have strived to maintain the randomness of the transactions, so as to produce meaningful averages. Basically, recordings of radio channels were made for several hours. These recordings were then played back and pertinent time points for Type T transactions recorded. This process was stopped as soon as the four pertinent points for each of 100 transactions were identified. An important fact was revealed in this part of the analysis. A majority of all voice Type T transactions are originated by scout cars. This was based on listening to several hundred transactions. Because of this, dispatcher and radio relief on the voice channel will only occur if digital terminals are used in scout cars as well as by footmen and scootermen. This is one of our recommendations (Section 8). The average radio time per transaction for the study sample is 25.4 seconds.

5.1.2.2 Objective 2 - Average Response Time - Voice

The three elements of a voice Type T transaction are listed in the previous paragraph. The middle element between the two radio transmissions is the officer waiting time or system response time. Table A-1 shows the response times ("Car Waiting Time" column) for the 100 transactions in the study sample. Response times vary widely, ranging from 1 to 688 seconds (11 minutes 28 seconds) in the sample. The major delay is due to the large dispatcher workload during the busy hour. The average response time for the study sample is 1 minute 53.7 seconds.

5.1.2.3 Objective 3 - Average Duration of Transaction - Voice

Durations of transactions are shown in Table A-1 for the study sample. Duration of transaction is simply the sum of the three elements making up a voice Type T transaction, i.e., the sum of radio time per transaction consisting of two radio segments (Paragraph 5.1.2.1) and system response time (Paragraph 5.1.2.2). The average duration of transaction for the study sample is 2 minutes 19.1 seconds.

5.1.2.4 Objective 4 - Average Number of Transactions During Busy Hour - Voice

To calculate the average number of transactions during the busy hour, we made the assumption that virtually all TAG, VIN, NAME, PERMIT, and BIKE WALES

inquiries from a dispatcher terminal originated with an officer in the field. This realistic assumption allowed us to prepare Table 5-3, which is derived from WALES SUMMARY OF TERMINAL ACTIVITY printouts. Ths table shows the total Type T transaction activity per transaction type and dispatcher terminal for a two-week period. This information is further summarized in Table 5-4. The figures in this table were taken as the number of Type T transactions originated by field officers in a two-week period.

The calculations that converted these figures to average number of transactions during the busy hour as shown in Table 5-5. Results of these calculations are in the fourth column of the table.

5.1.2.5 Objective 5 - Radio Relief

The basic assumption was made that, after conversion to digital operation, all current voice Type T transactions will be performed in the digital mode - a situation that will result in maximum radio relief. This assumption is not strictly true. Since some officers will not be equipped with digital terminals, there will still be some voice Type T transactions. However, we expect that the increase in the number of hits using digital terminals, and the projected reduction in their cost, will result in a large number of terminals in the MPD. In addition, the percentage of Type T transactions in the digital mode can be increased by the judicious allocation of terminals into difficult areas where Type T transactions are likely to originate. To calculate radio relief, we multipled the average number of transactions during the busy hour (Paragraph 5.1.2.4) by the average radio time per transaction (Paragraph 5.1.2.1). Results are in Column 6 of Table 5-5.

5.1.2.6 Objective 6 - Dispatcher Relief

Monitoring of voice channels indicated that, in terms of time, the dispatcher's main involvement in a Type T transaction is his conversation with the police officer originating the transaction.

Table 5-3. Number of T-Type Transactions Handled at Dispatcher Terminals for the 2-Week Period from 8/17/75 to 8/30/75 (Note 1)

Type of Trans \ District		1 DCP1 (Note 2)	2/3 DCP2	4 DCP4	5 DCP5	6/7 DCP6/DCP7	CW DCP8	SOD DCP9
TAG	QART	1198	807	946	1203	1116	554	821
	TART	61	67	67	45	53	19	86
	QART	1035	673	1178	905	1272	533	1070
	TART	41	39	41	54	71	60	59
	TOTAL	2335	1586	2232	2207	2512	1166	2036
VIN	QARV	20	15	15	27	33	5	23
	TARV	1	0	0	0	0	0	1
	QARV	60	8	26	26	44	6	20
	TARV	0	0	0	0	7	0	0
	TOTAL	81	23	41	53	84	11	44
NAME	QWAR	63	39	129	109	165	37	167
	TWAR	0	0	0	0	0	0	0
	QWAR	60	38	132	62	157	33	145
	TWAR	0	0	0	0	2	1	8
	TOTAL	123	77	261	171	324	71	320
PERMIT	QARP	61	43	131	92	134	71	231
	QARP	36	60	136	53	170	56	196
	TOTAL	97	103	267	145	304	127	427
BIKE	BIKE	198	21	14	111	30	8	25
	BIKE	167	44	13	76	18	2	10
	TOTAL	365	65	27	187	48	10	35

Entries for Week 8/17/75 – 8/23/75 →
Entries for Week 8/24/75 – 8/30/75 →
Total for Both Weeks → Note 3

QART – Tag Transaction
TART – Tag Transaction – Test Mode
QARV – VIN Transaction
TARV – VIN Transaction – Test Mode
QWAR – Name Transaction
TWAR – Name Transaction – Test Mode
QARP – Permit Transaction
BIKE – Bike Transaction

Note 1 – From WALES Summary of Terminal Activity Printout, for weeks 8/17/75 – 8/23/75
8/27/75 – 8/30/75

Note 2 – DCP1, DCP2 are WALES terminal identifiers
DCP1 is the dispatcher terminal for District #1

Note 3 – These figures are used in Table 5-4

Table 5-4. Number of T-Type Transactions Handled at Dispatcher Terminals for the 2-Week Period from 8/17/75 to 8/30/75

District / Type of Transaction	1 DCP1*	2/3 DCP2	4 DCP4	5 DCP5	6/7 DCP6/DCP7	CW DCP8	SOD DCP9	TOTAL
TAG	2,335	1,586	2,232	2,207	2,512	1,166	2,036	14,074
VIN	81	23	41	53	84	11	44	337
NAME	123	77	261	171	324	71	320	1,347
PERMIT	97	103	267	145	304	127	427	1,470
BIKE	365	65	27	187	48	10	35	737
TOTAL	3,001	1,854	2,828	2,763	3,272	1,385	2,862	17,965

*DCP1, DCP2, etc. are Wales Terminal Identifiers
DCP1 is the dispatcher Terminal for District #1

Table 5-5. Dispatcher/Radio Relief

District	Total No. of Type T Transactions (From Table 5-4)	Average No. of Type T Transactions Per Hour (Note 1)	Average No. of Type T Transactions During Busy Hour (Note 2)	Average Radio Time/Transaction in Minutes (From Table A-1)(Note 3)	Dispatcher/Radio Relief During Busy Hour in Min/Hr (Note 4)	% Dispatcher Relief During Busy Hour (Note 5)
	(TOT)	(AVG1)	(AVG2)	(D4)	(DRR)	(P1)
1	3,001	8.93	13.4	.42	5.6	9.3
2/3	1,854	5.52	8.3	.42	3.5	5.8
4	2,828	8.42	12.6	.42	5.3	8.8
5	2,763	8.22	12.3	.42	5.2	8.7
6/7	3,272	9.74	14.6	.42	6.1	10.2
CW	1,385	4.12	6.2	.42	2.6	4.3
SOD	2,862	8.52	12.8	.42	5.4	9.0
TOTAL	17,965	53.47	80.2	.42	33.7	8.0

NOTE 1: AVG1 = TOT/336 where No. of hours in 2 weeks = 336

NOTE 2: AVG2 = 1.5 X AVG1
Where 1.5 is the estimated average busy hour peaking factor (obtained by monitoring radio channels.)

NOTE 3: Sample in Table A-1 is for districts 4 and 6/7 only. However, we have assumed that average radio time per transaction is independent of radio channel

NOTE 4: DRR = AVG2 x D4

NOTE 5: P1 = DRR/60 x 100, where no. of minutes that dispatcher is active during busy hour = 60 (100%).

In slow periods, the dispatcher frequently handles only one transaction at the time and his nonradio involvement with that transaction can be measured. We found that response times in slow periods was short in relation to his radio time. From this we concluded that his involvement with the transactions outside of interchanges with the officer was also short in relation to his radio time. Therefore, as a first approximation, that dispatcher time per transaction was assumed to be equal to the radio time per transaction. This is reflected in Column 6 of Table 5-5.

5.1.2.7 Objective 7 - Average Queuing Time - Voice

Average queuing time for accessing the radio channel depends on two quantities:

- Average radio time per transaction - for all transactions, not just Type T
- Radio utilization, i.e., fraction of time that radio channel is busy.

Given these two quantities, the top curve of Figure 5-2 was used to calculate the queuing time. For example, a utilization of .60 would yield a value for N_T of 2.5 (See Figure 5-2 for definition of symbols). From this value, we would calculate:

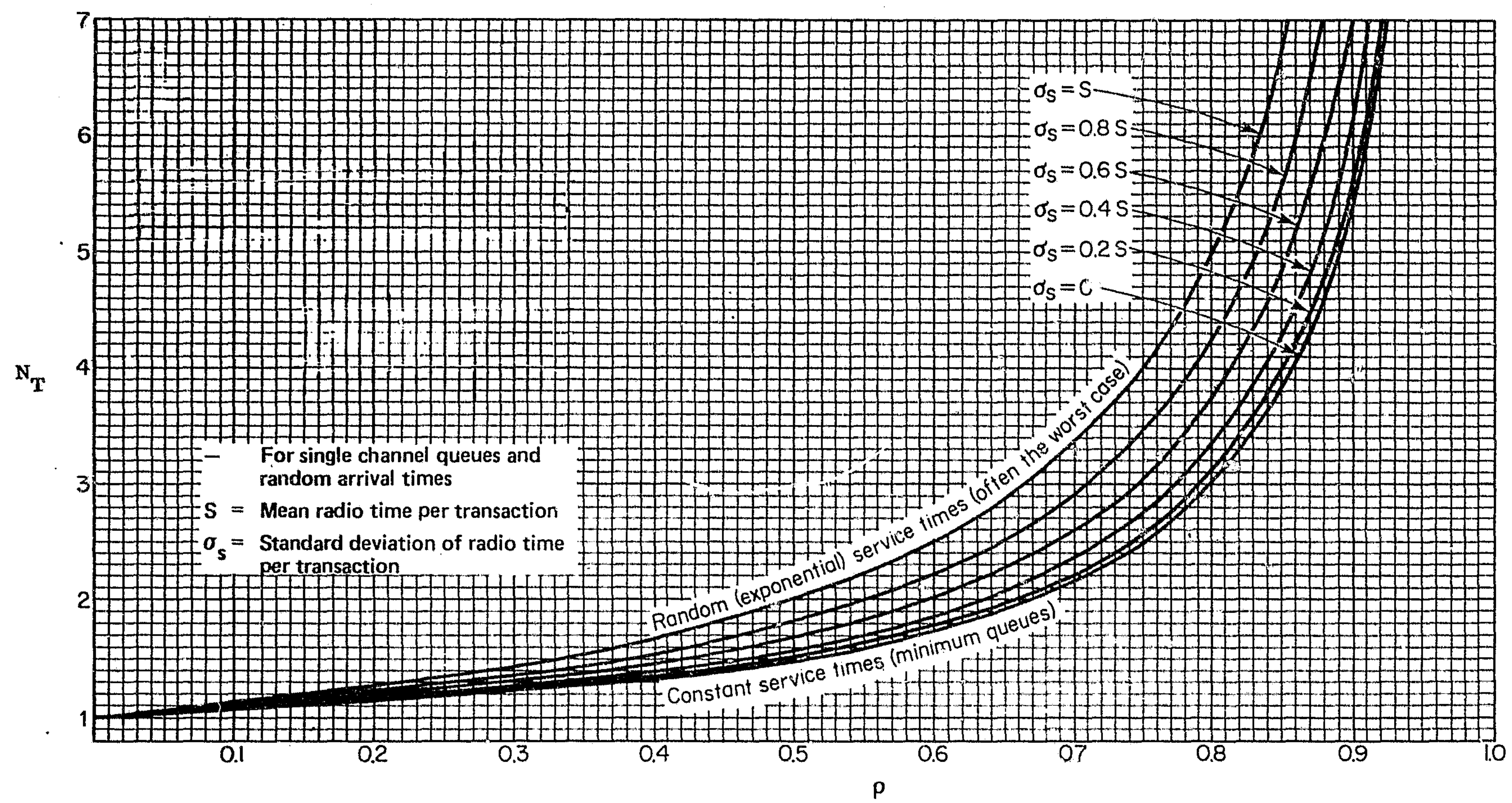
$$N_W = N_T - 1 = 1.5$$

If 10 seconds were the average radio time per transaction (S), queuing time t would be given by:

$$t = N_W \cdot S$$
$$= 1.5 \times 10 = 15 \text{ seconds.}$$

The top curve in Figure 5-2 was used since it yields the maximum waiting time for a given utilization, and thus provides conservative estimates of performance for both voice and the digital modes of operation. The average radio time per transaction and radio utilization used in the study were determined by monitoring the District 6/7 radio channel during the busy hour, and recording the number of transactions and the total time that the channel was occupied. We counted 144 transactions (of all types) and 36 minutes of radio time.

Using these figures, we proceeded as follows:



$N_T = 1 + \frac{\rho}{2(1-\rho)}\left[1 + \left(\frac{\sigma_S}{S}\right)^2\right]$ = Average time spent by a transaction in queue and on radio channel divided by average radio time per transaction.

$N_W = N_T - 1$ = Average time spent by a transaction in queue divided by average radio time per transaction.

$t = N_W \cdot S$ = Average queuing time for access to radio channel, where S is average radio time per transaction.

ρ = Radio utilization.

Figure 5-2. Queuing for Access to Radio Channels

- Average radio time/transaction = 36 x 60/144 = 15 seconds
- Utilization = 36/60 = .60.

From the top curve of Figure 5-2:

$$N_T = 2.5$$

$$N_W = N_T - 1 = 1.5$$

$$t = 1.5 \times 15 = 22.5 \text{ seconds}$$

This is the average waiting time for access to a current voice radio channel. If the digital mode is implemented, the radio time for all voice transactions on the same channel will be reduced by an amount equal to the radio relief.

The situation will then be:

- Number of remaining transactions = 144 - 15 = 129, where 15 is number of Type T transactions during busy hour for District 6/7 channel (Table 5-5)
- Number of minutes that radio channel is occupied = 36 - 6 = 30 minutes, where 6 minutes is approximate projected relief for District 6/7 channel
- Average radio time/transaction = 30 x 60/129 = 14 seconds
- Utilization = 30/60 = 0.5.

From the top curve of Figure 5-2:

$$N_T = 2.0$$

$$N_W = N_T - 1 = 1.0$$

$$t = 1.0 \times 14 = 14 \text{ seconds}$$

Thus, the improvement in waiting time due to radio relief is:

22.5 - 14 = 8.5 seconds (37.8%)

Table 5-6 shows the results of the queuing time analysis for voice channels.

Table 5-6. Queuing in Voice Channels [1]

	Voice Radio Channel Utilization During Busy Hour	Probability of Voice Channel Being Busy	Average Queuing Time for Access to Voice Radio Channel (Sec)
Without terminals in system	.60	.60	22.5
With terminals in system but on a separate radio channel[2]	.50	.50	14.0
Improvement due to installation of terminals [3,4]	16.7%	16.7%	37.8%

(1) Based on busy radio utilization of .60 (channel is busy 60% of time). This figure was obtained from monitoring District 6/7 radio channel.

(2) Figures in this row apply to voice radio channel after Type T traffic has been removed.

(3) Figures in this row show improvement in voice radio channel after Type T traffic has been removed.

(4) Although improvement figures apply to District 6/7 channel only, improvement in other busy channels (Districts 1, 4, 5, and SOD) are expected to be similar (see DRR column in Table 5-5).

5.1.2.8 Objective 8 - Average Radio Time/Transaction - Digital

The procedure for determining the value of this performance variable for each terminal consisted of calculating the following:

- Average time for radio bursts (d_1) associated with an inquiry from terminal to minicomputer (Tables 5-7 and 5-8).
- Average time for radio bursts (d_2) associated with one response from minicomputer to terminal (Tables 5-7 and 5-8).
- Average number of inquiries per transaction (N1) and responses per transaction (N2) for study sample of Table A-1 (Table 5-9). The basic assumption was that distribution of transaction types in digital mode would be the same as in voice mode.
- Average radio time per transaction:

$$S = N_1 \cdot d_1 + N_2 \cdot d_2$$

The third step in this four-step sequence was required because different types of transactions involve different numbers of inquiries and responses. For example, a tag transaction for a DC vehicle involves one inquiry and two responses, one from WALES and one from NCIC. A combined DC vehicle/name transaction needs two inquiries, one for the vehicle and one for the name, and four responses, two from WALES (vehicle, name) and two from NCIC (vehicle, name). For the study sample of 100 transactions, we found that 114 inquiries and 234 responses would be made if these transactions were carried out in the digital mode.

Note how close the two units are in terms of average radio time per transaction. Although the Burroughs system operates at 300 bauds, versus 600 bauds for the EMS terminal, it provides an NCIC response only in case of a hit. This has compensated for its slower speed, but has introduced this undesirable "hit-only" response feature which is discussed in Section 6.

Table 5-7. Average Radio Time per Transaction - EMS Terminal (T - Terminal M - Minicomputer)

1. Inquiry

Radio Time Segment	Duration (Seconds)
Transmission of Inquiry - T to M	1.04
Acknowledgement - M to T	.77
Average Radio Time Per Inquiry	1.81

2. Response

Radio Time Segment	Duration (Seconds)
Request for Response - T to M	.82
Transmission of Response - M to T	1.00
Acknowledgement - T to M	.82
Average Radio Time Per Response	2.64

3. Transaction

From Table A-1:

Average No. of inquiries/transaction	= 114/100 = 1.14
Average No. of responses/transaction	= 234/100 = 2.34
Average radio time/transaction (excluding retransmission)	= 1.14 x 1.81 + 2.34 x 2.64 = 8.24 seconds
Average radio time/transaction (including 10% retransmission)	= 8.24 x 1.1 = 9.06 ≈ 9 seconds

This average radio time/transaction was used in deriving the curves of Figure 5-3.

Table 5-8. Average Radio Time Per Transaction-Burroughs Terminal
(T - Terminal, M - Minicomputer)

1. Inquiry

Radio Time Segment	Duration (Seconds)
Transmission of Inquiry - T to M	1.8
Acknowledgement - M to T	.8
Average Radio Time per Inquiry	2.6

2. Response

Radio Time Segment	Duration (Seconds)
'Response Ready' Message - M to T	.8
Acknowledgement - T to M	.8
Transmission of Response - M to T	1.8
Acknowledgement - T to M	.8
Average Radio Time per Response	4.2

3. Transaction

(a) With NCIC Response Under Hit & No-Hit Conditions

From Table A-1:
Average No. of inquiries/transaction = 114/100 = 1.14
Average No. of responses/transaction = 234/100 = 2.34
Average radio time/transaction (excluding retransmissions) = 1.14 x 2.6 + 2.34 x 4.2 = 12.79 seconds

Average radio time/transaction (including 10% retransmission) = 12.79 x 1.1 ≈ 14.1 seconds

(b) With a NCIC Response Under Hit Conditions Only assuming a 10% NCIC Hit Rate

From Table A-1, the average no. or responses for 100 transactions will now be:
114 + .10 (108) + 12 ≈ 137 instead of 234 for case (a)

Average no. of inquiries/transactions = 114/100 = 1.14 as before
Average no. of responses/transactions = 137/100 = 1.37
Average radio time/transaction (excluding retransmissions) = 1.14 x 2.6 + 1.37 x 4.2 = 8.72 seconds
Average radio time/transaction (including retransmissions) = 8.72 x 1.1 = 9.59 seconds ≈ 9.6 seconds

Table 5-9. Voice Transactions Summary
(See Table A-1)

Type of Transactions (Note 1)	Quantity	No. of Inquiries	No. of Wales Responses	No. of NCIC Responses	No. of Miles Responses
T/DC	44	44	44	44	
T/MD	12	12	12	12	12
T/OTHER	12	12	12	12	
T/DC, T/DC	2	4	4	4	
T/DC, N	4	8	8	8	
T/DC, N, P	1	3	3	2	
T/DC, T/OTHER	4	8	8	8	
N	13	13	13	13	
N, N	1	2	2	2	
N, T/OTHER	1	2	2	2	
VIN	1	1	1	1	
P	5	5	5	0	
	100	114	114	108	12

The above figures show that, for the sample of Table A-1, 100 transactions involved a total of 114 inquiries and 234 (114 + 108 + 12) responses. These figures are used to calculate the average radio time per transaction in digital mode (Tables 5-7 and 5-8).

NOTE 1 - T/DC: Tag Transaction/DC Registration
T/OTHER: Tag/Registration in other than DC and MD
N : Name Transaction
VIN: VIN Transaction
P: Permit Transaction
T/DC, N: Transaction consisted of a Tag and Name Inquiry/Response

5.1.2.9 Objective 9 - Average System Response Time - Digital

System response time for the digital mode was defined as the difference between time of response and time of inquiry as recorded on EMS minicomputer printouts. The Burroughs printouts could not be used since inquiry and response times are only shown to the nearest minute - an insufficient accuracy to determine response times measured in seconds. We did not consider this to be a problem since response times in the digital mode are mainly a function of the processing load in WALES, NCIC, and MILES and are expected to be almost identical for both terminal units.

The raw data collected to calculate response time is shown in Appendix B. We chose several EMS minicomputer printouts arbitrarily and recorded the pertinent times for over 100 selected transactions. From the table, average WALES, NCIC, and MILES response times were calculated to be 10.6, 18.2 and 78.1 seconds, respectively.

Response times for the voice and digital modes of operation were compared by taking the transactions of Table A-1 and determining what their average response time would be in the digital mode. We had already determined their average response time in the voice mode to be 1 minute 53.7 seconds (Paragraph 5.1.2.2).

By an examination of Table 5-9, the number of transactions involving each combination of responses was determined to be:

WALES response only	- 5 transactions
WALES + NCIC responses	- 83 transactions
WALES + NCIC + MILES responses	- 12 transactions
Total	100 transactions

$$\text{Average response time} = \frac{(5 \times 10.6) + (83 \times 18.2) + (12 \times 78.1)}{100} = 25.0 \text{ seconds}$$

This contrasts with the average response time of about 1 minute 54 seconds in the voice mode.

5.1.2.10 Objective 10 - Average Duration of Transaction - Digital

A digital transaction consists of the following:

- Time to enter inquiry at terminal
- Radio time for transmission of inquiries and responses
- System response time (waiting time at terminal).

The duration of transaction is the sum of these times.

Based on our operation of the terminal, we estimated that an average of 10 seconds would be required by an officer to enter an inquiry at the terminal. This was based on tag transactions since these represent the vast majority of transactions (Tables A-1 and B-1).

Radio times were calculated as follows, using figures from Table 5-8:

- Transactions with WALES response only:

Inquiry:	1.81
WALES response:	2.64
Total	4.45

- Transactions with WALES and NCIC responses:

Inquiry:	1.81
WALES response:	2.64
NCIC response:	2.64
Total	7.09

- Transactions with WALES, NCIC and MILES responses:

Inquiry:	1.81
WALES response:	2.64
NCIC response:	2.64
MILES response	2.64
Total	9.73

Adding these totals to 10 seconds gave the duration of transaction less the response time as follows:

WALES response only:	10 + 4.45 ≈ 14 seconds
WALES + NCIC responses:	10 + 7.09 ≈ 17 seconds
WALES + NCIC + MILES responses:	10 + 9.73 ≈ 20 seconds

Adding these three figures, as applicable, to the response time, yields the total duration of transaction for the transactions in Appendix B. In performing the calculations, we assumed that the radio bursts associated with the responses take place after all responses for each transaction become available at the minicomputer for transmission to the terminal. This results in a maximum (conservative) estimate for the durations and transactions. The average duration of transactions was found to be 39.9 seconds as compared to about 2 minutes 19 seconds in the voice mode.

5.1.2.11 Objective 11 - Average Queuing Time for Access to Digital Channels - Digital

The objective was to determine queueing time as a function of the number of terminals on the digital channel and terminal activity. Figure 5-3 was derived to relate these three variables. Given any two, the third can be found. For example, if there were 105 terminals on the channel, and each generated two transactions per hour, a queuing time of 10 seconds would be obtained from the curve labeled n = 2. By using one point on one curve of the figure, the method used to derive these curves can be described. For example, to determine the queuing time, given 60 terminals on the digital channel and two transactions per hour per terminal, we proceeded as follows:

- Number of transactions per hour for all terminals: 60 x 2 = 120
- Radio time per hour = 120 x 9 = 1080 seconds, where 9 seconds is average ratio time per transaction (S), as derived in Table 5-7
- Radio utilization $= \frac{1080}{3600} = 0.3$

From Figure 5-2,

$$N_T = 1.44$$

$$N_W = N_T - 1 = .44$$

$$t = N_W \cdot S$$

$$= .44 \times 9 \approx 4 \text{ seconds.}$$

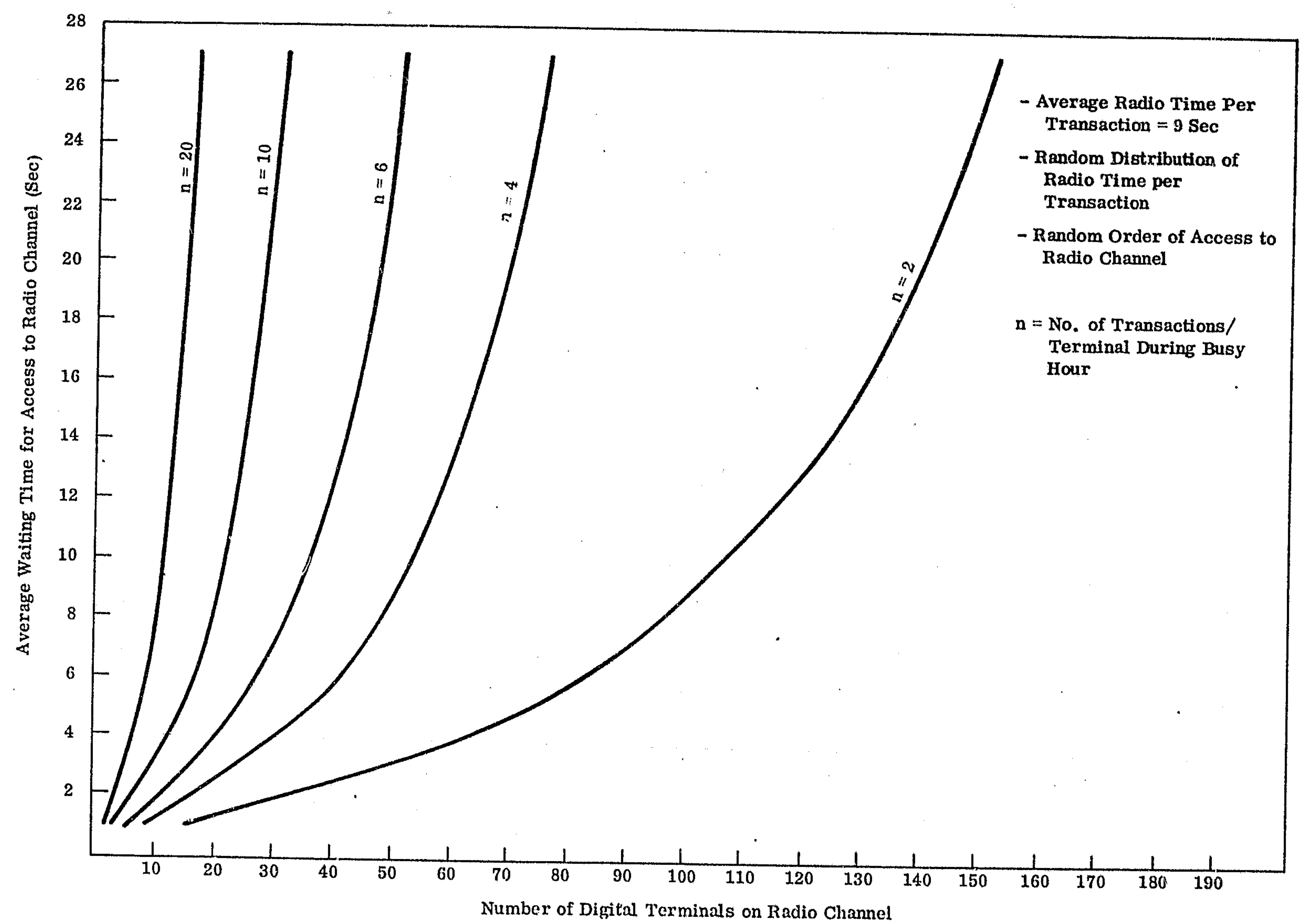


Figure 5-3. Queuing for Access to Digital Radio Channel

This completed the calculations required to derive point A in Figure 5-3.

The next step was to compare the performance of the voice and digital modes in terms of queuing time for access to radio channels. The average queuing time for access to voice channels was found to be 22.5 seconds as described in Paragraph 5.1.2.7. To determine the corresponding figure for the digital channel from Figure 5-3, a decision needed to be made on the number of transactions per hour in the digital mode. From the quantity, values for the number of terminals on the digital channel and the terminal activity can be estimated and Figure 5-3 used in determining queuing time. We decided on 80 transactions per hour since this is the average number of transactions during the busy hour on all voice channels combined (Table 5-5).

We knew that 80 transactions per hour on all channels resulted in a queuing time of 22.5 seconds on the busiest channels (e.g., District 6/7). If the digital mode were implemented, these 80 transactions would be on the digital channel. The problem was to determine the resulting queuing time, assuming that the digital channel would not be loaded with additional transactions. This assumption was made for queuing time comparison only.

Using figures of 40 terminals on the radio channels and n = 2 transactions per hour (80 transactions per hour), Figure 5-3 shows that the queuing time would be about 2.7 seconds. This compares most favorably with the voice mode figure of 22.5 seconds.

5.1.2.12 Objective 12 - Average Number of Transactions During Busy Hour

This variable can be calculated using Figure 5-3. For example, if the average queuing time were set at 10 seconds, the average number of terminals on the channel for n = 2 could not exceed 105, and the average number of transactions per hour could therefore not exceed:

$$105 \times 2 = 210.$$

The same value would be obtained for queuing time equal to 10 seconds using any other curve in Figure 5-3.

To compare the average number of transactions during the busy hour in the voice and digital modes, a method similar to that described in Paragraph 5.1.2.11 was used. We knew from Table 5-5 that the voice channels collectively handled 80 transactions per hour with a queuing time of 22.5 seconds. We decided that a valid comparison was to compare 80 with the number of transactions per hour that would produce a queuing time of 22.5 seconds on a digital radio channel. The n = 2 curve of Figure 5-3 indicates that for that terminal activity, and a queuing time of 22.5 seconds, approximately 140 terminals could be placed on the radio channel. This corresponds to an average number of transactions per hour equal to:

$$140 \times 2 = 280.$$

This is a distinct improvement over the corresponding figures in the voice mode (80). The same result would be obtained by using any curve in Figure 5-3.

5.2 RADIO SYSTEM ANALYSIS

The objective of this analysis was to identify the impact of the digital mode of operation on the MPD radio system. This impact was assessed in terms of three important aspects of digital operation:

1. Voice/Data Interference
2. Errors in Transmission
3. Radio Channel Overload.

5.2.1 Summary of Results

1. There is a serious voice/data interference problem that imposes a mandatory requirement for a separate digital channel. Both the technical considerations discussed in Paragraph 5.2.2 and the field officers' opinions contained in Section 7 make it clear that a separate channel is required.
2. There were numerous transmission errors encountered during the study period. However, we believe that most of these were due to the voice/data interference problem and to the use of low powered personal radios in scout cars. These problems were so serious that they masked errors due to the terminals and the transmission medium that would be encountered in a normal situation (no voice/data interference and no personal radios in cars).
3. Design of a future digital system should provide for radio channel overload by allowing for expansion to at least two digital channels. These channels could be full voice band channels or one voice band channel split into two subchannels.

5.2.2 Voice/Data Interference

The results of the user survey (Section 7) indicate conclusively that voice/data sharing of the channel is an unsatisfactory arrangement. Virtually every user who amplified upon the numerical rating by appending written explanations indicated that the voice traffic on the channel seriously limited the effectiveness of the digital communications system.

Were the CW-1 channel as free of voice traffic as implied by its "emergency channel" designation, the Voice/Data channel sharing scheme might be operationally practical. However, CW-1 is frequently receiving moderate to heavy usage because it is used as a backup channel when one of the district channels is out of service. Although both the Burroughs and EMS units have features to prevent data interfering with voice, they cannot have any protection against voice interfering with data--and that is the basic problem. The many instances of data errors due to interference by voice are apparently the result of near simultaneous transmissions by the digital terminal and a patrol car radio or the dispatcher, during periods of severe contention for the channel. This is not surprising since the same problem of simultaneous keying of two transmitters is evident on the voice network during the busy hours. Because of these considerations, a separate channel should be used for digital Type T transactions. The protective "anti-interference" features would be effective in a digital channel and could minimize interference between transactions. The relative protection offered by the Burroughs and EMS units is covered in Section 6.

CONTINUED

1 OF 4

Another aspect of a digital channel is that it is superior to the voice/data shared channel in terms of the number of digital transactions that could be performed during the busy hour (Paragraph 5.1).

5.2.3 Errors in Transmission

As noted previously, data transmission errors occurred frequently. Unfortunately, it was not possible to determine the relative contribution of individual causes since this distinction was masked by the voice/interference problem. The only other identifiable cause of errors in data transmission was the frequent use of digital terminals in vehicles without an external antenna. Use of the low powered personal radio with the "rubber ducky" antenna inside a steel vehicle is a marginal proposition. Even if a truly man-portable terminal is eventually obtained, it is going to see frequent use from the inside of patrol cars, at least until all patrol cars have special digital terminals of their own. It is important, therefore, that the terminal and the patrol car radios be equipped to interface with each other via a plug-in cord. The specifications for a "universal" car/scootermen/footmen terminal are summarized in Section 8.

5.2.4 Radio Channel Overload

One of the desired results following the installation of digital terminals is a large increase in the number of type T transactions, and the associated increase in the number of hits. It is therefore likely that the dedicated radio channel will become overloaded. The result would be an excessively long queuing time.

From Figure 5-3, a queuing time of 10 seconds and a terminal activity of four transactions per hour limits the number of terminals on the digital channel to just over 50. If the goal were to install 100 terminals within the MPD with this terminal activity, a second radio channel would be required to provide a queuing time of 10 seconds. Any future digital system should include provisions for expansion to at least two digital channels. Specifically, the minicomputer should be equipped with a communications interface unit that provides a minimum of two digital ports.

A possible alternative to the use of additional channels is the splitting of the original dedicated channel into two digital subchannels. This appears practical since the radio channel is characterized as nearly flat from 300 to 3000 Hz, except for a notch at 2400 Hz (3 dB points ± 150 Hz) used for the receiver voting scheme. The available bandwidth below 2200 Hz can easily support two 300-baud FSK channels. The Bell 103 Series Modems, for example, utilize 1070 Hz (space) and 1270 Hz (mark) for a "low channel" and 2025 Hz (space) and 2225 Hz (mark) for the "high channel." The latter band is the same as that of the Burroughs terminal. Separate digital ports on the minicomputer would be required for the two subchannels.

5.3 COMMUNICATIONS WITH WALES

Communications between officer and WALES is relatively simple in the current voice mode. The officer tells the dispatcher what he wants to know, and the dispatcher sends an inquiry to WALES, obtains a WALES response, and gives the officer the pertinent details. From the officer's viewpoint, this method of communication has the advantage of simplicity and reliability in that he trusts the accuracy of the information provided to him by the dispatcher. Unfortunately, the dispatcher's workload during the busy hour prevents him for giving each officer the attention the latter would like to receive. This results in long response times and subsequent annoyance by both impatient officer and busy dispatcher. During interviews with officers, CSC was told that the tone of annoyance in the dispatcher's voice during busy periods discouraged officers from making routine inquiries. Thus, current voice communications associated with WALES transactions is simple, but the number of transactions during the busy hour is limited due to dispatcher workload.

By contrast, transactions from digital terminals are more complex to initiate by the officer but they bypass the dispatcher entirely. This removes the fear of the "dispatcher's wrath" as a factor in the number of transactions that can be performed by an officer during the busy period. He is now limited only by his desire to work, his skill at operating the digital terminal, and the speed with which WALES, NCIC, and MILES will provide him with responses.

On balance, the digital mode of operation is preferable if the officer is thoroughly trained in the use of digital terminals (Paragraph 6.8). He will benefit from a shorter system response time, will produce a larger number of hits due to the larger number of transactions that he will initiate, and his performance will be independent of dispatcher workload and mood.

5.4 SECURITY

Digital transmission is inherently more secure than voice transmission, even without the use of special codes, since monitoring of digital transmissions requires a modem and a printer (or CRT) in addition to the receiver. Only determined and capable individuals can acquire the necessary information and equipment to monitor the digital transmissions. Therefore, digital operation is superior to voice operation from the standpoint of security.

SECTION 6

COMPARISONS OF BURROUGHS AND EMS SYSTEMS

An important phase of this study was the comparison of the Burroughs and EMS systems in terms of their value to the MPD. Ultimately, the system with the greatest value to the MPD is the one that will encourage police officers to initiate the larger number of transactions, and therefore produce the larger number of hits. This encouragement can only be provided to the officer by a system in which the terminals have reasonable physical proportions, and system operation is simple and reliable.

We found that both systems need significant improvements prior to offering a viable alternative to current voice operation. However, we believe that, on balance, the Burroughs system is superior to that of EMS as detailed in the paragraphs that follow. It is important to note that both units were evaluated in their prototype form, including major modifications made by the suppliers during the course of the study. Both manufacturers are planning improvement to the units, if given the job to develop an improved digital terminal. These planned enhancements were not taken into account in our comparison, which is summarized in Table 6-1.

6.1 COMMUNICATIONS WITH WALES

There is a communications sequence between terminal and minicomputer associated with each transaction originated at a digital terminal (Tables 5-7 and 5-8). The nature of this communications sequence is an important factor in the comparison. This is because the method of information interchange between officer and central computer has a great impact on the convenience of the digital system to the officer and, as a result, on his acceptance of such a system.

The performance of the digital system in terms of terminal-minicomputer communications is dependent on the following:

- Number and type of messages between terminal and computer for each transaction

Table 6-1. Comparison of Burroughs and EMS Systems

Evaluation Item	Better System*	Paragraph Where Comparison Details Can Be Found
Communications with WALES		
Number and Type of Messages	B	6.1.1
Powering Down	B	6.1.2
Idle Channel Detection	E	6.1.3
'Response Ready' Indication	B	6.1.4
Handling of Responses at Terminal	B	6.1.5
Error Procedure - Transmit Sequence	Equal	6.1.6.1
- Receive Sequence	B	6.1.6.2
Ability to Recall Display	B	6.1.7
Ability to Clear Messages at Minicomputer	B	6.1.8
Physical Aspects		
Size	E	6.2.1
Weight	E	6.2.1
Keyboard	B	6.2.2
Display Brightness	Equal	6.2.3
Power Considerations	B	6.3
Security	Equal	6.4
Reliability	Equal	6.5
Maintainability	E	6.6
Safety	Equal	6.7
Training	Equal	6.8
Traffic Considerations	E	6.9

* B = Burroughs, E = EMS

- Powering Down method
- Technique for idle channel detection by terminal
- Method of indicating to terminal that response from computer is ready
- Handling of responses at terminal
- Recovery procedures under error conditions
- Ability to recall display
- Ability to clear messages at minicomputer.

Each of these factors is discussed separately in the following paragraphs.

6.1.1 Number and Type of Messages

The communications sequence for the Burroughs and EMS systems are similar in that both terminals transmit an inquiry, receive an acknowledgement, receive a response, and transmit an acknowledgement of the response. Where they differ is that the Burroughs computer sends a message ahead of the response to indicate that a response message is ready at the computer. The officer can then recieve the message by depressing the ACK key. By contrast, the officer using the EMS terminal may query the computer from time to time to determine if the response is available, unless the WALES/NCIC/MILES responses (as applicable) are all ready before the terminal powers down -- a rare occurrence.

The method used at Burroughs is superior since the officer need only wait until a message is ready instead of actively seeking to determine if one is ready by transmitting queries to the computer. The EMS technique results in inconvenience to the officer and introduces additional accesses to the radio channel with the associated channel loading and queuing impacts.

During the course of the study, Burroughs introduced a system change that has a negative impact on system operation. This modification suppresses transmission of NCIC responses to the terminal unless a NCIC hit is obtained. It is true that this reduces queues at the minicomputer, response time, channel loading, and queuing time for access to the radio channel. However, we believe that this positive impact is more than offset by the operational disadvantages of such a change from the officer's viewpoint.

He now does not know if he is going to receive an NCIC response since he is unaware of whether his inquiry will generate an NCIC hit. He must therefore wait long after the WALES response has been received until he is virtually sure that no NCIC response is forthcoming. This is a highly unsatisfactory method of operation and we recommend that Burroughs change its software to provide an NCIC response for all transactions in which an inquiry was sent to NCIC.

6.1.2 Powering Down Method

Both units will power down after 15 seconds after the last terminal activity. There is, however, a major difference between the two. After powering down, the Burroughs terminal turns off its display, but the EMS unit shuts off completely. When this happens at the Burroughs terminal, no messages are lost. Messages can be recalled and displayed by depressing the DISPLAY key. At the EMS terminal, powering down causes a loss of messages, whether not yet transmitted to the computer or just received from the computer. The result is that the lost message must be reentered at the terminal for transmit messages or requested again from the computer for a received message. This is an annoying source of delay that must be removed in the "ideal" terminal specified in Section 8. The radio retransmissions resulting from this feature add to the channel loading and reduce the maximum number of terminals that can be assigned to the radio channel.

The Burroughs terminal is operationally superior with its design of the power down feature.

6.1.3 Idle Channel Detection

The Burroughs unit depends on the officer's "listening" for an idle channel, whereas the EMS terminal automatically monitors the radio channel and transmits on detection of an idle conditions. For shared voice/data operation, automatic monitoring is more convenient and reduces voice/data interference. This monitoring technique is mandatory for operations on a separate digital channel, as specified in Section 8.

The EMS idle channel detection technique is superior to that used by Burroughs.

6.1.4 "Response Ready" Indication

As discussed in Paragraph 6.1.1, the Burroughs computer sends a message to the terminal when a response is ready for transmission to the terminal. This indication is given to the officer by the PRESS ACK TO RCV lamp going on. There is no equivalent indication in the EMS system. Instead, the officer must request the response often several times, until it becomes available and sent to him after his query.

This is an important advantage of the Burroughs terminal.

6.1.5 Handling of Responses at the Terminal

The Burroughs equipment has a lamp that goes on when a message is received at the terminal. The officer can then display that message and acknowledge receipt of the message by depressing the ACK key. In the EMS, the message is received after officer's request (Paragraph 6.1.4) and immediately displayed. The Burroughs technique is superior because the officer can display the received message at his convenience, not necessarily when it is received. He may be busy at the exact time that the message is received and may want to display it a few moments later.

The Burroughs has a better method of handling responses at the terminal.

6.1.6 Error Recovery

6.1.6.1 Transmit Sequence

If errors occur in the transmission of messages from terminal to computer, the transmit light on the Burroughs terminal starts to flash 10 seconds after transmission of message to the computer. The officer then listens for a clear channel and retransmits the message by depressing the TRANSMIT key.

In an error condition, the EMS terminal automatically retransmits three times in an attempt to obtain a response from the computer. If the unit fails to achieve a satisfactory transmission during the four attempts, it will power down and the entered data will be destroyed.

The EMS unit has the advantage of automatic retransmission but the disadvantage of a possible loss of message. Because of this, we rate both units equal for error procedure in the transmit sequence. The "ideal" terminal specified in Section 8 will have both automatic retransmission and no loss in messages.

6.1.6.2 Receive Sequence

If errors occur in the transmission of messages from computer to terminal, the RCV light of the Burroughs terminal will blink. The computer and terminal repeat the receive sequence during which the computer retransmits the response to the terminal. Repetition of the receive sequence must be initiated by the terminal operator.

The method used by EMS, in a receive error condition, is to retransmit the message from the terminal to the computer, thus initiating a new transmit and receive sequence. This method unnecessarily increases response time, radio channel loading, and queuing for access to the radio channel.

The Burroughs technique is better.

6.1.7 Ability to Recall Display

As discussed in Paragraph 6.1.2, both units power down in 15 seconds, but the EMS unit loses the latest message in its buffer (transmit or receive) while the Burroughs unit does not. After powering down has occurred, the Burroughs display can be recalled if the officer needs to view the message again. This is, of course, impossible with the EMS unit--a distinct disadvantage of that equipment.

6.1.8 Ability to Clear Messages at the Minicomputer

By entering the CM code at the Burroughs terminal, the officer can clear all outstanding messages for that terminal in queue at the minicomputer. This does not include messages from WALES/NCIC/MILES that have not yet been received at the minicomputer, since these messages are not yet in queue.

The EMS equipment does not have this clearing capability from the terminal. Messages are cleared only after they have been received and acknowledged,

one at the time, by the terminal. This is a drawback of the EMS equipment, since this clearing feature is important. An officer might want to initiate a critical transaction, while he has several routine transactions in progress. Without this clearing feature, he usually gets responses on a first-in-first-out basis and he must wait for receipt of all his routine responses, prior to receiving the one in which he is particularly interested. The clearing feature allows him to remove responses associated with earlier routine transactions.

6.2 PHYSICAL ASPECTS

6.2.1 Size and Weight

The size comparison of Table 6-2 shows that the Burroughs terminal is more bulky, having more than 2-1/2 times the volume of the EMS. While the Burroughs terminal is a development model and does not necessarily represent the configuration and packaging that would be used for production units, the overall dimensions cannot be significantly reduced as long as the present keyboard, display, and battery are used. The long dimension is effectively established by the 32-character Self-Scan display module. The keyboard and display module together determine the minimum height, and the smallest dimension of the battery determines the minimum depth. The weight of the Burroughs terminal is more than twice that of the EMS unit.

The EMS unit has been designed to work with officer radio batteries--an arrangement which has proved to be unsatisfactory due to excessive battery drain. EMS has recently supplied battery units for their terminals and the current relative size and weight are shown in Table 6-2.

As described to CSC, the new EMS battery unit holds two of the standard ni-cad battery packs used in the patrolman's radio, and fits into the bracket in the terminal. In addition, EMS has supplied a case with shoulder strap for carrying the battery-equipped unit. An optimum battery pack for a terminal should be somewhat smaller and lighter (Section 8). The two-radio pack scheme was chosen for convenience since the DC MPD has the necessary chargers for these battery packs.

Table 6-2. Terminal Hardware Characteristics

Feature or Characteristic	Burroughs	EMS
Size, volume	$9\frac{1}{2}$ W x $5\frac{1}{2}$ H x 2-3/4" D, 136 in^3	$8\frac{1}{2}$ H x $3\frac{1}{2}$ W x 1-3/4 D, 52 in^3 (without radio bracket)
Weight (Approximate)	5 lbs. (w/battery)	2 lbs. w/o battery, 4 lbs. w/2 battery packs
Carry Assist	Flexible case w/shoulder strap	Case w/shoulder strap
Battery	6 V, 2.6AH Gel. cell. 1.34 lb. 5.28L x 1.31W x 2.63"H, 12-16 hr. charge time	Uses radio (PR-25) battery pack. $7\frac{1}{2}$V, 1.5 AH, approx. 1 lb. 3-1/8 x 2-1/8 x 2" nominal (equiv. 6-"c" cells). Fast charge capability
Keyboard	45 keys, full alphanumeric, raised bezel, $\frac{1}{4}$" sq. keys on 5/8" centers (oak #415) tactile feedback: 0.07" pre-travel, 0.125" total key travel. Gold alloy metallic contact type, 3 oz. oper. force. Rated at 20×10^6 operations.	18 keys, fully sealed, X-Y matrix type Wild Rover Corp. #TC-1.
Modem	FSK 2025 Hz (Space) 2225 Hz (Mark)	FSK 1170 Hz (Space) 1870 Hz (Mark)
Data Rate, Code	300 baud, asynchronous, 10 unit code - 7 info., 1 par., plus start & stop	600 baud, asynchronous, 10 unit code - 6 info. (ASCII), 1 parity, plus 1 unit start and 2 unit stop
Power Consumption	3 W in Receive standby, 9 W w/Display ON	8-9 W when ON w/ or w/o display
Internal Voltages	-12V dc & +250V dc (6V Battery)	-12V dc & +250V dc ($7\frac{1}{2}$V Battery)
Sensing of Channel Activity at Terminal	No	Yes
Sensing of Channel Activity at the Mini	Data locked out if channel active, 1 sec. delay voice can preempt data	Voice locked out if data being transmitted. Data locked out if data or voice on channel.
Display	32 Char. Burroughs Self-Scan, plasma, 5x7 dot matrix characters. Required 8.6W true power.	16 Char. Burroughs Self-Scan

From its inception, this program's objective has been to develop a man-portable terminal. Observed and reported usage however, consists primarily of the generation of inquiries by officers while seated in a scout car. The size and weight objectives depend heavily on the manner in which the terminal is to be used. In addition, there are critical tradeoffs to be made between the size/weight objectives and the objectives for the display (number of characters) and the keyboard (full alphanumeric or shift mode). It is therefore important to define the manner in which the terminals will actually be used. If, for example, there is no expectation of having special digital terminals installed in the cars, it must be assumed that available man-portable units would see a great deal of use in the cars. For use in the car, the minimization of size and weight is not as important since the terminal would likely rest in an officer's lap or in the car seat. Also, required battery capacity would not be as great, since the unit could be plugged into the car's 12 V dc system for power (and into the car transmitter as well, instead of the PR radio). If, on the other hand, the intended usage is almost exclusively by foot patrolmen and scootermen, size/weight and sufficient battery capacity for a full shift are the paramount consideration.

It is CSC's opinion that digital terminals will be used in scout cars and by scootermen and footmen. As a result, the size and weight will be determined by footmen requirements. Our research indicates that the size and weight of the two units evaluated could be significantly reduced without any major negative impact of display and keyboard design (Section 8).

6.2.2 Keyboard

6.2.2.1 Burroughs

The Burroughs terminal employs a full alphanumeric keyboard of 40 keys, plus five control keys. The keyboard is in four rows and no shifting is necessary. The top row contains the numbers 0 through 9. The lower three rows contain the letter keys and special character keys. In spite of its resemblance to a four-row typewriter keyboard, the Burroughs terminal keyboard is not laid out like a typewriter. Letters are laid out alphabetically, left to right in each row. Many of the users commented about

about the letter layout on the keyboard, suggesting that the standard typewriter layout be used. Apparently some of the using officers were touch typists.

CSC's recommendation is that the alphabetical layout be used in the "ideal" terminal (Section 8) since most officers are not typists, and an alphabetical arrangement is far superior for nontypists. Also, the key spacing on the unit is slightly less than that on a typewriter. The effect is to shorten the rows by about 1-1/4 inch. This slightly closer spacing of the keys might cause a touch typist to make errors.

The comparison chart includes some additional detail on the keyswitches used to make up the Burroughs keyboard. The keyswitch mechanism seems to be adequate with respect to "feel." It has approximately 55 percent pre-travel; about 3 ounces of force is necessary to "bottom" the switch after the light pre-travel. In other respects, this keyswitch mechanism appears adequate except that it is not specified to be fully weatherproof.

A keyboard made up of individual switches (Burroughs) does not perform the coding function. In this case, the encoding is performed by a separate circuit consisting of three CMOS ICs and three transistors. Power required for the keyboard encoder circuit is negligible however (500 μW idle, 2 mW key depressed).

Burroughs has indicated that the selection of this keyboard was influenced in two ways: (1) full alphanumeric layout was specifically requested by DC MPD: (2) selection of the keyswitch mechanism was based on off-the-shelf availability and lead time. Burroughs' indicated desire was to use an elastomeric type switch. It has a very low profile, is completely sealed, and can be had with snap action tactical feedback.

6.2.2.2 EMS

The EMS terminal uses a keyboard of 21 keys. The individual keyswitches are Wild Rover Corp. Model TC-1. These are fully sealed units with snap action tactical feedback. A 3 key wide x 4 key high selection of the keyboard is similar to that used on touch tone phones except that the numerals are placed above the set of letters, i.e., [1 ABC] [6 PQR], etc. The zero digit key includes special symbols for dash (-),

comma (,), and slash (/). The lower right hand key of the 3 x 4 set is labeled SPACE and the lower left key, ROLL. A set of nine additional keys are labled CLEAR, RECALL, BKSP (backspace), INQ (inquire), STA (status), MSG (message), REQ (request), ONH (officer needs help), and ACK (acknowledgement).

Operationally, this keyboard is distinctly different from the alphanumeric type that the Burroughs terminal employs. The difference lies in the method of entering "alpha" information. The lower case designations on the keys are selected by following the particular keystroke by one, two, or three depressions of the ROLL key. Using the [1 ABC] key as an example, the display will follow this action by progressively displaying a 1, an A, a B and a C in the first character position. Although this mode of operation allows for a much smaller keyboard, it required considerably more time and finger motion to enter "alpha" information. Tag inquiries, which usually include seven alpha symbols (T, 3 tag letters, slash, 2 letters for state) require considerably more time and concentrated attention on the part of the user than would be the case with an alphanumeric keyboard. Entry of names is even slower and more frustrating. While the user survey did not specifically indicate dissatisfaction with the "alpha" function of the keyboard, we believe that this feature alone was responsible for the marginal average rating given to the keyboard (Section 7). Reaction differed widely, however, with 33 percent of the users rating the keyboard unsatisfactory and almost as many (27 percent) rating it more than adequate. CSC's conclusions regarding keyboards is that the Burroughs keyboard is more than adequate. It is easy to use but is too large for use in a terminal (to be truly "man-portable"). The EMS keyboard is of marginal acceptability, the negative aspect being entirely due to the relative difficulty of entering "alpha" information.

From the standpoint of operational acceptability, the keyboard is probably the single most important hardware-associated feature of a man-portable terminal. Neither the Burroughs or EMS keyboards are entirely satisfactory, but the Burroughs is considered better due to its ease of use. In Section 8, we offer several alternatives as a solution to the keyboard problem.

6.2.3 Display Brightness

Both the EMS and Burroughs terminals employ Burroughs Self-Scan alphanumeric plasma displays. The Burroughs terminal uses a 32-character self-scan alphanumeric display module. The EMS uses a 16-character version of the same The brightness of this display is not adequate when used on the street in daylight. In bright sunlight, the characters displayed are completely washed out.

The requirement for an alphanumeric display that can easily be read under conditions ranging from complete darkness to bright sunlight is a challenging one. This is particularly true if the requirements for small size, low power operation, and multiplex capability are added. Liquid crystal displays (LCDs) are believed to be the most promising display technology for this requirement. They have ideal power and readability characteristics, i.e., negligible power consumption and contrast that increases with ambient brightness.

LCDs can be read with as low a light level as provided by street lights at night. Readability in complete darkness can be provided for by pushbutton-controlled backlighting. Few alphanumeric LCDs are available at this time--most are the seven-segment type for numbers. Hamlin Corporation makes a 1-inch high LCD alphanumeric display but none smaller. Hamlin advises, however, that they have recently developed an LCD alphanumeric module as a proprietary product for IBM. This LCD module is made up of a dot matrix and apparently can be employed in much the same way as the self-scan. Hamlin would not supply any further information about this development. It seems safe to predict, however, that suitable LCDs will soon be available. Section 8 specifies the general requirements for the display of an ideal terminal.

The Burroughs and EMS are equal in display brightness since they both use the same display.

6.3 POWER CONSIDERATIONS

As shown in the comparison table, power consumption of the Burroughs terminal is approximately 9 watts when the display is operating. When the terminal is ON, but

nothing is displayed, the power consumption is less than 3 watts. The EMS requires approximately 8 watts while operating, whether the display is active or not.

The power down feature on the Burroughs terminal turns off the display 15 seconds after the last keyboard activity, automatically reducing power consumption to the low level of less than 3 watts. Substantial reduction in average power consumption is thereby achieved, since the display, which accounts for more than 60 percent of the power consumed, is powered up under complete control of the operator only when it is actually required to display information. Messages are displayed only on command of the operator, and once a message has been displayed and read, the display can be turned off by keying the CLEAR button. For most responses from the system, a 5-second message display is adequate. If the user does not clear the display, it times out automatically in 15 seconds. We estimate that a complete tag inquiry transaction with a no hit response can be accomplished by an experienced user with only a 20 to 30 second total display time (message composition + WALES response + NCIC response).

The EMS power down feature turns the entire unit off after 15 seconds. Whenever the unit is on, the full 8 watts is consumed, even if no message is displayed. Power consumption of the two terminals is best compared on the basis of average watt-hours of energy consumed per transaction. Although this performance variable was not measured, it is clear that the Burroughs terminal, because of its power saving features, is much more energy efficient that the EMS.

Until a satisfactory low power display becomes available, every possible measure must be taken to minimize the on time of the power hungry displays.. Burroughs seems to have fulfilled this requirement completely.

6.4 SECURITY

The "unauthorized listener" aspect of security was discussed in Paragraph 5.4. More critical is the protection of the data base, i.e., preventing unauthorized access to WALES, MILES, and NCIC. Both EMS and Burroughs have included in their systems a means of identifying the particular terminal that is making an inquiry and recording the time, terminal number, and details of each transaction. These features provide a sufficient measure of protection against the two most likely kinds of attempts to intrude on the system; use of a stolen terminal and mimicing of a terminal. A minor software change in the minicomputer can "lock out" a lost or stolen unit. Periodic checking of the mini printouts would probably reveal any significant incidence of mimic-type unauthorized inquiries.

If additional security measures are needed at any time, these can be implemented in the system software. The techniques to provide additional security are well known and widely used to protect timeshare data processing systems against freeloaders. Passwords, and/or ID numbers are the usual techniques. In the case of police officers, a digit sequence that included the badge number might be an appropriate identifier.

Both systems are rated equal in the area of security.

6.5 RELIABILITY

Failure rate data is not available for either of the two terminals so it is not possible at this time to discuss their reliability in terms of "mean time between failure" figures. Both suppliers have indicated, however, that effective quality control measures were in effect during assembly, that high quality materials and parts were used, and each unit was checked out after assembly. Future suppliers of terminals should be requested to perform a reliability demonstration prior to acceptance of the equipment by the MPD.

6.6 MAINTAINABILITY

The EMS terminal employs pluggable circuit boards. The maintenance philosophy is that eventually the user's maintenance organization will perform maintenance on a board-replacement or assembly-replacement basis.

The construction of Burroughs terminal reflects that it is a developmental prototype. The circuit boards are hand-wired. Maintenance should not be difficult, however, since the ICs are socket mounted and the connections between boards are made with IC-type plugs and sockets.

Based on available information, we are rating EMS superior in maintainability.

6.7 SAFETY

No hazards to the user were identified for either the Burroughs or EMS terminals. Both units employ +250 V internally to power the plasma display. However, access to the high voltage is possible only if the case is opened. Because of this, we rated the two units equal in safety.

6.8 TRAINING

Both units were found by CSC engineers to be fairly easy to use, in terms of knowing what to do, as compared to the ease in doing it. We recommend that a simple training program be developed by the MPD for training officers in the use of terminals. This program should include a set of instruction on how to enter various inquiries and interpret the responses. Officers should practice in class by generating transactions under the supervision of a competent instructor. The officer should only be allowed to operate terminals in the field after he has demonstrated in class his proficiency in using them. We also recommend that a summary of the operating instructions be attached to the terminals or put on plastic coated cards that officers can carry in their pockets.

6.9 TRAFFIC CONSIDERATIONS

The analysis of Paragraph 5.1 showed that the average radio time per transaction is the key variable on which the radio channel loading and queuing time for access to radio channel depend. The average radio time per transaction in approximately 9 seconds for EMS (Table 5-7) and 14.1 seconds for Burroughs (Table 5-8), assuming the Burroughs system will not suppress no-hit NCIC response. This suppression is an undesirable freature. Because of its shorter average radio time per transaction, the EMS system is superior to that of Burroughs from the traffic standpoint.

SECTION 7

OFFICER ACCEPTANCE

The purpose of this phase of the study was to determine officer acceptance to the digital terminals. The intent was to obtain an independent assessment of the units by police officers without any outside influence from CSC or the equipment manufacturers.

To determine officer acceptance, CSC prepared a questionnaire containing 15 important evaluation items related to the performance of digital terminals. The questionnaire was completed by 39 officers who were asked to rate each evaluation item, and to make any remarks that they felt were appropriate. Results of this police officer survey are summarized in Paragraph 7.1 and given in detail in Paragraph 7.2.

7.1 SUMMARY OF RESULTS

The officers' overall reaction to the terminal units in their present form was negative. These were the most frequently stated objections, and the number of officers who objected.

1.	Batteries need to be changed too frequently (Statement was made for Burroughs and EMS)	27
2.	Terminal too large (Burroughs and EMS)	26
3.	Terminal too heavy (Burroughs and EMS)	25
4.	Excessive voice/data interference (Burroughs and EMS)	25
5.	High failure rate (Burroughs and EMS)	15
6.	Keyboard is not standard teletypewriter keyboard (Burroughs only)	8
7.	Display contrast is insufficient in sunlight (Burroughs only)	8
8.	Not enough information displayed to officer (Burroughs only)	5

In addition to these problems, officers' remarks indicated a general frustration in getting information to and from the minicomputer.

Items 1, 2, 3, 6, 7, and 8 are legitimate weaknesses that will be corrected in the improved terminal specified in Section 8. Voice/data interference (Item 4) was discussed in Paragraph 5.2.2, and is a problem resulting from the sharing of one radio channel for voice and data rather than for a deficiency in the design of the digital terminals. Voice/data interference and the lack of knowledge of some officers in the use of the terminals were at the root of the officers' frustration. It is the latter that caused officers to state that units had a high failure rate (Item 5). In fact, the units did not lose any of their capability. Messages were simply not getting through because of interference and lack of officer knowledge in the operation of the terminals. For example, the EMS unit requires that a response from the minicomputer must be acknowledged by the terminal operator. If this is not done, the message will remain at the top of the queue at the minicomputer and will be transmitted to the terminal each time the officer requests a response. One can easily imagine the disconcertment of the officer who gets the same message as a response to every inquiry that he makes. This situation persists until receipt of the message is acknowledged by the terminal. Some of the officers were not aware of this.

In conclusion, we believe that this survey brought out some of the major weaknesses in both terminal units. Unfortunately, the environment in which the terminals operated causes problems and negative comments from officers even through the difficulties encountered were not dependent on terminal design. In its independent evaluation, CSC took this environment into account and gave the digital mode of operation a much more favorable rating (Section 2).

7.2 DETAILED SURVEY RESULTS

Tables 7-1, 7-2, and 7-3 show the performance ratings given to the units by police officers. The officers were asked to give a score of 1, 2, or 3 for each evaluation item for 'not adequate,' 'adequate' and 'more than adequate,' respectively. Numbers were assigned to the questionnaires according to the unit that was rated on the questionnaire - B1 through B23 for Burroughs, E1 through E15 for EMS, and BE1 for the questionnaire containing ratings for both units. A list of officers who completed the

Table 7-1. Officer Acceptance – Burroughs Unit

EVALUATION ITEM	SCORE																								TOTAL	AVERAGE
	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	BE-1		
SIZE	1	3	2	-	1	2	1	1	1	1	1	2	1	1	1	1	1	2	2	2	2	-	1	1	31	1.4
WEIGHT	2	3	2	-	1	2	1	1	1	1	1	2	2	1	1	1	1	2	2	2	2	-	1	2	34	1.5
UNIT FAILURE RATE	1	3	2	1	1	-	1	1	1	1	-	1	1	-	1	3	1	1	2	1	2	1	3	1	30	1.4
FREQUENCY OF BATTERY CHANGES	1	2	1	1	1	2	3	2	1	-	2	2	1	1	1	2	1	1	1	1	1	1	1	1	31	1.3
KEYBOARD	2	2	3	2	1	2	3	2	2	1	1	2	2	2	1	3	1	3	2	2	3	2	2	3	49	2.0
DISPLAY	3	2	1	1	2	2	2	2	3	2	2	2	3	2	1	3	1	2	2	2	1	1	2	2	46	1.9
ADEQUACY OF LAMP INDICATORS	2	2	2	-	2	2	2	1	2	1	2	2	2	2	1	3	1	1	3	2	2	-	2	2	41	1.9
MESSAGE CORRECTION CAPABILITY	3	2	2	1	2	1	3	3	1	2	2	2	3	2	1	3	1	2	3	2	2	1	2	2	48	2.0
MESSAGE RECALL CAPABILITY	3	2	2	1	2	1	3	1	1	2	2	2	3	-	1	3	1	2	3	1	2	1	2	3	44	1.9
COMPOSING INPUT MESSAGE	3	2	2	1	2	1	2	1	1	2	1	2	3	2	1	3	1	2	3	2	2	1	2	1	43	1.8
PRESENTATION OF OUTPUT MESSAGE	2	2	2	1	-	2	1	2	3	1	2	1	2	1	1	3	1	2	1	2	2	1	1	1	37	1.6
POWER DOWN FEATURE	2	2	1	1	-	2	2	-	-	-	-	2	2	-	1	-	1	1	2	-	1	1	-	1	22	1.5
ABILITY OF SYSTEM NOT TO LOSE MESSAGES	3	1	2	1	2	2	3	1	-	1	1	1	3	1	2	3	1	2	3	1	2	1	3	2	42	1.8
REMOVAL OF MESSAGES FROM MINICOMPUTER	3	3	2	1	2	2	3	1	-	1	2	1	3	1	1	3	1	2	1	1	2	1	2	3	42	1.8
INTERFERENCE WITH VOICE TRANSMISSION	2	2	1	1	2	1	1	1	1	1	2	1	2	1	1	1	1	1	3	2	1	1	1	2	33	1.4

Scores: 1 – Inadequate; 2 – Adequate; 3 – More than adequate.

Table 7-2. Officer Acceptance - EMS Unit

EVALUATION ITEM	SCORE																TOTAL	AVERAGE
	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	BE-1		
SIZE	1	1	2	2	1	2	1	1	1	2	2	-	1	1	1	2	21	1.4
WEIGHT	1	2	1	1	1	1	1	2	-	1	2	-	1	1	1	2	18	1.3
UNIT FAILURE RATE	1	1	3	3	1	1	1	1	1	1	1	-	1	1	1	1	19	1.3
FREQUENCY OF BATTERY CHANGES	1	1	2	2	1	1	3	1	1	1	1	-	1	1	1	2	20	1.3
KEYBOARD	2	2	1	1	3	3	2	2	3	3	2	-	1	1	2	1	29	1.9
DISPLAY	2	2	2	2	3	3	1	2	3	3	2	-	1	1	1	2	30	2.0
ADEQUACY OF LAMP INDICATORS	2	2	2	2	2	2	1	2	-	1	1	-	1	2	1	2	23	1.6
MESSAGE CORRECTION CAPABILITY	2	1	1	1	2	2	1	1	3	2	2	-	1	2	1	2	24	1.6
MESSAGE RECALL CAPABILITY	1	1	1	1	2	2	1	1	3	3	2	-	1	2	1	1	23	1.5
COMPOSING INPUT MESSAGE	2	2	2	2	2	2	1	1	3	2	2	-	1	1	1	2	26	1.7
PRESENTATION OF OUTPUT MESSAGE	2	1	2	2	1	2	1	1	3	2	2	-	1	2	1	3	26	1.7
POWER DOWN FEATURE	1	1	1	1	1	1	1	1	-	2	-	-	1	1	1	1	14	1.1
ABILITY OF SYSTEM NOT TO LOSE MESSAGES	1	1	1	1	1	1	1	1	1	2	2	-	1	1	1	2	18	1.2
REMOVAL OF MESSAGES FROM MINICOMPUTER	2	2	-	-	1	-	1	1	1	1	1	-	1	1	1	3	16	1.3
INTERFERENCE WITH VOICE TRANSMISSION	1	1	3	3	1	1	1	1	1	1	1	-	1	1	2	2	21	1.4

Scores: 1 - Inadequate; 2 - Adequate; 3 - More than adequate.

Table 7-3. Officer Acceptance - Summary

EVALUATION ITEM	AVERAGE SCORE (FROM TABLES 7-1 and 7-2)	
	BURROUGHS UNIT	EMS UNIT
SIZE	1.4	1.4
WEIGHT	1.5	1.3
UNIT FAILURE RATE	1.4	1.3
FREQUENCY OF BATTERY CHANGES	1.3	1.3
KEYBOARD	2.0	1.9
DISPLAY	1.9	2.0
ADEQUACY OF LAMP INDICATORS	1.9	1.6
MESSAGE CORRECTION CAPABILITY	2.0	1.6
MESSAGE RECALL CAPABILITY	1.9	1.5
COMPOSING INPUT MESSAGE	1.8	1.7
PRESENTATION OF OUTPUT MESSAGE	1.6	1.7
POWER DOWN FEATURE	1.5	1.1
ABILITY OF SYSTEM NOT TO LOSE MESSAGES	1.8	1.2
REMOVAL OF MESSAGES FROM MINICOMPUTER	1.8	1.3
INTERFERENCE WITH VOICE TRANSMISSION	1.4	1.4

questionnaires is submitted to the MPD under separate cover. This list relates officer name to questionnaire number.

Since all but one officer tested only one unit, care must be exercised in comparing the two units from the figures in Table 7-3, but we can draw interesting conclusions. From the table:

- The officers rated both units as less than adequate since average scores for evaluation items ranged from 1.3 to 2.0 for Burroughs and 1.1 to 2.0 for EMS (2.0 is adequate).
- Both units have many of the same good and bad features since there is a high degree of correlation between the scores for the two units. For eight out of 15 evaluation items, the scores are within 0.1 of each other.
- The major deficiencies are frequency of battery changes (1.3/1.3), size (1.4/1.4), weight (1.5/1.3), power down feature (1.3/1.1). The low scores for interference with voice transmission (1.4/1.4) and unit failure rate (1.4/1.3) are not terminal dependent, as described in Paragraph 7.1.
- The EMS was rated very low in the system's ability not to lose messages (1.2) and removal of messages from the minicomputer (1.3). We believe this this is due to a lack of knowledge by some officers in the operation of the EMS terminal, particularly the acknowledgement procedure (Paragraph 7.1).

Twenty-one officers made remarks on their questionnaires. These remarks are shown in Table 7-4 exactly as they were written by the police officers. They are very consistent with the scores of Figures 7-1 through 7-3.

Of particular interest are the comments related to the use of digital terminals in cars. As seen in Section 2, CSC is recommending that a 'universal' portable terminal unit be desighed for use in cars as well as by footmen and scootermen.

Table 7-4. Officer Remarks

Questionnaire Number	Remarks
B3	The computer is fairly adequate considering the experimental stage. Unit is very slow in response time, and many times same tag no. will have to be entered before unit accepts same.
B5	With changes in weight and size, minicomputer could be useful to a foot patrolman.
B6	Should develop capability of use which does not depend on availability of regular radio channel.
B7	If computer works properly, could be a great asset to scout car personnel and a deterrent to crime.
B8	1. The unit is too big and should be condensed. 2. Too much duplication of prior message that should be cleared and no longer available to be displayed. 3. Sometimes when you press the keys they duplicate the number or letter. 4. The message sometimes is distorted and the information is not very informative. 5. The sequence is outrageous--meaning, I press the transmit button and and after 20 seconds, if it blinks, then press again. After pressing buttons 10 or so times, you can get a little impatient and no response. I personally think that there is a better system or unit that can be innovated. There are entirely too many problems with the Burroughs unit.
B9	The Burroughs terminal I used was bulky, awkward, and not dependable and at this time is not functional for street use even in a two-man unit. Definitely should not be used in one man unit or scooter.
B10	Machine is not practical for police work in its present state. It should be refined for quicker results and easier message input. Size and weight hampers use as bulkiness makes use difficult.
B12	For my use, I don't believe the hand-held computer to be practical. I like a quick response with correct information. I find myself reluctant to believe the computer to be precise so I run the inquiry over the PR radio via the station terminal at 6D or to the radio dispatcher.
B13	If Burroughs machine was smaller in size it could be used on foot patrol as well as in scout cars.
B14	Based on my experiences with the portable terminal over the past

Table 7-4. Officer Remarks (Cont'd)

Questionnaire Number	Remarks
B14 (con't)	four months, I must rate its overall performance as very poor. We were constantly frustrated with hours of inquiries with no returns or responses. On many occasions the returns were jumbled and unintelligible. (For example, one inquiry was answered T/AKQ48$01D@@ 0@@@@@@). The information returned was much too brief and insufficient for normal use. The Burroughs computer was "portable" in name only. Its tie in with the PR25 radio actually meant the necessity of carrying two PR25 radios, one for the station channel and one for the CW1 frequency. It was impractical to try and use only one radio, switching back and forth, mainly because of the slow response from the minicomputer. The Burroughs was also troublesome when it became necessary to leave the vehicle to answer a call. It could not be left unguarded in the vehicle, and it was very restricting, especially during hostile situation. In my opinion, the only way it could be incorporated into useful police service (if the multitude of technical problems can be resolved) would be to mount the unit somewhere near the radio console, charging it off the engine battery, and transmitting by the more powerful vehicle radio. I cannot envision the unit ever being practical for use by either footmen or scootermen.
B17	Officer used the Burroughs for seven days and the machine did not perform adequately. Machine would not work inside buildings. Awkward to carry around. Time consuming to feed the data into the machine and then go to other means to get correct data back.
B18	The machine is a valuable tool which I enjoyed having during vehicular patrol. But the failure rate was so overwhelming (e.g., on an average 50 attempted entries we would have approximately 10 to 15 good returns) that it frustrated us to the point that we would avoid any official who might assign it to us. Of all the problems encountered, the lack of a directed, non-voice channel was the greatest. Big leap for some money and add some other small refinements and we'll have a tool which could increase our arrest capabilities by 1/3.
B20	Concept of mini-computer is excellent idea and I believe it will prove to be a tremendous asset to law enforcement. However, the system tested by me needs many refinements. Recommend increased number of functions, to include stolen articles, criminal histories.

Table 7-4. Officer Remarks (Cont'd)

Questionnaire Number	Remarks
B21	The minicomputer does seem to be a very good idea for car officers. Gives good response and saves air time for other units. With improved lighting and longer battery, computer will prove its value. Computer worked for 5 hr. on the radio designed for the computer when that radio was placed in a cruiser charger. Quicker and better responses.
B23	It's apparent that the Burroughs unit was designed for scout car use, because of the size of the terminal, batteries and radio. I would therefore, prefer that it be made a more permanent part of the car's console, as the motrac radio is. If it is ever designed for footmen and scootermen, it would evidently have to be made even smaller, therefore eliminating more features that it has now.
E1	The terminal is no good for day to day police work.
E2	Should have had a better training session regarding the instrument prior to the use of same. All in all I would rate the particular unit I used as inadequate and impractical for use by this department.
E6	I found the portable terminal to be too heavy for a footman, also not sufficient enough to hold charge over 1 to 2 hours. Also, I made numerous entries getting no returns. If this unit could be hooked up to a centralized unit which would give returns every time this unit would be very helpful in finding wanted persons and vehicles.
E11	Training in the uses of the computer and ways of using it should be instituted in order to insure that it is used to its full capabilities.
E12	If the computer is to be used by the Department there should be classes given to the personnel that are going to use it. The problem is nobody knows how to operate it. Good idea if works properly.
E13	If it would work the only drawbacks are: a) strap too short, presses on artery in the neck; b) no lights on board, unable to hold flashlight and work computer; c) ties up both hands exposing officer to danger when running suspects.

SECTION 8

PRELIMINARY SPECIFICATION FOR AN IMPROVED DIGITAL TERMINAL

As indicated in Section 9, CSC recommends that the MPD continue in its efforts to implement a digital communications capability in Washington. Unfortunately, both the Burroughs and EMS systems are inadequate in their present form. An improved digital system is required, incorporating the strengths of the systems evaluated, but none of the weaknesses. A summary of a specification for such an "ideal" system is shown in Table 8-1. This specification was based on CSC's experimentation with the terminals as well as on comments received from police officers and discussions with Burroughs and EMS. If one or both of the two systems, as currently designed, was found to be adequate in a particular area, e.g., communications discipline, then the approach used has been specified, i.e., we did not attempt to devise a new technique where we judged that an existing Burroughs and/or EMS technique was satisfactory.

Our goal in preparing this preliminary specification is to provide a tentative set of requirements that can be discussed among MPD, CSC and equipment manufacturers. These requirements can then be modified as required until they reflect the practical ideal system from the MPD viewpoint. These modified requirements will form the nucleus of a detailed specification that will be sent to potential system suppliers as part of a request for proposal.

Table 8-1. **Preliminary Specification for an Improved Digital System**

Application	Scout cars, footmen and scootermen		
Type of radio channel	Digital (no voice)		
Number of radio channels used for digital operation	2 (minimum)		
Data Rate	600 Baud (minimum)		
Monitoring of Radio Channel by terminal	Automatic		
Suppression of responses under "No-Hit" condition	None		
Communications Discipline - Message Sequence	Inquiry Text	(T to M)	
	Acknowledge	(M to T)	
	Response is Ready	(M to T)	
	Send Response	(T to M)	
	Response Text	(T to M)	
Terminal Indicators	TRANSMIT Lamp	ON:	Message has been transmitted but not acknowledged
		FLASH:	Message has not been acknowledge for 10 sec. after transmission (transmission error)
		OFF:	No inquiries in present transmit mode
	RESPONSE READY Lamp	ON:	Response is ready at minicomputer for transmission to terminal
		FLASH:	Terminal has received a 'response ready' message in error
		OFF:	No responses are ready
	WAIT Lamp	ON:	Response is forthcoming from minicomputer
		OFF:	No response is forthcoming from minicomputer

Table 8-1. Preliminary Specification for an Improved Digital System (Cont'd)

Terminal Indicators (Continued)	RECEIVE Lamp ON: Terminal has received response from minicomputer FLASH: Received message is in error OFF: Message has been acknowledged by officer
Size	No larger than PR-25. Approximately same shape and volume (about 1-1/8 x 7½ x 2½)
Weight	2 lb w/battery & case
Carry Assist	Case that attaches to belt
Power Source	Objective: Same type battery used in radios and connector for operation from vehicle battery
"Powering Down" Feature	Shall apply to display only with no loss of message
Display	16 to 32 characters alphanumeric, readable from dark to bright sun, low power (LCD technology promising - with backlight for full darkness condition)
Display Recall	Officer shall be able to recall display after powering down has occurred
Keyboard	Full alphabet keyset. Numerals could be upper case (shift mode). Minimum key size--spacing similar to hand held calculators. Illuminating technique desirable.
Clearing of Messages at Minicomputer	Officer shall be able to clear messages in queue at minicomputer by transmitting simple message from terminal
Adapter for Scout Car Use	Car holder similar to charger stand for radio. Attached to dash, driveshaft tunnel or steering column. Powered from car electrical system. Terminal plugs or clips in car holder and is then automatically connected to car radio. Internal battery is charged while terminal is used in vehicle
Security	No special provisions. Adequate security is inherent in digital mode.
Reliability	Mean Time Between Failures: 1000 to 2000 hours
Maintainability	Plug-in replaceable circuit cards

SECTION 9

RECOMMENDATIONS

Based on the results of this study, we recommend that the MPD continue its activity toward the possible implementation of a digital system. We suggest the following specific steps:

1. Prepare a detailed system specification that reflects the strengths of the Burroughs and EMS units, but none of the weaknesses. The system specified should meet the general requirements of Section 8, and any amendments to these requirements recommended by the MPD.
2. Transmit a system specification, as part of a request for proposal, to interested system suppliers including, but not limited to, Burroughs and EMS.
3. Evaluate proposal, including both technical and cost considerations, and select a system supplier to provide a prototype version of the "ideal" system.
4. Evaluate prototype system in a 90-day experiment similar to that conducted with the Burroughs and EMS units.
5. Request system supplier to make any required modifications and provide quote for production quantities of 50 to 200 units.
6. If quote is acceptable, order and install digital system.

As stated in Section 1, cost considerations were not a part of this study. They are also not a part of these recommendations, which should all be qualified with the phrase "If available funds permit." We strongly believe that steps 1 to 3 should be carried out as soon as possible to allow the MPD to determine the cost and technical characteristics of a practical "ideal" system. The end of step 3 represents the next decision point in the development of a digital system capability for the MPD. We estimate that the cost of reaching that decision point will be relatively small, limited only to that associated with the preparation of a system specification and evaluation of proposals from system suppliers.

APPENDIX A

TRAFFIC DATA FOR TYPE T TRANSACTIONS CURRENT VOICE OPERATION

Table A-1 contains the study sample of voice transactions.

A.1 DEFINITION

A transaction consists of a scout car inquiry to the dispatcher, the dispatcher work associated with the inquiry, and the dispatcher response to the scout car.

A.2 ABBREVIATIONS

Trans.	Transaction
No.	Number
Sec.	Seconds
Type of Transaction (Trans. Type Column)	T: Tag N: Name P: Permit V: VIN B: Bicycle T/DC: Tag Transaction/Vehicle registered in DC

A.3 CALCULATIONS

T1 - Start time of radio transmission from car to dispatcher
T2 - End time of radio transmission from car to dispatcher
T3 - Start time of radio transmission fromdispatcher to car
T4 - End time of radio transmission from dispatcher to car

D1 = T2 - T1 = Duration of radio transmission from car to dispatcher
D2 = T3 - T2 = Car waiting time = response time
D3 = T4 - T3 = Duration of radio transmission from dispatcher to car
D4 = D1 + D3 = Total radio time
D5 = D1 + D2 + D3 = Duration of transaction

All D values are in seconds

Table A-1. Traffic Data for Type T Transactions – Current Voice Operation

Trans No.	Date (1976)	District No.	Trans. Type	Scout Car No.	Transmission From Car to Dispatcher: Starts (T1)	Ends (T2)	Duration (Sec) (D1)	Transmission From Dispatcher to Car: Starts (T3)	Ends (T4)	Duration (Sec) (D3)	Car Waiting Time (Sec) (D2)	Total Radio Time (Sec) (D4)	Duration of Trans. (Sec) (D5)	Remarks
1	2/6	4	T/DC	40	02:47:44	02:47:57	13	02:50:34	02:50:39	5	157	18	175	Occupied
2			T/DC	44	50:13	50:23	10	51:56	52:02	6	93	16	109	
3			T/MD	762	58:43	58:54	11	00:58	01:02	4	124	15	139	
4			T/MD	173	03:04:08	03:04:23	15	03:05:49	03:05:54	5	86	20	106	Occupied
5			T/DC	763	04:46	04:58	12	06:46	07:10	24	108	36	144	
6			T/DC	762	15:11	15:27	16	16:59	16:62	3	92	19	111	
7			T/VA	697	16:03	16:13	10	17:26	17:28	2	73	12	85	
8			T/DC	44	17:37	17:48	11	20:40	20:44	4	172	15	187	
9	2/6	4	T/DC	256	00:14:12	00:14:26	14	00:16:41	00:16:48	7	135	21	156	Occupied
10			T/DC	135	18:50	19:07	17	19:12	19:23	11	5	28	33	
11			N	949	19:45	20:06	21	20:56	21:21	25	50	46	96	
12			T/DC	694	34:04	34:18	14	34:28	34:39	11	10	25	35	
13			T/MD	694	40:40	40:57	17	41:41	41:50	9	44	26	70	
14			T/MD	694	47:54	48:12	18	50:02	50:11	9	110	27	137	
15			T/VA	137	48:37	48:49	12	50:58	51:08	10	129	22	151	
16			T/DC	127	52:08	52:19	11	52:31	52:36	5	12	16	28	
17			N	184	01:36:43	01:36:54	11	01:38:54	01:39:02	8	120	19	139	
18	2/7	6/7	T/DC	762	38:13	38:25	12	41:02	41:06	4	157	16	173	Occupied
19			T/DC, T/Ohio	187	50:38	50:56	18	56:22	56:24	2	326	20	346	
20			T/VA	171	02:00:31	02:00:38	37	02:12:06	02:12:09	3	688	40	728	
21			N	171	02:10	02:29	19	12:14	12:16	2	585	21	606	
22			T/DC	183	06:42	06:50	8	12:22	12:26	4	332	12	344	
23			T/MD	187	12:55	13:08	13	14:00	14:06	6	52	19	71	
24			T/DC	44	18:54	19:05	11	21:47	21:51	4	162	15	177	
25	2/8	6/7	T/DC	184	01:07:03	01:07:22	19	01:09:13	01:09:16	3	111	22	133	
26			T/DC	177	11:44	11:51	7	13:43	13:46	3	112	10	122	
27			T/DC	55	12:56	13:09	13	13:57	14:06	9	48	22	70	Occupied
28			T/ALA	174	17:28	17:42	14	22:20	22:23	3	278	17	295	
29			T/MD	177	18:23	18:35	12	20:17	20:22	5	102	17	119	Occupied
30			T/DC	290	18:47	19:02	15	27:06	27:37	31	484	46	530	
31			T/DC	979	28:30	28:45	15	30:19	30:22	3	94	18	112	
32			P	979	31:00	31:12	12	37:47	37:50	3	395	15	410	
33			T/NC, N	177	34:22	35:08	46	39:54	40:14	20	286	66	352	
34			P	979	36:58	37:10	12	37:12	37:14	2	2	14	16	
35			T/DC	290	42:31	42:45	14	44:12	44:14	2	87	16	103	
36			T/DC	189	42:50	44:07	77	44:35	44:42	7	28	84	112	
37			T/VA	173	43:10	43:59	49	47:16	47:20	4	197	53	250	

Table A-1. Traffic Data for Type T Transactions – Current Voice Operation (Cont'd)

Trans. No.	Date (1976)	District No.	Trans. Type	Scout Car No.	Transmission From Car to Dispatcher			Transmission From Dispatcher to Car			Car Waiting Time	Total Radio Time	Duration of Trans.	Remarks
					Starts (T1)	Ends (T2)	Duration (Sec) (D1)	Starts (T3)	Ends (T4)	Duration (Sec) (D3)	(Sec) (D2)	(Sec) (D4)	(Sec) (D5)	
38			T/DC, N, P	183	02:00:07	02:00:51	44	02:03:52	02:03:55	3	181	47	228	Occupied
39			T/MD	179	01:33	01:49	16	01:54	01:58	4	5	20	25	
40			T/DC	179	17:18	17:32	14	19:35	19:41	6	123	20	143	
41			N	183	24:04	24:30	26	26:46	26:58	12	136	38	174	
42			T/DC	597	32:02	32:23	21	33:42	33:46	4	79	25	104	
43			T/DC	974	32:29	32:51	22	33:33	33:40	7	42	29	71	
44			N	597	33:51	34:25	34	34:30	34:32	2	5	36	41	
45			T/DC	272	36:41	37:01	20	37:27	37:43	16	26	36	62	
46			T/DC, N	183	41:06	41:55	49	45:34	45:44	10	219	59	278	
47			T/DC	173	45:02	45:23	21	48:00	48:03	3	157	24	181	
48	2/8	6/7	T/DC	179	47:18	47:30	12	48:14	48:23	9	44	21	65	
49			T/DC	974	49:12	49:20	8	50:44	51:04	20	84	28	112	
50			VIN	173	54:01	54:26	25	56:07	56:11	4	101	29	130	
51	2/14	4	N	949	22:35:08	22:35:39	31	22:42:00	22:42:11	11	381	42	423	
52			T/OHIO	742	48:42	49:04	22	50:30	50:41	11	86	33	119	
53			T/OHIO	742	53:54	54:20	26	54:40	54:47	7	20	33	53	
54			T MD	741	55:20	55:37	17	55:38	55:40	2	1	19	20	
55			T/DC	941	55:59	56:10	11	56:23	56:38	15	13	26	39	
			T/DC											
56			N	741	23:00:52	23:01:15	23	23:01:22	23:01:26	4	7	27	34	
57			P	941	01:56	02:22	26	02:25	02:30	5	3	31	34	
58			T/MD	949	04:52	05:07	15	05:10	05:12	2	3	17	20	
59			P	941	08:31	08:49	18	08:55	08:59	4	6	22	28	
60	2/14	4	N	742	23:09:24	23:09:40	16	23:09:54	23:10:12	18	14	34	48	
			T/DC											
61			T/DC	741	13:50	14:06	16	14:11	14:13	2	5	18	23	
62			T/MD	123	19:50	20:05	15	20:14	20:16	2	9	17	26	Occupied
63			T/DC, T/DC	134	21:35	21:49	14	21:52	22:07	15	3	29	32	
64			T/DC, N	126	22:30	23:07	37	23:09	23:12	3	2	40	42	Occupied
65			T/DC	126	27:48	28:00	12	28:02	28:04	2	2	14	16	
66			T/DC	137	28:31	28:41	10	28:43	28:47	4	2	14	16	Occupied
67			T/DC	123	37:37	37:49	12	37:52	37:56	4	3	16	19	Occupied
68			T/DC	132	38:45	38:54	9	38:58	39:02	4	4	13	17	Occupied
69			N	137	40:10	40:40	30	41:11	41:17	6	31	36	67	
70			T/DC	941	53:21	53:38	17	53:41	53:44	3	3	20	23	
71			T/MD	126	53:56	54:08	12	54:32	54:40	8	24	20	44	

Table A-1. Traffic Data for Type T Transactions - Current Voice Operation (Cont'd)

Trans. No.	Date (1976)	District No.	Trans. Type	Scout Car No.	Transmission From Car to Dispatcher: Starts (T1)	Ends (T2)	Duration (Sec) (D1)	Transmission From Dispatcher to Car: Starts (T3)	Ends (T4)	Duration (Sec) (D3)	Car Waiting Time (Sec) (D2)	Total Radio Time (Sec) (D4)	Duration of Trans. (Sec) (D5)	Remarks
72		4	N	126	01:47:55	01:48:24	29	01:48:30	01:48:33	3	6	32	38	
73			N	134	53:30	53:56	26	55:21	55:29	8	85	34	119	
74			T/TENN	140	02:00:33	02:00:48	15	02:03:30	02:03:35	5	152	20	172	Occupied
75			T/DC	126	03:07	03:20	13	04:44	05:00	16	84	29	113	Occupied
76			N	126	04:23	04:38	15	08:32	08:40	8	234	23	257	
77			N	144	12:28	12:53	25	14:14	14:34	20	81	45	126	
78			T/DC	148	17:06	17:22	16	17:28	17:31	3	6	19	25	Occupied
79			T/DC	129	21:11	21:35	24	21:56	22:03	7	31	31	62	
80			T/DC	132	00:00:26	00:00:36	10	00:06:14	00:06:20	6	338	16	354	Occupied
81			T/DC	941	10:51	10:56	5	12:44	12:54	10	108	15	123	Occupied
82			T/MICH	126	15:46	15:58	12	17:51	17:58	7	113	19	132	
83			T/DC	745	20:38	20:52	14	21:12	21:19	7	20	21	41	Occupied
84			T/DC	130	22:30	22:41	11	22:53	22:57	4	12	15	27	Occupied
85			T/MD	123	23:02	23:12	10	23:57	24:03	6	45	16	61	Occupied
86			N	130	24:57	25:24	27	26:32	26:53	21	68	48	116	
87			T/DC	941	25:39	25:52	13	27:21	27:27	6	89	19	108	Occupied
88			N	941	27:30	27:47	17	30:14	30:26	12	147	29	176	
89			T/DC	942	32:26	32:39	13	33:23	33:30	7	44	20	64	
90			T/DC	136	42:54	43:05	11	43:19	43:28	9	14	20	34	Occupied
91			T/VA	949	43:44	43:55	11	44:50	44:52	2	55	13	68	
92			T/DC	942	47:56	48:12	16	48:18	48:29	11	6	27	33	Occupied
93			N, N	132	48:36	49:03	27	55:32	55:36	4	389	31	420	
94			T/DC	135	49:55	50:07	12	55:40	55:53	13	333	25	358	
95			P	135	51:00	51:15	15	59:16	59:21	5	481	20	501	
96			T/DC	124	01:05:41	01:05:57	16	01:12:27	01:12:46	19	390	35	425	
97			T/VA	119	15:08	15:18	10	17:40	17:51	11	142	21	163	
98			T/VA	130	31:14	31:23	9	31:27	31:29	2	4	11	15	
99			T/DC	125	35:07	35:10	3	35:27	35:31	4	17	7	24	
100			T/DC	126	39:49	40:05	16	40:12	40:15	3	7	19	26	
						TOTAL	1798			739	11371	2537	13908	
						AVERAGE	17.98			7.39	113.71	25.37	139.08	

APPENDIX B

TRAFFIC DATA FOR TYPE T TRANSACTIONS
DIGITAL OPERATION

Table B-1 contains the study sample of digital transactions.

B.1 DEFINITION

A transaction consists of a terminal inquiry to WALES and the WALES response to the terminal. When NCIC and MILES responses are received, these responses are also part of the transaction.

B.2 ABBREVIATIONS

Trans.	Transaction
No.	Number
Sec.	Seconds
Type of Transaction (Trans. Type Column)	T: Tag
	N: Name
	P: Permit
	V: VIN
	B: Bicycle
	T/DC: Tag Transaction/Vehicle registered in DC

B.3 CALCULATIONS

T5 = Time of inquiry from digital terminal
T6 = Time of WALES Response
T7 = Time of MILES Response
T8 = Time of NCIC Response

D6 = T6 - T5 = Response time for WALES
D7 = T7 - T5 = Response time for MILES
D8 = T8 - T5 = Response time for MILES
D9 = Transaction Time = D6 + 14 for transactions including a WALES response only
D9 = Transaction Time = D8 + 17 for transactions involving WALES and NCIC responses
D9 = Transaction Time = D7 + 20 or D8 + 20, whichever is larger, for transactions involving WALES, NCIC and MILES responses

All D values are in seconds.
See text for derivation of equations.

Table B-1. Traffic Data for Type T Transactions - Digital Operation

Trans. No.	Date (1975)	Terminal Number	Transaction Type	Time of Inquiry (T5)	Time of WALES Response (T6)	Time of MILES Response (T7)	Time of NCIC Response (T8)	Response Time -WALES(Sec) (D6)	Response Time -MILES(Sec) (D7)	Response Time -NCIC(Sec) (D8)	Duration of Transaction (D9)
1	9/19	3	T	08:04:09	08:04:21	-	08:04:23	12	-	14	31
2			T	08:50:05	08:50:18	-	08:50:21	13	-	16	33
3			B	08:50:59	08:51:03	-	-	4	-	-	18
4			T	08:52:39	08:52:43	08:52:54	08:52:57	4	15	18	38
5			T	09:01:43	09:01:46	-	09:01:48	3	-	5	22
6			T	10:20:13	10:20:17	10:20:31	10:20:19	4	18	6	38
7			T	10:22:30	10:22:46	-	10:22:49	16	-	19	36
8			T	10:28:19	10:28:23	10:28:38	10:28:31	4	19	12	39
9			T	10:31:36	10:31:42	-	10:31:51	6	-	15	32
10			T	10:31:51	10:32:14	-	10:32:18	23	-	27	4
11			T	10:36:36	10:36:54	-	10:37:01	18	-	25	42
12			T	10:41:58	10:42:28	-	10:42:38	30	-	40	57
13			T	10:44:34	10:44:42	10:48:49	10:44:46	8	255	12	275
14			T	11:00:41	11:01:00	-	11:05:03	19	-	262	279
15			P	11:07:40	11:07:49	-	-	9	-	-	23
16			T	11:08:41	11:08:56	-	11:09:12	15	-	31	48
17			T	11:37:00	11:37:11	-	11:37:47	11	-	47	64
18			T	11:42:40	11:42:48	11:44:52	11:42:52	8	132	12	152
19			T	11:45:20	11:45:26	-	11:45:41	6	-	21	38
20			V	12:27:15	12:27:32	-	12:27:35	17	-	20	37
21			T	12:30:44	12:30:49	12:32:30	12:30:51	5	106	7	126
22			T	11:48:29	11:48:42	-	11:48:45	13	-	16	33
23			T	11:49:21	11:49:30	-	11:49:46	9	-	25	42
24			T	11:50:02	11:50:14	-	11:50:25	12	-	23	40
25			N	12:06:02	12:06:05	-	12:06:15	3	-	13	30
26			N	12:12:59	12:13:10	-	12:13:14	11	-	15	32

Table B-1. Traffic Data for Type T Transactions - Digital Operation (Cont'd)

Trans. No.	Date (1975)	Terminal Number	Transaction Type	Time of Inquiry (T5)	Time of WALES Response (T6)	Time of MILES Response (T7)	Time of NCIC Response (T8)	Response Time -WALES(Sec) (D6)	Response Time MILES (Sec) (D7)	Response Time -NCIC(Sec) (D8)	Duration of Transaction (D9)
27	11/13	3	T	14:23:52	14:24:04	-	14:24:07	12	-	15	32
28		1	T	14:47:38	14:47:59	-	14:48:02	21	-	24	41
29	11/14	3	T	07:51:24	07:51:32	-	07:51:35	8	-	11	28
30		3	B	07:52:05	07:52:06	-	-	3	-	-	17
31		3	T	07:53:21	07:53:24	-	07:53:28	3	-	7	24
32		5	T	13:31:20	13:31:29	-	13:32:02	9	-	42	59
33		1	T	15:00:27	15:00:39	-	15:01:07	12	-	40	57
34		1	T	15:03:28	15:03:33	-	15:03:39	5	-	11	28
35		1	T	15:06:11	15:06:15	15:06:29	15:06:20	4	18	9	38
36		1	T	15:09:23	15:09:36	-	15:09:39	13	-	16	33
37		1	T	15:14:47	15:15:03	-	15:15:05	16	-	18	35
38		5	T	15:23:00	15:23:04	-	15:23:36	4	-	36	53
39		5	B	15:23:40	15:23:42	-	-	2	-	-	16
40		1	T	15:23:58	15:24:06	-	15:24:09	18	-	11	26
41		1	T	15:30:12	15:30:34	-	15:30:37	22	-	25	42
42		1	T	15:32:31	15:32:50	-	15:32:52	19	-	21	38
43		1	T	15:39:14	15:39:27	-	15:39:29	13		15	32
44		1	T	15:42:57	15:43:20	-	15:43:23	23	-	23	40
45		1	T	07:52:38	07:52:45	-	07:52:48	7	-	10	-7
46		1	T	09:27:30	09:27:46	-	09:27:49	16	-	19	36
47		1	T	09:53:08	09:53:32	-	09:53:35	24	-	27	44
48		1	T	10:37:16	10:37:23	-	10:37:26	7	-	10	27
49	11/15	1	T	11:05:01	11:05:09	-	11:05:12	8	-	11	28
50		1	T	11:47:48	11:48:00	-	11:48:03	12	-	15	32
51		1	T	11:50:58	11:51:10	-	11:51:13	12	-	15	32
52		1	T	12:00:12	12:00:24	-	12:00:27	12	-	15	32
53		1	T	12:04:13	12:04:23	-	12:04:26	10	-	13	30
54		1	T	12:07:53	12:08:01	-	12:08:03	8	-	10	27
55		1	T	12:14:14	12:14:26	-	12:14:28	12	-	14	31
56		1	T	12:18:47	12:19:07	-	12:19:10	20	-	13	30
57		1	P	12:22:09	12:22:15	-	-	6	-	-	20

Table B-1. Traffic Data for Type T Transactions - Digital Operation (Cont'd)

Trans. No.	Date (1975)	Terminal Number	Transaction Type	Time of Inquiry (T5)	Time of WALES Response (T6)	Time of MILES Response (T7)	Time of NCIC Response (T8)	Response Time -WALES(Sec) (D6)	Response Time -MILES(Sec) (D7)	Response Time -NCIC (Sec) (D8)	Duration of Transaction (D9)
58	11/15	1	T	12:23:38	12:23:42	12:23:52	12:23:45	4	14	7	34
59		1	T	12:30:01	12:30:13	-	12:30:16	12	-	15	32
60		1	T	12:40:11	12:40:18	-	12:40:21	7	-	10	27
61		1	T	12:41:50	12:41:58	-	12:42:01	8	-	11	28
62		1	T	12:44:12	12:44:20	-	12:44:23	8	-	11	28
63		1	T	12:47:31	12:47:51	-	12:47:53	20	-	22	39
64		1	P	12:51:55	12:51:57	-	-	2	-	-	16
65		1	T	13:00:34	13:00:42	-	13:00:44	8	-	10	27
66		1	T	13:02:51	13:03:02	-	13:03:05	11	-	14	31
67		1	T	13:07:24	13:07:32	-	13:07:35	8	-	11	28
68		1	T	13:10:33	13:10:40	-	13:10:42	7	-	9	26
69		1	T	13:11:26	13:11:34	-	13:11:36	8	-	10	27
70		1	T	13:23:57	13:24:09	-	13:24:11	12	-	14	31
71		1	T	13:49:37	13:49:45	-	13:49:47	8	-	10	27
72		1	T	14:02:00	14:02:07	-	14:02:10	7	-	10	27
73		1	T	14:27:02	14:27:11	-	14:27:14	9	-	12	29
74		1	T	14:30:32	14:30:39	-	14:30:42	7	-	10	27
75		1	T	14:35:23	14:35:39	-	14:35:42	16	-	19	36
76		1	T	14:40:56	14:41:08	-	14:41:10	12	-	14	31
77		1	T	14:42:58	14:43:08	-	14:43:10	10	-	22	39
78		1	T	14:44:33	14:44:40	-	14:44:43	7	-	10	27
79		1	T	14:48:34	14:48:46	-	14:48:49	12	-	15	32
80		1	T	14:50:42	14:50:54	-	14:50:57	12	-	15	32
81		1	T	14:53:47	14:53:55	-	14:53:58	8	-	11	28
82		1	T	15:03:22	15:03:35	-	15:03:37	13	-	15	32
83		1	V	15:26:35	15:26:38	-	15:26:41	3	-	6	23
84		1	T	15:36:48	15:36:59	-	15:37:03	11	-	15	32
85		1	T	15:38:39	15:38:46	15:38:56	15:38:49	7	17	10	37
86		1	T	15:48:37	15:48:54	-	15:48:57	7	-	20	37
87	11/16	1	P	00:44:30	00:44:32	-	-	2	-	-	16

Table B-1. Traffic Data for Type T Transactions - Digital Operation (Cont'd)

Trans. No.	Date (1975)	Terminal Number	Transaction Type	Time of Inquiry (T5)	Time of WALES Response (T6)	Time of MILES Response (T7)	Time of NCIC Response (T8)	Response Time -WALES(Sec) (D6)	Response Time -MILES(Sec) (D7)	Response Time -NCIC(Sec) (D8)	Duration of Transaction (D9)
68	11/16	1	T	00:46:19	00:46:35	-	00:46:37	16	-	18	35
89	11/17	1	T	02:51:40	02:52:07	-	02:52:10	17	-	30	47
90		1	T	03:01:07	03:01:14	-	03:01:17	7	-	10	27
91		1	T	03:03:42	03:03:54	-	03:03:57	12	-	15	32
92		1	T	03:10:01	03:10:16	-	03:10:18	15	-	17	34
93		1	T	03:13:07	03:13:27	-	03:13:29	20	-	22	39
94		1	T	03:18:06	03:18:18	-	03:18:20	12	-	14	31
95		1	T	03:22:23	03:22:47	-	03:22:50	24	-	27	44
96		1	T	03:26:16	03:26:24	-	03:26:26	8	-	10	27
97		1	T	03:28:44	03:29:04	-	03:29:07	20	-	23	40
98		1	T	03:31:05	03:31:09	03:34:12	03:31:12	4	187	7	207
99		1	T	03:46:47	03:46:57	-	03:46:59	10	-	12	29
100		1	P	03:48:24	03:48:30	-	-	6	-	-	20
101		1	T	03:54:29	03:54:37	-	03:54:40	8	-	11	28
102		1	T	04:22:06	04:22:14	-	04:22:17	8	-	11	28
103		1	T	04:24:52	04:25:00	-	04:25:03	8	-	11	28
104		1	T	04:30:13	04:30:20	-	04:30:22	7	-	9	26
105		1	T	04:32:20	04:32:27	-	04:32:29	7	-	9	26
106		1	T	04:34:08	04:34:27	-	04:34:29	19	-	21	38
107		1	T	04:40:43	04:40:50	-	04:40:53	7	-	10	27
108		1	T	04:45:37	04:45:45	-	04:45:48	8	-	11	28
109		1	P	06:40:00	06:40:07	-	-	7	-	-	21
110		1	T	06:52:39	06:52:50	-	06:52:53	11	-	14	31
111		1	P	06:55:18	06:55:24	-	-	6	-	-	20
112		1	T	07:00:13	07:00:21	-	07:00:23	8	-	10	27
113		1	T	07:03:08	07:03:19	-	07:03:22	11	-	14	31
114		1	T	07:05:16	07:05:26	-	07:05:29	10	-	13	30
115		1	T	07:09:19	07:09:36	-	07:09:38	17	-	19	36
116		1	T	07:13:20	07:13:28	-	07:13:30	8	-	10	27
117		1	T	07:15:10	07:15:22	-	07:15:24	12	-	14	31
							TOTAL	1243	781	1947	4667
							AVERAGE	10.62	78.1	18.20	39.89

64258

March 29, 1976

Final Report
on

Hand Held Digital Inquiry Terminals and Field Trial System

Prepared for

The Government of the District of Columbia
Metropolitan Police Department
Washington, D.C.

Contract No. 0147-AA-NS-0-5-FA

Burroughs Corporation
Federal and Special Systems Group
Paoli, Pa. 19301

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FOREWORD

The development, test and evaluation effort covered by this report was performed for the Metropolitan Police Department, Washington, D. C., under Contract Number 0147-AA-NS-0-5-FA as accepted by the District on September 5, 1974. This contract was executed under sponsorship of the Law Enforcement Administration Agency (Grant #73-SS-99-3304 as amended by LEAA Grant #74-SS-99-3311; Project title: "Pilot Police Man Portable Digital Communications System". The DCMPD contract was awarded to Burroughs Corporation in response to proposal number B-3396-D, entitled, "Hand Held Digital Inquiry Terminals and Field Trial System".

ACKNOWLEDGMENTS

Acknowledgment is accorded to the Law Enforcement Assistance Administration whose support of the innovative concept of a man portable digital inquiry terminal for police applications made this pilot project possible. Special acknowledgment must be accorded to the many officials, officers and civilian employees of the District of Columbia Metropolitan Police Department, and in particular, to Deputy Chief Theodore E. King and Sergeant Charles A. Peacock, whose administrative coordination and technical assistance provided an invaluable and essential element in the performance of the pilot development and study effort.

ABSTRACT

In accordance with paragraphs 4 and 7 of Contract #0147-AA-NS-0-5-FA this "Final Report" provides a comprehensive technical description and history of the "Pilot Police Man Portable Digital Communications System" and Burroughs evaluation of in-field system performance. The report presents background data in support of design criteria and design decisions. It describes system evolution and modifications effected during the system test and evaluation period. It also provides a comprehensive description of the developmental system as well as Burroughs evaluation of system performance. Also provided are conclusions and recommendations concerning the viability and implementation of a truly compact, light weight, "Hand Held Terminal" and digital inquiry system for police applications.

SECTION 1

INTRODUCTION

In September of 1974, the Burroughs Corporation, Special Systems Division, Federal and Special Systems Group, contracted with the Government of the District of Columbia, Metropolitan Police Department to Design, Test, and Evaluate a "Pilot Police, Man Portable Digital Communications System". The contracted effort was, as its title indicates, considered to be a "Pilot" or "Developmental" Task. The System, otherwise known as " The Hand Held Digital Inquiry Terminals (HHT) Field Trial System", was to consist of 5 battery powered, man portable Digital Inquiry Terminals and a Central Terminal Controller to provide interface with the existing Washington Area Law Enforcement System (WALES). The portable terminals were required interface with unmodified General Electric Model PR-25, UHF radios (Hand Held Radios) via the existing speaker/mike jack provided on these radios. The central controller, a Burroughs B 711 microprocessor, would provide a direct interface between the existing DCMPD "City Wide 1", UHF/audio network and the WALES data base system. The B 711 would receive modulated, pseudo analog digital inputs directly from the remote Hand Held Terminals; reformat these inputs for WALES compatibility and, in emulation of a 2740 I/O terminal, forward these inputs to WALES. The B 711 would additionally receive inquiry responses from WALES, and by emulating a 2740 terminal and the visual, manual and vocal functions of a dispatcher, scan, edit and compress these responses and transmit the most pertinent response data directly to the Hand Held Terminals. The Pilot System was required to be implemented without modification to the existing radio system or equipments and without modification of the existing WALES hardware or software. It was additionally required that the pilot system equipments be implemented and tested on the existing DCMPD, City Wide 1 Radio Network, in a voice/digital overlay mode.

The purpose of the HHT System was to allow foot, scooter, or car mounted policemen, in the field, to input direct digital inquiries to the WALES Data Base and to receive fast, readable, plain text responses directly from WALES, without the aid or intervention of a dispatcher.

The immediate goal of the HHT pilot program was to provide equipments whereby the concept of a man portable digital inquiry system could be tested, in a tactical police environment and evaluated from technical, tactical and human factors viewpoints. The ultimate goal was to use the experience gained through the pilot program field tests to determine the functional viability of a Hand Held Digital Inquiry Terminal; to learn through actual experience the needs of the field policeman with respect to inquiry responses and to determine the feasibility of providing a truly compact, low cost, Hand Held Computer Terminal for Law Enforcement applications.

Section 2 of this report describes, in detail, the design considerations in the System Development Phase. Section 3 provides a description of the delivered developmental system. In Section 4, the field tests and system modifications and enhancements implemented during the test period are discussed. Finally, Section 5 provides an evaluation of the performance of the developmental system as well as conclusions and recommendations on product development and implementation.

SECTION 2

DESIGN CONSIDERATIONS IN THE HHT DEVELOPMENT PHASE

2.0 DESIGN CONSIDERATIONS IN THE SYSTEM DEVELOPMENT PHASE

2.1 General

The Hand Held Terminal program was, by contract definition, a short term, low budget experimental exercise. The immediate purpose of the program was to put functional equipments in a tactical police environment as quickly as possible and to initiate field tests, with a fully functional system. Therefore, certain design tradeoffs were necessary in the interest of defined schedules. The purpose of the following discussion is to outline the technical aspects of the developmental program; to discuss design tradeoffs, where applicable, and to provide a description of the state-of-the-art technology available during the developmental phase and, where possible, to contrast this technology with that which is now, or will soon be, available for production implementation.

2.1.1 Salient Developmental System Design Considerations

The following elements constituted the salient considerations in the developmental HHT system design phase:

- System Interface Considerations
- Physical Size of the Man Portable Terminal

- Hand Held Terminal Keyboard
- Hand Held Terminal Logic
- Hand Held Terminal Display
- Hand Held Terminal Modem and Modulation Techniques
- Hand Held Terminal Power System
- Hand Held Terminal/Processor Communications Discipline
- Processor to Audio Network Interface
- Hand Held Terminal Processor

2.1.1.1 System Interface Considerations

Early in the contract period, several technical meetings were held with representatives of the District of Columbia Metropolitan Police Department and, separately, with representatives of the General Electric Company, Mobile Radio Division, Lynchburg, Virginia. These meetings resulted in Burroughs acquisition of significant and previously undefined information germane to the Hand Held Digital Inquiry Terminal pilot system design.

General Electric Company graciously provided specific, non-proprietory, technical information on the radio equipment used in the DCMPD "City Wide 1" communications network. Information provided by General Electric Company included: PR 25 Hand Held Radio characteristics, satellite receiver and base transmitter characteristics; and , importantly, information on the G. E. Voting Logic equipment and system "attack times" (i. e., "front porch delay" or system keying time), inherent in the GE system. The DCMPD provided information and block diagrams showing the audio interconnections in the City Wide 1 Radio network. This information resulted in the development of the HHT/City Wide 1, system block diagram shown in Figure 2-1. This Figure illustrates, in simplified form, the DCMPD City Wide 1 communications network with the then proposed Burroughs HHT System elements indicated by dashed line blocks.

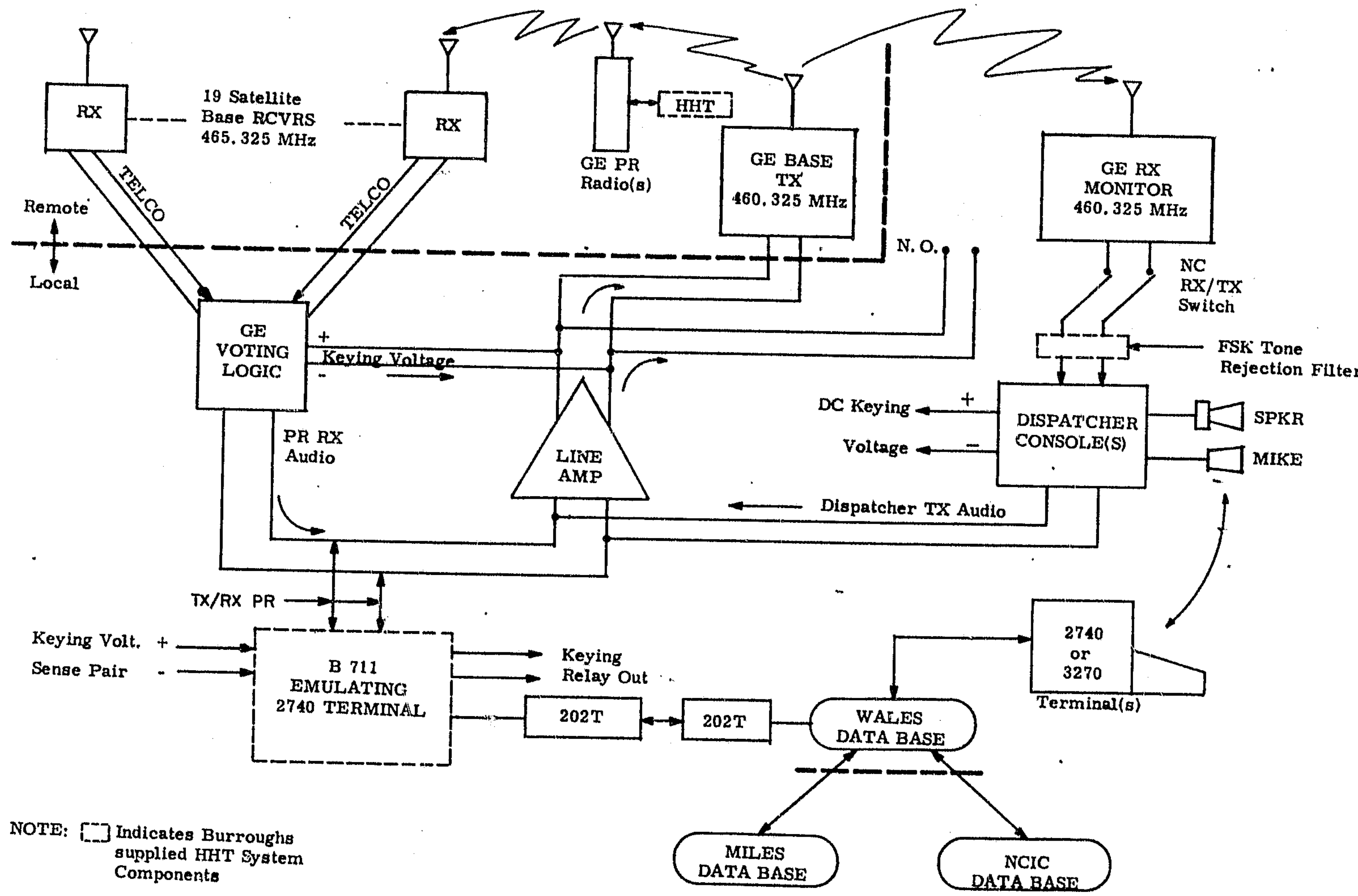


Figure 2-1. DCMPD CW1 Communications Network with HHT

During these discussions, DCMPD personnel also provided Burroughs with information on the 2740 terminal to WALES interface; specifically message types, formats, codes and communications discipline. It was additionally mutually agreed that the Burroughs supplied HHT Field Trial System would be confined to implementation of the following inquiry types:

- TAG INQUIRY: (vehicle license tag)
- VIN INQUIRY: (Vehicle serial/registration number)
- PERMIT INQUIRY: (operators license)
- NAME INQUIRY: (response limited to outstanding wants and warrants)
- BIKE INQUIRY: (bicycle registration number)

2.1.1.2 Physical Size of the Man Portable Terminal

User acceptance of a man portable digital inquiry terminal, particularly in Law Enforcement applications, will depend to a large extent on the physical size and weight of the terminal equipment. An awkward and cumbersome device will receive limited acceptance by the foot patrolman, while an extremely compact, light weight design, similar for example, to a pocket model electronic calculator would, at least in concept, be highly acceptable and would be used to its maximum functional capability.

With contemporary technology, the defining factors which reflect on terminal size and weight are keyboard size, display size, logic circuitry and, most importantly, the effect of all of these elements on terminal power requirements.

Figure 2-2 is a block diagram of the Burroughs Hand Held Terminal design proposed and implemented in the developmental program. This diagram, with some variations in functional specifies, typifies the basic functional blocks required in any interactive, battery powered, keyboard entry display terminal. The magnitude and characteristics of the functions may vary as may the method of implementation, but the essentials are the same. All of the functional elements of this block diagram can, in a production design, be provided in a configuration compatible with the compact Hand Held Terminal concept.

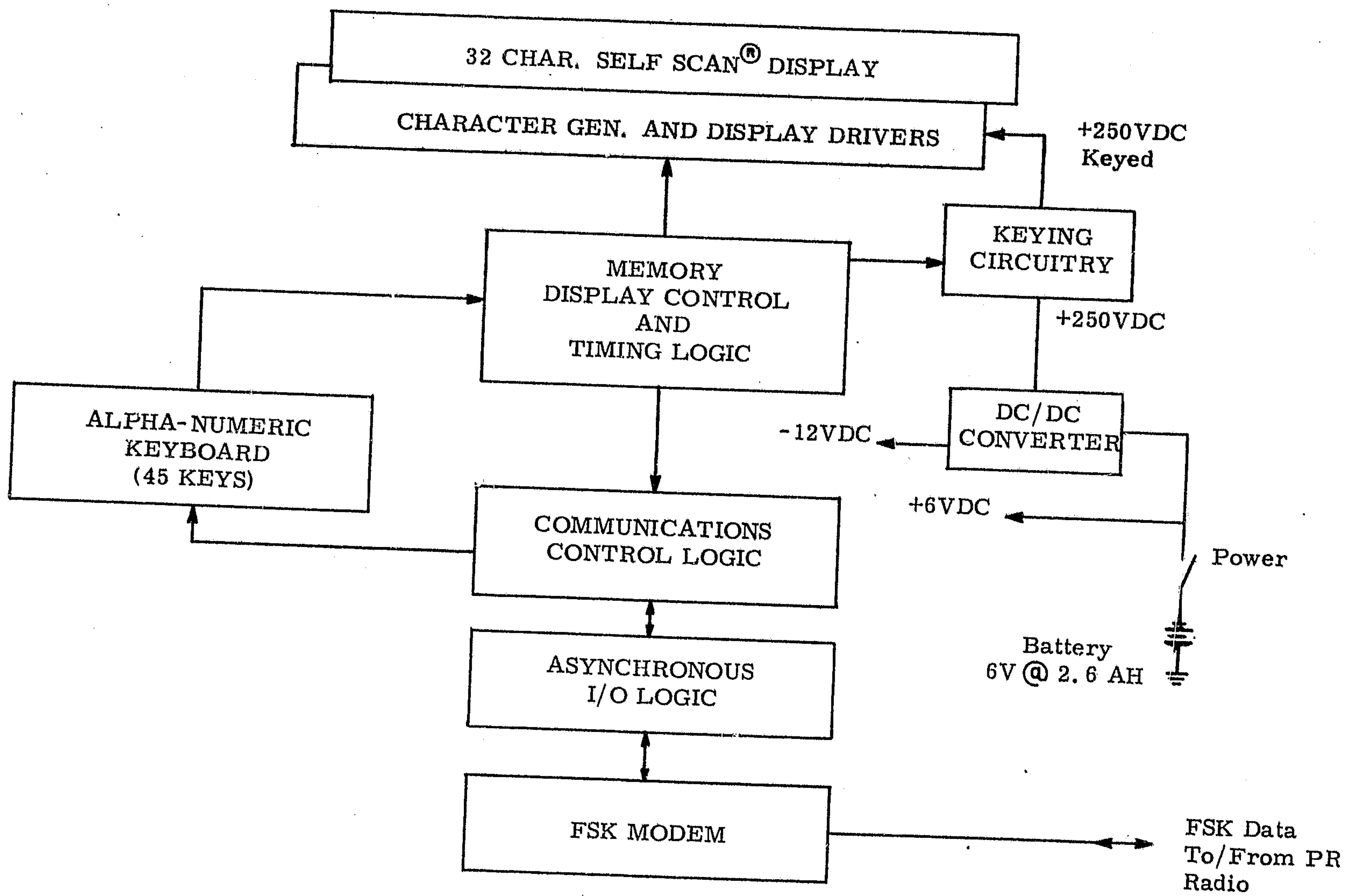
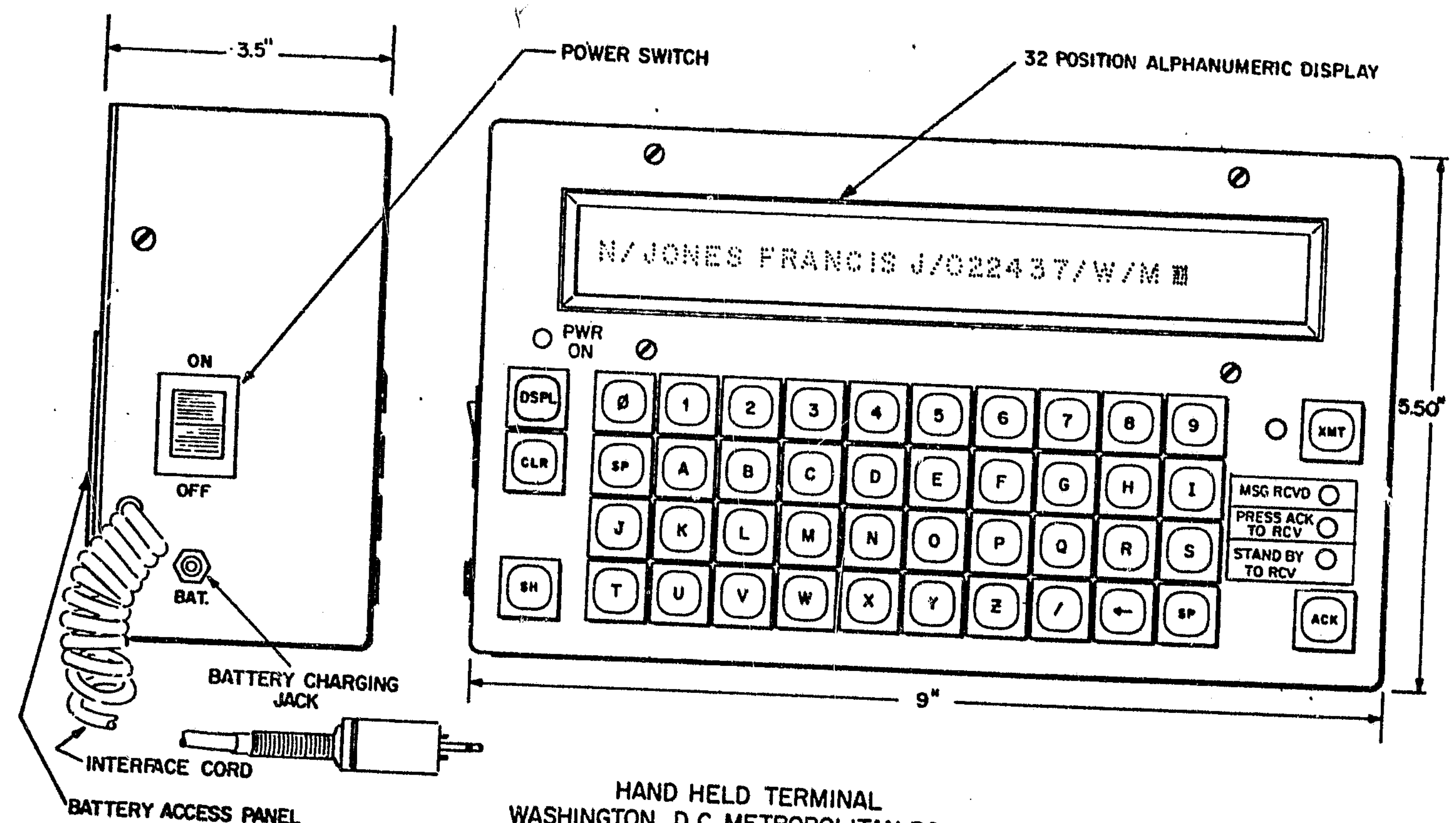


Figure 2-2. Block Diagram Developmental HHT



HAND HELD TERMINAL
WASHINGTON, D.C. METROPOLITAN POLICE
(DEVELOPMENTAL MODEL USING 5/8" KEYS)

Figure 2-3. Physical Size of HHT

Large scale integration of the logic circuitry, either by custom LSI or by the implementation of an LSI microprocessor can reduce the number of logic chips by a factor in the order of 10 to 1, as compared with approximately 90 devices required to implement the logic design with off-the-shelf SSI and MSI logic elements.

The contemporary emergency of pocket size slide rule calculators, having 40 or more keyboard keys, provides ample illustration of the feasibility of a compact, full alpha-numeric keyboard. A 32 character alpha-numeric display element can also be provided in a compact design but, with state-of-the-art techniques existing at the time of the implementation of the development system design, presents a special challenge with regard to power requirements and brightness as discussed below in considerable detail.

In the interest of the expediency necessary to satisfy the requirements of the Hand Held Terminal developmental program, within the limits of the time and financial resources provided, the Burroughs Developmental Model Terminal, as stated in Burroughs proposal number B-3396-D, sacrificed physical size and weight while still providing a man portable device having capabilities suitable for concept test and evaluation purposes.

The Burroughs proposal estimated the physical size of the HHT developmental models to be 9" w × 4-3/8" h × 2.5" d. The actual size of the developmental model terminals provided (See Figure 2-3) was 9" w × 5.5" h × 3.5" d. The weight, including internal battery and protective cover is 5.6 pounds. This size and weight are reasonably consistent with the proposed estimate. Careful consideration of the physical size of the developmental HHT in relation to the size of the GE PR-25 radio, however, made clear that the mounting concept in the original Burroughs proposal, (i.e., with the HHT physically "strapped" to the PR-25) would be far too combersome for reasonable handling. The originally proposed mounting concept would not only encumber the use of the terminal, but would make it unreasonably difficult for the patrolman to carry and operate the PR-25 radio during field trials. An alternate method and, in Burroughs opinion, the only reasonable method, was to provide the developmental model terminal in an instrument type case configuration with a shoulder strap. An umbilical cord, with connector, was provided as an integral part of the terminal.

In the field trials, the terminal could be slung over the shoulder, separate from and not connected to the PR radio. When the terminal is to be used, it can be simply plugged into the "speaker/mike jack" on the PR radio (the radio can, if desired, still remain in its case mounted on the patrolman's hip). Conversely, and importantly, the patrolman can still use the radio without the terminal and without being encumbered by the size of the terminal). It is significant to note that the increase in the developmental model terminal size and mounting concept was primarily the result of a design decision to provide a self-contained battery in the terminal rather than to draw power from the PR-25 radio as tentatively discussed in the Burroughs proposal. (In retrospect, this decision seems to be justified in that the resulting extension of terminal and radio battery life proved an asset in evaluation of the system concept).

2.1.1.3 Hand Held Terminal Keyboard

Burroughs Hand Held Terminal Proposal Number B-3396-D discusses various ways of implementing an alphanumeric entry keyboard in the developmental terminal. These techniques ranged from a "touch tone" type, 12 key array with multi-character shift capability to an "Ouija Board" entry system. In subsequent negotiations, prior to contract award, it was determined by DCMPD request, that the Burroughs field trial model would provide a "full" alphanumeric keyboard consisting of approximately (40) discrete keys. In the course of an initial design analysis, subsequent to contract award, Burroughs researched and conducted tests on various keyboard designs and techniques. As a result of these tests and related prior experience, it was determined that a key size of approximately 1/4" with 1/2" center to center key spacing would provide the optimum compact keyboard design. It was additionally concluded that the provision of a raised bezel, separating the keys, was required to minimize multi-key depression effects (particularly with a gloved operator) and that the optimum design should provide tactile feedback as opposed to techniques whereby key depression does not result in any perceptable motion or touch reaction. A survey of keyboard

and key switch manufacturers was conducted. Manufacturers contacted were: Burroughs Corporation, Chromerics, Wild Rover, Texas Instruments, Cherry, Microswitch, Oak Industries, Gray Hill and MISAK Corporation. As a result of this survey, it was readily apparent that a keyboard of the desired configuration could be provided. The thin elastic, or elastromeric membrane technique, in conjunction with a metallic snap action element to provide tactile feed back offers the best potential for design and cost optimization as well as "water proof" capability. It quickly became apparent, however, that engineering and tooling costs and, more importantly, lead time, would preclude the incorporation of an optimum, custom designed keyboard in the Hand Held Terminal developmental model.

The only viable alternative for the developmental model design was to find an off-the-shelf keyswitch of acceptable size and characteristics and to incorporate this keyswitch in a discrete key array with a minimum component, low power encoder design. The Oak Industries type 415 key switch selected for the developmental terminal satisfies these requirements. This key switch is .415 inches high and can be mounted on 5/8", center to center, spacing. (Standard alphanumeric key spacing is 3/4".) The key switch provides a satisfactory degree of tactile feedback; total key travel is 0.1" with a nominal pre-travel of 0.070". The key top has a raised, concave plateau, thereby providing good touch and selection characteristics.

In the Hand Held Terminal developmental model, the Oak Industries key switch is incorporated in a Burroughs designed, minimum component, low power keyboard. The keyboard encoder requires three CMOS SSI integrated circuit chips and three transistors. Power requirements for the keyboard/encoder design are approximately 500 microwatts in the idle state and only two milliwatts with a key depressed.

2.1.1.4 Hand Held Terminal Logic Design

The obvious technology for implementation of any compact logic design is Large Scale Integration (LSI) logic circuitry, whether in the form of custom LSI chips or by use of an off-the-shelf microprocessor, programmed via read only memory

(ROM) devices. The use of custom LSI in the developmental terminal was quickly dismissed; due to high "front end" costs, long lead time, typical reitterative design cycles, and because the rigidity of design would be unsuitable for a developmental system. Careful consideration was given to the use of a single chip microprocessor, including the Burroughs LSI "Mini-D". Although it was clear that the use of a microprocessor would provide the most compact design, it was also clear that available PMOS, NMOS and/or bipolar microprocessors and compatible peripheral logic elements, including programmable read only memories (PROMS), would consume considerably more power than a comparable functional design using complementary MOS (CMOS). CMOS power requirements in a "low speed" design are an order of magnitude lower than other integrated circuit technologies. Not only are the inherent power requirements less with CMOS but, importantly, CMOS will operate dependably over a wide range of supply voltage (typically +3 to + 15 VDC). CMOS is therefore eminently suitable for application with unregulated battery supplies and does not require power supply regulation and the power losses associated with regulation.

Once again, a developmental model design trade-off was made in the interest of design expediency and terminal power requirements, and off-the-shelf CMOS, SSI and MSI integrated circuits were used wherever possible. (Incidentally, at the writing of this report, CMOS microprocessors have been announced which were unavailable during the developmental model design phase).

2.1.1.5 Hand Held Terminal Display

The display device is an important, if not the most critical element in the Hand Held Terminal design; display size and power requirements being the most critical parameters to be dealt with. Display size must be considered both from the standpoint of the minimum number of characters necessary for the required application and from the purely human factors standpoint of character size, resolution, brightness and contract ratio. Display size, however, is not a limiting factor since there are numerous proven techniques available to gain optimum effects from a limited number of physically small characters (e.g.: memory paging, display scrolling, and display magnification). Unfortunately, the power requirement can not be as easily dismissed since this parameter has serious

impact on the system power supply design, weight and packaging, particularly in a battery operated device.

With the present proliferation of pocket calculators it is natural to attempt to draw a direct comparison between these compact battery operated devices which provide up to 16 display characters and a Hand-Held alphanumeric terminal. If it can be done in a pocket calculator, why is it a problem in a Hand Held alphanumeric terminal? The answer is quite simple.

The pocket calculator display is a numeric only device and is typically implemented with a seven segment display element. The average usage (i.e., elements illuminated per character, in a typical 16 character numeric display) is 5, or a total of $16 \times 5 = 80$ illuminated elements per average 16 character display. (assuming all 16 characters are used which is, in itself, a worst case assumption).

It is generally accepted that the generation of the alphanumeric character font, as required in the Hand Held Terminal, can be most efficiently accomplished with a 5×7 dot matrix. That is, with a minimum resolution of 35 elements per character. The average usage (i.e., elements illuminated per character) is 20, or a total of 320 elements per typical 16 character display.

In this typical simple example the ratio between the display elements required for an alphanumeric display to those required for a numeric only display is 4:1. If we assume that the display elements in both applications are of the same type (e.g., LED's) then the power ratio is also 4:1. In actual fact, however, the power ratio is considerably higher. This is true for two reasons: (1) because of market considerations more development effort (as of the time of the developmental HHT design effort) has been expended on lower power, numeric, monolithic display devices than has been the case with alphanumeric LED devices and, (2) since the typical alphanumeric LED device is implemented in a 5×7 matrix, the ratio between the magnitude of peripheral logic and drive circuitry required for the alphanumeric device as compared to the numeric only device is exponential rather than linear. A comparison of application specifications for typical monolithic LED displays (Hewlett Packard, Monsanto, Texas Instruments and Dialco) shows that the actual power ratio is between 10:1 and 20:1. A formidable consideration in the design of a portable, battery operated system.

Given, then, that an alphanumeric display requires significantly more power than a numeric display and that power is THE critical parameter in the design of a portable, battery operated system, the need for selecting the most power efficient display device in the Hand Held Terminal design is axiomatic. Available technology reduces this selection to one of two device types: a monolithic 5 X 7 LED device or a 5 X 7 dot matrix plasma display.

In the Hand Held Terminal development model design, Burroughs has selected the Burroughs model SSD0132-0030, 32 character, Self Scan® Plasma Display. Table 2-4 shows a comparison of power requirements for the Self Scan® display and a typical 32 character display using 5 X 7 alphanumeric LED elements. The table is a conservative calculation providing justification for the use of the Self Scan® Display simply and solely on the basis of power requirements. It is additionally worth noting that because of its unique method of matrix scanning the Burroughs Self Scan® Display requires less than 10 percent of the drive circuitry required for the LED array or for other comparable plasma displays.

It is also worth noting that although on-going development of small low power alphanumeric display devices holds promise of new display elements in the future; particularly 14 and 16 element LEDs, small alphanumeric LCD devices and low power electroluminescent matrices, such devices were not available during the HHT design phase.

Table 2-4

Comparison of Power Requirements

32 Char. Self Scan vs 32 Char. Monoltihic Led Array

Burroughs SSD0132-0030 Self Scan Display

Character Type:	5 X 7 Dot Matrix
Number of Characters:	32
Assumed Battery Supply:	6VDC
Scan Method:	Horizontal, Self Scan®

Display Power Requirements

+250V	30 MA (Max)	= 7.5W
-12 V	-50 MA (Max)	= .6W
+5V	100 MA (Max)	= .5W
Total power (Max)		= 3.6W

Assumed Eff. of DC/DC Conv. = 80%

Steady State Battery Power

Worst Case	= 10.75W
Typical	= 6.00W

Hewlett Packard 4082-710X 5 X 7, LED, Alphanumeric Indicator

Character Type:	5 X 7 Dot Matrix
Number of Characters:	32
Assumed Battery Supply:	6 VDC
Scan Method:	Vertical

Average I/LED =	= 10 MA
Average LEDS ON/Char	= 20
Average Display Current:	=

$$\frac{10\ MA}{LED} \times \frac{20\ LED}{Char.} \times 32\ Char = 6.4A$$

Steady State Battery Power (AV) = 38.4W

Power Ratio, LED (AVE)/SS(MAX) = 3.6:1 (32 Char. Display)

2.1.1.6 Hand Held Terminal Modem

The digital data generated by the Hand-Held Terminal System must be transmitted through existing voice grade radio circuits and TELCO lines (See Figure 2-1). In the field trials the HHT system was to be tested on the DCMPD, City Wide 1 radio net, in a voice/digital overlay mode. The tests were to be conducted without modification to the existing voice grade radio equipment or to the Radio/TELCO communications link. The major considerations in the HHT digital interface are:

(1) achievement of maximum data rates with minimum probability of error and;

(2) minimization of interface circuit complexity as necessary to satisfy the low power and low volume requirements of the Hand Held Terminal design.

Since only five (5) terminals are to be implemented in the field trial system, and the maximum text message length per terminal is 32 characters, the achievement of a high data rate is not critical to pilot system throughput. In a fully operational, tactical system, however, where the number of Hand Held Terminals in the system may be one hundred or more, efficient channel usage and system throughput will require optimization of the digital data rate. One of the goals of the field trial system is, in fact, to empirically evaluate the characteristics of the communication system in order to determine system throughput and required data rates from a tactical viewpoint.

For the field trial system, however, the only hard restriction imposed which reflects on data transmission rate is an FCC regulation limiting the duration of digital transmissions, in a radio, voice/digital overlay communication system to less than two (2) seconds. A data rate of 300 bps (bits per second) will more than satisfy this requirement; i. e. :

- 35 character/message $\times$ 10 bits/character $\times$ /Sec/300 bits = 1. 666 Sec/Msg.
- Text message = 2 address characters, 32 text characters and 1 block check character

The aforementioned FCC regulation not withstanding, there are purely technical reasons regarding the selection of 300 bits per second as the Hand Held Terminal Pilot Program data rate.

The direct transmission of raw digital data at rates of above 110 bps over voice grade TELCO lines is, as has been well established, not technically practical. Further limitation imposed by the nature of the audio circuitry used in typical UHF radio equipment, particularly the use of pre-emphasis and de-emphasis filters, further supports the limitations imposed on direct transmission of raw digital data.

(See the Kelley-Ward report on "Investigation of Digital Mobile Radio Communications", LEAA dated October 1973).

Transmission of data rates higher than 110 bps requires the implementation of base band modulation - demodulation of the digital data (Modems). Of the various types of Modem techniques available, e. g. , FSK (frequency shift keying), PSK (phase shift keying) and DPSK (differential phase shift keying) to name a few; FSK is the simplest technique to implement with respect to minimization of size and of required power. FSK modulation, where the binary shift in base band frequency is directly related to the binary value of the data is most efficiently implemented (from the standpoint of circuit compactness and accuracy) when the binary frequencies contain the maximum number of cycles per bit as the base band will allow. The base band in the DCMPD City Wide 1 UHF/TELCO system is essientially flat from 300 Hz to 3000 Hz with a notch filter, for the comparator logic squelch tone at 2400 Hz with 3 dB points at ± 150 Hz.

The FSK tones implemented in the Burroughs Hand Held Terminal System are 2025 Hz (space) and 2225 Hz (mark) at a data rate of 300 bps. These frequencies provide a worst case FSK cycle/bit relationship of approximately 7. 42:1 and 6. 75:1 for a binary 1 and a binary 0 respectively. The Hand Held Terminal FSK modem provides a sinusoidal output with phase coherent frequency shifting. These characteristics, as well as minimization of the difference between the two modulating frequencies, allow the Hand Held Terminal data to be transmitted through the UHF radio audio circuits without experiencing detrimental effects due to the audio pre-emphasis and de-emphasis filters. Phase distortion and jitter are reduced, resulting in excellent digital transmission characteristics.

2. 1. 1. 7 Hand Held Terminal Power System

The Hand Held Terminal Developmental models include a self contained 6V, 2. 6 AH (at 20 hour rate), gelled electrolyte battery. The separate battery philosophy was chosen in order to provide maximum battery life for the Hand Held Terminal without effecting battery life of the PR25 transceiver. Additionally the 6V gel/cell battery output voltage is more suitable and efficient for the operation of the internal circuitry of the Hand Held Terminal than is the 7. 5V, 1. 5 AH battery provided in the transceiver. The gel/cell battery was selected over the NICAD battery primarily since it provides acceptable power to weight/volume ratio, does not exhibit the memory and reverse polarity properties of NICAD batteries and was readily available in a self-contained, HHT design compatible package.

In the idle mode (with the display extinguished) the HHT consumes less than three watts (measured). With the display illuminated, power consumption is approximately 9 watts. Three internal voltages are required: the raw battery voltage (6.36 volts at full charge) - 12 VDC and + 250 VDC. The -12 and 250 voltages are developed by means of a highly efficient DC/DC converter. In order to conserve power and maximize battery life, the 250 VDC supply is keyed off when the display is not in use (idle mode). With the 2.6 AH gel/cell battery, assuming a 50 percent power on duty cycle during normal HHT use and a projected 10 percent "display on time" during usage, battery capacity should be sufficient for an eight hour shift period.

The gel/cell can be fully charged in approximately 12 hours and separate battery chargers will be provided for each Hand Held Terminal. The gel/cell may be stored indefinitely in a fully charged state with little shelf loss. Expected battery life is up to 400 charge/discharge cycles. Battery replacement cost is less than 1/8th that of the transceiver NICAD battery. The HHT design allows the battery to be recharged without removal from the terminal or, for quick return to operation, a discharged battery may be quickly replaced by removal of a battery access plate.

The maximization of HHT usage with respect to battery capacity rests in the keying of the display voltage and display function. In the "stand by" or "idle mode" of operation, the HHT display is off. The display is keyed on when the operator composes a message and will remain on until the XMIT key is depressed or until approximately 15 seconds after the last keyboard entry has been made.

When a response is received by the Hand Held Terminal a single LED is illuminated rather than the display. By depressing the ACK key, the operator, at his discretion, will activate the display to view the incoming message. The display will self extinguish after approximately 15 seconds. A longer view of the

message text is possible, if required, simply by redepressing the display key.

2.1.1.8 Hand Held Terminal/Processor Communications Procedure

In any interactive digital communication system, a communications discipline (i.e., a means to establish message priorities and message sequencing as well as an orderly and efficient recovery from transmission errors) must be implemented. In a typical multidrop digital system a Poll and Select procedure is used; the processor holds master status with control over all terminal transmissions. The Poll and Select method of communication discipline has been "tried and proven" and is well established as the method for implementation on dedicated digital channels. This technique, however, in its various forms, requires that the master element (usually the processor) "continuously" send sequential poll (are you ready to transmit) messages and select (are you ready to receive) messages to all terminals and that the terminals respond, in sequence, with a ready/not ready message. The continuous poll and select messages represent a comparatively insigificant overhead function in the dedicated digital system. However, in a digital/voice overlay system they would represent an intolerable voice interference factor.

The communications discipline for the Hand Held Terminal system has, therefore, been specifically designed by Burroughs for the voice/digital overlay network on which the system will be implemented. This discipline (described in detail in Section 3) is essentially a psuedo contention mode procedure. The communication line is, in the digital sense, normally idle. Since the system is basically an inquiry system, with no unsolicited responses generated by the processor, all message sequences originate, at the operator's discretion at the terminal. All terminal inquiries and responses are manually activated by operator action. Error detection and recovery is accomplished by time outs in the HHT and operator notification is by means of status indicators.

This procedure eliminates the unwanted "continuous" digital tones from the digital/voice overlay system and, additionally allows the terminal operator to have full control over digital transmissions on the network. Not only does the terminal operator control the digital messages transmitted from "his" terminal, he also controls the transmission of text responses from the processor.

2.1.1.9 Processor to Audio Network Interface

The B 711 processor will interface to the DCMPD City Wide 1 radio net, as shown in Figure 2-5. Three interface pairs are provided as follows:

Transmit/Receive Pair:	Balanced 600 ohm (maximum length 1000 ft.)
Keying Pair:	Isolated terminals of SPST, N.O. relay. Relay rating: 100V@ 1 A max., cable length 1000 ft. max. (to keying power supply in CW1 module)
Key Voltage Sense Pair:	High impedence (greater than 100K ohms) balanced pair. Max length 1000 ft. (connects to keying voltage pair in system)

The following functional restrictions are imposed on the processor to audio interface:

a. The processor shall not transmit digital data while the digital/voice network is active. (i.e., voice or digital transmissions in progress).

b. The processor, when transmitting shall cease transmissions when a voice transmission is initiated.

These restrictions are met by design of the interface circuitry within the B 711 processor.

Restriction "a" is satisfied as follows: The processor/network interface shall continuously monitor the DC keying voltage in the network. If the processor is not transmitting and the keying voltage is high, voice transmission is assumed. The processor will not initiate digital transmission until at least 1 second after the keying voltage goes low.

CONTINUED

2 OF 4

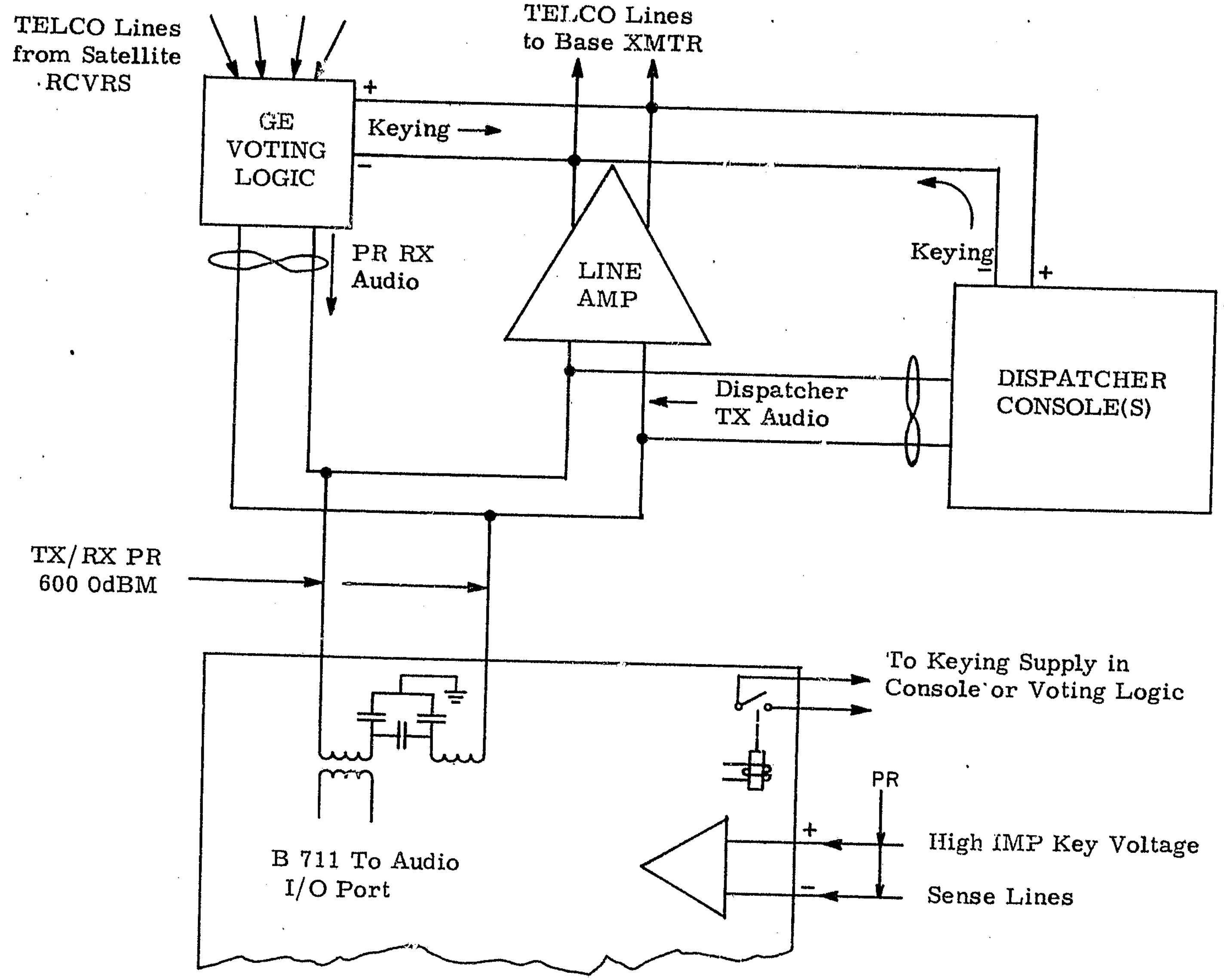


Figure 2-5. Interface Diagram HHT Processor to Audio Network

Restriction "b" is satisfied as follows: When the processor tries to initiate a transmission it must first sense keying voltage low, then set the keying relay at the processor interface thereby setting the keying voltage high. Processor waits 0.6 seconds (worst case radio attack time) then initiates digital transmission. While transmitting, processor continuously monitors receive line (i.e. monitors its own transmission) and compares transmitted data with receive data. If transmitted and receive data do not compare exactly, processor assumes transmission is being "garbled" by coincident voice transmission and terminates digital transmission.

2.1.1.10 Hand Held Terminal Processor System

In the developmental Hand Held Terminal System, the interface between the remote hand held terminals and the WALES date base system is provided by a Burroughs B 711 processor as illustrated in Figure 2-1. In compliance with the contract design restriction of "no modification to the existing City Wide 1 radio network or the WALES hardware or software", the B 711 emulates a 2740 terminal. The B 711 was selected for implementation in the Hand Held Terminal developmental system design because of its inherent emulation capability. The B 711, is an interpreter based system. That is, the B 711 architecture is such that its functions are independent of machine hardware. Machine functions are defined by microprogram elements called "firmware". In point of fact, it is the firmware which defines, in the conventional sense, the machine architecture and therefore the basic processor functions. Hardware interfaces to the B 711 are also undefined in the basic system architecture and can be structured to suit specific applications by implementation of custom designed hardware elements called Device Dependent Ports (DDPs) and custom designed firmware controllers.

In the developmental Hand Held Terminal system, the B 711 operating system includes both executive and microprogram functions. A virtual machine (i.e., one which is independent of machine functions) is provided by a control application language (CAL) interpreter. Executive functions (task scheduling and queueing) are provided in this virtual machine by the real time control system (RTCS) which also handles date/time manipulations and other centralized functions. The

system I/O is handled at the hardware interface by microcontrollers, which convert data transfers at the byte/word/group level to message transfers that are handled at the virtual machine level (i.e. by CAL programs).

In addition to its inherent "building block capability", the B 711 system was implemented in the developmental Hand Held Terminal System because the CAL interpreter and basic elements of the RTCS were developed on a previous program having requirements similar to those of the HHT system, thereby simplifying the software design aspects of the developmental system.

The hardware consistency of the B 711 system and peripherals provided for the HHT developmental system include the following standard Burroughs products and peripherals:

- B 711 processor with 48k byte core memory
- L-Console with 15" platten printer
- Dual Disk bulk store
- A9114 card reader
- TD700 I/O display terminal
- B 711/WALES custom interface (DDP)
- B 711/Audio Net. custom interface (DDP)

SECTION 3

DESCRIPTION OF THE DELIVERED DEVELOPMENTAL SYSTEM

3.0 DESCRIPTION OF THE DELIVERED DEVELOPMENTAL SYSTEM

3.1 GENERAL

Section 3 provides a detailed description of the Hand Held Terminal Developmental System delivered to the District of Columbia Metrolplitan Police Department by Burroughs Corporation. The system description is that of the final system, including system enhancements and modifications made during the field trial period, as described in Section 4. Not included in this section, but provided, under separate cover, to the DCMPD are complete software and firmware listings for the B 711 system as well as punched card decks and disk copies of the B 711, HHT system software and firmware.

This section is presented in three parts:

- The developmental model terminal (See Figure 3-1).
- The system inquiry and response formats
- The B 711 system and peripherals provided in the developmental system configuration.

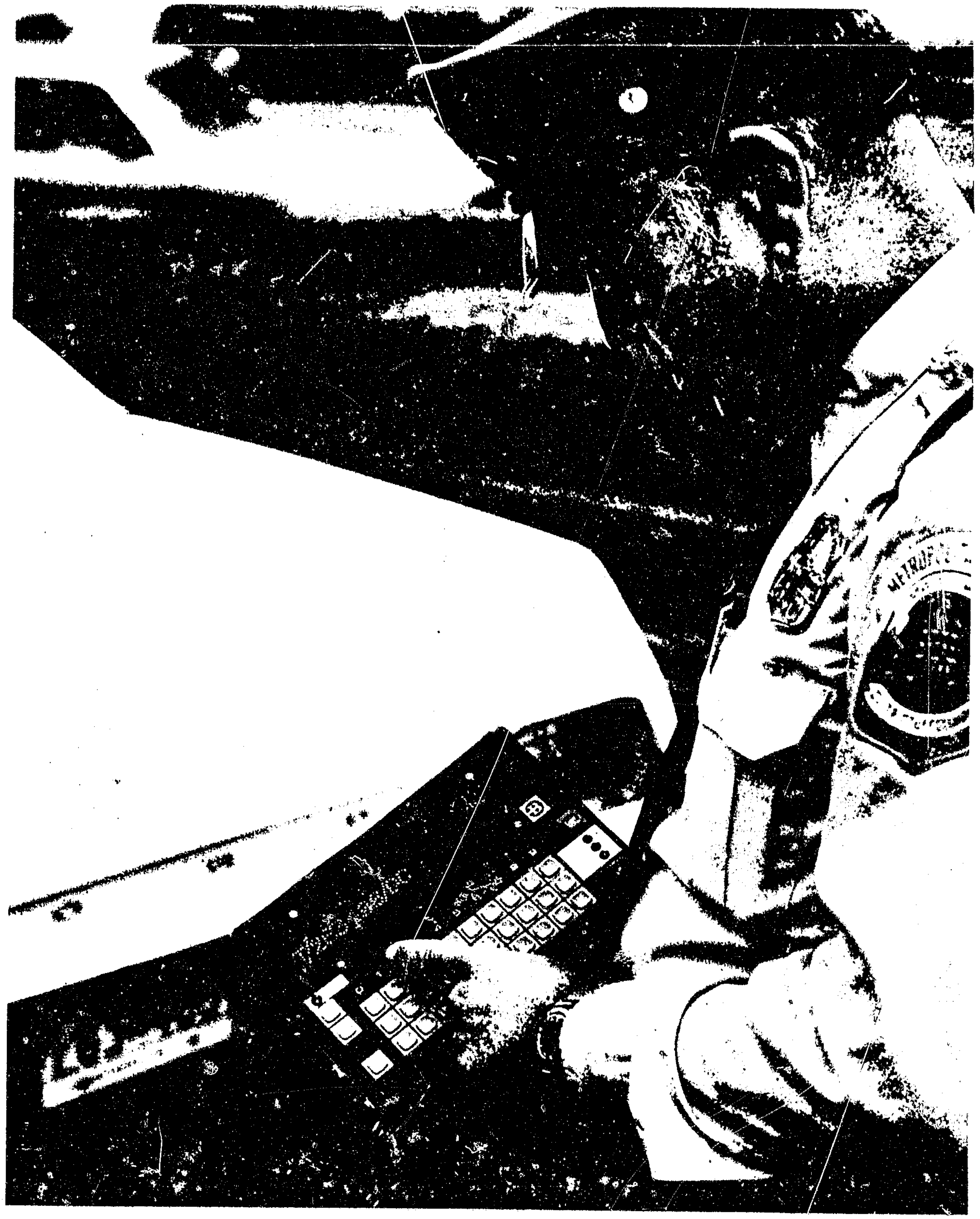


Figure 3-1. Burroughs Developmental Model HHT in Field use by the DCMPD

3.1.1 The Terminal.

The Burroughs developmental model Hand Held Terminal is shown in Figures 2-3 and 3-1. Specific characteristics of the terminal are as follows:

3.1.1.1 Terminal Specifications

SIZE: 9" w X 5.5" h X 3.5" d

WEIGHT: 5.6 lbs including battery, protective cover and shoulder strap

BATTERY: 6V at 2.6 AH, rechargeable gel/cell (quick change via rear cover plate)

POWER: 3 watts standby; 9W display on

DISPLAY: 32 character alphanumeric Burroughs Self Scan®

KEYBOARD: 45 keys; 40 alphanumeric plus 5 function keys

STATUS INDICATORS: 4 LEDS

POWER KEYING: Display on upon key depression. Automatically turns off (standby mode) on transmit or approximately 15 seconds after the last entry key depression.

DISPLAY CURSOR: Illuminated "square" on display indicates position of next character to be entered.

BUILT IN MODEM: FSK, phase coherent, sinusoidal

FSK TONES: Mark: 2225 Hz
SPACE: 2025 Hz

BAUD RATE: 300 baud, asynchronous

COMMUNICATIONS DISCIPLINE: "Manual contention mode"

ERROR DETECTION: Character parity and BCC

ERROR INDICATION: Flashing LED upon detection of RCV error

XMIT ACKNOWLEDGEMENT: Transmit LED extinguishes upon terminal receipt of acknowledgement from processor. Flashes if processor does not acknowledge within 15 seconds.

RETRANSMIT: Composed message remains in memory until manually cleared; can be retransmitted without reentry.

BATTERY LIFE: Approximately four hours with terminal power continuously on and display on duty cycle of 10 percent. Up to 8 hours with terminal power on duty cycle of 50 percent and display on duty cycle of 10 percent.

TERMINAL INTERFACE: Plugs directly into external speaker/mike jack on GE PR-25 Hand Held Radio.

3.1.1.2 Terminal Function Keys

DISP: (Display) Keys the display power ON. Display remains on until XMIT KEY is depressed or until approximately 15 seconds after last entry key depression, whichever is first.

CLR: (CLEAR) Clears display memory only when depressed while display is on.

XMIT: (TRANSMIT) depression initiates Push to Talk function in radio and transmits contents of display memory.

ACK: (ACKNOWLEDGE) depression initiates Push to Talk function in Radio and transmits ACK or NAK (negative acknowledge) to processor depending on whether received message was "Valid" or contained error. If the received message is valid, depression of ACK key transmits an acknowledgement to the processor and keys the terminal display on, thereby displaying the received message. If the received message contained an error, depression of the ACK key transmits a NACK (negative acknowledgement) to the processor thereby requesting retransmission by the processor of the response message.

SHF: (SHIFT) when depressed in conjunction with the "CLR" key, clears all terminal functions to "initiate" state, extinguishes status LEDS and resets ACK/NAK) function key circuitry to ACK state.

←: (Back Space) moves cursor right to left for keyboard entry correction.

3.1.1.3 Terminal Status Indicators

PWR ON: (Power On) illuminates when Terminal ON/OFF switch is in the ON position.

XMIT: (Transmit) Illuminates subsequent to depression of XMIT Key, when inquiry has been transmitted from the terminal. Extinguishes when terminal receives valid acknowledgement from processor. Flashes when the terminal does not receive valid acknowledgement from processor within 15 seconds.

Press ACK to RCV: (PRESS ACKNOWLEDGE KEY TO RECEIVE). Illuminates when the processor notifies the terminal that it has an inquiry response in queue for the terminal. Informs the terminal operator to press ACK key to request the pending response message from the processor.

STANDBY TO RCV: Illuminates when the terminal operator has requested a pending response message from the processor by depressing the ACK key in response to a "PRESS ACK TO RCV" indication. Extinguishes when the requested response has been received by the terminal.

MSG RCV'D: (MESSAGE RECEIVED) Illuminates steadily when a requested valid inquiry response has been received by the terminal. Flashes when an error has been detected in the received message. Extinguishes when the "ACK" key is depressed.

3.1.1.4 Hand Held Terminal System, Terminal/B 711 Communications Terminal

As explained in Section 2 of this report, the communications discipline for the Developmental Terminal to B 711 interface was specifically designed by Burroughs for the Digital/Voice overlay communications network in which the system is used. This communications discipline is shown schematically in Figure 3-2 and further defined in Table 3-3.

The communications discipline is, in essence, a "manual contention mode" procedure, designed to minimize digital tones on the digital/voice overlay network and to optimize digital communications integrity. In a somewhat unorthodox but effective manner, the HHT/B 711 communications procedure gives full control of digital transmissions on the network to the terminal operator. Not only does the terminal operator control the digital messages transmitted from "his" terminal, he also controls the transmission of text responses from the processor.

It is significant to note that that subject communications procedure is separated into two distinctly separate parts: the transmit sequence and the receive sequence. Each sequence is independent of the other. This separation was intentional and implemented specifically for the following reasons.

1. In the total HHT/WALES/NCIC/MILES System, the response times to a HHT inquiry are indeterminate, being dependent on: Voice traffic on the communications net, length of WALES/NCIC and MILES responses (transfer of long WALES Files, to the B 711 processor can, for example, take up to two or three minutes), system activity at the time of inquiry etc. The time from initiation of an inquiry at the Hand Held Terminal to the time of receipt of a WALES response to the B 711 can therefore vary from approximately 15 seconds to 15 minutes or more.

2. The separation of transmit and receive cycles in the Hand Held Terminal communications discipline relieves the terminal user from waiting for an inquiry response before initiating a new inquiry. In Law Enforcement applications the terminal user may want to enter a large number of contiguous, individual, inquiries and let the responses build up in the processor in sequential queue until the Operator is ready to receive these responses. A police officer sequentially entering auto license tag numbers in a parking lot or along a street and then, at his discretion, sequentially requesting responses to these inquiries is a typical example of a valid terminal application where immediate response to a single inquiry is neither necessary nor desired.

This does not imply that "quick" response to a terminal inquiry is not desirable or possible with the Hand Held Terminal system. It simply provides valuable flexibility in the terminal operation.

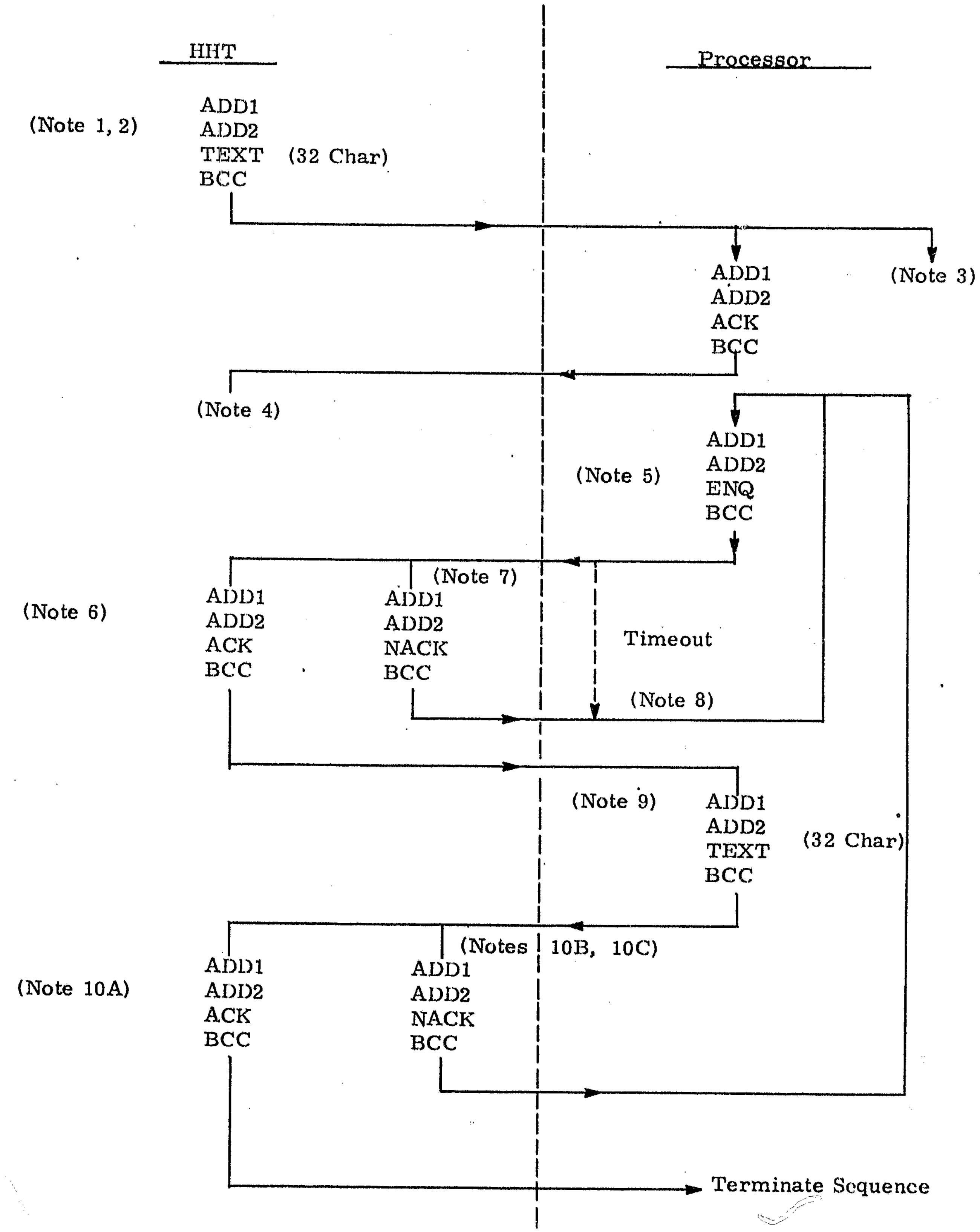


Figure 3-2. Communications Discipline (HHT)

Table 3-3. Communications Discipline (HHT)
(See Figure 3-2)

NOTES:

1. Note that the HHT Self Scan® Display is normally extinguished.

   The display is enabled by depressing the (DISP) Key. The display is extinguished by depressing the ACK key or the Transmit (XMIT) Key. Extinguishing the display does not destroy data in the display memory. The display memory is altered by and only by:

   a. Power off
   b. Entering new text while in display mode (display on)
   c. Depression of the Clear (CLR) Key, while in display mode (display on).
   d. Receipt of a Solicited Text message from the processor.

   Normal mode for the HHT is the RECEIVE STANDBY MODE. This mode is exited only while HHT transmission is in progress.

2. HHT operator enables display by depressing Display Key. (During compose, HHT remains in the RCV STANDBY mode). After composing entry via key-board, operator depresses XMIT key. Upon depression of XMIT key:

   a. Self Scan® Display extinguishes, displayed data remains in memory.
   b. XMIT light illuminates and remains illuminated (See notes 3 and 4).
   c. Upon completion of transmission, HHT reverts to the RCV STANDBY mode and initiates a 15 second time out delay.

3. If processor receives error message from HHT or does not RCV message at all, processor does not respond.

Table 3-3 (Cont'd)

4. Upon receipt of valid ACK from processor, the HHT XMIT light extinguishes. Operator may then wait for ENQ response from processor or may compose and transmit new messages. (An ENQ response illuminates the PRESS ACK TO RCV indicator.)

   If after termination of the HHT 15 second XMIT timeout no valid ACK is re-ceived from processor, the XMIT light will flash indicating incomplete handshake. The operator may, at his discretion:

   a. Retransmit by depressing XMIT key. (Normal action.)
   b. Re-enter Display mode.
   c. Respond to ENQ if an ENQ has been received (See Notes 6, 7, 8).
   d. Go to voice.

5. All text messages from the Proc to a HHT must be preceded by this ENQ message.

6. Receipt of a valid ENQ message from the processor lights the "Press ACK to RCV" light on the HHT indicating to the operator that the processor has a text message in queue.

   The HHT operator, may, at his discretion depress the ACK key thereby transmitting an ACK message (Request for text message) to the processor Upon completion of the ACK transmission from the HHT the "Press ACK to RCV" light extinguishes, and the "STANDBY to RCV" light illuminates. The "STANDBY to RCV" light remains illuminated until:

   a. Receipt of a Text Message by the HHT
   b. Receipt of a new ENQ message by the HHT
   c. Depression of the Clear (CLR) Key in conincidence with the shift (SHF) key
   d. Power OFF

7. If the ENQ message is received in error by the HHT (valid address but in-valid parity or BCC) the PRESS ACK TO RCV light will flash on the HHT.

Table 3-3 (Cont'd)

The HHT operator may, at his discretion:

a. (Normal operation) Depress the ACK key thereby transmitting a NAK message (request for retransmission of last message from processor) - upon completion of the NAK transmission, the PRESS ACK TO RCV light extinguishes and the HHT returns to RCV STANDBY mode.

b. Depress the Shift (SHF) Key in coincidence with the Clear (CLR) Key which extinguishes all indicators.

8. If after sending an ENQ message to a HHT, the processor receives a NAK response from the HHT, the processor will re-send the ENQ message.

If after approximately 1 minute subsequent to sending an ENQ message to a HHT the processor receives no response from the HHT, the processor will retransmit the ENQ twice at approximately 2 minute intervals. If still no response from the HHT, the processor will terminate the sequence pending receipt of a valid message from the HHT. (Either Text-ACK or NAK).

9. If the prcessor has more than one text message in queue for a designated HHT, the processor will wait for completion of each ENQ/TEXT CYCLE before sending the next sequential ENQ message. (This cycle may be interrupted only by transmission of specific "Clear Message" by the HHT. Clear Message (CM) is a special, manually composed instruction message transmitted by the HHT in normal transmit mode).

10. Receipt of a Text Message by the HHT will extinguish the HHT STANDBY TO RCV light and enter the RCVD message into the HHT memory.

a. If the RCVD message is "good" (No parity or BCC errors), the MSG RCV'D light will illuminate. Depression of the ACK Key will extinguish the MSG RCV'D light and enable the display for readout. An ACK message will be transmitted to the processor.

Table 3-3 (Cont'd)

If the PRESS ACK TO RCV light on the HHT has been re-illuminated by receipt of an ENQ message the processor will treat the ACK response as a normal ENQ hand shake and will transmit the next text message in queue.

If the PRESS ACK TO RCV light on the HHT has not been illuminated (no message in queue) the processor will consider the ACK response as the acknowledgement of a terminated sequence.

b. If an error is detected in the received text message, the MSG RCV'D indicator on the HHT will flash. The operator depresses the ACK key thereby transmitting a NACK message to the processor. Upon receipt of the NACK message the processor will re-transmit an ENQ message (i.e., re-enter the ENQ Text cycle).

c. If, after a reasonable wait the MSG RCV'D light does not illuminate after an ENQ acknowledge it can be assumed that the processor did not receive the ENQ acknowledge or the processor did not respond with a validly addressed text message. By re-depressing the ACK key the HHT operator may re-establish the communications discipline.

Special Notes

1. An ACK Message from the HHT is always interpreted by the processor as a request for next message.

2. A NACK Message from the HHT is always interpreted by the processor as a Request for Re-transmission of Last Message (i.e., repeat of the ENQ/TEXT cycle).

3. Conditions for Transmission of an ACK message from the HHT are as follows:

   Depression of the ACK key when the HHT is not in a RCV error state i.e., PRESS ACK TO RCV light and/or MSG RCV'D light not flashing.

Table 3-3 (Cont'd)

4. Conditions for the transmission of a NACK message from the HHT are as follows:

   Depression of the ACK key when the HHT is in a RCV error state, i.e., PRESS ACK TO RCV light and/or MSG RCV'D light flashing.

5. The ACK key and ACK/NACK transmission from the HHT is specifically disabled while the HHT is in the XMIT or XMIT timeout mode.

3.1.1.5 HHT Interface Definitions

3.1.1.5.1 HHT Receive Message Formats (To HHT from Processor)

a. RCV Test Message:

   AD1, AD2 (Text, 32 Character) BCC

b. Processor acknowledgement of text message transmitted from the HHT:

   AD1, AD2, ACK, BCC

c. Notification by processor to HHT that processor has a text message in queue for transmission to the HHT:

   AD1, AD2, ENQ, BCC

3.1.1.5.2 HHT Transmit Message Formats (From HHT to Processor)

a. Text Message:

   AD1, AD2 (Text, 32 Characters) BCC

b. Request for next message (ACK):

   AD1, AD2, ACK, BCC

c. Request for repeat of last transmission (NAK):

   AD1, AD2, NAK, BCC

3.1.1.5.3 Baud Definition:

Asynchronous transmission, each character 10 bits as follows:

Mark = 1
Space = 0

1	2	3	4	5	6	7	8	9	10

Bit 1 = Start Baud, always logic 0 (space) following a mark to space transition

Bit 2 = LSB of a 7 bit data, control or address character

Bit 3 through 7 = Data bits

Bit 8 = MSB of character

Bit 9 = Parity; provides odd parity for bits 2 through 8

Bit 10 = Stop baud: Always a logic 1 (mark) indicating end of asynchronous character.

3.1.1.5.4 Character Definitions

ADD1: Most significant character of a two character terminal address.

ADD2: Least significant character of a two character terminal address.

The two most significant bits of each address character must be true (logical 1). The ADD1, ADD2 combination provides a total of 1024 terminal addresses (See Figure 3-4).

ACK: Acknowledge character
NACK: Negative acknowledge character
ENQ: Enquiry character
BCC: Block check character

An error check character consisting of the longitudinal binary sum (without carry) of each of the 7 data bits of all characters in the message including control bit, but excluding start, stop and parity bits. The 9th bit of the BCC character shall be an odd parity bit for the BCC character.

b7 →					0	0	0	0	1	1	1	1
b6 →					0	0	1	1	0	0	1	1
b5 →					0	1	0	1	0	1	0	1
b_4 ↓	b_3 ↓	b_2 ↓	b_1 ↓	Col 8 → / Row 8 ↓	0	1	2	3	4	5	6	7
0	0	0	0	0	*ACK		◤BLANK	◤Ø	@	◤P	•ADD60	•ADD70
0	0	0	1	1			!	◤1	◤A	◤Q	•ADD61	•ADD71
0	0	1	0	2			"	◤2	◤B	◤R	•ADD62	•ADD72
0	0	1	1	3	*NAK		#	◤3	◤C	◤S	•ADD63	•ADD73
0	1	0	0	4			$	◤4	◤D	◤T	•ADD64	•ADD74
0	1	0	1	5			%	◤5	◤E	◤U	•ADD65	•ADD75
0	1	1	0	6			&	◤6	◤F	◤V	•ADD66	•ADD76
0	1	1	1	7			◤/	◤7	◤G	◤W	•ADD67	•ADD77
1	0	0	0	8			(	◤8	◤H	◤X	•ADD68	•ADD78
1	0	0	1	9			)	◤9	◤I	◤Y	•ADD69	•ADD79
1	0	1	0	A			*	:	◤J	◤Z	•ADD6A	•ADD7A
1	0	1	1	B			+	;	◤K	[	•ADD6B	•ADD7B
1	1	0	0	C	*ENQ		/	<	◤L	~	•ADD6C	•ADD7C
1	1	0	1	D			–	=	◤M	]	•ADD6D	•ADD7D
1	1	1	0	E			•	>	◤N	}	•ADD6E	•ADD7E
1	1	1	1	F			⌐	?	◤O	}	•ADD6F	•ADD7F

◤ Indicates characters which may be entered via keyboard
* Indicates control characters
• Indicates address characters

Figure 3-4. HHT Character Codes

3.1.1.5.5 Developmental Model Terminal Addresses

The addresses of the 5 terminals provided to the DCMPD in the developmental system are as follows (base 8, per Figure 3-4).

Terminal #	ADD1	ADD2
0	70	70
1	70	71
2	70	72
3	70	73
4	70	74

3.1.2 Hand Held Terminal Inquiry and Response Formats

By mutual agreement between the Burroughs Corporation and the DCMPD, the inquiry message types processed by the developmental model Hand Held Terminal system are restricted to the following:

- TAG INQUIRY: (vehicle license tag)
- VIN INQUIRY: (vehicle serial/registration number)
- PERMIT INQUIRY: (vehicle operators permit)
- NAME INQUIRY: (response limited to wanted persons)
- BIKE INQUIRY: (bicycle registration number)

The following subparagraphs describe and illustrate the text formats of the respective inquiry types and response data as displayed on the Hand Held Terminal Display. Also discussed is an additional HHT input message format called Clear Message (CM).

3.1.2.1 TAG Inquiries

The message type indicator for vehicle license tag inquiries is T/

Tag inquiries can be input via the Hand Held Terminal for the vehicle license tag of any state or special tags such as diplomatic or government vehicle tags. In the DCMPD system, DC tags are processed by WALES and NCIC (FBI, National

Crime Information Center). Maryland tags are processed by WALES, NCIC and MILES (the Maryland State counterpart of the WALES data base system). Other state and special license tag inputs are processed by WALES and NCIC. WALES and, when appropriate, MILES responses are always returned to the HHT. All NCIC responses are printed on the B 711 L console printer but only NCIC HITS are sent to the Hand Held Terminal.

The HHT entry format for tag inquiries is as follows:

T/NUMBER/ST■

where:

- T/ – is the message header for tag inquiries
- Number – is the tag number
- / – is a field separator and
- ■ – is the cursor position on the display

Response formats for tag inputs are as follows:

WALES

T/XXXXXXXXXXXX YYYYYYY OO ZZZZNM

where:

- T/XXXX... – is a repeat of the 1st 14 characters of the input inquiry.
- YYYYYYY – is the first 8 characters of the vehicle owners last name.
- OO – is the model year of the vehicle
- ZZZZ – is a four character abreviation of the vehicle make
- N – indicates that an NCIC inquiry has been initiated via WALES
- M – indicates that a MILES inquiry (if applicable) has been initiated via WALES

An example of a NO HIT response to a DC tag inquiry is as follows:

HHT input:

T/123456/DC■

WALES response:

T/123456/DC COLLIER 72 CHEV N

An example of a HIT response to a MD tag input is as follows:

HHT input:

T/ABCDEF/MD■

WALES response:

T/ABCDEF/MD **STOLEN NM

MILES response:

T/ABCDEF/MD **STOLEN MILE

NCIC response:

T/ABCDEF/MD ***STOLEN NCIC

If there is no record on file of the tag number entered, NO REC will appear in place of the name, year and make fields.

If the input was invalidly entered (e.g. with no state abbreviation or improper header, etc.) then, NO REC *INVALID will appear in place of the name, year and make fields.

For DC responses, where a "HIT" is made, the model year and make fields will be replaced by one of the following as appropriate:

- *STOLEN – the vehicle is on record as stolen
- *FELONY – the vehicle is wanted in connection with a felony
- *REVOKD – the owners' permit was revoked
- *SUSPND – the owner's permit was suspended
- *MV NN or *PK NN – there are outstanding moving or parking warrants against the vehicle. NN = the number of warrants e.g. *PK 1 or *PK 99

*WARNGS – violation warnings were issued against the vehicle

*GLASSES – the vehicle owner must wear glasses when driving (or other record comment as appropriate)

NCIC responses can be as follows:

***STOLEN – the vehicle is listed as stolen by the FBI NCIC

**BAD SCN – the B 711 cannot interpret the response received from NCIC

**ERROR – the request was improperly entered

**DOWN – the NCIC computer is down

MILES responses can be as follows:

**STOLEN – the vehicle is listed as stolen in the MILES data base

NO REC – MILES has no record of the tag number in file

UNDEFINED – the B 711 processor cannot interpret the MILES record received

3.1.2.2 VIN and PERMIT Inquiries

The message type indicator for a VIN inquiry is V/

example:

V/123456789ABCD■

The message type indicator for a PERMIT inquiry is P/

example:

P/123456789ABCD/ST■

where: P/ - is the message type header

The following characters are the permit number:

/ - is the field separator

ST - is the two character state abbreviation

■ - is the cursor position

Responses to HHT VIN and PERMIT inquiries are essentially the same as those for tag inquiries as defined in paragraph 3.1.2.1. All responses will contain the first fourteen characters of the input request. This is followed by the owner's name, NO REC, INVALID, *DOWN* or HIT responses as defined in paragraph 3.1.2.1.

3.1.2.3 NAME Inquiries

The message type header for a name inquiry is N/

Name inquiries are entered via the HHT in the following format:

N/LAST - FIRST - M/DOB/RACE/SEX■

where: N/ – is the message type header

LAST – is the subject's last name

FIRST – is the subject's first name

DOB – is date of birth and is entered in the form:

MMDDYY, for example February 24, 1976 is entered as 022476

RACE – is entered as W = White

N = Negro

O = Oriental

SEX – is entered as M or F

/ – are field separators and are required

\- – is a space

■ – is cursor position

DOB, RACE and SEX are optional for the WALES system. DOB, however, is necessary for the input to be processed by NCIC.

If DOB and RACE and SEX are omitted the HHT entry must be made in the following form:

N/LAST-FIRST-M////■

If there is no middle initial, exclude both the space following the first name and insert a / directly after the first name or initial.

A WALES response to a name inquiry consists of a repeat of up to the first twenty four characters of the input name inquiry plus the following data:

NO REC	–	there is no record in the WALES data base
IINVALD	–	the input request format was incorrect
MANY	–	there are more than three HITS corresponding to that name (i.e. more than three persons) - Reenter name with more information e.g. DOB, RACE, SEX, FULL NAME.
CONT	–	at least one WALES match was made on the name input - the match could be on the actual name, an alias of that person or a sound alike name (SOUNDEX)

The *CONT* line will be followed by one to three groups of two 32 character lines each giving ID and offense information.

The format of WALES name response data is as follows:

Line 1 NAME ** HEIGHT DOB
Line 2 OFFENSE ** COMMENT N*

where:

NAME – is the primary name returned from WALES

HEIGHT – is given in feet and inches

DOB – is given in MMDDYY format
e.g. 022476 is February 24, 1976

OFFENSE – is the B 711 abbreviation of the WALES offense CODE e.g.

LOF ESC	-	Look out for - escaped
JUV ABS	-	juvenile absconder
CRIT MP	-	critical missing person
MISS PR	-	missing person
ATT LOC	-	attempt to locate

COMMENT – is a significant ID comment found in the WALES FILE
e.g. NO WANT STATUS
MAY BE ARMED
ADDRESS (partial)

N – indicates that an NCIC inquiry was initiated by WALES

* – after the N indicates the last line of the WALES response. if there is no N, * will be the last character of the last line of the WALES response.

An NCIC response to a name inquiry has several formats. The first line of the response will repeat up to 18 characters of the input name inquiry followed by:

*DOWN** NCIC	–	indicates NCIC computer is down
NO REC NCIC	–	NCIC has no record on file for the name inquiry
*BAD SCN NCIC	–	the B 711 could not interpret the NCIC response
***HIT NCIC	–	NCIC has a record of the name requested. This response is always followed by one 32 character line in the following format:

example: NAME ** OFFENSE HEIGHT

where:

NAME – is the primary name returned by NCIC. It may be the primary name of an alias or a sound alike name (with the same DOB as the input)

OFFENSE – the HHT system abbreviation of the NCIC offense code

HEIGHT – 3 digit height e.g. 5 10 = 5 feet 10 inches

3.1.2.3.1 NCIC Offense Code Abbreviations

The following is a list of HHT system abbreviations of the NCIC codes as returned to the HHT, as a result of a name inquiry HIT.

1. TREASON - treason
2. DESERTN - desertion
3. IMMIGR - immigration
4. HOMICID - homicide

5. KIDNAP - kidnapping
6. SEX ASS - sexual assault
7. ROBBERY - robbery
8. ASSAULT - assault
9. ABORTN - abortion
10. ARSON - arson
11. EXTORTN - extortion
12. BURGLRY - burglery
13. LARCENY - larceny
14. CAR THFT - car theft
15. FORGERY - forgery
16. FRAUD - fraud
17. EMBZLMT - embezzlement
18. RCV STL - receiving stolen goods.
19. PROPRTY - property offenses
20. DRUGS - drugs
21. SEX OFF - sexual offenses
22. OBSCNTY - obscenity
23. FAMILY - family offenses
24. GAMBLNG - gambling
25. COM SEX - commercial sex
26. LIQUOR - liquor
27. OBS POL - obstructing police
28. ESCAPE - escape
29. OBS JUS - obstructing justice
30. BRIBERY - bribery
31. WEAPONS - weapons
32. PUB PEA - public peace offenses
33. TRAFFIC - traffic offenses
34. HEALTH - health offenses.
35. CVL RTS - civil rights
36. INV PRV - invasion of privacy
37. SMUGLNG - smuggling

38. ELECTN - elections
39. ANTITRU - antitrust
40. TAX - tax envasion
41. CONSVTN - conservation
42. CRIMES - crimes
43. PROPRTY - property
44. MORAL - morals
45. PUB ORD - public order

3.1.2.4 Bike Inquiries

In the District of Columbia it is required that all bicycles be registered with DCMPD, and a registration number is engraved on the bicycle frame. Since bicycle theft is a serious problem, particularly in urban centers, bicycle registration is an effective means of identifying stolen bicycles.

The message type header for a HHT bike inquiry is B/

Bike inquiries are entered in the following format:

B/123456 ■

where:

B/ - is the bike inquiry header.
123456 - is the bicycle registration number
■ - is the HHT display cursor position.

Examples of Bike inquiry responses to the HHT are as follows:

No HIT Response

B/123456 - **123456 - SAE ***

where:

B/123456 - is a repeat of the input
**123456 - is the matching registration number drawn from the WALES Data Base
SAE - the bicycle owner's initials

Hit Response

B/123456   STOLEN ***

B/123456   123456   STOLEN ***

Other responses to a bike inquiry can be: (1) input repeat followed by ** NO REC, indicating that the input bike registration number is not on file or (2) input repeat followed by *INVALID, indicating that an error was made, by the HHT operator, in the input message format.

3.1.2.5 Clear Message (CM) HHT Input

Since the HHT/WALES Communications procedure has been specifically designed to enable inquiry responses to build up in sequential queue in the B 711 system and to be sequentially requested at the convenience of the HHT operator, a procedure must be made available to eliminate the response queue in the case that the operator wants an "immediate" response to a "critical or emergency" inquiry. The Clear Message terminal input (CM) was designed to cope with this contingency. By entering the characters CM at the terminal and transmitting this message to the B 711 system, the system, upon receipt of the CM input, clears all pending responses for that specific terminal from queue. The next input, from that terminal, will therefore be processed "immediately". The terminal operator is, therefore, not required to "wade-through" pending responses in order to receive a response to his priority inquiry.

3.1.3 The Burroughs B 711 Processor and Peripherals in the Developmental Hand Held Terminal System

The Burroughs B 711 CPU System used in the developmental Hand Held Terminal system is comprised of the following elements:

- B 711 processor with 48K Byte Core memory
- A9343-1 L-Console (Keyboard and printer)
- TD700 Self Scan® 256 character display and keyboard
- B 9480-12 Dual Disk Drive
- A 9114-1, 80 column card reader

- Custom B 711 to Audio Net interface port (DDP)
- Custom B 711 to WALES interface port (DDP)
- System Software and Firmware

The Burroughs B 711 processor provides the interface between the HHT's/Radio communications network and the WALES System. The B 711 system emulates a 2740 terminal and, in effect, performs some of the functions normally performed by a 2740 or 3270 operator. The processor receives FSK modulated digital inputs from the Hand Held Terminals. It reformats these inputs for WALES compatibility and forwards them to WALES via the B 711 to WALES interface. The B 711 system additionally receives inquiry responses from WALES, NCIC and MILES, via the B 711/WALES interface and scans, edits and compresses these responses; transmitting the most significant information contained in the response records to the Hand Held Terminals in a 32 character format. A printer (the L Console) located at the processor position provides a Hard Copy Record, with time and date identifiers, of all Hand Held Terminal Communications. Additionally, a Burroughs TD700 Self Scan®, 256 character display terminal is located at the DCMPD, "City Wide 1" dispatchers position. The TD700 provides the dispatcher with an exact, dynamic readout of each Hand Held Terminal input and response. By means of simple keyboard entires at the TD700 display the dispatcher can:

- Change the levels of HHT transaction information displayed on the TD700 from all inputs to various levels of "HITS" only.
- Update the time and date reference for the system
- Display System Time
- Assign officer ID names or numbers to each HHT in the system
- Additionally, the TD700 will automatically alert the dispatcher if a terminal has initiated a request but has not acknowledged a response within 5 minutes (possible indication of officer in trouble).

By means of the TD700, the dispatcher is immediately alerted to all critical HHT activities and may, at his discretion, intervene via voice communications to provide assistance or additional information to the HHT user.

The A9114-1 card reader and the A 9480-12 Dual Disk Drive were provided in the developmental system to facilitate software loads, and software changes and modifications as necessary in an experimental field trial system.

3.1.3.1 Hand Held Terminal, B711 Software System

The software for the developmental Hand Held Terminal System is written in Control Application Language (CAL) for execution on a B 711 system having the configuration defined in paragraph 3.1.3.

The operating system for the B 711 includes both executive and microprogram functions. A virtual machine (i.e., one which is independent of machine functions) is provided by the CAL Interpreter. Executive functions (task scheduling and queueing) are provided in this virtual machine by the Real Time Control System (RTCS), which also handles date/time manipulations and other centralized functions. The system I/O is handled at the hardware interface by microcontrollers ("firmware"), which convert data transfers at a byte/word/word group level to message transfers that are handled at the virtual machine level (i.e., by CAL programs). Figure 3-5 provides a block diagram for the B 711, Hand Held Terminal software system.

3.1.3.1.1 The CAL Interpreter

The CAL interpreter is written in TRANSLANG and occupies low order memory in the system. All CAL instructions are translated into machine functions by the interpreter. CAL instructions may be in one of five formats. As a CAL program is being executed, interrupts are being detected at the microlevel, and a microprogrammed I/O system time shares the use of the microprocessor on a demand basis.

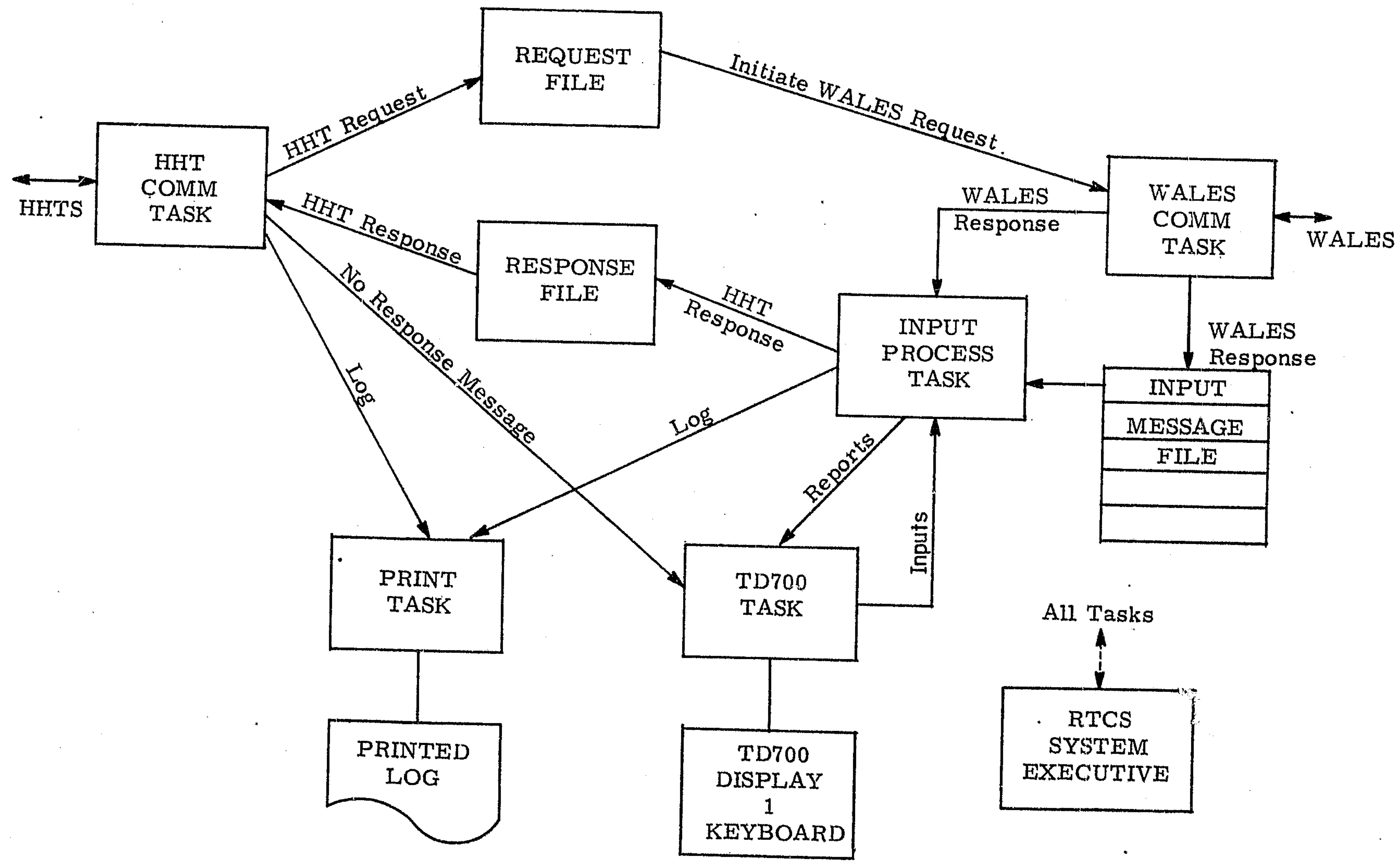


Figure 3-5. Software System (HHT)

3.1.3.1.2 Real Time Control System (RTCS)

The Real Time Control System is an executive program written in CAL and implemented in the B 711 processor. The RTCS provides a means for conveniently handling the asynchronous behavior required in a real-time system. Mechanisms are provided to queue tasks to a particular job; to allow jobs to be queued by specifying a time for activation and to permit software time-outs.

The RTCS allows a multi-programming environment; in addition to one program in control mode (RTCS), N programs may be defined in normal mode. Programs are assigned unique priorities, which determine the execution sequence. The RTCS assumes a fixed job mix, with all jobs resident in memory.

3.1.3.1.3 Task Mix

The tasks in the developmental HHT system are assigned priorities as indicated in Table 3-6. In general, the highest priority tasks are low in percentage of system time utilization, assuring their immediate execution but not inhibiting the other tasks from completing their necessary functions.

3.1.3.1.4 Data Flow

In the idle state the only tasks active are the HHT Comm Task (HCT), the WALES Comm Task (WCT) and the TD700 Comm Task (TCT), which are monitoring for incoming communications to the system. When the HCT receives a valid request from a HHT it places the entry in the request file (Table 3-7) and sets bits in the entry indicating that the entry is to be printed and sent to WALES. It also queues data to the print task directing that the entry be printed. The print task will reset the appropriate bit in the status word at the completion of logging. At the next poll of the initiating HHT by WALES, the WALES Comm Task detects the entry in request file, reformats the request for WALES compatability and transmits to WALES. Incoming responses from WALES are placed in an input message file and a command is queued to the Input Process Task to scan the WALES data. The Input Process Task will relate the input to an existing, correlating, entry in the request file, extract the pertinent data, make one or more entries into the response file (Table 3-8) and notify the print task that there is a response to be logged and the

TD700 task that there is a Request-Response pair to be displayed. The System responds in accordance with the inquiry and response types discussed in paragraph 3.1.2.

Table 3-6. Task Mix

Priority	Task	Type
0	TD700 Task	Queue
1	Print Task	Queue
2	WALES Comm Task	Unqueue
3	Input Process Task	Queue
4	HHT Comm Task	Unqueue

Table 3-7. Request File

Size: 50 30-Word Entries

Request Addition: Count is kept of number of terminal entries in table. If number is less than 50 the new request is made in a blank entry. If the number is 50 (request file full) the new entry will replace the oldest entry having at least a WALES response.

Entry Format:

- Word 1: Terminal Address
- Word 2-24: Request Text
- Word 25: Status Word
  - Bit 1: Entry to be printed.
  - Bit 2: Entry to be sent to WALES
  - Bit 3: WALES Response pending.
  - Bit 4: NCIC Response pending
  - Bit 5: Miles Response pending
- Words 26-29: ID Data to Request by WALES for NCIC, Miles inquiries
- Word 30: Sequence Number

Words	1	2-24		25	26-29	30
	Address	Request	Text	Status	ID Data	Sequence

Table 3-8. Response File

Size: 100 17-Word Entries

Response Addition: Entry can be put in any slot with a zero status word.

Entry Format:

Word 1: Terminal Address
Word 2-16: Response Text
Word 17: Status Word

Bit 1: Entry to be printed
Bit 2: Entry to be sent to terminal
Bit 3: Inquiry response pair to be sent to the TD700 display

Word 1	2-16	17
Address	Response Text	Status

3.1.3.2 B 711 L Console Printer Log

The B 711 printer provides a hard copy log of all HHT/B 711, WALES/B 711 and B 711 to HHT transactions, with time and date preambles provided for each transaction. For example, a typical log for a completed HHT transaction, as provided at the L Console printer, is as follows:

12 AUG 1975 21:03 FROM TER 02 T/123456/DC
12 AUG 1975 21:03 FOR TER 02 T/123456/DC, JONES, J* STOLEN
12 AUG 1975 21:04 TO TER 02 T/123456/DC, JONES, J* STOLEN

where:

FROM - Indicates the inquiry, exactly as received from the terminal.

FOR - Indicates a response has been received from WALES: scanned and edited and that a response ready signal, "ENQ" has been transmitted to the respective terminal.

TO - Indicates that the response data (exactly as shown) has been transmitted to the respective terminal and that the terminal operator has acknowledged receipt of the response by depressing the ACK key at the terminal; also that the ACK response has been received by the processor.

The "TO" indication, equivalent to a 10-4 response in voice communications, provides an accurate record of digital communications integrity. The L-Console log is, therefore, in HHT digital communications, equivalent to, and as useful as, the tape recordings normally maintained in Law Enforcement Voice Communications Systems.

3.1.3.3 The Burroughs TD700 Input and Display Terminal

The TD700 input and display terminal serves an important function in the Hand Held Terminal system. Located at the police dispatcher's position, the TD700 enables the dispatcher to initiate and change certain file related data in the B 711 processor and, importantly, to be apprised at all times of critical HHT Digital System Inquiry and Response Transactions.

The TD700 system consists of a 32 character per line, eight line, Burroughs Self Scan® display panel and a full alphanumeric keyboard.

In the normal display mode, the TD700 will present a display format as indicated in Figure 3-9A. Figure 3-9B illustrates a typical operational display presentation.

3.1.3.3.1 Display Entry Codes

3.1.3.3.1.1 Change Time (CT)

Purpose: To set Date and Time in the B 711 system

A

Row	Display (columns 1–32)
1	TERMINAL NO {XXXX} {ID DATA}
2	
3	REQUEST:
4	UP TO 32 CHAR HHT INQUIRY
5	RESPONSE:
6	UP TO 32 CHAR SYSTEM RESPONSE
7	
8	{■ } {HHMM} {DDDYYY}

FORMAT

B

Row	Display (columns 1–32)
1	TERMINAL NO 0004 2ND DIST
2	
3	REQUEST:
4	T/1 2 3 4 5 6/DC
5	RESPONSE:
6	T/1 2 3 4 5 6/DC JONES, J *STOLEN N
7	
8	{■ } 21 : 32 14 AU 75

Figure 3-9. Normal TD 700 Display Format

Method: Enter the characters CT in the braced forms field (last line, first field of figure 3-9A) and Press XMIT Key on the TD700 Keyboard. The normal display will be replaced by a change time format (last line of figure 3-9A). Enter time and Julian date in the forms fields provided, where:

HHMM = TIME e.g. 2132 = 21:32 HRS

DDDYY = Julian Date e.g. 22775 = 14 Aug 75

Transmit new time input. The display will be replaced with a new display having a Line 8 form, for example, as shown in Figure 3-9B.

3.1.3.3.1.2 Set ID Data (ID)

Purpose: To provide an association between an HHT address and a terminal user.

Method: Enter the characters ID in the braced forms field (last line, first field per figure 3-9A) and press the XMIT Key on TD700 Keyboard. The normal display will be replaced by a change ID format (first line of Figure 3-9A). Enter terminal number and an 8 character ID designation in the (XXXXX), (ID DATA), fields respectively. (The ID Data must be 8 characters and may be any designation (e.g. officers name, badge, district, etc.) e.g.,

(XXXXX) = 0004 = Terminal Number 4
(ID DATA) = 2nd DIST = Second District

Transmit the new ID input.

The display will be replaced with a new display having a line 1 form, for example, as shown in figure 3-9B.

3.1.3.3.1.3 Change Display Priority Level (CP)

Purpose: To change the priority level of the HHT input and response message types sent to, and displayed on the TD700 or, in other words to provide a message "Filter". Since all HHT input and response message pairs will sound an alarm and transmit an HHT transaction display to the TD700, it is desirable to filter out or "mask off" some of these messages so that "trivial" HHT transactions do not disturb the dispatcher. This is accomplished by setting a display message priority level at the TD700. Once set, only message types at that level or above that level are sent to the TD700. The TD700 message priority levels and associated codes are presented in Table 3-10.

Method: Enter the characters CP in the braced field shown in the first field, last line, of the normal display (Figure 3-9) and press the TD 700 XMIT key. The normal display is replaced with a four character braced priority field. Enter a four digit priority code (Table 3-10) in this field and transmit. The priority display will be replaced by a normal display, as in Figure 3-9A, with the request and response data nulled. From that point, until the priority level is changed, only request-response transactions having a priority number equal to, or greater than, the level set will be transmitted by the B 711 CPU to the TD700 display.

3.1.3.3.2 Alerting the Dispatcher of a "Critical" HHT Transaction

The occurance of a "Critical" HHT transaction (i.e., one having a priority level equal to or greater than that set by the dispatcher) will cause an alarm to sound and the RCV indicator to illuminate at the TD700 display terminal. The Alarm will "beep" approximately once every 5 seconds until the dispatcher depresses the RCV key on the TD700 Keyboard, at which time the "Critical" HHT transaction

will be displayed on the TD700 screen, (e.g. see Figure 3-9B). The dispatcher, at his discretion, may then take action as necessary; perhaps by intervening by voice communications.

Table 3-10. TD700 Display Priority Levels

Priority	Types
0000	Bike, Tag, Permit, VIN, Name - "NO REC", NCIC - "Bad SCN, Mile - "Undefined"
0001	NCIC Vehicle - "NO REC"
0002	NCIC - "Error" Tag, VIN, Permit - "Restriction"
0004	NCIC "Down" Tag, VIN, Permit - "Restriction"
0006	Tag, VIN, Permit - "Warning"
0008	Tag, VIN, Permit - "Parking War"
0010	Tag, VIN, Permit - "Moving War"
0012	Tag, VIN, Permit - "Revoked", "Suspended"
0020	Bike, Tag, VIN, Permit - "STOLEN" First 2 Lines of Name Responses other than "NO REC or INVALID"
0030	Tag, VIN, Permit - "Felony"
0040	NCIC Vehicle "STOLEN"

The offense line of all name inquiries is given a priority level equivalent to the NCIC offense code for the offense. These values typically range from 0100 for treason to 7300 for public order offenses and will always be displayed, if encountered, as a "HIT".

3.1.3.3.3 TD700 "No Response Message"

If an HHT operator inputs a request but does not acknowledge the system response to that request within 5 minutes, a terminal "No Response" message, showing the terminal identification, is sent to the dispatcher via the TD700 display. This is to alert the dispatcher that an officer in the field is not accepting his inquiry response and may be in trouble.

3.1.4 FSK Tone Rejection Filter

An additional and significant HHT system component supplied to the DCMPD by Burroughs Corporation is the FSK tone rejection filter illustrated in Section 2, Figure 2-1. Although the need for this device was foreseen at the very beginning of the HHT development effort, it was not installed until nearly half way through the field test and evaluation period, when the filter was installed in the audio line between the City Wide 1 UHF receiver output and the dispatcher monitoring positions. Prior to this installation, the dispatchers were subjected to the virtually "continuous" and, as tests showed, extremely irritating FSK tones inherent in the developmental HHT digital/voice overlay system.

A band rejection filter was therefore installed by Burroughs which provides approximately 20 dB attenuation "notches" at the pure FSK tone frequencies (2025 Hz and 2225 Hz). The end result is the attenuation of the FSK modulated digital signals, and associated harmonics, to a barely audible, and completely tolerable level, with no perceptable degradation of voice reception at the dispatchers head set.

SECTION 4

FIELD TESTS OF THE BURROUGHS DEVELOPMENTAL HHT SYSTEM

4.0 FIELD TESTS OF THE BURROUGHS DEVELOPMENTAL HHT SYSTEM

4.1 INTRODUCTION

Section 4 describes, in detail, the six month HHT developmental system field tests, as required by contract 0147-AA-NS-0-5-FA, and related Burroughs activities conducted during the test period. Information is presented in chronological sequence, covering the period from system installation at DCMPD Headquarters in Washington, D.C., to the termination of formal field tests on February 7, 1976. The context of the information and data presented in this section is very nearly a verbatim repetition of the written technical progress reports delivered to the DCMPD during the subject field tests. Some editorial changes have been made in the interest of continuity of presentation. The presentation format, however, provides an historically accurate account of developmental system field trial activities. Some test results and preliminary evaluations are provided as they were developed during the field tests. Burroughs final evaluation of system performance is, however, provided in Section 5 of this report. It should also be noted that whereas Section 3 of this report describes the characteristics of the final "System", this section additionally discusses system changes and enhancements, resulting from the "learning process" of the field tests, which resulted in the evolution of many of the developmental system functional characteristics presented in Section 3.

4.2 INITIAL INSTALLATION AND TEST (14 JULY 1975 TO 11 AUGUST 1975)

4.2.1 System Installation and Acceptance

The Burroughs "Hand Held Digital Inquiry Terminal Field Trial System" was delivered to the DCMPD on 14 July 1975. System installation and interconnection was completed and the WALES, NCIC and MILES data base systems were successfully accessed via a Burroughs Hand Held Digital Inquiry Terminal, from the streets of Washington, D. C. on 19 July 1975. As a result of the additional initial field tests, minor hardware and software modifications were made and, on August 7, 1975, the system was accepted by the customer for initiation of the field tests. Five Hand Held terminals were distributed to various districts in the D. C. Metropolitan Police Department for implementation, test and evaluation under normal tactical police environments.

4.2.2 Initial Observations on System Field Operation

With the delivery and field implementation of the Burroughs HHT developmental system, the innovative concept of a man portable, compact, battery-operated interactive computer terminal, operating over an existing voice grade radio/TELCO network, with unmodified hand held radio tranceivers, was, for the first time, elevated from a theoretical possibility to an operating reality. Since the system, at this time, had been in operation for just a few weeks, it was neither possible nor appropriate to attempt to draw final conclusions. Indeed, the very novelty of the system and the fact that it was still undergoing initial and normal "startup" phenomena precluded, at that juncture, any scientific objectivity in system evaluation. There were, however, certain initial observations; some obvious, others subtle which deserve comment:

1. The relatively limited brightness of the HHT display and LED function indicators rendered use of the HHT, in direct sunlight, virtually impossible. The device was usable under subdued ambient light conditions, such as shaded areas or in a car during daylight, but the display and LED indicators "washed out" in direct sunlight. This condition was not unexpected, being a

characteristic of the display device used (the only practical device then available, as explained in Section 2). The immediate result, however, was the tendency of the user to use the terminal in car, rather than "on the street."

2. The size and weight of the Burroughs developmental terminal, as proposed and delivered, could be more appropriately termed "man portable" rather than Hand Held even though it could be carried and used in a hand held manner. Considering the equipment normally carried by a foot patrolman, including his hand held radio, the additional load of the developmental terminal, although completely feasible, is tactically impractical. As previously reported, the terminal size and weight can be reduced in a production model. Surprisingly, however, the size, weight and limited display brightness drew attention to the need for, and the feasibility of, a compact, low cost, portable and easily removeable interactive digital alphanumeric terminal for vehicular applications.

3. The Burroughs "manual contention mode" communications procedure implemented in the developmental system proved, after minimum instruction, simple to operate and functioned well in effecting error recovery, in keeping the terminal operator in control of digital transmissions and apprised of response and error status. Although potential for procedure improvement was noted, the basic concept proved sound and effective. The inherent capability of entering sequential inquiries (e.g. license tags) and then soliciting contiguous sequential responses from the system was quickly learned and used, to a considerable extent, by the police oficers.

4. The entire concept of a digital/voice overlay system, with voice priority (voice overriding and terminating digital data transmissions) is, although technically viable, of highly questionable

practical efficiency. It was surprising to note (although, in retrospect, understandable) that in a communications system where literally hundreds of hand held and mobile radios may be in service at any one time, radio users quickly learn, that by simply keying up their transceivers without any need or intent to communicate, they can terminate the "annoying tones". This unexpected but very human response is a severe and real problem and accounted for more than 50 percent of transmission errors in the Hand Held Terminal system. It was hoped that the problem would diminish as the users became accustomed to the tones and understood their purpose and nature. (In retrospect, the problem was reduced but not totally eliminated). Additional improvement could be achieved by higher transmission rates and resulting shorter tone bursts. It quickly became obvious, however, that even with only 5 digital terminals in use, some form of channel multiplexing (e.g. data over voice, which is impossible in an existing system using standard, unmodified radio equipment) or the more obvious solution: a dedicated digital channel, are the only positive means of eliminating voice/data and "nuisance keying" contention. The latter being the most effective method.

5. Initial tests and experiments clearly indicated that random bit errors due to short duration impulsive noise had little effect, if any, on the digital error rate of the system, operating on the UHF-FM radio/TELCO channel on which it was being tested. The major sources of digital error, as previously indicated, were "noise bursts" due to "nuisance keying" and digital/voice contention.

Since bit or character errors could be viewed on the terminal display and the B 711 printer and since voice and keying interrupts can be heard, it was relatively simple to verify these observations. Shadow fading, due to urban structures and/or topographical characteristics was also clearly noted with an accompanying degradation of voice

reception by the hand held transceivers. This phenomenon is, of course, well known in voice communications with mobile and portable UHF transceivers but since digital conversation is less forgiving than voice with respect to fading, it is far more noticeable and frustrating to the digital terminal user. Multi-path fading was not clearly identified as a communications problem in the initial tests, most probably due to the relatively high ratio of FSK tone cycles per bit. It was obvious, however, that when the channel was voice idle and the terminal was used in favorable terrain locations, the digital system was virtually error free. Digital contention between terminals did, at times of intentional high multi-terminal activity, result in errors and/or interrupted communications but the "manual contention mode" communications discipline enabled error recovery without loss of data.

4.3 FIELD TESTS (11 AUGUST 1975 to 18 NOVEMBER 1975)

4.3.1 Summary

Subsequent to on site system acceptance, on 7 August 1975, minor HHT system software problems were detected and corrected. As the result of "on line" operating experience, software enhancements were also implemented during the first three months of the field test period.

Two (2) B 711 processor hardware failures occured early in the test period (8/19 and 9/12). Both outages involved multiple chip failures in the Burroughs equipment and apparently occured in coincidence with catastrophic commercial power outages at the DCMPD computer facility. The Burroughs equipment failures were diagnosed by Burroughs engineers as the result of severe ground loop transients on the communications interface line between the Burroughs TD700 Display, located in the Communications Room on the sixth floor of the Municipal Building and the B 711 CPU located in the Shared Computer Facility on the first floor. The suspected transients were ostensibly secondary to the commercial power failures in the Shared Computer Facility. Corrective action was taken by providing an additional frame ground connection between the B 711 and the TD700. Subsequent to this action, on 15 September, the Burroughs B 711 processor and peripherals operated continuously 24 hours a day, 7 days a week, without failure, despite reported reoccurances of power failure at the DCMPD computer facility. (In retrospect, this performance was maintained through the entire field test period.)

One Hand Held Terminal malfunction was detected and repaired in September. This malfunction was non-catastrophic, affecting power drain from the HHT battery, but not otherwise affecting terminal performance. The problem was the result of fabrication error (a transistor in backwards). No other terminal failures were observed during the subject period of the system field tests.

An additional system enhancement was effected, on 11/13/75, with the installation and test of a Burroughs supplied Band Reject Filter in the City Wide 1 audo network. The filter was installed in the audio line between the UHF base receiver output and the dispatcher monitoring positions. Prior to installation of this device, the dispatchers were subjected to "continuous" and "extremely irritating" FSK tones inherent in the HHT System.

It is interesting to note that the persistance and "piercing" nature of the tones, rather than voice interference was the major complaint of the dispatchers. The notch filler provides approximately 20 dB attenuation of the pure FSK tones (2025 and 2225 Hz). The result is the attenuation of the FSK modulated digital signals, and associated harmonics to a barely audible and highly tolerable level, with no perceptable degradation of voice reception at the dispatcher's head set. This necessary enhancement was well received by the dispatchers.

During the initial 3 months of the 6 month test period, all five of the Burroughs development model Hand Held Terminals were deployed, in various districts and divisions, throughout the DCMPD and were used in normal tactical environments. The system use was periodically monitored by Burroughs engineers, both by examination of the system logs (B 711 console printouts) and by active participation in, and observance of, the use of the terminals in tactical scout-car patrols.

User reaction to the terminals and the system concept during this period was mixed; ranging the full gamut of extreme enthusiam to marginal acceptance. However, when viewed in the light of a developmental and field trial exercise, for which the system was intended, it was clear, even at this stage of the field tests, that system experience could be catagorically classified as highly successful. The technical, human factors and application requirement data gained provided invaluable, practical information which could not be obtained in any manner other than actual field trial.

4.3.2 Software Modifications (Correction of Deficiencies)

In the initial stages of the Hand Held Terminal field tests certain system software deficiencies were detected and corrected as itemized below:

4.3.2.1 Abnormalities in the WALES to B 711 Interface

In the initial weeks of the field trials, communications "time outs" were occurring at the WALES to B 711 interface. Although these "time outs" had no direct perceptable effect on the operation of the Hand Held Terminal system, they were, at times, overloading the WALES System Activity Display and printout monitoring functions, necessitating the deactivation of the WALES to B 711 communication line by the WALES operator. The problem was traced to a software error in the B 711 system and was corrected.

4.3.2.2 Permit Inquiries

The software algorithm to handle permit inquiries did not function when the system was initially tested. This deficiency was corrected by software modifications.

4.3.2.3 Accommodation of Long Message Blocks (WALES to B 711)

During the test and evaluation stage it was discovered that, occasionally, some WALES message Block lengths exceeded the design capacity of the B 711 firmware. This resulted in a Wales to B 711 communication "hangup", whereby the B 711 never received the WALES End of Block character and did not acknowledge the receipt of block. This caused a "time out" and retransmission loop by WALES and ultimately the terminal requesting the long response was dropped from the

WALES/B 711 Poll sequence. The B 711 Firmware was modified to increase the buffer size to 480 characters. Also a modification was made to enable the entire Message Block to be received, regardless of Block length. The receipt of Block is acknowledged, but only 480 characters per block are stored. These modifications eliminated the intermittent communication loop problem.

4.3.2.4 Malfunction of Print Task

A software problem was detected whereby the receipt of certain Hand Held Terminal inputs would intermittantly cause the B 711 printer to continuously print erroneous data and ultimately cause a halt in the B 711 operating system. This problem was traced to an error in a branching instruction resulting from a software enhancement modification. The problem was corrected.

4.3.2.5 Error in Name Reporting

The initial software algorithm for scanning WALES messages for vehicle owner and permit names did not provide for the Senior suffix, (as in John J. Jones, Sr.) causing SR., if present, to be printed and reported instead of the owner's last name. This deficiency was corrected.

4.3.3 Software Enhancements

As a result of system operating experience and "in field" observation of police applications certain software enhancements were implemented as follows:

4.3.3.1 HHT Response Modifications

As initially designed, the B 711 response to a HHT Tag inquiry provided a repeat of the tag number and the owner's last name. If no Wants or Warrants were detected in the WALES response, "no record" (NO REC) statement was appended. Observation of police officers using the terminal clearly indicated that an indication of the "make" and year of the vehicle, in response to a NO HIT inquiry would

be tactically valuable. Consequently the system software was modified to provide Tag responses as follows:

1. In file but NO HIT response:
   (Tag number) (Owner's last name) (Year) (Make)
2. Tag number not in File:
   (Tag number) (NO REC)
3. HIT response
   (Tag number) (Owner's last name) (*HIT designation)
   *Where HIT designation is, for example:

   STOLEN, FELONY, MV WAR, PK WAR, SUSP, REVOKED, etc.

Additionally, in the initial design, Parking Warrant and Moving Warrant HITS were displayed as PK WAR, and MV WAR respectively, regardless of the number of warrants on record. These responses were modified to indicate the number of warrants in file, e.g.: PK 20 and MV 5.

Both of these modifications proved to be useful and were well received by the terminal users.

4.3.3.2 Modification to HHT Transaction Printouts

The HHT transaction log as printed on the B 711 console, was initially designed to provide an exact duplication of the messages received from, and transmitted to, the Hand Held Terminals; with date, time and terminal address indicated. For example:

12 AUG 75 21:03 FROM TER 02 T/XXXXXX/DC
12 AUG 75 21:03 TO TER 02 T/XXXXXX/DC, Jones, J* STOLEN

Although this technique provided a valid record of the in and out HHT transactions, there was no information indicating that the response to the HHT inquiry was actually received and acknowledged by the terminal operator. The logging sequence was therefore modified as follows:

12 AUG 75 21:03 FROM TER 02 T/XXXXXX/DC

12 AUG 75 21:03 FOR TER 02 T/XXXXXX/DC. JONES, J* STOLEN
12 AUG 75 21:04 TO TER 02 T/XXXXXX/DC. JONES, J* STOLEN

Where:

"FROM" Indicates the inquiry, as received, from the terminal

"FOR" Indicates the response has been received from WALES; scanned and edited and that a response ready signal, "ENQ", has been transmitted to the respective terminal.

"TO" Indicates that the response was sent to the terminal, that the terminal operator acknowledged receipt of the response by depressing the ACK key at the terminal, and that the ACK was received by the B 711.

The "TO" indication, equivalent to a 10-4 response in voice communications, provides a more accurate record of communications continuity and additionally proved an invaluable asset in the analysis of system operation.

4.3.4 Evaluation of Hand Held Terminal Response Times

Throughout the first three months of the Hand Held Terminal test and evaluation period various tests were conducted in order to comparitively evaluate the response time of voice inputs to the dispatcher with response times of direct digital inputs via the Hand Held Terminal. Since most of these tests were, by coincidence, conducted when voice activity was relatively high on the voice/digital overlay system, and severe contention existed between voice and digital traffic, no truly meaningful comparison could be made. It was clear, however, that under optimum conditions, i.e., a clear channel, good radio communications and a competent dispatcher, digital responses to the Hand Held Terminal are rarely, if ever, as efficient and flexible as voice inputs and responses via the dispatcher. These conditions are, of course, not representative of operating conditions found in a congested communications channel of a typical metropolitan police department.

In order to obtain a meaningful comparative measure of voice versus direct digital inquiry response times, the following controlled tests were conducted:

1. A highly active voice channel was monitored for a continuous 1 hour period. Voice inquiries on tags and permits were manually recorded. The response times for these inquiries were also recorded. The response times recorded were defined as the time from initial request by the officer in the field, including repeats and dispatcher request for clarification to final receipt and acknowledgement of the response by the inquiring officer.

2. The radio was then switched to the City Wide 1 channel which, at the time was clear (a virtual dedicated digital channel). The same inquiries noted and recorded on the congested voice channel were entered, via the Burroughs Hand Held Terminal, over the "clear" City Wide 1 channel. Response times recorded included the time from initiation of "Typing" the inquiry into the Hand Held Terminal, to receipt and acknowledgement of a valid response.

The results of this test, showing the response time comparisons, are provided in Table 4-1. An additionally significant point, evident in Table 4-1, is the fact, a total of only 9 tag and permit inquiries were made during the one hour test period. The significant conclusion drawn from this specific observation and additional observations by Burroughs engineers is that when a voice channel is used, primarily for communications involving resource dispatching, status reporting and tactical management, a relatively small portion of the congested channel capacity is available for data base inquiries. In other words, in the existing voice dispatching system the actual use and potential of the data base system is severely inhibited due to channel congestion.

Table 4-1. Response Time Comparisons

(A comparison of Voice responses on a congested channel and HHT digital responses on a clear channel.)

Type of Inquiry	Voice Response Time	HHT Response Time	Remarks
TAG VA	3 Minutes	20 Seconds	HHT includes WALES and NCIC responses.
TAG DC	5 Minutes	30 Seconds	HHT includes WALES and NCIC responses.
TAG DC	6.5 Minutes	42 Seconds	HHT includes WALES and NCIC responses.
TAG MD	8 Minutes	1 Minute, 20 Seconds	Voice request was requested after 5 minutes because of no response. WALES response to HHT, 56 sec. MILES response, 1 minute, 20 sec.
TAG DC	2 Minutes	45 Seconds	HHT includes WALES and NCIC responses.
TAG DC	2 Minutes	40 Seconds	HHT includes WALES and NCIC responses.
PERMIT DC	3 Minutes	25 Seconds	HHT includes WALES and NCIC responses.
TAG DC	6 Minutes	38 Seconds	Voice response was NO REC. HHT response provided Name and Veh. information.

Table 4-1 (Cont'd)

Type of Inquiry	Voice Response Time	HHT Response Time	Remarks
			NCIC was down and reported by the HHT system but not reported by the dispatcher.
TAG MD	4 Minutes	1 Minute	Voice Response was NO REC (Presumably WALES only) HHT response included WALES-NO REC, (40 Sec) MILES NAME & VEH info and NCIC NO REC

4.3.5 Field Performance of the HHT Developmental System

Tables 4-2 through 4-4 provide a tabulation of Hand Held Terminal system inquiry transactions from September 2, 1975 through November 13, 1975. These tabulations are summarized as follows:

Period	Inquiries	Hits
9/2/75 through 9/30/75	1827	134
10/1/75 through 10/31/75	947	83
11/3/75 through 11/13/75	462	41

It should be noted that these tabulations list the total number of recorded HHT inquiries processed (deleting invalid inquiries and contiguous repeats of the same inquiry) and do not attempt to segregate TEST inquiries, from truly tactical inquiries. The same point applies to the HITS recorded. Many of the recorded HITS are the result of test inquiries (both by police officers and Burroughs engineers), although the B 711 printouts clearly imply (but do not verify) a significant number of tactical HITS.

User reaction to the Hand Held Terminal system during this period ranged from extreme enthusiasm to marginal acceptance. It was apparent that the degree of acceptance was directly and obviously related to system parameters extant at the time and place of HHT use. It was the observation of Burroughs Engineers, participating in "in-field" scout car patrols with police officers, that when the City Wide 1 channel was relatively clear of voice traffic (resulting in minimal voice/digital contention) and when the terminal was used in an area where the City Wide 1 radio system coverage was good; the using officer would input approximately 50 to 100 "pre-apprehension" inquiries per shift as opposed to "a few" "post apprehension" inquiries on the existing voice system. The using officers cited the unrestricted ability to obtain quick, pertienent information on randomly selected suspect vehicles, prior to stopping a vehicle, as the major asset of the present developmental system. Additionally cited is the psychological effect, with regard to both the police officer and the suspect vehicle operator, of the officer having pertinent information, including the vehicle owners name and list of offenses, if any, prior to officer-vehicle operator contact.

On the negative side, user dissatisfaction with the HHT system (disregarding size and battery life factors which are correctable in a "production" terminal) could clearly be attributed, in the order of significance, to the following major factors:

1. The inability, at times, to "get through" with a digital inquiry due to superfluous keying and voice priority interrupts on the City Wide 1 radio channel. Although City Wide 1 was reported to Burroughs engineers as an "emergency channel", it is frequently used as a tactical and technical (when another channel is "down") backup channel, with peak use at full channel capacity. The obvious conclusion previously drawn and reinforced by this observation is that a digital/voice overlay system, although theoritically viable is not operationally practical.

2. The inability to establish reliable digital communications when the City Wide 1 channel is "voice idle". Burroughs engineers investigated this phenomenon extensively with the following findings:

a. In the DCMPD districts in which in-field tests were conducted and observed by Burroughs Engineers (i.e., 1st, 2nd and 3rd districts), digital transmission integrity from the HHT/PR radios, through the Satellite repeaters to the B 711 system were notably good. Significantly the characteristics of the Voting System did not prove to be problematic, primarily because of the short digital transmissions. Significant fading with resulting digital errors was observed only in those topographical areas in which degradation of voice transmissions due to urban structures was also noted with the accompanying degradation of voice communications. These phenomena were also expected as well known and documented characteristic of a UHF radio system in an urban environment. In most cases shadow fading could be clearly identified and circumvented by "short distance" relocation of the Hand Held Terminal.

b. Transmissions from the B 711 processor, via the City Wide 1 Base transmitter were in many areas of the districts observed, of substantially less quality than the reverse transmissions. This apparent characteristic of the City Wide 1 radio system was particularly noted and reinforced by tests conducted in the 1st district on November 13th and 14th, 1975. When tests were conducted from elevated locations in the 1st district (i.e. 5th floor of the municipal building and the 8th floor of the Quality Inn Motel, New Jersey Ave and D St. N.W.) digital performance of the Hand Held Terminals was excellent while monitoring of voice reception by the PR radios could be catagorized as "acceptable". However, when tests were conducted at street level (both in a patrolling scout car and on foot) Transmissions from the HHT to the B 711 were also excellent (as evidenced by the B 711 logs) while receipt of digital transmissions to the Hand Held Terminals was virtually non-existant and was accompanied by barely audible and sometimes "garbled" voice reception by the PR radios. (Two radios and two terminals were used in these tests). Although the aforementioned tests were conducted by empirical evaluation of system operation, and no signal strength readings were taken, reasonable conclusions can be made regarding the inefficiency of the coverage provided by the City Wide 1 Base Transmitter. It was also noted that this condition would vary periodically. This periodic change remained a mystery until it was learned that the City Wide 1 base station transmissions were switched on a periodic (week to week) basis from the primary transmitter, located in one section of the city, to a backup transmitter located in another section of the city. It was further learned that marginal communications coverage was not simply a characteristic of the City 1 channel but was typical of other city wide communications channels not only in the District of Columbia, but in most large urban centers.

Table 4-2. HHT Inquiry Transactions 9/2/75 through 9/30/75

Date	Inquiries	Hits	Terminals (In Order of Usage)
9/2	155	17 PK WAR	01-02-04
9/3	249	2MV, 16 PK, 2 SUSP.	01-00
9/4	193	7 PK	01-04-02
9/5	66	5 PK	01-02-04
9/6	111	11 PK, 1 STOLEN V, 1 NAME 2 SUSP.	00-02-04
9/7	44	3 PK, 3 SUSP, 2 STOLEN VEH	00
9/8	91	4 PK, 1 SUSP, 2 STOLEN VEH	02-00-04-03
9/9	74	4 PK, 6 STOLEN VEH	02-04-01-00
9/10	92	2 PK, 3 STOLEN VEH	04-03-02-01
9/11	17	0	01-B700 DOWN 13:10
9/12	9/15	NO INPUTS DUE TO SYSTEM REPAIR & TEST (See para. 1)	
9/16	89	TEST INPUTS	00
9/17	116	1 PK, 1 MV, 3 STOLEN VEH	03-04-01
9/18	6	1 STOLEN VEH	04
9/19	63	7 PK, 1 SUSP, 2 STOLEN VEH	01-00-04
9/20	13	0	04
9/21	0	0	--
9/22	60	2 PK, 1 STOLEN BIKE, 1 STOLEN VEH 1 NAME - FELONY	03 (TEST INPUTS)
9/23	68	2 PK, 1 MV, 2 STOLEN VEH	02-04
9/24	111	11 PK	00-01-02
9/25	60	1 PK, 1 STOLEN VEH	03-01-04-02
9/26	20	4 PK, 1 STOLEN VEH	00-03
9/27	2	0	00
9/28	1	0	02
9/29	9	1 PK	04
9/30	117	3 PK, 1 REVOKED	00-02
Totals	1,827 INPUTS	134 HITS	

Table 4-3. HHT Inquiry Transactions 10/1/75 through 10/31/75

Date	Inquiries	Hits	Terminals (In Order of Usage)
10/1	52	2 PK WAR	00-02-04
10/2	1	1 PK	04
10/3	89	7 PK	00-03-04
10/4	0	-	-
10/5	16	1 STOLEN VEH	03
10/6	21	0	04-01
10/7	42	2 PK	02-04
10/8	117	5 PK, 3 SUSP	00-04-01
10/9	125	7 PK	02-00-01-04
10/10 thru 10/13		NO RECORDS AVAILABLE	--
10/14	12	1 STOLEN VEH	01
10/15	29	4 PK	03
10/16	109	9 PK, 2 NAME-FELONY 1 STOLEN VEH.	00-01-02-03
10/17	5	0	04
10/18	36	2 PK	00
10/19	14	1 MV	02-03
10/20	17	1 PK, 1 NAME, FELONY	04-03-02
10/21	78	5 PK, 1 SUSP.	01-02-04
10/22	5	0	04
10/23	8	1 PK	02
10/24	12	1 NAME, FELONY	02
10/25	2	0 0	00
10/26	0	- -	-
10/27	0	-	-
10/28	43	5 PK	02
10/29	42	2 PK	00-02
10/30	23	4 PK	02
10/31	49	8 PK, 1 MV, 1 NAME FELONY	02
Total	947 INPUTS	83 HITS	

Table 4-4. HHT Inquiry Transactions 11/3/75 through 11/13/75

Date	Inquiries	Hits	Terminals (In Order of Usage)
11/3	45	6 PK WAR	02-04
11/4	27	0	02-04
11/5	43	5 PK, 1 MV, 1 REVOKED	00-02
11/6	52	2 PK, 1 STOLEN VEH.	00-02-03-04
11/7	24	3 PK, 2 SUSP.	02
11/8	0	-	-
11/9	0	-	-
11/10	47	1 PK, 1 STOLEN VEH.	02-03
11/11	39	2 PK, 1 STOLEN VEH.	02
11/12	56	3 PK	02
11/13	129	3 PK, 8 NAME, 1 STOLEN VEH.	00-02
Totals	426 INPUTS	41 HITS	

4.4 FIELD TESTS (18 NOVEMBER 1975 TO 7 FEBRUARY 1976)

4.4.1 Summary

Burroughs HHT System related technical activities during the last and final three months of the System field tests can be summarized as follows:

- Ongoing System evaluation
- Software enhancements
- Software modifications as a result of changes by the DCMPD in the WALES I/O operating system.
- Terminal repair

4.4.2 System Evaluation

On going evaluation of the HHT System operation reinforced the statements made and conclusions drawn in the test period covered by paragraph 4.3 of this section of this report. Namely, that the prime obstacles to optimum system performance in the DCMPD system tests were heavy voice traffic on the digital/voice overlay communications link and deficiencies in the coverage provided by the City Wide 1 Base Transmitter(s).

There were, however, additional B 711 System software enhancements and modifications performed during the last three months of the system test period which further improved system operation.

4.4.3 Software Enhancements

4.4.3.1 Screening of Contiguous Inputs of the Same Inquiry

During the evaluation period it was noted by Burroughs engineers that errors in acknowledgment and message responses from the B 711 to the HHT would result in the terminal operator repeatedly reentering the same input message. Although the processor would normally receive and process the input, the response was often not received by the terminal, usually because of voice interrupts or poor

radio transmissions from the base transmitter to the terminal. This resulted in the contiguous inputs of the same message being built up in queue and being repeatedly sent to the terminal as individual responses, causing an abnormal increase in digital "air time" and considerable confusion and frustration on the part of the using officer.

A B 711 software modification was therefore made whereby all inputs from the B 711 are compared with the previous input from the same terminal. If a contiguous input is the same as its predecessor and the predecessor response has not been acknowledge by the HHT. The contiguous response is ignored by the processor and not forwarded to WALES. While this does not cure the problem of poor radio transmissions to the terminals, it mitigates the effects of this system problem. The terminal operator can now input any contiguous number of the same input message prior to a response for that message and will receive only one response to that input.

4.4.3.2 Printout of Clear Message (CM) on the B 711 Console

The system has always had a capability for the terminal operator to clear the queue of previous messages in the B 711 processor. This is accomplished by entering a CM code from the terminal. This function is normally used when the terminal operator wants to ignore pending responses to previous inputs and get an "Immediate" response to a current, and usually urgent inquiry. In the original software design the CM function worked well but an indication that the CM function was invoked was not printed on the B 711 Console. A software modification was made to print "Clear Message", with an identification of the originating terminal, on the B 711 Console. This modification provides a more comprehensive indication of terminal activity and additionally assists in the evaluation of System performance.

4.4.3.3 NCC Responses

In the original System design all Tag inputs from the HHTs were forwarded to NCIC via WALES and an NCIC response was always returned to the HHT via the B 711. Field tests indicated that approximately 95 percent of all HHT inputs are

Tag inputs and only 1 or 2 percent of these inputs result in an NCIC HIT while the WALES hit ratio is 10 to 15 percent. A B 711 software change was therefore made whereby only NCIC HIT responses are returned to the HHT. This change reduced the "Air Time" for a HHT inquiry by approximately 50 percent thereby decreasing response time to the HHT. The HHT operator still receives WALES responses and, if appropriate, MILES responses to all input Tag Messages but only NCIC HITS are returned to the HHT's. NCIC NO RECORD responses are dropped by the B 711 to HHT interface routine but are printed out on the B 711 console. An NCIC HIT is not lost, however, since it is held in queue until received and acknowledged by the terminal operator.

4.4.4 Software Modifications

At the end of December, 1975, the DCMPD made radical changes in the WALES communications processor Software in order to improve WALES response time. These modifications were not compatible with the original Burroughs HHT System software design, thereby rendering the HHT System inoperative. A cooperative effort between DCMPD and Burroughs programmers effected software modifications to both the WALES and the B 711 systems which returned the HHT System to full operation within a week of implementation of the WALES Software changes.

4.4.5 Terminal Repairs

Two Hand Held Terminals were repaired by Burroughs in January, 1976. Both had intermittent solder joints on the hand wired prototype circuit boards. These terminals were repaired by Burroughs and returned to service within 48 hours of report of failure.

4.4.6 Present HHT System Status

At the writing of this report, the Burroughs Developmental HHT system is fully operational and still in use by the DCMPD.

The Department has purchased the B 711 System (which was previously on loan for the duration of the field tests) and plans to continue to use the developmental system.

During the closing weeks of the developmental system field trial period and subsequent to the termination of formal field tests, the DCMPD distributed the terminals to districts and divisions whose tactical missions are most compatible with the terminal capabilities and whose locations are in the more favorable areas of City Wide 1 communication coverage. Data is being accumulated by the DCMPD on the actual tactical HITS effected by the terminal system and the impact of the HIT ratio, as compared with voice inquiries to the WALES data base. Complete information is not available, at this time, but preliminary reports indicate that terminal inquiries are averaging 85 per day per each of the five terminals and that the HIT ratio is averaging 17 percent as compared to less than 10 percent on standard voice inquiries to the WALES data base.

Considering that over 95 percent of all inquiries via the Hand Held Terminal system, during the formal field trial period, were random tag inquiries and in consideration of the fact that the District of Columbia, has millions of dollars in outstanding collateral on unpaid vehicle violations (parking warrants, moving warrants, etc.) as is proportionally typical of all metropolitan areas; it is expected that continued implementation of the developmental system will, in addition to assisting in other Law Enforcement activities, provide a formidable tool in the location and apprehension of so-called "scoff-laws", resulting in relatively low collection costs and realization of significant revenue by the District of Columbia.

SECTION 5

BURROUGHS EVALUATION OF THE HAND HELD DIGITAL INQUIRY TERMINALS AND FIELD TRIAL SYSTEM PERFORMANCE

5.0 BURROUGHS EVALUATION

5.1 GENERAL

The central objectives of the "Pilot Police Man Portable Digital Communications System Project" were to provide a completely functional developmental system to the District of Columbia Metropolitan Police Department and to implement, test, and evaluate the elements of that system in a tactical, in-field, police environment.

The results of this program were highly successful. Not only was the required system developed and tested but the tests in both positive and negative aspects accomplished the intended purpose of the project. The result was the accumulation of real and useful information and experience as opposed to purely theoretical hypotheses concerning application requirements, human factors and overall system considerations. The project additionally resulted in a firm, field tested, base line for further hand-held, intractive digital terminal development and implementation.

An overall conclusion which was sensed at the beginning of the project and reinforced during the field trials is that the concept of a truly hand held interactive, alphanumeric digital communications terminal for police applications is viable but is significantly dependent on the characteristics of the complete communications system rather than simply on the design of the terminal itself.

In the case of the Hand Held Digital Inquiry Terminal there are presently evolving supporting technologies, not only in the components required as part of the terminal design, but in police radio communications systems in general. The very concept of a Hand Held Digital Inquiry Terminal, having virtually all of the elements and capabilities of a desk size, office type, computer terminal was beyond practical consideration just a few years ago. With the implementation and test of the Burroughs HHT system not only has the concept been elevated to a practical reality, but the power and potential applications of a completely self contained hand held terminal, particularly in Law Enforcement applications were clearly demonstrated. The fact that the DCMPD is continuing to use the developmental system effectively, even after completion of the project, is evidence of system potential.

The purpose of this section of the "final project report" is to provide an evaluation of the developmental system performance and to enumerate, not only the salient positive aspects of the system but also to discuss system limitations. The future potential of the system concept is also discussed.

5.2 DEVELOPMENTAL SYSTEM EVALUATION AND CRITIQUE

5.2.1 HHT Size and Weight

The size and weight of the prototype terminal provided by Burroughs under the subject contract can best be described, in the context of in field police implementation, as man portable rather than Hand Held, in comparison to a contemporary hand held or pocket size calculator. The primary factors which had effect on the size of the developmental device were display size, the method of logic implementation and the effect of these factors on battery size and weight.

An analysis of terminal implementation techniques show that a production model of the terminal is now possible in size and weight comparable to a hand held calculator or a contemporary hand held police radio transceiver. Reduction of logic size and power requirements is not a technical limitation since either custom CMOS LSI or an off the shelf CMOS microprocessor can be used and are presently available. In view of the evolving market for a HHT, lower development costs and lead time as well as an inherent capability for product versatility, make the microprocessor technique the most attractive method for initial production implementation.

In the developmental system the display size and fixed memory capacity of 32 characters proved sufficient for the intended application but the display of more than 32 characters was clearly desirable. Limited display brightness presented a problem in field use when the display was exposed to direct sunlight.

In a production model, display size can be reduced by the use of fewer and smaller characters, while message length can be increased by means of controlled display "marqueing" (i.e., right to left movement) techniques. This capability of display marqueing is a basic functional capability of the Burroughs Self Scan® display and has been frequently and successfully implemented in Burroughs products. Display brightness can be enhanced by various techniques, including display shielding and filtering. With the Self Scan® display these design factors will mitigate but not eliminate display "washout" in direct sunlight.

New developing display technologies and techniques offer potential solutions to both the display brightness and power problems. Alphanumeric LED displays, however, still require more power than the Self Scan® display and offer little in the way of brightness improvement. Small LCD alphanumeric displays offer the best potential solution to both the brightness and power requirements but are presently available from limited sources and only in 14 or 16 element discrete character formats. The 14 to 16 element characters are adequate but it is significant to recognize that discrete character display types do not lend themselves to implementation in "marqueing display" techniques since it would be required to "move" the display in character by character increments. The visual effect of this type of display movement is virtually unreadable and in no way comparable to the smooth, comfortably readable display motion available with a continuous dot matrix display, such as the Self Scan® . Line by line "scrolling" is feasible using LCD's but experiments have shown that with a single display line and a small display line length (e.g., 16 characters) as required for terminal size minimization, line by line scrolling results in a discontinuity of display integrity which, in turn, results in the loss of communications continuity by the display viewer. Dot matrix, electroluminescent displays hold promise for further decreasing display power requirements but are still in the experimental and development stage and do not appear to offer any significant improvement in display brightness. The implementation of a small, hard copy printer in a Hand Held Interactive Terminal is a possibility that has not been adequately explored but which deserves consideration.

5.2.2 The Effects of Size and Weight in Police Applications

In view of the experience of the Burroughs developmental system field trials it seems apparent that even if the Hand Held Terminal were reduced to a size comparable to a hand held calculator, its use, as an appendage to a hand held radio, would receive limited acceptance by "foot patrolmen" particularly in consideration of the continuous evolution of hand held radios which are considerably smaller than the PR25 radios used in the developmental system field tests. This statement is rendered in recognition of comments made by police officers, during the field tests, regarding the size and weight of the equipment now carried by the foot patrolman and the encumberance which would result from an additional piece of equipment. It also seems apparent, in view of current advancements in hand held radio technology and corresponding advancements in digital technology that the concept of a hand held radio/digital terminal in a single, integrated package is a natural product of technological evolution and could be achieved in the near future.

However, the HHT field tests clearly illustrate the present need for, and achievability of, a small, moderately proved, interactive digital inquiry terminal for vehicular applications. Such a terminal could draw power from the vehicle's battery, further reducing terminal size and could, for example, be attached to the vehicle radio via a microphone type cable and be "hung" on the dashboard in a

manner similar to the radio microphone. There are no technical limitations inherent in the design of such a fully interactive, alphanumeric digital inquiry terminal. There are, however, certain inherent factors in existing typical radio equipments which will limit the implementation of the terminal with respect to overall system considerations.

5.2.3 Communications System Considerations

In the developmental system field trial period, it quickly became apparent that voice/digital and transceiver "nuisance keying" contention was a primary obstacle to reliable digital system performance. The immediate reaction was, and still is, that a voice/digital overlay system on a large metropolitan police department communication channel is neither practical nor efficient. This conclusion was not unexpected and was clearly supported in the field tests with only five terminals "on line". In a system where a hundred or more digital terminals may be employed, voice/digital overlay is not only impractical, it is inviable.

In considering possible alternatives, short of a dedicated digital channel or channels, the concept of data over voice was explored. In a so-called data over voice system both digital and voice communications share the same channel but are allocated separate band widths within the channel baseband. Data over voice is simply frequency division multiplexing (FDM). FDM is common practice in both multiple voice channel and digital/voice communications systems. This technique is, however, not compatible with typical existing police mobile radio systems, for the following reasons:

a. These systems are not equipped to handle FDM; that is, they do not have the necessary base bandwidth and have no facilities for frequency division multiplexing or subchannel separation, and

b. Typical existing mobile police radio systems equipments are half duplex, being able to either transmit or receive at any one time but not capable of simultaneous transmission and reception. Additionally, a large number of mobile and hand held transceivers use the same channel.

Even if mobile radio equipments were designed or modified to handle FDM, the communication medium transients caused by simple keying of the many transceivers in the system would result in significant digital errors. Also a significant proportion of channel air time would still be dedicated to voice only transmissions. The end result would be substantially the same as direct voice/digital contention in a digital/voice overlay system. The only asset of FDM in a digital/voice system would be the suppression of audible digital tones. This can be a human factors asset in a system where digital communications are extremely short and occupy only a relatively small portion of the communications system air time, such as in a digital "status only" reporting system. For a sophisticated interactive digital inquiry system, however, FDM would not provide any improvement with regard to digital communications integrity and system throughput.

A dedicated digital channel (or channels) is, therefore, the most functionally efficient and practical method of implementing large scale digital communications in a city wide police communications network.

Even here, however, a subtle paradox exists. The hand held radio transceivers used by the DCMPD are multi-channel devices, with each transceiver, as is typical of most police transceivers, having four or more switch selectable channels. It would seem obvious that one or more of these channels could be used for digital transmissions with the using officer simply selecting a digital or voice channel to suit his immediate needs. Observation of police officers in the field, however, clearly indicated their nearly total dependence on voice communications while on active patrol. Because of this dependence they are "steadfastly" opposed to switching from their "home" channel for any purpose save the malfunctioning of that channel or the need to enter an emergency voice message when the home channel is overly congested. The clear implication of this observation is that a separate radio transceiver would have to be supplied to handle the dedicated digital channel if the full utilization and capabilities of the digital system were to be realized. Although this adds additional cost to the digital system, it is not an unrealistic concept. The additional transceiver can be a single channel, hand held, device mounted in car with an in car battery charger and an external antenna.

Additional radio system improvements are also required to support a sophisticated digital system. The primary and most necessary improvements are better communications coverage by the base transmitter and importantly, a reduction of the digital radio channel attack times (i.e. system keying times) as further discussed below.

5.2.3.1 Additional Communications System Considerations

In the developmental Hand Held Terminal field trial system a General Electric radio system, including PR25 hand held transceivers, was used. The worst case radio channel attach time for this system is 600 milliseconds. (Attack time, otherwise known as "front porch delay" is the time, in either communications direction, from the "keying up" of a mobile radio or the base transmitter to the point at which all radio system components are capable of passing either voice communications or digital data). For voice communications, a 600 millisecond delay is completely tolerable, in a digital communications system, however, where, for example, transmission of a complete digital message at 300 baud may require slightly more than one second, the 600 millisecond front porch delay represents significant, and in a multi-terminal interactive system, intolerable communications overhead. System throughput can be enhanced by increased digital rates but to be effective the increased data rates must be accomplished by a significant decrease in radio system attack time. Reduction of radio system attack time is achievable and necessary to optimize digital system throughput. Although it can be decreased, it must be considered that attack time cannot be eliminated in a transceiver system.

The digital data rate implemented in the developmental Hand Held Terminal system was 300 baud, subsequent to field tests it is now obvious that the City Wide 1 radio system can, without modification, support digital data rates of at least 600 baud. The radio system could support data rates up to 1200 baud by modification of the radio equipment and TELCO communications lines; specifically, bypassing the audio circuits in the radio equipment and by using conditioned digital grade circuits in the TELCO segments of the Radio/TELCO communications system.

Technically, if the radio system were improved to support FSK data rates of 1200 baud, then data rates of up to at least 4800 baud could surely be achieved by implementation of PSK or DPSK modulation techniques. However, since we are presently concerned with a Hand Held Digital Inquiry System, PSK and DPSK techniques are "pushing" the state of the art with respect to real estate and power requirements. Single chip LSI, FSK circuits capable of reliable operation up to 600 baud have been made commercially available only within the last 18 months. There is reason to believe that single chip LSI, PSK and DPSK modems will be commercially available in the near future. At the present time, however, available modems suitable for reliable hand held digital inquiry terminal applications are limited to 600 baud, FSK.

5.2.4 Hand Held Terminal to Data Base Communications Discipline

In the developmental system the "manual contention mode" communications discipline was designed and implemented primarily to handle the digital/voice contention in the overlay system and successfully achieved its purpose. In a dedicated channel a more conventional poll and select discipline or more probably an automatic contention mode procedure could be used. The exact design of the communications procedure will depend on a number of factors including, the maximum number of terminals on the channel, the probability of the number of terminals in service at any one time, digital data rates, the system "attack time", etc. Because of the nature of the radio system and the existance of relatively high system turn around time (being dependent on the radio channel attack time), it is most probable that a random contention mode discipline, with automatic contention recovery would be used. In this type of procedure the communications line is normally idle and any device on the line, including the central controller, is allowed to assume "control" of the line and transmit at its own discretion but no device can transmit while the line is busy. In the case of multi-transmission contention, which will occur, the central controller senses the resulting garbled transmission, broadcasts a poll mode control transmission to all terminals on the line and commences to sequentially poll the terminals. When the poll sequence is terminated and the line is again idle, the central controller sends a broadcast,

resume contention mode transmission, to all terminals. Because of the system turn around time resulting from radio "attack time", the poll sequence must be kept to a minimum. This can be accomplished most efficently by allowing the poll sequence to expand and contract depending on the number of terminals actually in active operation.

When a terminal first comes into active service, it will announce its presence to the central controller by its first completed transmission. Once announced, the respective terminal address will be added to the recovery poll sequence. It will remain in the poll sequence only so long as the terminal continues to be active. If no transmissions are received by the processor from any terminal for a specified time period, say three to five minutes, that terminal will be dropped from the poll sequence, thereby reducing the contention recovery overhead.

Another significant factor in the HHT communications discipline is error detection and recovery. Certainly error detection and recovery is required and can be implemented by conventional character parity and longitudinal parity checks. Based on the developmental system field trial experience, however, the need for error correction codes is questionable. At best, these codes (e.g. hamming code, cyclic codes, convolutional codes, etc.) will correct a few random bit errors while adding significant overhead to the system. Since the field trials showed random bit errors to be an insignificant factor as compared to errors caused by noise bursts and since system air time and HHT real estate are premium elements in a HHT digital radio system, error correction codes would probably be sacrifices in their favor.

5.2.5 Communications System to Data Base Interface

In the developmental system, the Hand Held Terminals were interfaced to the WALES data base system by the Burroughs B 711 processor which, in interfacing with WALES, emulated a 2740 I/O terminal. This method of interface was used simply because the developmental system was required to be implemented without change, in hardware or software, to the existing WALES system. When used in connection with a system of the size and capability of WALES, the processing functions of the interface processor are superfluous. A more efficient system can be achieved by transferring the interface processing functions to the WALES system either by direct storage of HHT system compatible records or by implementation of the processing algorithms necessary to produce HHT compatible records. If the interface processor were eliminated, the WALES to HHT interface would be reduced to WALES software and a relatively simple WALES to radio network hardware element. There are other applications and systems, however, where an interface processor would still be required.

5.3 THE NEED FOR, AND EFFICACY OF, AN INTERACTIVE, HAND HELD DIGITAL INQUIRY TERMINAL IN LAW ENFORCEMENT APPLICATIONS

The relatively recent implementation, by local Metropolitan Police Departments, of "On Line" data base systems with direct data base access by police dispatchers, has added a new dimension to Law Enforcement Techniques and efficiency. It was clearly shown, however, in the developmental HHT system field tests, that access to the data base system by the field officer is severly limited due to voice congestion in the existing audio communications networks. The concept of a Hand Held Digital Inquiry Terminal which could ultimately provide "a computer terminal for virtually every patrolman" is a logical and realistic extension of the existing data base and voice communications systems. A direct parallel can be drawn, with respect to evolution and potential, between the Hand Held Terminal and the Hand Held Radio. Many veteran policemen can well remember the large and bulky "walkie-talkies" first introduced as "man portable units", and have seen the evolution of these devices to the point where they are now approaching pocket size dimensions.

As was noted in the field tests of the developmental system, the data base inquiries by a field officer via conventional voice communications are limited, because of voice channel congestion to a few, mostly "post contact" or "post apprehension" inquiries per officer per shift. Using the developmental Hand Held Digital Inquiry Terminal, an officer would often input as many as 50 to 100 pre-apprehension inquiries per shift. The using officers, when using the terminals under favorable conditions (i.e. good radio communications coverage and minimum digital voice

contention) have cited the unrestricted ability to obtain quick, pertinent information on randomly selected suspect vehicles, prior to stopping a vehicle as the major asset of the developmental system. Additionally cited was the psycholgical effect, with regard to both the police officer and the suspect vehicle operator, of the officer having pertinent information, including the vehicle owner's name and list of offenses, if any, prior to officer-vehicle operator contact. The "hit ratio" particularly with regard to location and identification of so called "scoff laws" has also proved to be a significant positive factor of the developmental Hand Held Terminal System. These field tested, positive factors give testimony to the future potential of a well designed, system integrated, Hand Held interactive digital system. Other, significant factors regarding communications efficiency, increased use of the data base system, and overall increased efficiency of tactical resource management further re-enforce the merits of a Hand Held, interactive digital inquiry system in law enforcement applications.

C O P Y

MAN-PORTABLE DIGITAL TERMINALS IN THE LAW ENFORCEMENT ENVIRONMENT

TECHNICAL BULLETIN #050175-6

ELECTROMAGNETIC SCIENCES, INC.

This bulletin describes the use of Electromagnetic Sciences' man-portable digitalterminals as designed for the Washington, D. C. Metropolitan Police Department (DCMPD) system.

The Electromagnetic Sciences (EMS) system is designed to provide the foot patrolman with access to the Washington Area Law Enforcement System (WALES). The WALES system has the necessary warrant files and stolen property files already set-up for access from CRT terminals. The EMS system is designed to permit access to these files without having to re-program the WALES computers. The terminals and computer interface unit (CID) are programmed to permit the following inquiries to be made by patrolmen;

(1) Name Inquiries
(2) Drivers License Permit Inquiries
(3) Vehicle Tag Inquiries
(4) Vehicle Identification Number Inquiries
(5) Bike Registration Inquiries

Since the WALES computers also have access to the Maryland Information Law Enforcement System (MILES) and the National Crime Information Center (NCIC), the foot patrolman can make inquiries which are ultimately responded to by either WALES, MILES, or NCIC.

REMOTE DATA TERMINAL (RDT)

The RDT used in this system is truly man-portable. It is packaged in a leather case along with a G.E. PR-25 transceiver. Because the RDT obtains its power from the transceiver, it has automatic power down capabilities to avoid unnecessary battery drain. The RDT has four modes of operation, namely:

(1) Keyboard Mode
(2) Transmit Mode
(3) Receive Mode
(4) Display Mode

The RDT is powered-up by depressing the CLR (Clear) key. This brings the unit up, clears the display and display memory and places the unit in the keyboard mode. The officer now enters the data he wishes to transmit to the master. If for example, he wishes to inquire about a vehicle license tag number, he would enter the character "T" for Tag Inquiry, followed by the tag number, then followed by two alpha characters identifying the state the tag is registered in. Once this information is keyed into the terminal via the alphanumeric keyboard and the officer has verified the accuracy of his information (which is present on the alphanumeric display), he depresses the INQ (Inquiry) key. This places the RDT in the transmit mode. The message is at this time transmitted to the CIU. When transmission is complete, the RDT switches to the receive mode. If it does not receive a message in five seconds, it reverts back to the transmit mode and re-transmits the same message. It then switches to the receive mode again, awaiting a message from the CIU. It will continue this sequence until either a message has been received from the CIU or it has attempted four transmissions without success. If it fails to receive an answer after four attempts, it will automatically power down. At this time, if the officer still wants to communicate, he must power up the terminal, re-enter his message, and attempt communications again. If, however, the RDT does receive a response from the CIU, it will enter the display mde and display the first sixteen characters of the message. After a short delay, it will begin to move the remainder of the message across the display. The display is a self scan type, designed to move characters off the left side of the display as the next character is moved into the right most position of the display. Since the display uses a 5 x 7 dot matrix character generator, the scanning from right to left is accomplished one dot at a time, thus making the display very readable. The RDT has a 64 character message buffer and the display will self scan until all 64 characters have been displayed. Once the message is completelydisplayed, the RDT reverts to the keyboard mode awaiting an input from the officer. If the officer did not properly understand the message, as it was being scanned, he can depress the RCL (Recall) key which causes the entire message to be scan isplayed again. The officer can now acknowledge that message by depressing the ACK key, which will transmit an acknowledgement message to the CIU, or he may choose to ignore the message, clear the display, and enter a new message. If he does not do anything for five seconds, the terminal will power down automatically. However, the message he just received is not lost, for it is held by the CIU until an acknowledgement has been received from the RDT.

The terminal has six transmit function codes which permit six different types of messages to be encoded to the CIU; they have been assigned as follows:

(1) INQ - Inquiry to WALES computer
(2) STA - Officer's status
(3) MSG - Message routed to dispatcher
(4) REQ - Request for pending messages to the officer
(5) ONH - Officer needs help, emergency message routed to dispatcher
(6) ACK - Acknowledgement of received messages

The first code is used for the inquiries described above. The remaining codes (2) through (6) are used for message routing and passing information to the dispatcher. The terminal is versatile in its use since each of these transmit function keys on the terminal can be assigned as the end-user desires. These assignments are made by the CIU or Law Enforcement Computer. In the case of DCMPD, the assignments are programmed into the CIU. Therefore, in this application, as in most applications, the CIU provides the basic functions of (1) message buffering both to and from the terminals, (2) message routing both to and from the terminals, and (3) communications interface to the host computer. Message routing is possible since each RDT has its own identification code which is always transmitted with each message. The CIU also transmits the RDT identification code to selectively identify the RDT for which the message is intended. Each RDT must recognize its identification code before it will accept any message, thus providing secure communications.

COMPUTER INTERFACE UNIT - (CIU)

In the Washington system, the CIU has other functions which it must also accomplish, including

(1) message traffic analysis
(2) message priority queuing
(3) information search and data compression of data from the WALES computer
(4) message formatting between the terminals and WALES computer
(5) dispatcher alarming and display for specified events

The messages from the terminals are routed to either the WALES computer (in case of inquiries) or to the dispatcher (in all other cases). As messages are received by the CIU, it decides the type of message from the transmit function code. If for instance, the received message is an inquiry for WALES, the message is re-formated and tagged with terminal ID and time, and then buffered in a time sequence queue awaiting servicing by WALES. The message is also routed directly to the local logger for traffic analysis. When the WALES computer accepts the inquiry the original message is passed to a queue awaiting a response from WALES. When WALES responds to the original inquiry it is linked up with the original message and passed to a transmit queue awaiting its turn for transmission to the originating RDT. At this time, two additional queues can be generated dependent upon the WALES response. One is for inquiries forwarded to NCIC and the second for inquiries forwarded to MILES. These queues will stay active until the NCIC and MILES responses are received through WALES. They are then linked to the appropriate response and passed to the transmit queue. At this time, message traffoc ama;usos queues are also generated for the system logger. If a "hit" (outstanding warrant) has been found, it is also passed to the dispatcher's information display and alarmed for dispatcher attention. The transmit queues are activated for transmission each time the originating RDT transmits to the CIU. If the total time between message tagging (upon receipt) and activation of the transmit queue is less than five seconds, the transmit queue is passed to the RDT. If the total time is greater than five seconds, the queue is held until the next transmission from the originating RDT is received. Once the transmit queue is passed to the originating RDT, it is kept at the top of the queue until an acknowledgement is received from the patrolman. If the message transmitted by the CIU is not acknowledged, the same message will be transmitted next time the originating RDT transmits. This provision prevents messages from being lost from the CIU.

In the case where an inquiry cannot be answered in five seconds, and if there is no pending message in the transmit queue, the CIU will send a "message received" acknowledgement to the RDT. This notifies the officer in the field that his message was received and is being processed.

Non-inquiry messages are routed to the dispatcher and alarmed for his attention. His interaction is then required as established by the user's operational procedures.

The CIU was deliberately designed to be the major decision-making part of the system. Operationally the system can be modified as required by redefining the CIU without any modifications to the RDT's. Thus in the EMS system, either the CIU or the user's computer defines the system capabilities. The man-portable terminal then becomes a universal terminal not restricted in use or application. In fact, the RDT can perform as a universal input/output peripheral to the user's system.

FINAL REPORT

COVERING THE PERIOD FROM 5 JULY 1974 THROUGH 30 AUGUST 1975

MAN PORTABLE DIRECT COMPUTER ACCESS COMMUNICATION SYSTEM

CONTRACT NUMBER 0142-AA-NS-0-5-FA

Presented To: Deputy Chief
Coordinator for Data Processing
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Revised June 15, 1976

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I. INTRODUCTION

This report summarizes the development and delivery of the Man Portable Direct Computer Access Communication System developed under Contract Number 0142-AA-NS -0-5-FA for District of Columbia Metropolitan Police Department (DCMPD). It reviews the design accomplishments, as well as departures from the orginally proposed concepts. The period from 5 July 1974 through 31 December 1974 was covered in detail in four previously submitted progress reports and is reviewed here only with regard to major decisions. The REMOTE DATA TERMINAL (RDT) and the CENTRAL ELECTRONICS UNIT (CEU) are discussed separately with cross-references, as required. The sections on SYSTEM PERFORMANCE and SYSTEM EVALUATION include both the Remote Data Terminals and the Central Electronics Unit, as well as the interfaces to the DCMPD radio system to the WALES computer system. The section on WORK IN PROGRESS details the present activities and future plans of Electromagnetic Sciences, Inc. (EMS) in this area of technology and summarizes the impact on the DCMPD. The RECOMMENDATIONS apply to future interests of DCMPD and to other potential users of similar systems.

II. SYSTEM DESCRIPTION

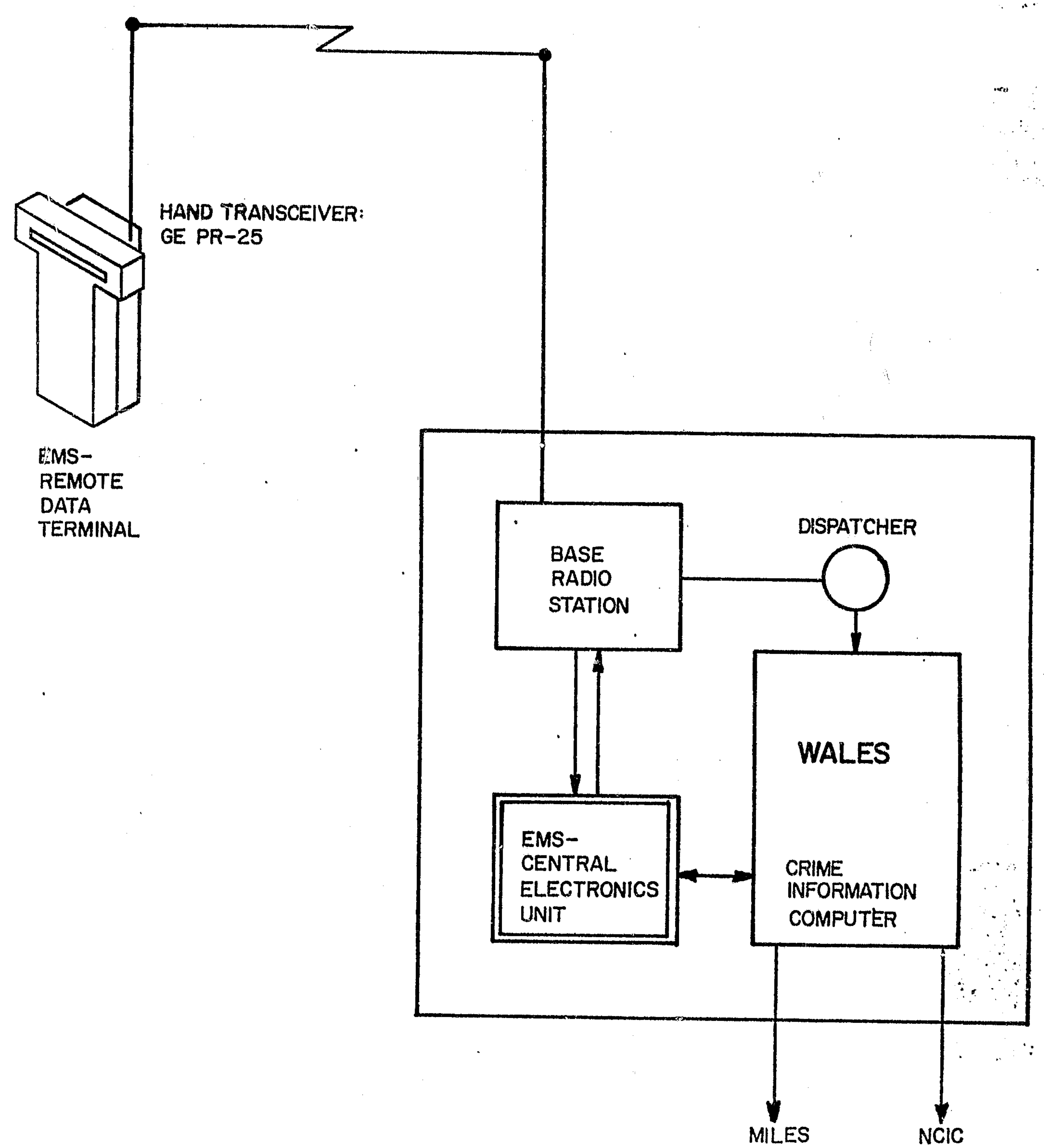
The Man Portable Direct Computer Access, Communication System developed and installed by EMS, Inc. includes the following equipment:

--A man-portable Remote Data Terminal (RDT) - 5 units.

--One Central Electronics Unit (CEU) with operating software.

The system configuration (figure II-1) shows how the EMS delivered hardware is integrated into the existing WALES operation. A more detailed functional description of the RDT and the CEU are in section III and IV respectfully.

Patrolman's link to computer



III. REMOTE DATA TERMINAL

Progress on the RDT through December, 1974, was essentially on schedule except in the areas of the mechanical packaging and the incorporation of the final display configuration.

The Burroughs displays were not received until mid-January, 1975. The units differed from what had been expected in some physical dimensions (spacing between driver board and display tube and details of tube itself) which necessitated a redesign of the display interface circuit board and a modification of the tentative housing structure.

All electronic circuitry for a prototype RDT, except for the PR-25 (G.E. radio) interface circuitry, was assembled in final dimensional form by early February. The logic system and terminal programming did not change materially after this time. EMS had understood, at the initiation of the contract, that one or more PR-25 and a compatible PE-45 (small G.E. radio) for the completion of the development in mid-March.

EMS, in early February, scheduled the evaluation RDT's through normal production channels. A design review at this time disclosed many areas which could be potential sources of problems in both production and field maintenance. A proposal was made to and accepted by DCMPD personnel, during the week of 10 February, to take the necessary time to mechanically redesign the unit to solve these potential problems. In particular, the stake pin (wire-wrap) interconnections between circuit boards were to be replaced by a mother-daughter board arrangement so that circuit boards could easily be replaced in the field as a first level maintenance scheme. The anticipated delay in delivery was two months (to about 1 May, 1975). Note that CEU software problems (discussed later) were, at this time, likely to produce a comparable delay in the overall program.

During the mechanical redesign of the RDT, two new Intel integrated circuit elements were introduced into the resign to save space and power; however, the devices had not, at that time, been fully characterized. They were later replaced by original circuitry because of unexpected minor differences between production units and evaluation samples.

The new layout of most of the circuit boards for the mother-daughter board arrangement was completed by mid-March; however, final interface problems with the PR-25 had just been solved and the new transceiver interface circuit board layout was not completed until early April. The design of the external housing of the RDT was also completed during this time. By the second week of April, the complete RDT had been released to production.

The first prototype RDT, in final form, was operated with a PR-25 radio link during the third week of April. Extensive testing of this unit resulted in one minor circuitry modification (to avoid keying of the radio when the RDT is powered up) which was incorporated in the production units. During early May, a problem with display ionization was discovered with the prototype unit. Extensive tests of the production display tubes over a three week period showed that the displays would be totally unsatisfactory in the RDT application because of ionization (Turn-on) delays of many seconds. Consultation with Burroughs (and the return of one display tube) revealed that ionization in the dark environment inside the RDT housing was a statistically random function since the tubes had not been filled with a radioactive gas mixture during manufacture. Accordingly, all display tubes were returned to Burroughs for rework at the end of May. In the interim, the production except for final assembly, of the RDT's had been completed and all individual circuit boards had passed check out. During the second week of June, the reworked display tubes were received, the RDT's were assembled, and final test and burn-in was started. By 22 June, all units had received 100 hours or more of burn-in at elevated temperature.

The RDT's were hand carried to DCMPD on the morning of 24 June. Communications tests at DCMPD on 24 June were unsuccessful because of unexpected signal switching delays in the UHF radio link. A read-only-memory program patch for one of the RDT's on 25 June permitted successful communications to be established. It was note, however, that communications could not occur during times of very heavy noice traffic since the terminal waited for the channel to remain clear for approximately three seconds before initializing a transmission. A study of the typical voice communications patterns showed that the RDT should be able to transmit between voice exchanges without interrupting voice intelligence. Accordingly, all RDT's, except one, were returned to Atlanta on 27 June for program modifications.

The programmable microprocessor feature of the RDT's permitted reprogramming to correct the above problems without any hardware change which, had it been required, would have necessitated additional burn-in to minimize potential component failures. The four RDT's were returned to DCMPD on 8 July, along with a reprogrammed read-only-memory integrated circuit for modification of the unit which had remained at DCMPD. All units provided satisfactory communications; however, during the week a problem of crosstalk to an adjacent channel was reported. This was traced to modulation inside the PR-25 caused by noise introduced on the battery terminals by the RDT. Accordingly, two of the RDT's and one DCMPD PR-25 were carried to Atlanta on 11 July. The particular PR-25 radios in use at DCMPD were found to be more susceptible to this type of noise than the unit which had been purchased by EMS. A power filter was designed and installed in the two RDT's. These units were returned to DCMPD, along with the PR-25 radio, and filters were installed in the other three units on 16 July. No other changes or repairs have been made to the RDT's since that time.

During the various phases of testing at DCMPD, the typical PR-25 battery was found to be incapable of being charged to its rated ampere-hour capacity. This resulted in very short battery life with the RDT. Some batteries also showed a much higher internal resistance than anticipated. The conclusion was that only batteries which are known to meet a 1.5 ampere-hour specification should be used with the RDT.

IV. CENTRAL ELECTRONICS UNITS

As described in previous documents, the CEU consists of a ModComp II/10 computer with communications channels for the WALES and radio link interfaces and with an ASR-33 Teletype unit for console control. A small amount of custom circuitry, designed by EMS, provides the interface to the radio link while a standard Modem (provided by DCMPD) provided the interface to WALES.

Essentially, the entire development effort for the CEU was that of writing the various program modules (software) to provide the required functions. Delays in delivery of the computer to EMS caused corresponding delays in programming effort.

A major developmental problem area was the lack of direct access to the WALES system. Accordingly, a WALES simulator, using an 8-bit microprocessor system, was designed and programmed. This effort, however, accomplished very little, since incomplete specifications were used for the simulator design as were used for the CEU application software. Software efforts involving the RDT presented no problem, since a prototype RDT could be directly connected to the CEU (bypassing the necessity for a radio link).

The development of the software system was contracted to a third party who was fimiliar with law enforcement computer systems. The number of man-hours of available effort was insufficient for the magnitude of the task. A system review during January, 1975, revealed that the efforts up to that time had produced a software

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system incapable of the desired level of performance. The contract programming arrangement was discontinued and the complete software system, except the EXTRACT module, was reconfigured. New flow charts were prepared and the major effort of rewriting the program modules was started. The first complete system generation (combining the EMS software with the ModComp operating system) was performed at Ft. Lauderdale, Flordia, during the third week of April.

Check out of the software system continued through May. Considerable time was lost during early May because of ModComp hardware problems; however, the problems were eventually solved. The CEU was transported to DCMPD on 9 June and installation began. A prototype RDT was hard-wired to the CEU to facilitate check out. By 13 June, the CEU was partially communicating with WALES. The radio link was not connected until the week of 16 June. Tests were started with the RDT's on the radio link on 24 June.

Many problems were encountered with the EXTRACT program module. The design of the module was based upon information that the WALES output format was very rigid and that line counts and positions of key words within a line could be relied on. This did not prove to be the case. The data from WALES to the CEU is blocked into transmissions of approximately seven lines each. A major problem is in determining when the last block of a response has been received. A major problem also exists in identifying a response and relating it to a particular inquiry. For example, the response to a name inquiry may not even contain the exact name which had been entered. It was also found that WALES may, at times, insert extra lines into a response, for example, stating that some particular file has been temporarily deactivated. In addition, broadcast messages, which are completely meaningless to the CEU, are transmitted by WALES. These problems are not deficiencies in the WALES software design, since WALES is designed to transmit data to a terminal for an operator to read and not for another computer to read. It is

presently believed that an EXTRACT program of this type can never be totally satisfactory since it would always be subject to the exact WALES data format.

Through the process of program patching, problems with the EXTRACT program were solved, one-by-one. The program, at the present time, appears to provide a satisfactory level of performance; however, anomalies may still be expected when unusual responses are received from WALES. The most severe problem exists when WALES has sent all of the blocks of data relating to a particular inquiry and the CEU has not identified the final block as the last. This problem was solved, in the case of NCIC and MILES responses, by a time-out system, since these responses can be positively identified by comparison of the numbers assigned by the WALES system. A time-out cannot be used, reliably, with the initial WALES response, since the time-out could occur due to the slowness of WALES and since the responses cannot always be identified with a particular inquiry. A single time-out could result in a loss of sequence, causing later responses to be related to the incorrect inquiry (a possibility which is considered totally unacceptable).

In the final design, the five communications lines between WALES and the CEU are used asynchronously with respect to the RDT's; thus, if one line becomes locked out because the CEU is awaiting a response which it never receives, all of the RDT's may still be serviced on the remaining four lines. The CEU restart operation clears all communications lines and should be used at the start of each shift of operation

V. SYSTEM PERFORMANCE

This section details performance aspects of the system which are considered to be noteworthy accomplishments.

- The RDT was implemented with a single-line dot-matrix display having a 16 character capacity (as opposed to the two-line by 8-character).

- A 64-character internal buffer was implemented (as opposed to the proposed 16-character memory), together with column scanning of the display, to provide a greater readability.
- A backspace function, for error correction, was added.
- Automatic power control replaced the original on-off switch function.
- New maximum dimensions for the RDT (including the T-shape for the display) were agreed to by DCMPD personnel at a design review in August, 1974. The final design resulted in dimensions somewhat less than those agreed upon.
- The final weight of the RDT is less than 2 pounds (against a design goal of less than 6 pounds).
- The design of the unit is such that it can be sealed to be completely waterproof (the delivered units were not completely sealed because of of the test program nature of the present contract).
- The RDT provides automatic error checking and retransmission.
- The transmit function key identification code and the RDT unique identification code are transmitted with each message exchange.
- Received messages are not displayed unless they are error free.
- The radio channel is checked automatically for activity and transmissions do not occur unless the channel is clear.
- The battery life design goal of one digital transaction every five minutes for a period of eight hours is met by the terminals, as originally delivered, under the assumption that the radio channel quality and

activity are such that retransmissions do not occur. The terminals were, however, modified after delivery to increase the power down delay, at the request of DCMPD personnel.

- The logic design of the RDT was implemented by means of a microprocessor system to provide flexibility for future changes and improvements. All terminal functions are software defined and may be altered without hardware changes other than replacing of read-only-memory devices. This design also permitted the addition of a large number of special display symbols, although only those which are used are marked on the keyboard.
- A user activated acknowledgement function was incorporated into the system to insure that message switching through transmit function keys reserved for these purposes.
- The RDT was implemented with a total of only 21 keyboard switches which provides for sufficient spacing to permit operation of the unit by gloved hands, while maintaining a small panel size. A full alpha/numeric keyboard would actually simplify the RDT logic, but would result in greater overall RDT size or much smaller keys.
- The original concept of the Central Electronics Unit maintaining the active control over all data communications was changed at the design review in August, 1974, and the final design gives the RDT user complete control with the CEU remaining passive. Thus, the user may enter successive inquiries, while completely ignoring responses from the CEU, and later command the retransmission of all of the responses.
- The choice of a computer for the implementation of the Central Electronics

Unit was upgraded from a ModComp I/15 to a ModComp II/10 to provide increased software capabilities.

- The originally proposed CRT console device was replaced by a ASR-33 Teletype unit to provide standalone programming capability and to provide permanent written logs of transactions (A CRT display has also been provided on a consignment-only basis for use in the dispatch area).

- The RF and computer interface units were incorporated within the ModComp rack to minimize space requirements.

- Although the message editing, under the original proposal, was to "be limited to just demonstrating the concept" an effort was made to provide more extensive extraction of data forwarded by WALES. Although this effort has been generally successful, a final determination of the required data must await the completion of the evaluation phase of the program.

- No RDT or CEU hardware failures have been experienced since the delivery of the system, although one CEU software problem was initially misinterpreted as a hardware problem.

VI. SYSTEM EVALUATION

This section identifies certain system considerations which can be modified or changed to improve system performance for production versions of a hand-held terminal. Any future improvement should be analyzed as to its cost/performance trade-offs. A major consideration with the RDT is battery life. The RDT requires approximately 12 watts of power or approximately 1.5 amperes of current from the PR-25 battery (a peak current requirement of not greater than 4 amperes was specified in the contract). Reasonable battery life is obtained at a use rate of not more than one data transaction every five minutes, dependent upon the ini-

tial condition of the battery. Approximately 50 per cent of the total RDT power is required for the display. Alternate displays are currently available which provide the required performance at less power. A redesign of the terminal using a CMOS microprocessor and modification of the DC-DC converter so to power down the display only and leave the terminal in a stand-by mode would greatly reduce power consumption.

The display brightness of the RDT is less than desirable under high ambient light conditions. The state of the art does not permit further improvements at this time without further increasing the power requirements. Possible future developments in the areas of liquid crystal or light emitting film displays may permit improvements in display readability but are not economically practical at present prices (LCD = $40 - $50 per character).

A terminal of smaller dimensions might be desirable and is technically possible; however, minimum dimensions must take into account the minimum operable display and keyboard sizes. A reduction in weight would likely accompany any appreciable reduction in size. The display can, for example, be redesigned to eliminate the T-shape structure; however, a volume production requirement is first necessary. A physical separation of the RDT from the PR-25 should presently be considered as a means of reducing the apparent size and weight of the RDT.

Inquiries forwarded to WALES through the CEU typically result in responses of several hundred characters. Extraction is performed by the CEU to compress the response to the RDT to 64 characters of less. The present software of the CEU is considered adequate for the field evaluation of the RDT. It is not, however, adequate for a fully operational system. The extraction process must eventually be incorporated into the WALES software so that the CEU simply forwards the response to the RDT as received. Additional effort on the CEU software, at this time and except for minor changes, is not considered warranted.

The DCMPD radio link, as a data transmission medium, has not presented any major difficulties. Noise burst and voice on the channel cause data retransmissions; however, the system is designed to automatically to recover from such occurrences. The presence of data bursts on a channel which is monitored for voice has, however, been irritating to the dispatchers. A reduction in the data modulation level to a point where it would not be objectionable would greatly degrade the quality of the data communications. Altering the frequencies of the data tones and/or the incorporation of local filtering might help to solve this problem. Separate voice and data channels would eliminate any conflict with the terminal user and other users on a shared channel.

VII. WORK IN PROGRESS

Work is continuing at EMS to provide improvements in the RDT/CEU system. In particular, provisions are being made to add coil cords for the signal interface to the PR-25, as an option. In conjunction with this, a battery box is being designed to be inserted in the place of the PR-25. The combination of the two will permit the operation of the RDT on battery power separate from the radio, for prolonged battery life. This arrangement will also permit the use of the PE-45 radio. The battery box will hold two standard PR-25 batteries, only one of which is active at a time. Thus, a spare battery is automatically carried with the RDT. These changes will be implemented in part or all of the terminals which have been delivered to DCMPD.

A later modification of the RDT will add the capability of using a belt carried battery pack so that the total weight of the hand carried portion of the unit will be reduced to approximately two pounds. Because of the necessity

of providing batteries and chargers with this arrangement, it will be offered only as an extra cost option. The batteries will, however, have much greater electrical capacity than now provided by the PR-25 battery.

EMS is continuing to investigate means of reducing the power requirements of the RDT. Appreciable improvements can be made by adopting fixed programming of the internal RDT logic and by a redesign of the display drive circuitry. Neither of these changes are practical except with manufacturing quantities of 500 or more units. Thus, the implementation of these changes must await production orders. An additional side benefit of these changes will be the elimination of the present T-shape of the RDT and a possible increase in display brightness. The overall volume of the RDT and, possibly, the weight will also be reduced.

EMS is in the process of designing filters for use at the dispatchers' console to reduce the irritating effect of the data tones. These filters will be tested at DCMPD and will be permanently installed if worthwhile improvements results.

Some improvements to reduce data retransmissions (due to data errors) are being investigated. These improvements, which are at the CEU interface, will be incorporated in the DCMPD system, if they prove worthwhile.

EMS will continue to evaluate the CEU software system, particularly with regard to the extraction of desired data from the WALES responses. As improvements are found, they will be incorporated at DCMPD. No major effort to completely rewrite the software is anticipated, at this time, as all of the previously major software problems have now been solved. An all CMOS terminal is being breadboarded using an RCA 1802 Microprocessor and a 44 keyboard with raised keys. Different types of displays have been obtained to determine the practicality of their use. Hopefully, a second generation terminal will evolve that will improve the concept for wider acceptance of digital communication over RF links and especially law enforcement.

VIII. SUMMARY

The CEU and 5-RDT's, as delivered, meet the requirements of the contract, as interpreted (reported here and in previous letter reports) during various technical conferences and design reviews. Design changes during the development, although resulting in compromises in some areas, have resulted in a higher overall level of performance than originally speficied.

The concept of Digital Communications for the foot patrolman via radio channels was proven practical, and with the aforementioned areas of improvement, could be economically implemented.

IX. RECOMMENDATIONS

Only one major problem became ovbious during the system development: that of data extraction from the WALES response. It is recommended that, any future operational and/or experimental system, the actual data which is to be returned to the RDT be properly formatted in the central computer system rather than the interface controller. With the present extraction process, any changes in the central software system may also require changes in the CEU software. Similarly, any additions to the types of inquiries requires additional CEU software. If the CEU were made transparent to the types of inquiries and data, the user would be able at will, to add to or change features of the system.

Based upon the interest generated by this program from the many law enforcement agencies that have been made directly to Electromagnetic Sciences, Inc., it is recommended to continue to use and evaluate the installed system. An advanced

system should be developed that could be used in-car, as well as out of vehicle. It should be modular, with printer option, and could be moved from vehicle-to-vehicle. EMS is working toward these goals.

POWER TURN-ON

The Data Access Terminal (DAT) is turned on (powered up) by pressing the CLEAR key. The DAT automatically turns off (powers down) several seconds after the last keyboard operation or communications exchange. The DAT does not have an on/off switch.

KEYBOARD ARRANGEMENT

The keyboard is arranged into three groups of keys plus two special keys.

The upper row of three keys are display function keys. The CLEAR key powers up the DAT or, if already powered up, clears the entire display (destroys any data which has been entered from the keyboard or received from the central computer). It also interrupts any current mode of operation and returns the DAT to the keyboard entry mode. The RECALL key is used to re-read a message that is longer than 16 characters (either received from the central computer or entered on the keyboard). A message cannot be recalled after the DAT has powered down. The BKSP key backspaces the display (destroys the last character on the display). One or more backspaces may be used for correction of data entered from the keyboard.

The center group of twelve keys is used for keyboard data entry. Entry is basically numeric plus space; that is, the keys marked "0" through "9" produce their respective number on the display as each key is pressed. The last number on the display can be converted to the alpha characters listed under that number on the keyboard by pressing the ROLL key 1, 2, or 3 times. For example, if the "1" key has been pressed and "1" is the last character on the display, pressing the ROLL key will convert the "1" to an "A". A second pressing of the ROLL key will convert the "A" to a "B" and a third pressing to a "C". If the ROLL key is pressed more than three times, undesired characters will be obtained. BKSP to remove the character and reenter. Although many special symbols can be obtained by multiple operations of the ROLL key, only the "-" and "/" are to be used in the present application of the DAT. In particular, the ".", as marked below the "0", is <u>not</u> to be used.

The four keys on the right side of the DAT are transmit function keys. When one of these keys is pressed, any data on the display is transmitted to the central computer, along with a code which identifies the key which has been pressed. The STAtus and MSG (message) keys do not forward the data to WALES, but simply display the data on the dispatcher's console. Action as a result of such data is not presently anticipated and, thus, these keys should not be used. Only the INQuiry key is used to request information from WALES. See later descriptions of inquiry formats. The use of the REQuest key will be described under MODES OF OPERATION.

The ONH key (lower right corner, covered by the leather case) sounds an alarm at the dispatch center and displays any data which was on the DAT display at the dispatcher's console. This OFFICER-NEEDS-HELP function is not presently to be used.

The use of the ACKnowledge key (lower left corner) will be described under MODES OF OPERATION.

MODES OF OPERATION

The DAT has four modes of operation:

A. Keyboard Mode. The DAT is placed in the keyboard mode any time the CLEAR key is pressed and, also, automatically at the end of a recall mode. The green light is on in this mode and data may be entered from the keyboard, as previously described.

B. Transmit Mode. When any of the transmit function keys (including the ONH and ACK) is pressed, the DAT leaves the keyboard mode and enters the transmit mode. The green light remains on if the radio channel is busy. The yellow light comes on during actual data transmission to the central computer. If the radio channel is busy for several seconds (as indicated by the green light staying on) the DAT will power down and the entered data will be lost.

C. Receive Mode. At the completion of the data transmission the DAT will enter the receive mode to await a message from the central computer. If an error free message is received, the DAT will enter the recall mode. If a message is not received, the DAT will reenter the transmit mode and retransmit the DAT message. The DAT will try a total of four times to get a response. If it does not receive a response, it will power down and the entered data will be destroyed. The red light is on during the receive mode. If the DAT does not retransmit (red light stays on more than about five seconds), the radio channel is busy and the DAT will power down. Note that voice communications are required to have priority over data (by FCC regulations) and the DAT will not transmit if a "key-down" condition is detected on the channel. The operator does not have to be concerned about waiting for "channel clear"; however, a very busy channel will make data communications difficult, since data will frequently have to be reentered on the keyboard.

D. Recall Mode. The recall mode is entered by pressing the RECALL key and is entered automatically after the reception of an error free message from the central computer. In this mode, the first 15 characters of a message are displayed for several seconds and,

then, the remaining characters are moved smoothly across the display from right to left until the end of the message is visible. The maximum message length (either entered from the keyboard or received from the central computer) is 64 characters. At the end of the recall mode, the DAT reenters the keyboard mode. If the message is 15 characters or less in length, the initial display is offset one character to the right and a one character shift to the left indicates reentry into the keyboard mode. The green light is on during the recall mode; however, the motion of the message or offset of the message distinguishes the recall mode from the keyboard mode.

As noted in the above discussions, the DAT modes of operation are highly interrelated. The keyboard is inactive in modes other than the keyboard mode; however, the CLEAR key is always active and its operation at any time will remove the DAT from its current mode and return it to the keyboard mode.

Note that the DAT can receive a message only within the few seconds after it has transmitted a message. Thus, all communications are under control of the DAT; that is, the central computer cannot, at will, communicate with the DAT.

Messages for the DAT are accumulated at the central computer in a "message stack" for each DAT. Each message is placed below the previous message in the stack as it is formulated. Each time the DAT transmits to the central computer, the message at the "top" of the stack (oldest message) is sent to the DAT or, if no messages are in the stack, the word "ACKNOWLEDGE" is transmitted. The reception and display of any message from the central computer (including the word "ACKNOWLEDGE") indicates that the central computer has received the transmitted message without error. The REQuest key at the right side of the DAT is used to request transmission of the message at the top of the stack, when there are no other messages to be sent to the central computer. A message remains in the stack at the central computer until it is ACKnowledged by the DAT. The acknowledge code tells the central computer that the last message has been received and understood and that the message is to be destroyed and the next message in order sent. The acknowledge code is transmitted only one time by the DAT for each time the key is pressed; that is, the retrys do not occur as for the other transmit function keys. This is to avoid unintentional loss of messages.

SEQUENCE OF OPFRATION

The operating sequence for making inquiries with the DAT is as follows:

1. Power up the DAT by pressing the CLEAR key or, if a previous message is still on the display, press the CLEAR key to remove that message.

2. Format the desired inquiry as described in a later section and press the INQuiry key. If no response is received during the transmit/receive sequences, the inquiry must be reentered. If the word ACKNOWLEDGE is received, the WALES response is not immediately available and the operator should wait a few seconds and then press the CLEAR and REQuest keys to see if the WALES response is now available; or, another inquiry may be entered. Note that several inquiries may be active at one time.

3. When a response is received, the original inquiry is repeated at the beginning of the message and should be noted, particularly if several inquiries have been entered. The letters NCIC and/or MILE at the end of the message indicates that inquiries have been forwarded to these respective systems and responses should be available shortly. Other message content will be described later. If the message was not fully read on the first display scan, press the RECALL key to rescan the message. If the DAT powers down before the message is fully read, press the REQuest key to receive the message again.(after powering up the unit by pressing the CLEAR key).

4. When the message has been fully read and noted, press the ACKnowledge key (if the DAT is powered down, press the CLEAR key first) <u>one time only</u>. If additional messages are now available, the top of stack message will be transmitted by the central computer. If no messages are available, the word ACKNOWLEDGE will be transmitted. If <u>no</u> response is received, <u>do not</u> reACKnowlegde at this time; instead, use the REQuest sequence to see if the central computer did, in fact, receive the acknowledge code (otherwise, a message may be lost). See later examples of actual sequences.

INQUIRY FORMATS

The system is presently implemented for TAG, VIN, NAME, PERMIT, and BIKE inquiries. The inquiry format is simplified over that used at fixed terminals (such as in the dispatch area). For example the entry QART/123456/DC on the DAT will <u>not</u> work. Instead, the correct entry is T123456/DC. The format must <u>exactly</u> follow the examples shown on the following pages. Note, in particular, that the "/" symbol is <u>not</u> used after the initial letter. Note, also, that the "." and "(" shown on the keyboard are <u>not</u> presently to be used in inquiries. When an improper format is detected at the central computer, the INVALID FORMAT message will be returned to the DAT.

Tag Inquiry Format: TXXXXXX/SS (T is always entered first)

where XXXXXX is tag letters or numbers (separators such as space and hyphen must not be used)
and SS is standard two letter state abbreviation.

Valid examples:
T123456/DC
T1/DC (Single digit tag number)
TAMR505/MD
TSTATUS/GA (Tag reads STATUS)

VIN Inquiry Format: VXXXXXXXXXXX/CCCC/YY/SS (V always first)

where XXXXXXXXXXX is Vehicle Identification numbers and/or letters,
CCCC is make abbreviation,
YY is last two digits of year,
and SS is state abbreviation.

Valid example: V446379H150931/BUIC/69/DC

Name Inquiry Format: NLLLLL-FFFFƀNNN/MMDDYY/R/S (N always first)

where LLLLL is last name,
FFFF is first name or initial (note that hyphen separates last and first names with no spaces),
ƀ is a single space,
NNN is middle name or initial,
MM is two digit month of birth (01 for January)
DD is two digit day of birth (01, 05, 16, etc)
YY is last two digits of year of birth (note that separators are not used between month, day, and year),
R is race code,
and S is sex (M or F).

Note carefully the following Valid Examples with regard to missing information and the use of the "/" symbol:

NJONES-TOM C/010351/W/M NJONES-T C/010351//M NJONES-TOM C//W/M NJONES-T/010351 NJONES-TOM C///M NJONES-TOM C/010351/W	Message may be truncated for missing information at the end; however, additional "/" symbols must be used to identify fields for missing data within the message.

Permit Inquiry Format: PXXXXXXX/SS (P always entered first)

where XXXXXXX is permit numbers or letters
and SS is permit state abbreviation.

Valid example: P2721960/DC

Bike Inquiry Format: BXXXXXX (B always entered first)

where XXXXXX is bicycle registration number.

Valid example: B112233

TO MAKE AN INQUIRY:

1. Press the CLEAR key
2. Key in the data as shown above
3. Press the INQuiry key

Note: Do not key in SPACEs following the valid format.

EXAMPLE OF AN IDEAL INQUIRY SEQUENCE

In this example, it is assumed that the WALES, NCIC, and MILES computers give immediate response to the inquiry, that the radio communications channel is clear, and that there are no communications error which result in retransmissions.

1. Press CLEAR. Enter TAMR506/MD and press INQuiry.

   The yellow light comes on briefly during DAT transmission, the red light comes on briefly during DAT reception, and the following message is displayed:

   ```
   |<-Initial--->|
   | WALE AMR506/MD NO REC NCIC MILE
                  |<------Final->|
   ```

2. Press ACKnowledge. After communications sequence, the following is displayed:

   ```
   |<-Initial --->|
   | NCIC AMR506/MD NO RECORD
               |<-----Final->|
   ```

3. Press ACKnowledge. After communications sequence, the following is displayed:

   ```
   |<-Initial --->|
   | MILE AMR506/MD RUTH JEAN NELSON
                  |<----- Final ->|
   ```

4. If ACKnowledge is again pressed, the word ACKNOWLEDGE will appear on the display.

5. If ACKnowledge is not pressed (in step 4.) and another inquiry is entered, the response of step 3. will be repeated since the central computer assumes that this message has not been read and understood.

Note: The order of the MILE and NCIC responses (steps 2. and 3.) depends upon the relative speeds of the respective computers at the particular time. That is, the MILE response may be received first.

The Initial and Final positions on the display are shown in the above examples.

THE NORMAL INQUIRY SEQUENCE

Several things can occur to make the inquiry sequence less than ideal. The frequency of such happenings depends upon the severity of the causing condition.

1. The radio channel is busy when the INQuiry key is pressed and for several seconds thereafter: The DAT will power down and the inquiry must be reentered. Data communications of other DAT's will not normally cause this condition. Heavy voice traffic will make use of the DAT difficult.

2. Voice comes in on top of the data communications: Will normally cause a data error which will be recovered automatically without operator action. The yellow and red lights will come on more than once. A long voice communications will, however, cause the DAT to power down with the red light on. Either the central computer or the DAT could not get the channel (remember, by FCC regulations, voice has priority).

3. The DAT is operated in a location of poor reception or transmission: The DAT will power down after transmitting four times (yellow light comes on four times). Check quality of voice communications.

4. Weak battery in PR-25: DAT may transmit four times without receiving a message or DAT may power down prematurely during the sequence. Replace the PR-25 battery.

5. WALES, NCIC, and/or MILES computers are slow in response (more typical than not, during times of heavy usage): The word ACKNOWLEDGE will be displayed. Do not reenter the inquiry. It has been received, without error, by the central computer. Use the REQuest sequence after a few seconds or continue with entry of other inquiries. When a message is received and understood, be sure to ACKnowledge the message as soon as possible. Failure to do so can use up the available message stack area in the central computer and lock out all of the DAT's.

6. WALES down: Response to an inquiry is WALE DOWN. Do not enter additional inquiries until the REQuest/ACKnowledge sequence results in the word ACKNOWLEDGE from the central computer.

7. NCIC and/or MILES down: WALES response is returned normally with NCIC DOWN or MILES DOWN message appended. WALES inquiries may continue; however, the NCIC/MILES inquiries will not be initiated by the system.

8. Operation in direct sunlight: The DAT display must be shielded from direct sunlight and bright reflections in order to be visible. Some sunglasses may also make the display invisible. Note that, because of internal power regulation, the condition of the PR-25 battery has little effect on the brightness of the display.

CONTENT OF COMPUTER RESPONSES

The first word of the response (WALE, NCIC, or MILE) identifies the computer system generating the response. The original inquiry (truncated in some cases) follows next. Because of the message stacking at the central computer, the response is not necessarily associated with the last inquiry entered. The letters NCIC and/or MILE at the end of the WALES response indicate that the inquiry has been forwarded to that respective computer system. NCIC DOWN and/or MILE DOWN messages may also appear at the end of the WALES response. Note that only Maryland Tag and VIN inquiries are forwarded to MILES. Bike inquiries enter the WALES system only. Inquiries without sufficient identifying information are not forwarded to NCIC.

The words NO REC or NO RECORD in a response indicates that the respective computer system does not contain a file on the particular inquiry. The INVALID FORMAT response indicates an error in entering the inquiry: for example, the first character is not a B, N, P, T, or V; the inquiry length is incorrect for a DC Permit or Bike number; an invalid symbol or character was included in the inquiry; etc. A name inquiry with insufficient identifying information may result in the message MULT RESP CALL DISPATCH. Caution: Because of the similarities in name spelling and because of the "sound alike" features in the WALES and NCIC computer systems, names should generally be rechecked with dispatch in the case of a "hit".

In some cases, the WALES computer does not check the validity of entry data. For example, the inquiry T123456/DB will give NO REC, even though DB is not a valid state abbreviation.

The only information returned to the DAT from MILES is the name of the registered owner for a Tag or VIN inquiry. If there is a serious offense against the vehicle, an NCIC "hit" would, however be obtained.

The NCIC response will show NO RECORD unless a "hit" is found, in which case the "hit" will be described (i.e., STOLEN).

If a WALE response has a name immediately following a Tag or VIN number (or initials following a Bike number), the number is in the computer file and no offenses are listed against that number. If offenses are present, the key offense word will appear immediately after the inquiry in the response. For "hits" on Name inquiries, only the most serious offense will be described.

THE PR-25 RADIO

The DAT receives its power from the PR-25 radio. The PR-25 must contain a battery which is in good condition and the radio must be properly installed in the DAT for the terminal to function properly. The PR-25 must also contain a minor modification for the DAT to properly receive data. Verification of this modification is made by installing the PR-25 in the DAT, including the top cable connection, and then checking the PR-25 for normal voice communications. The loudspeaker of the PR-25 will not be active unless the modification has been made. DO NOT transmit inquiries with an unmodified PR-25 radio since the inquiries will be received properly by the central computer, but, will tie up the available message stack area, as the DAT cannot receive the messages.

The Battery: Only batteries which have been verified to be in top condition should be used with the DAT system. Also, the battery should have been on charge for 14 hours before being installed. The CHARGE light on the battery charger does not indicate the condition of charge of the battery.

Radio Installation: Install a fully charged battery in the PR-25. Insert the PR-25 into the space provided at the back of the DAT with the battery compartment toward the DAT (antenna away from the DAT). Lift the rubber connector cover on the top of the radio and insert the DAT cable connector so that the three pins align with the three holes in the radio and the two pins align with the two holes. Do not force. Press the bright metal springs on two sides of the connector while inserting. The connector should lock into place. Check to insure that the DAT powers up properly. Note that the radio is not presently secured into the DAT. The DAT should be operated only in a generally upright position to insure the electrical contact with the radio battery connections (at base of radio). If the DAT fails to operate, make sure the radio is oriented properly and press the radio firmly into the DAT bracket. The radio can be used for normal voice communications as the push-to-talk switch can be operated through the leather case of the DAT. It is not necessary to disconnect the DAT cable for voice communications.

PR-25 Controls: Set the radio controls as instructed for normal voice communications. The volume control must be adjusted for normal comfortable voice reception. The DAT cannot receive data if the volume control is turned completely down; however, the adjustment is not critical. Data communications is active only on the CW1 channel. Do not operate the push-to-talk key on the radio while the DAT is powered up.

PR-25 Removal and Battery Replacement: Turn the PR-25 off. If the DAT is in its leather case, grip the cable connector with two fingers on the black sides of the connector and pull upward. In some cases, the push-to-talk key must be pressed lightly through the leather case for the PR-25 to release. In other cases, removal can be aided by exerting additional force by gripping the base of the antenna or by pushing upward on the speaker grill. Caution: Do not push back the protective covering of the antenna. After the PR-25 has been lifted an inch or so, disconnect the DAT cable by pressing the bright metal springs on the connector and lifting upward. Completely remove the PR-25 and replace the battery in the normal manner. Note that the battery compartment cover must be fully seated and closed or the PR-25 will not slide into the DAT properly. If the DAT is not in its leather case, the PR-25 removal can be aided by pressing the push-to-talk key and pushing upward (Be sure PR-25 has been turned off).

OPERATING INSTRUCTIONS FOR THE HHT

I. POWER ON SEQUENCE

A. Opening Case

1. Lift exposed corner of cover to reveal cord.
2. Attach cord to transceiver
3. Pull on cover until the keyboard is exposed.
4. Fold cover behind the back of the unit and press fasteners together. There are two positions for this connection; use whichever is more comfortable.
5. Your hand may be inserted between the unit and cover as a means of support for unit.

B. Power on Sequence

1. Push power switch to ON position.
2. Simultaneously depress the Shift and Clear keys; release.
3. Depress and release Display key; display should illuminate.
4. Simultaneously depress the Shift and Clear keys; release. Display should extinguish. Terminal is now ready to operate.

II. DATA COMMUNICATIONS SEQUENCE

A. Transmit Sequence

1. Depress and release Display key. Display should illuminate. Display will remain illuminated until approximately 15 seconds after the last key is depressed or until XMIT is depressed.
2. Type in inquiry as per Section IV.

3. To send inquiry to computer; listen for clear communications channel, then depress and release XMIT key.

4. XMIT light will illuminate when the message is sent.

5. If the computer receives the message, it will send a short message to the HHT to turn off the XMIT light.

6. If after 30 seconds there is no response from the computer, the XMIT light will flash. Again listen for a clear channel and then depress and release the XMIT key. (Retransmit)

7. Repeat this sequence until the XMIT light extinguishes.

NOTE: To conserve power turn Power switch to OFF when not actively using the terminal.

B. <u>Receive Sequence</u>

1. When an answer is ready, the computer will send a short message that illuminates the "Press Ack to Rcv" light.

2. Listen for a clear channel, then depress and release the Ack key.

3. The Wait light will illuminate.

4. The Wait light will extinguish and the RCV light illuminates when the message is received. (If an error is detected, the RCV light will blink).

5. Listen for a clear channel, then depress and release the Ack key.

6. If the message was received correctly, the display will illuminate, revealing the response. If an error was encountered anywhere in the sequence, the computer will start over by lighting the "Press Ack to RCV" light. In this case repeat step II, B, 1.

7. A flashing light indicates an error on the received data. Follow the sequence above, the computer will correct the sequence and continue by lighting the "Press Ack to RCV" light again.

III. COMPLETION SEQUENCE

A. <u>Electronic Power Off</u>

1. Push power switch to off position.

2. Disconnect cord from transceiver.

B. <u>Closing Case</u>

1. Pull cover until it is connected to unit at only one edge.

2. Fold cover in front of keyboard and attach to fastener at top rear of case.

3. Place cord on top of cover at the top of the case.

4. Fold back the extra cover to enclose cord. Press fasteners to seal.

IV TYPES OF INQUIRIES

A. <u>Bike</u>

1. Entry form:

B/ x x x x x x

Where $_x$ is a numeric digit and is the cursor.

2. Responses are listed in the attached examples, Section V.

B. <u>Tag (License plate number)</u>

1. Entry form:

T/ n u m b e r / s t

Where number is the license number, st is the 2 character abbreviation for the state and is the cursor.

2. Responses listed Section V.

C. <u>Vehicle Identification Number</u>

1. Entry form:

V/ n u m b e r

Where number is the vehicle identification number and is the cursor.

2. Responses listed in Section V.

D. <u>Name</u>

1. Entry form:

N/ l a s t - f i r s t - m/d o b/r a c e/ s e x

Where last is surname, first is given name or initial and is mandatory m is middle initial and is optional.

"__" is a space.

dob is date of birth Ex. February 12, 1932 is 021232

race is W, N, O

sex is M or F

2. dob or race are optional.

3. An extra / must be added if sex is missing. eg: / in place of M.

4. If there is no middle initial, exclude both __space and M.

5. See examples for additional information.

E. <u>Permit</u>

1. Entry form:

P/ n u m b e r/ st

Where number is operator's permit number, st is 2 character state abbreviation.

2. Responses listed in Section V.

F. <u>Clear Messages</u>

1. Purpose: To clear all outstanding messages to terminal

2. Entry Form:

CM

3. No response is given. All pending responses queued to the terminal entering the CM code, with the exception of those responses which have been initiated but not yet received from WALES/ NCIC/ MILES are deleted.

```
11 JL 75  12:16  FROM TER 02  B/105599
11 JL 75  12:17  TO   TER 02  B/105599   **105599 - DRB     ***

11 JL 75  12:17  FROM TER 02  B/100041
11 JL 75  12:17  TO   TER 02  B/100041   **100041 - STOLEN***

11 JL 75  12:17  FROM TER 02  B/003456
11 JL 75  12:18  TO   TER 02  B/003456   **003456 - NO REC***

11 JL 75  12:18  FROM TER 02  B/21A344
11 JL 75  12:18  TO   TER 02  B/21A344   **21A344 - ERROR ***

11 JL 75  12:18  FROM TER 02  T/1/DC
11 JL 75  12:19  TO   TER 02  T/1/DC           WASHINGT           N
11 JL 75  12:19  TO   TER 02  T/1/DC                 **NO REC  NCIC

11 JL 75  12:19  FROM TER 02  T/XXXX/DC
11 JL 75  12:20  TO   TER 02  T/XXXX/DC        BEYER     GLASSES N
11 JL 75  12:20  TO   TER 02  T/XXXX/DC              **NO REC  NCIC

11 JL 75  12:20  FROM TER 02  T/127218/DC
11 JL 75  12:21  TO   TER 02  T/127218/DC      SCHICK   *STOLEN N
11 JL 75  12:21  TO   TER 02  T/127218/D^            ***STOLEN NCIC

11 JL 75  12:23  FROM TER 02  T/729389/DC
11 JL 75  12:23  TO   TER 02  T/729389/DC      NO REC   *PK WAR N
11 JL 75  12:23  TO   TER 02  T/729389/DC            **NO REC  NCIC

11 JL 75  12:24  FROM TER 02  T/CC18495/PA
11 JL 75  12:24  TO   TER 02  T/CC18495/PA     NO REC             N
11 JL 75  12:24  TO   TER 02  T/CC18495/PA           **NO REC  NCIC

11 JL 75  12:26  FROM TER 02  T/1/MD
11 JL 75  12:26  TO   TER 02  T/1/MD
11 JL 75  12:26  TO   TER 02  T/1/MD           NO REC            NM
11 JL 75  12:26  TO   TER 02  T/1/MD                 **NO REC  NCIC
                                               NO REC          MILE

11 JL 75  12:27  FROM TER 02  T/CC18594/PA
11 JL 75  12:27  TO   TER 02  T/CC18594/PA     NO REC             N
11 JL 75  12:27  TO   TER 02  T/CC18594/PA           ***STOLEN NCIC

11 JL 75  12:27  FROM TER 02  T/AB2345/MD
11 JL 75  12:28  TO   TER 02  T/AB2345/MD      NO REC            NM
11 JL 75  12:28  TO   TER 02  T/AB2345/MD            **NO REC  NCIC
11 JL 75  12:28  TO   TER 02  T/AB2345/MD SPENCE               MILE.

11 JL 75  12:29  FROM TER 02  T/AYV65M/MD
11 JL 75  1  9   TO   TER 02  T/AYV65M/MD      NO REC            NM
11 JL 75  12:29  TO   TER 02  T/AYV65M/MD      NO REC          MILE
11 JL 75  12:34  TO   TER 02  T/AYV65M/MD            **NO REC  NCIC

11 JL 75  12:34  FROM TER 02  T/PX3583/MD
11 JL 75  12:37  TO   TER 02  T/PX3583/MD      NO REC   *PK WAR NM
11 JL 75  12:37  TO   TER 02  T/PX3583/MD MYERS                MILE
11 JL 75  12:37  TO   TER 02  T/PX3583/MD            **NO REC  NCIC

11 JL 75  12:37  FROM TER 02  T/MD/MD
11 JL 75  12:38  TO   TER 02  T/MD/MD          NO REC            NM
11 JL 75  12:38  TO   TER 02  T/MD/MD                ***STOLEN NCIC
11 JL 75  12:38  TO   TER 02  T/MD/MD          NO REC          MILE
```

```
11 JL 75  12:39  FROM TER 02  T/123ABC/XX
11 JL 75  12:39  TO   TER 02  T/123ABC/XX    NO REC           N
11 JL 75  12:39  TO   TER 02  T/123ABC/XX        **NO REC  NCIC

11 JL 75  12:39  FROM TER 02  T/123ABC
11 JL 75  12:40  TO   TER 02  T/123ABC       NO REC  *INVALD

11 JL 75  12:40  FROM TER 02  N/WHITE,WARREN/W/M
11 JL 75  12:41  TO   TER 02  N/WHITE,WARREN/W/M       *INVALD

11 JL 75  12:41  FROM TER 02  N/WHITE,WARREN//W/M
11 JL 75  12:41  TO   TER 02  N/WHITE,WARREN//W/M    NO REC

11 JL 75  12:43  FR(  TER 02  N/WHITE,W////
11 JL 75  12:43  TO   TER 02  N/WHITE,W////               *CONT*
11 JL 75  12:43  TO   TER 02  WHITE, WILLIAM H    **5 4 042519
11 JL 75  12:43  TO   TER 02  MISS PR      US**
11 JL 75  12:43  TO   TER 02  WHITE, WILLIE M     **     110525
11 JL 75  12:44  TO   TER 02  NO WANT STATUS
11 JL 75  12:44  TO   TER 02  HARRIS, ERISE       **5 6 021731
11 JL 75  12:44  TO   TER 02  PROB VIOLATION**MAY BE ARMED   *

11 JL 75  12:45  FROM TER 02  N/WHITE,W/021731///
11 JL 75  12:45  TO   TER 02  N/WHITE,W/021731///     *CONT*
11 JL 75  12:45  TO   TER 02  HARRIS, ERISE       **5 6 021731
11 JL 75  12:46  TO   TER 02  PROB VIOLATION**MAY BE ARMED  N*
11 JL 75  12:46  TO   TER 02  N/WHITE,W/021731//***HIT*   NCIC
11 JL 75  12:46  TO   TER 02  HARRIS, ERISE  M N**OBS JUS 506

11 JL 75  12:47  FROM TER 02  N/TRICE,T/080952//M
11 JL 75  12:47  TO   TER 02  N/TRICE,T/080952//M     *CONT*
11 JL 75  12:47  TO   TER 02  TRICE, TERRY DENE   **6 0 080952
11 JL 75  12:47  TO   TER 02  HOMICIDE-MURDE**ADDTL ADD 1000N*
11 JL 75  12:47  TO   TER 02  N/TRICE,T/080952//***HIT*   NCIC
11 JL 75  12:47  TO   TER 02  TRICE, TERRY DENE **HOMICID 600

11 JL 75  12:48  FROM TER 02  N/HOOD,LOUIS/030149//M
11 JL 75  12:49  TO   TER 02  N/HOOD,LOUIS/030149//M  *CONT*
11 JL 75  12:49  TO   TER 02  HOOD, LOUIS DUTTON  **5 10030149
11 JL 75  12:49  TO   TER 02  BURGL-TWO UNLA**ADD 5714 SEMINN*
11 JL 75  12:51  TO   TER 02  N/HOOD,LOUIS/03014****DOWN**NCIC

11 JL 75  12:52  FROM TER 02  N/HOWARD,P/011156//M
11 JL 75  12:56  TO   TER 02  N/HOWARD,P/011156//M    NO REC

11 JL 75  12:57  FROM TER 02  N/SMITH,J////
11 JL 75  12:57  TO   TER 02  N/SMITH,J////               *MANY*

11 JL 75  12:58  FROM TER 02  N/JAMES,JESSE/012847//M
11 JL 75  13:08  FROM TER 00  N/JAMES,JESSE/012847//M
11 JL 75  13:09  TO   TER 00  N/JAMES,JESSE/012847//M *CONT*
11 JL 75  13:09  TO   TER 00  MAHOGANY, FRANK BAKE**6 0 012847
11 JL 75  13:09  TO   TER 00  NO WANT STATUS  419 4TH ST NE N*
11 JL 75  13:10  TO   TER 00  N/JAMES,JESSE/0128***HIT*   NCIC
11 JL 75  13:10  TO   TER 00  JONES, JOHN HENRY **DRUGS   511

TD700 INOPERATIVE

NO RESPONSE FROM TERMINAL 00
```

```
11 JL 75  13:31  FROM TER 00  V/1132914740
11 JL 75  13:35  TO   TER 00  V/1132914740 NO REC          N
11 JL 75  13:35  TO   TER 00  V/1132914740      **NO REC  NCIC

11 JL 75  13:35  FROM TER 00  V/F10GEN01480
11 JL 75  13:35  TO   TER 00  V/F10GEN01480 NO REC         N
11 JL 75  13:41  TO   TER 00  V/F10GEN01480    ***STOLEN NCIC

11 JL 75  13:41  FROM TER 00  V/2B35H206476
11 JL 75  13:41  TO   TER 00  V/2B35H206476 FULLER         N
11 JL 75  13:41  TO   TER 00  V/2B35H206476     **NO REC  NCIC
```

END