

MOBILITY MONITORING SYSTEM AND VEHICLE PERFORMANCE
RECORDER REVISION(U) ARMY COMBAT SYSTEMS TEST ACTIVITY
(PROV) ABERDEEN PROVING GROUND MD T G BARTLETT ET AL
SEP 85 USACSTA-6169-REV F/G 13/6

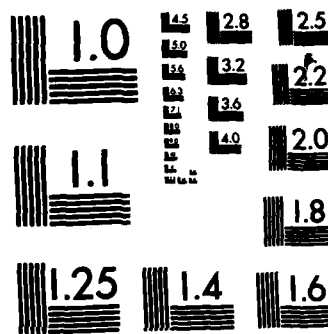
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REVISED
METHODOLOGY INVESTIGATION
FINAL REPORT
OF
MOBILITY MONITORING SYSTEM AND VEHICLE
PERFORMANCE RECORDER, PHASE I

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20 September 1985

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SUBJECT: Methodology Investigation Final Report of Mobility
Monitoring System and Vehicle Performance Recorder,
Phase I, TECOM Project No. 7-CO-PB4-AP1-007,
Report Number USACSTA-6169

Commander
US Army Combat Systems Test Activity
ATTN: STECS-DA-M
Aberdeen Proving Ground, MD 21005-5059

1. Subject report is approved.
2. Test for the Best.

FOR THE COMMANDER:

Grover H. Shelton
GROVER H. SHELTON
Chief, Meth Imprv Div
Analysis Directorate

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20. (bad for government) of test vehicle. This report covers the development of methodology that centers on the Vehicle Performance Recorder (VPR) (a small, self-contained microcomputer based data acquisition and processing system) to collect and process data during endurance testing. The data so collected provides immediate information for test control, and is entered into an overall data base for historical, trend, and other analyses. The implementation and application of this methodology to the Initial Production Test and Follow-on Evaluation of the High Mobility Multipurpose Wheeled Vehicle (HMMWV) is briefly covered.



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FOREWORD

The US Army Combat Systems Test Activity (USACSTA), Aberdeen Proving Ground (APG), MD, was responsible for the design of the Vehicle Performance Recorder, its software, the overall data acquisition scheme, and the methodology developed employing these elements.

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SECTION 1. SUMMARY

1.1 BACKGROUND

The US Army Combat Systems Test Activity (USACSTA) and other Army agencies routinely perform endurance tests of vehicular systems. These endurance tests are typically controlled only to the extent that a target number of miles and pedagogical mixture of terrain types (e.g., 30% primary road, 30% secondary road, 40% cross-country) referred to as a mission profile are established. The only measurements normally made are a road speed time history (sometimes) and the accumulated mileage at the instant failures occur (app C, ref 1).

During earlier Developmental Tests (DT) and Operational Tests (OT) of the High Mobility Multipurpose Wheeled Vehicle (HMMWV) conducted at APG, MD and Fort Hunter-Liggett (FHL) and Camp Roberts (CR), CA, respectively, the failure rates as reported from OT were several times those reported from DT. Although there are differences between the DT and OT philosophy, goals, record keeping, etc., this disparity in failure rate raised questions relative to the influence test courses have on reliability, availability, maintainability, durability (RAM-D) results. The Geotechnical Laboratory of the US Army Engineer Waterways Experiment Station was tasked to evaluate the courses used during HMMWV RAM-D testing (app C, ref 2). Their findings were that although APG courses were less demanding on driver and vehicle than the FHL and CR courses, the order of differences were small and the failure rate inconsistencies could not be attributed to the courses alone.

The Vehicle Performance Recorder (VPR), developed at APG, has been equipped with real-time processing algorithms to perform histogram and tachograph tasks suitable for monitoring test course and operator inputs during endurance testing. A VPR/HMMWV interface verification test was accomplished in May 1984 (app C, ref 3), and the VPR was used during endurance portions of the HMMWV Initial Production Test (IPT) and the Follow on Evaluation (FOE).

1.2 OBJECTIVES

The overall objective of this investigation is the improvement of vehicle test methodology through the use of the VPR and Mobility Monitoring System (MMS). Phase I of this investigation concentrates on the application of the VPR to endurance testing. Specific goals of this phase of the investigation include:

- a. The determination of critical, high information content parameters and real-time processing techniques.
- b. The placement of a methodology to determine caution and alarm limits on these critical parameters.
- c. The implementation of a data base management system for use during endurance testing, and the application of this data base management system to vehicle endurance testing.

It should be noted that although this report contains many specific references to HMMWV endurance testing, the objective of this study is the development of an improved, generally applicable, generic methodology relating to vehicular system endurance testing. The HMMWV is referenced because it is the first vehicle to make use of the methodology described herein.

1.3 SUMMARY OF PROCEDURES

The procedures developed for vehicle endurance testing are:

a. Using all available information, select a set of parameters to be monitored throughout testing. This step is the least amenable to standardization in that it is strongly dependent upon the vehicle under test. During the IPT of HMMWV the parameters chosen were control arm position and acceleration, engine speed, exhaust gas temperature, road speed, and absorbed power (at the driver's seat).

b. Choose transducers consistent with parameters in a above. Develop an installation and calibration strategy, update the file MVPRMC (app B) to include vehicle, and test specific actions and procedures.

c. Configure and initialize a System 2000 (S2K) data base consistent with the chosen parameters. At this point also, the type of reports desired should be determined in order that the data base design (in terms of key/non-key items and hierarchical structure) can be optimized for report generation.

d. Using a vehicle as close as possible to the test item, conduct a baseline test. In a baseline test, several passes are made over each test course under normal, high, and low stress conditions, with all parameters recorded (using the VPR) to generate a profile of distributions. From these data caution and alarm limits are calculated.

e. During testing, each test vehicle is instrumented with a VPR. Once or twice daily the collected data are transferred to a Data Retrieval System (DRS). Daily statistics are calculated and used to provide control of the test process. In addition, the data are entered into a data base management system for further analysis.

1.4 SUMMARY OF RESULTS

The procedures specified in the previous section were invoked during the IPT and FOE of HMMWV. While detailed results from these tests will not be presented here (a separate report is being prepared) the following have been observed:

a. During approximately 150,000 miles of endurance testing at six locations nationwide, the VPR and associated elements provided data acquisition and processing coverage for over 75% of the test miles. Most lost data can be attributed to transducer failures.

b. The data processing that was accomplished at the test site provided twice daily (or more often) the information needed by test personnel to adequately control the test so as to assure an appropriate level of testing.

c. A data base was established which allows rapid access to the data for trend, composite, and other analyses.

1.5 ANALYSIS

An endurance test involves extended operation of one or more test items under life cycles designed to simulate, under proving ground conditions, extended field use (app C, ref 1). The result of an endurance test is a prediction (within well defined confidence intervals) of the test item's ultimate failure rate. The procedures for failure determination, record keeping, and calculations are all well developed and generally applied.

The key element in an endurance test is the faithfulness of the simulated life cycle to the item's eventual environment. Although no data could be found, the general consensus is that vehicles which have done well during proving ground endurance testing have been reliable when fielded, whereas vehicles which have performed poorly during proving ground testing have not been reliable when fielded. Obviously vehicle endurance testing has been a successful program.

The Army is now emphasizing mobility and maneuverability in new vehicle systems, and these vehicles can easily outperform some of the existing test standards. For instance, the HMMWV can easily and safely negotiate USACSTAs Perryman 3 course while maintaining its speed above 45.0 km/hr (28 mph) for 10% of the time and averaging more than 37.0 km/hr (23 mph) while the course speed limit is only 32.2 km/hr (20 mph). It is anticipated that the actual HMMWV life cycle will include high speed cross-country travel and hence, this should be included in the vehicle's life cycle model.

The methodology described in this report provides three major features:

- a. The establishment of the operational capabilities of a vehicle prior to endurance testing.
- b. Monitoring of testing with timely reporting to provide a test control mechanism.
- c. A data base system to allow an historical view of the testing, thus enabling an examination of test location influence, test course influence, driver influence, etc.

1.6 CONCLUSIONS

It is concluded that the data acquisition, processing elements, and the methodology improvements described in this report provide a powerful and valuable tool with respect to the control, quantification, and standardization of vehicle endurance testing.

1.7 RECOMMENDATIONS

It is recommended that:

a. The vehicle simulated life cycle definition be expanded (beyond primary, secondary, and cross-country) to include roughness and speed of travel.

b. The instrumentation and procedures described herein be adopted as essential elements of vehicle endurance testing throughout the Army. The adoption of this recommendation would necessarily imply that funds for sufficient instrumentation for Army wide application would also be made available.

c. Further investigations be made, such that a ruggedized transducer set be available for future vehicle endurance testing.

d. Vehicle Performance Recorder, Data Retrieval System, and Data Base Management System (DBMS) software be enhanced for smoother operation.

e. Funding for this effort be continued.

SECTION 2. INSTRUMENTATION

2.1 VEHICLE PERFORMANCE RECORDER (VPR)

2.1.1 Hardware

The VPR, shown in Figure 2.1-1, is a small, self-contained data acquisition and processing system. It is designed to be installed on a vehicle to acquire and process data and store the results to provide a description of either system performance or test environment, or both. The VPR measures 33.0 by 25.4 by 22.8 cm (13 by 10 by 9 in.), weighs approximately 16.8 kg (37 lb), and requires 1.8 amps at 28 volts DC for operation. The VPR operates over a temperature range of -40° C to 85° C.

Figure 2.1-2 is a block diagram of the VPR hardware, consisting of a microterminal for operator-interface and printed circuit assemblies (six commercially available, three developed in-house) installed in a ruggedized housing. The printed circuit assemblies provide the following:

- a. An 8 bit CMOS microcomputer.
- b. Terminal interface.
- c. Sixteen K bytes of additional programmable read only memory (PROM) program storage.
- d. Sixty-four K bytes of additional random access memory (RAM) data storage.
- e. Thirty-two channel analog to digital converter (ADC).
- f. Four channel counter/timer.
- g. Four channel pulse conditioners.
- h. Four channel analog signal conditioner.
- i. Floating point math processor.
- j. Real-time clock.

The VPR will accommodate the following data channels:

- a. Four analog with signal levels of ± 5 mV to ± 5 V.
- b. Sixteen high level analog (a thermocouple preprocessor is available for use with these channels).
- c. Four discrete events (on/off).
- d. Four pulse or counter/timer.

2.1.1 (Cont'd)

Data from these channels may be processed and stored. The major limitation on the VPR's capabilities are the 64 K byte of RAM which is used to store either processed or raw data, and the speed with which the system's 8 bit microprocessor can process the data required. (Note that during HMMWV endurance testing the math processor was not installed and the VPR contained only 32 K bytes of RAM.)

The VPR's central processing unit (CPU) is based on a 2 MHz NSC-800 microprocessor. The NSC-800 is a CMOS microprocessor with an 8085 architecture which executes the Z80 instruction set. Included with the CPU are 4 K bytes of PROM, 2 K bytes of RAM, an 8 level priority interrupt controller, and a system clock.

The ADC has 32 single ended channels, with full scale inputs of ± 10 V and a conversion time of 50 microseconds (μs). The ADC has an accuracy of $\pm 0.1\%$, and a 12 bit resolution.

The VPR features both low (4) and high (16) level inputs to the ADC (the remaining 12 channels are unused). Figure 2.1-3 is a block diagram of one channel of the quad signal conditioner. This device features:

- a. Binary weighted gains ranging from 1 to 1024.
- b. Filter cutoff frequencies of 25, 50, 100, and 200 Hz.
- c. Optional bridge balance and bridge completion.

Figure 2.1-4 is a block diagram of the thermocouple preprocessor. This unit accepts up to 16 Chromel-Alumel thermocouples, and linearizes the output to 10 mV/C (relative to 0° C). The output of this unit is connected to one or more of the 16 high level inputs. (Any other high level signal can be so connected.)

The VPR has the capability to input and measure the frequency or period of up to 4 pulse trains. This is accomplished using a 4-channel, 16 bit counter and a 4 channel pulse conditioning subsystem. Figure 2.1-5 is a block diagram of the pulse conditioner. In this conditioner, a threshold voltage is set through a digital to analog converter by the CPU. This allows signal levels from 10 mV to 10 V. The output of the comparator (a logic level signal) is then either passed on through to the counter, or used to gate a 1 or 2 MHz clock (for one period) to the counter. In this way, the system can be used to measure either frequency or period over a large range of amplitudes.

The math processor is a fast, hardware based calculational unit. It performs the four basic arithmetic operations for:

- a. Single precision (16 bit) integers.
- b. Double precision (32 bit) integers.
- c. Single precision (32 bit) floating point numbers.

2.1.1 (Cont'd)

The math processor also calculates the transcendental floating point functions:

- a. Trigonometric - cosine, sine, tangent, inverse cosine, inverse sine, inverse tangent.
- b. Exponential and power.
- c. Common and natural logarithm.
- d. Square root.

The math processor can perform these calculations much faster (up to thousands of times) than software calculational routines.



Figure 2.1-1. Vehicle Performance Recorder.

2.1.1 (Cont'd)

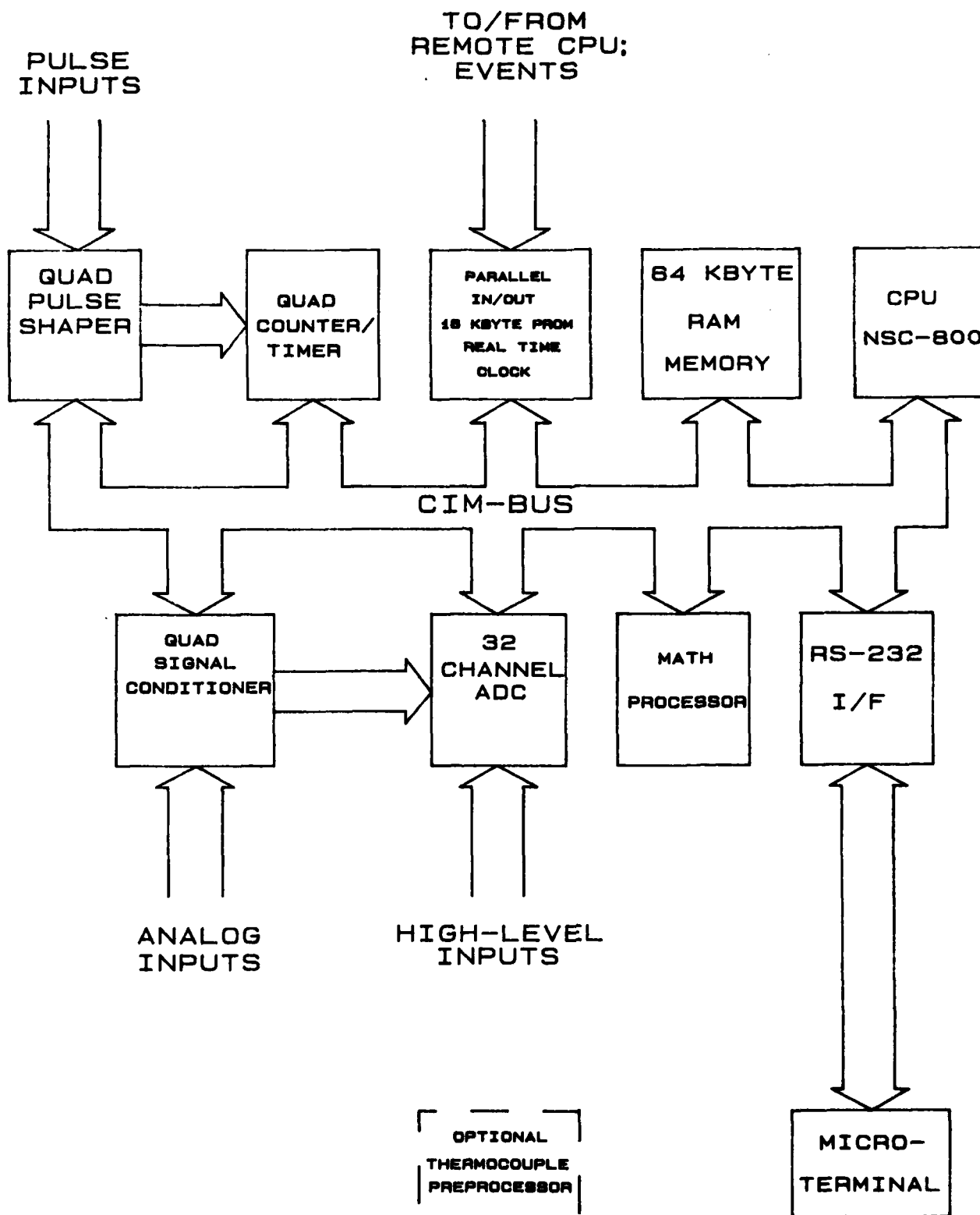


Figure 2.1-2. Vehicle performance recorder block diagram.

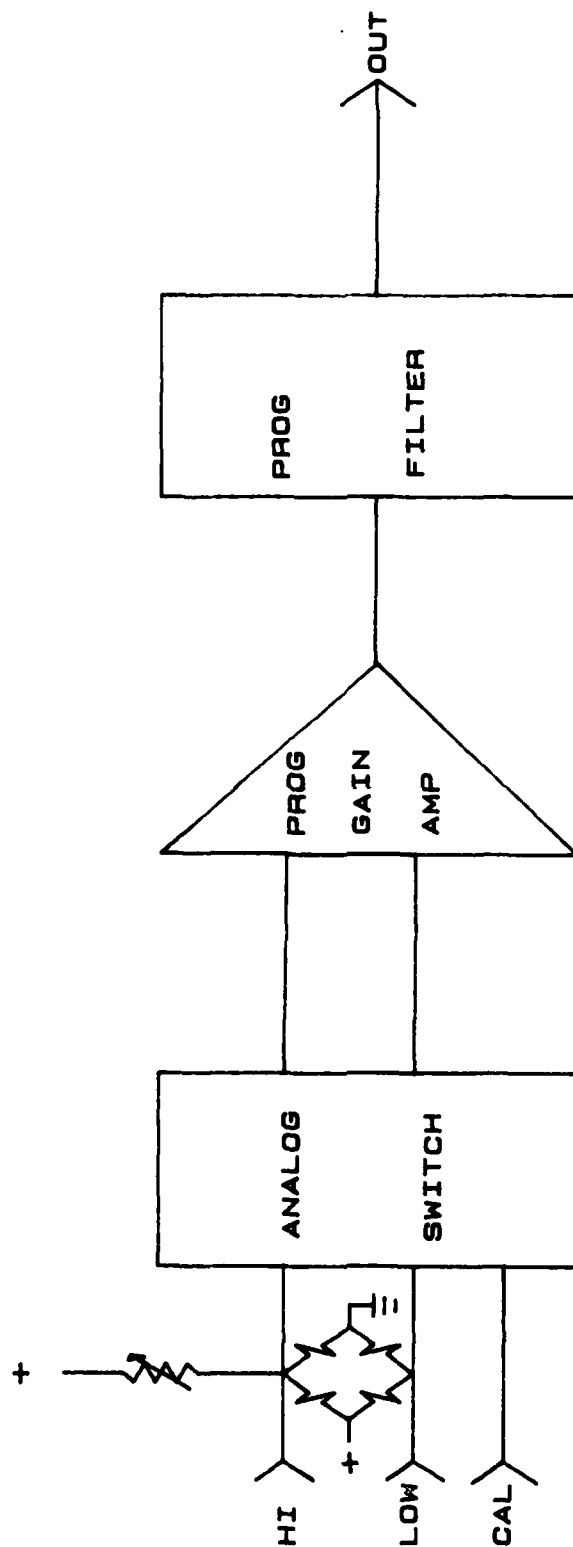


Figure 2.1-3. Quad signal conditioning (one channel).

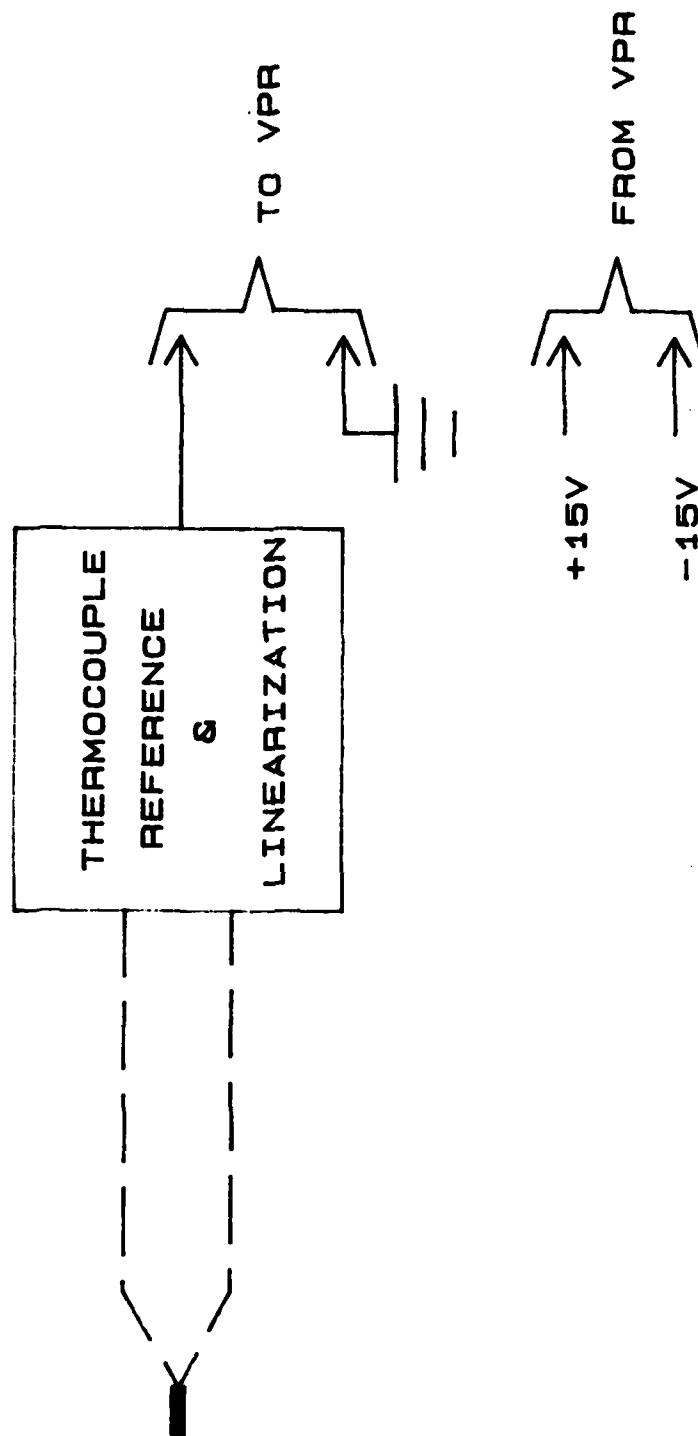


Figure 2.1-4. Thermocouple preprocessor (1 of 16).

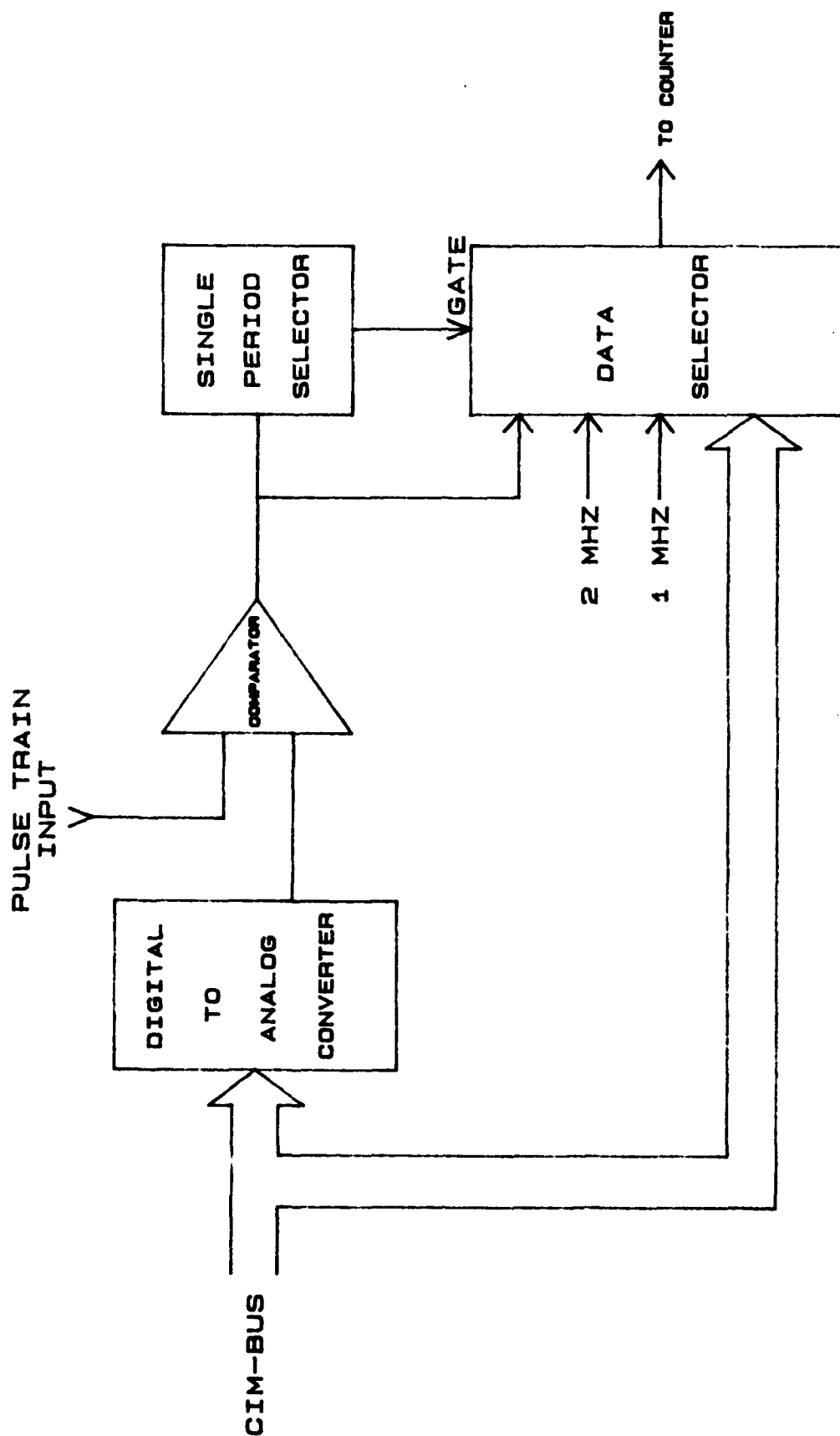


Figure 2.1-5. Quad pulse conditioner (1 of 4).

2.1.2 VPR Software

The discussion to this point gives the impression that the VPR is a collection of circuit boards and integrated circuits (ICs). A more complete depiction is shown in Figure 2.1-6. In this figure, which points out the software intensiveness of the VPR, the hardware pictured in Figure 2.1-2 occupies the lowest level. From a system's point of view, the VPR is designed like a stack of bricks, with each level making use of the functions provided by the level below. The system's hardware occupies the bottom level, above which reside the simplest, most hardware-dependent operating system functions (device drivers and interrupt handlers). In the upper levels are the applications programs.

In essence, the VPR is a set of virtual machines. The functions provided by a given level build upon those of part or all lower levels and are not distinguishable at higher levels from hardware features.

The VPR is designed around the commercially available real-time operating system kernel Versatile Real-Time Executive (VRTX) (app C, ref 4). VRTX provides the facilities necessary for:

- a. Task management.
- b. Inter-task communication and synchronization.
- c. Character I/O support.
- d. Interrupt servicing.

Table 2.1-1 lists the various VRTX calls.

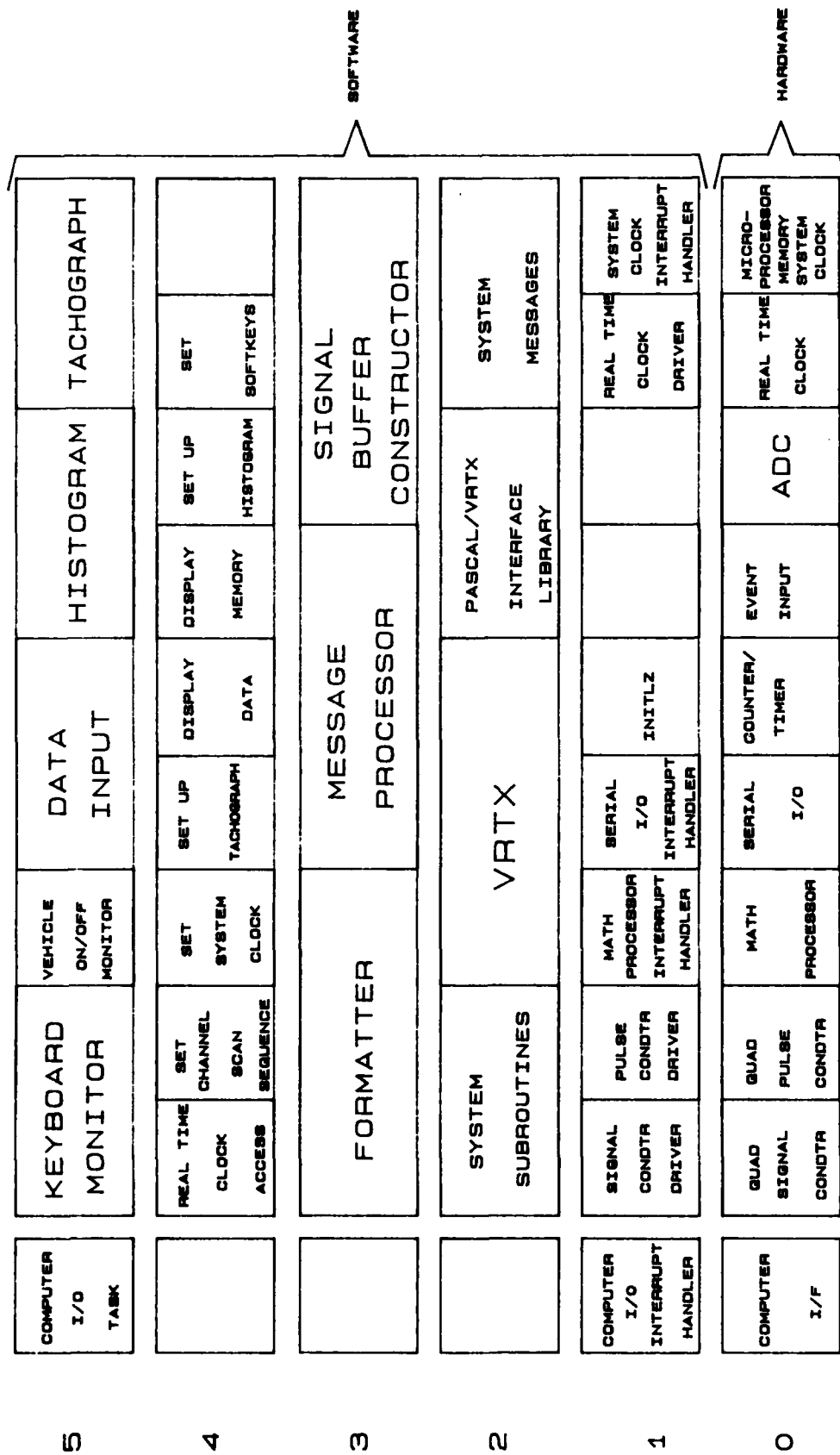


Figure 2.1-6. VPR system topology.

2.1.2 (Cont'd)

TABLE 2.1-1. VRTX CALLS

Group	Mnemonic	Function
Task Management:	SC_TCREATE	Task Create
	SC_TDELETE	Task Delete
	SC_TSUSPEND	Task Suspend
	SC_TRESUME	Task Resume
	SC_TPRIORITY	Task Priority Change
	SC_TINQUIRY	Task Inquiry
	SC_LOCK	Disable Task Rescheduling
	SC_UNLOCK	Enable Task Rescheduling
Communication and Synchronization:	SC_POST	Post Message
	SC_PEND	Post for Message
	SC_ACCEPT	Accept Message
	SC_QPOST	Post Message to Queue
	SC_QPEND	Pend Message from Queue
	SC_QACCEPT	Accept Message from Queue
	SC_QCREATE	Create Message Queue
Real-Time Clock:	SC_TDELAY	Task Delay
	SC_TSLICE	Enable Round-Robin Scheduling
Character I/O:	SC_GETC	Get Character
	SC_PUTC	Put Character
	SC_WAITC	Wait Character
Interrupt Servicing:	UI_POST	Post from Interrupt Handler
	UI_EXIT	Exit from Interrupt Handler
	UI_TIMER	Announce Timer Interrupt
	UI_RXCHR	Received-Character Interrupt
	UI_TXRDY	Transmit-Ready Interrupt
	UI_ENTER	Enter Interrupt Handler
	UI_QPOST	Post to Queue from Interrupt

Real-Time systems such as the VPR are designed to perform seemingly unrelated functions in a nonsequential manner, thereby utilizing system resources more efficiently. For example, the VPR can interleave the input of data from the ADC, histogram processing, and display of data on the terminal. VRTX supports these real-time functions by providing the basic mechanism for implementing multitasking, where a task is a complete execution path through code that demands the use of system resources. In real-time systems, several tasks appear to operate simultaneously through rapid allocation of CPU time.

2.1.2 (Cont'd)

In the VPR, as many as six tasks, each tagged with a unique identification number, can be active at one time. (The operating system kernel supports and the VPR could contain up to 255 tasks.) Each task is assigned a priority level, with control of the CPU being given to the highest priority task that is ready to execute. Tasks can create other tasks, as well as delete, suspend, and change the priority of themselves or other tasks.

In a multitask environment, tasks exist in one of the four following states:

a. Executing - The task has control of the CPU and is executing its assigned instruction path.

b. Ready - The task is ready for execution but cannot gain control of the CPU until (1) all higher priority tasks existing in the ready or executing state are either completed or suspended, and (2) it reaches the head of the queue of equal priority tasks.

c. Suspended - The task has been suspended mid-execution and is waiting to be readied by a system call or an event (e.g., a certain number of ticks expires or a special character arrives).

d. Dormant - The task has not been initiated, or its execution has been completed and it is now idle.

Figure 2.1-7 summarizes the task state transition.

A task may become suspended for any of the following reasons:

a. A Task Suspended call, SC_TSUSPEND, was issued specifying that task (either by priority or ID number).

b. The task suspended itself for a specified time delay using the SC_TDELAY call.

c. The task is waiting for a message from another task or interrupt handler (i.e., it issued an SC_PEND or SC_QPEND call but no message is posted yet).

d. The task issued an SC_WAITC call and is waiting for a special character to be sent from an I/O device.

e. The task issued an SC_GETC call, but the input buffer maintained by VRTX was empty, so it is waiting for input from an I/O device.

f. The task issued an SC_PUTC call, but the output buffer was full, so it is waiting to output to an I/O device.

Just as a number of different events may suspend a task, several events and calls can place a suspended task back in the ready state.

a. An SC_TRESUME call can be issued to ready a task that was suspended by an SC_TSUSPEND call.

2.1.2 (Cont'd)

b. A time delay can expire, thus readying a task that was either suspended by an SC_TDELAY call or timed out pending for a message.

c. A message can be posted (via an SC_POST, SC_QPOST, UI_POST, or UI_QPOST call) to a task that is waiting for a message.

d. A special character can be sent (via a UI_RXCHR call from an interrupt service routing) to a task that was suspended by an SC_WAITC call.

e. Characters can be sent to the input buffer from an interrupt service routine using the UI_RXCHR call; any tasks that were suspended on an empty buffer are then readied.

f. Characters can be removed from the output buffer by an interrupt service routine using the UI_TXRDY call; any tasks that were suspended on a full buffer are then readied.

In the VPR, VRTX is augmented by various software modules to provide the operating system environment (refer to fig. 2.1-6). These range from the most primitive, i.e., device drivers and interrupt handlers which embody the unique timing and control signal manipulation of the various hardware elements, to the high level applications tasks. Intermediate levels contain the command processors, utility and I/O processors, as well as VRTX and its extensions. The following paragraphs provide a discussion of the applications tasks, with the exception of the data processing tasks which are covered in section 3.

The operator interfaces to the VPR through a keyboard monitor (VPR-SYS) task which is created during and given control following power up initialization. The Warnier-Orr diagram (app C, ref 5) is shown in Figure 2.1-8. Upon entry this task initializes parameters and tables which control:

- a. Sampling rate.
- b. Which channels are sampled.
- c. Which channels are subjected to histogram processing.
- d. Offsets and scales to be applied before histogram processing.

Following these actions, the terminal soft keys are set with the various test course titles, the priority is changed to lowest, and two high priority tasks - the data input and vehicle status monitor - are created. The task then goes into an endless loop waiting on an input from the keyboard. The allowed inputs and a short explanation of those inputs is included as part of Figure 2.1-8. In each case the 2 letter mnemonic is entered and the operator is then prompted for any additional input. It should be noted that for proper data identification the VPR must have had the clock set, and the test location, vehicle identification, shift, and driver number entered.

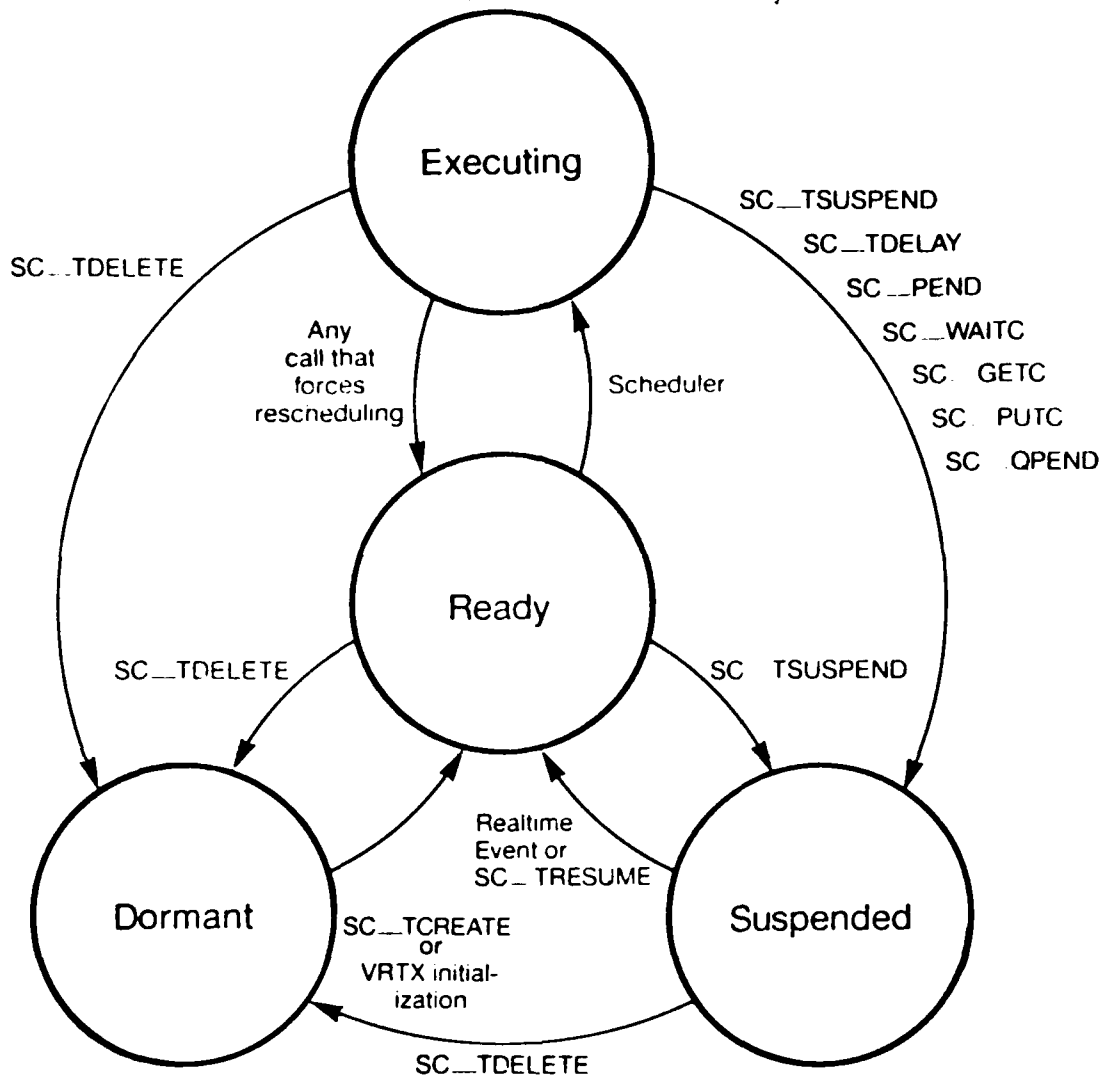


Figure 2.1-7. Summary of task state transition.

2.1.2 (Cont'd)

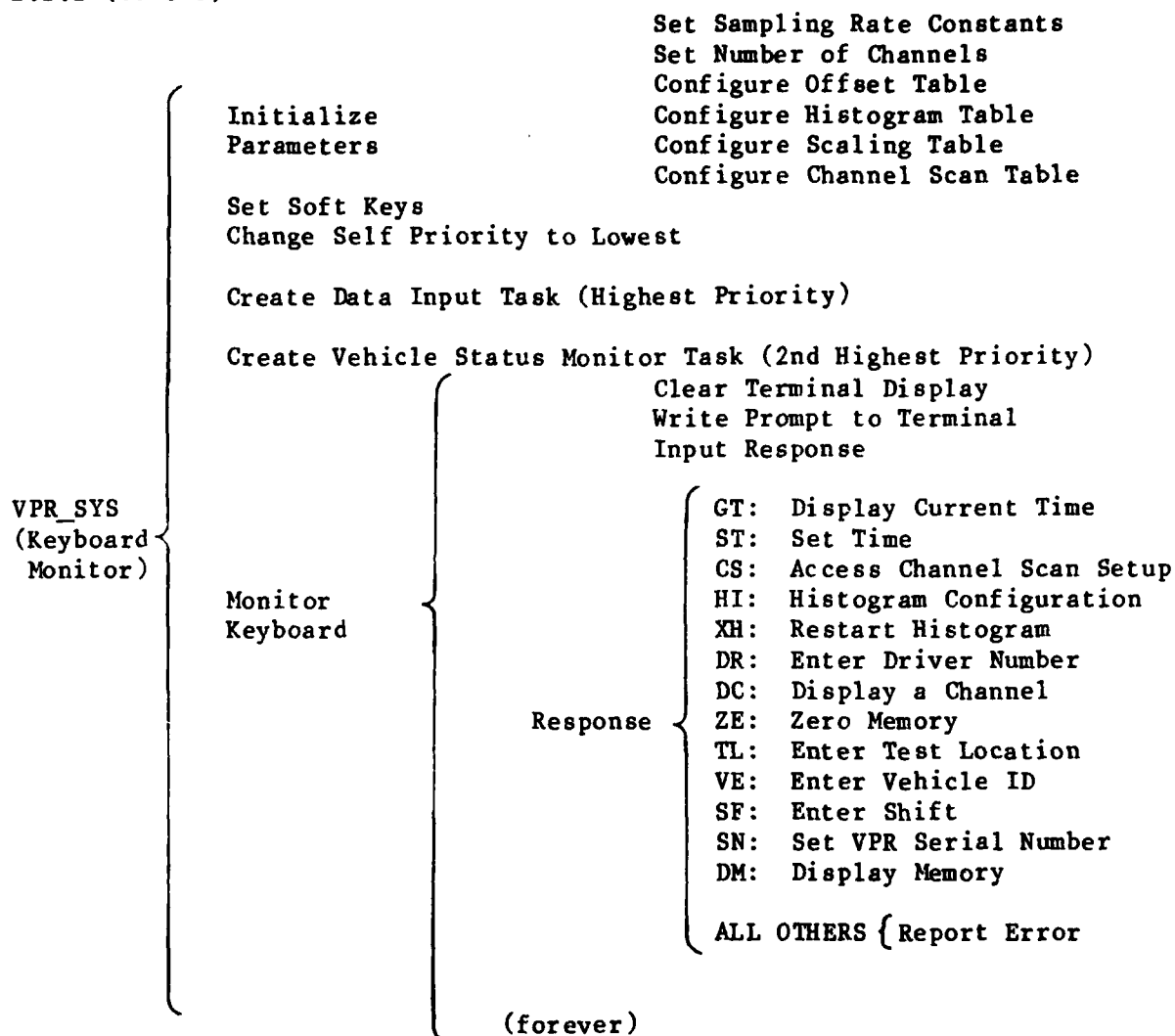


Figure 2.1-8. Warnier-Orr diagram of keyboard monitor task.

The data input task (shown in fig. 2.1-9) is the highest priority task in the system. When this task is created it runs immediately. This task is controlled by tables which determine the channels which are sampled and the rate at which they are sampled. The task carries out the "instructions" contained in the tables, stores the data in memory, then issues calls to first:

- a. Resume the data processing tasks.
- b. Self-suspend for the time determined by the sampling rate.

2.1.2 (Cont'd)

During the IPT of HMMWV, 3-channels of data were sampled 50 times per second, 2-channels were sampled 1 time per second, and 1-channel was sampled once every 30 seconds, so that the data input task was activated every 20 msec. The use of tables to control the channels and rates provides great flexibility in configuring the VPR for various testing situations.

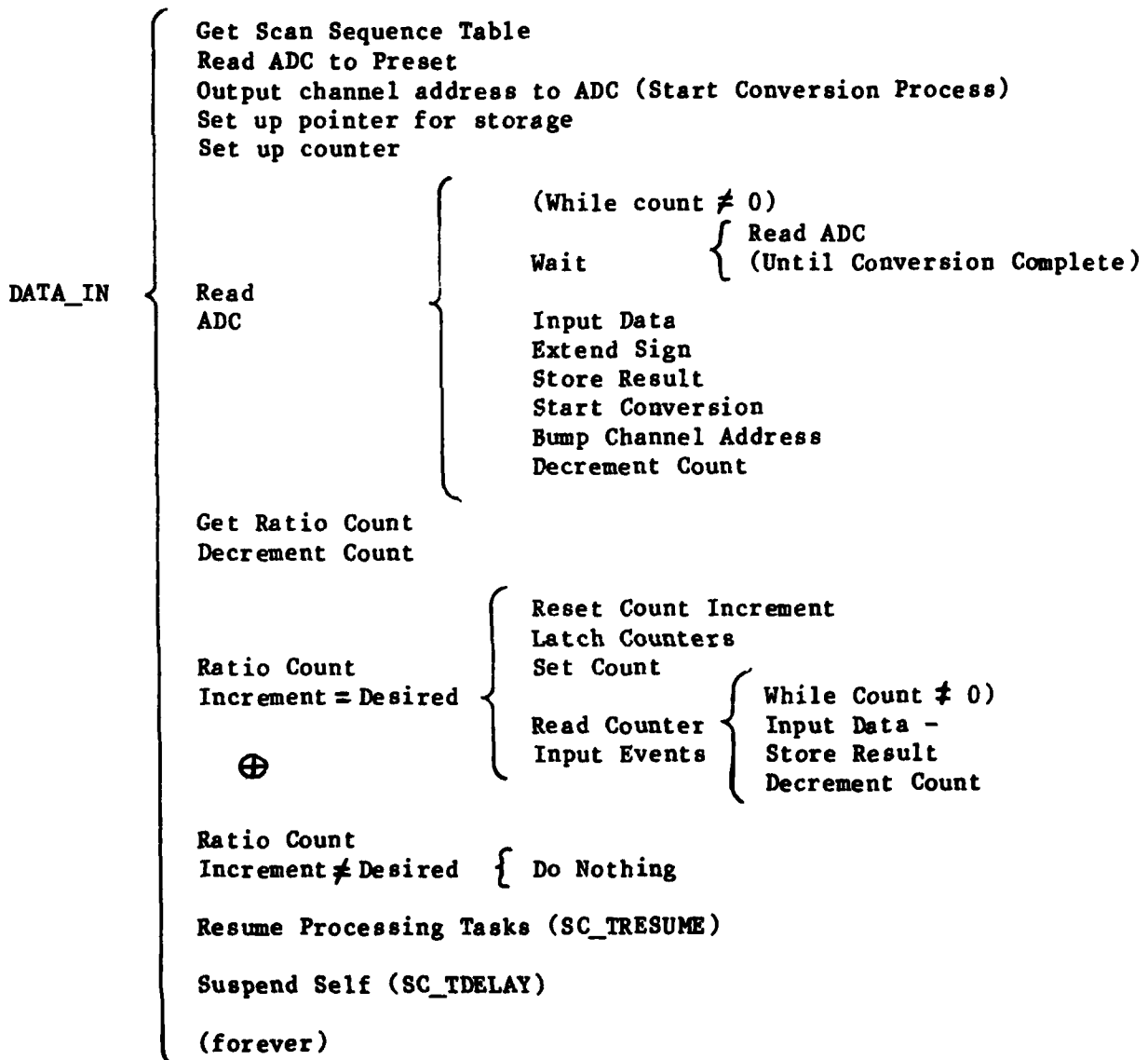


Figure 2.1-9. Warnier-Orr diagram of the data input task.

The second highest priority task is the vehicle on/off monitor (fig. 2.1-10). This is a very simple task whose function is to assure that the tachograph task is active any time that the vehicle is operating and that neither the tachograph nor histogram tasks are active when the vehicle is not operating. This task runs once each 5 seconds.

2.1.2 (Cont'd)

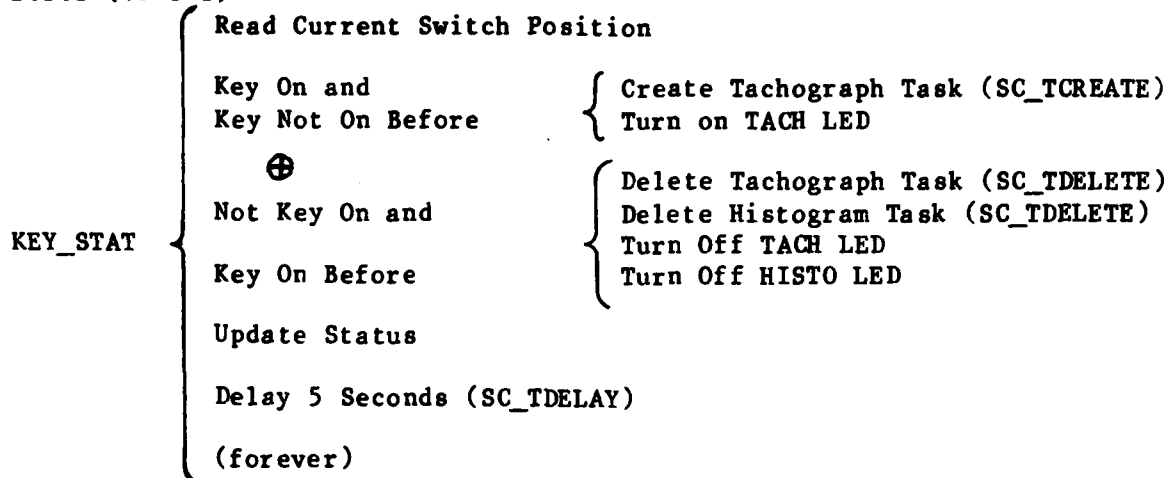


Figure 2.1-10. Warnier-Orr diagram of the vehicle status task.

The data transfer task is shown conceptually in Figure 2.1-11. This is another monitor program, with the commands in this case originating from the Data Retrieval Computer (DRC). The DRC issues commands, and the VPR responds with the appropriate data.

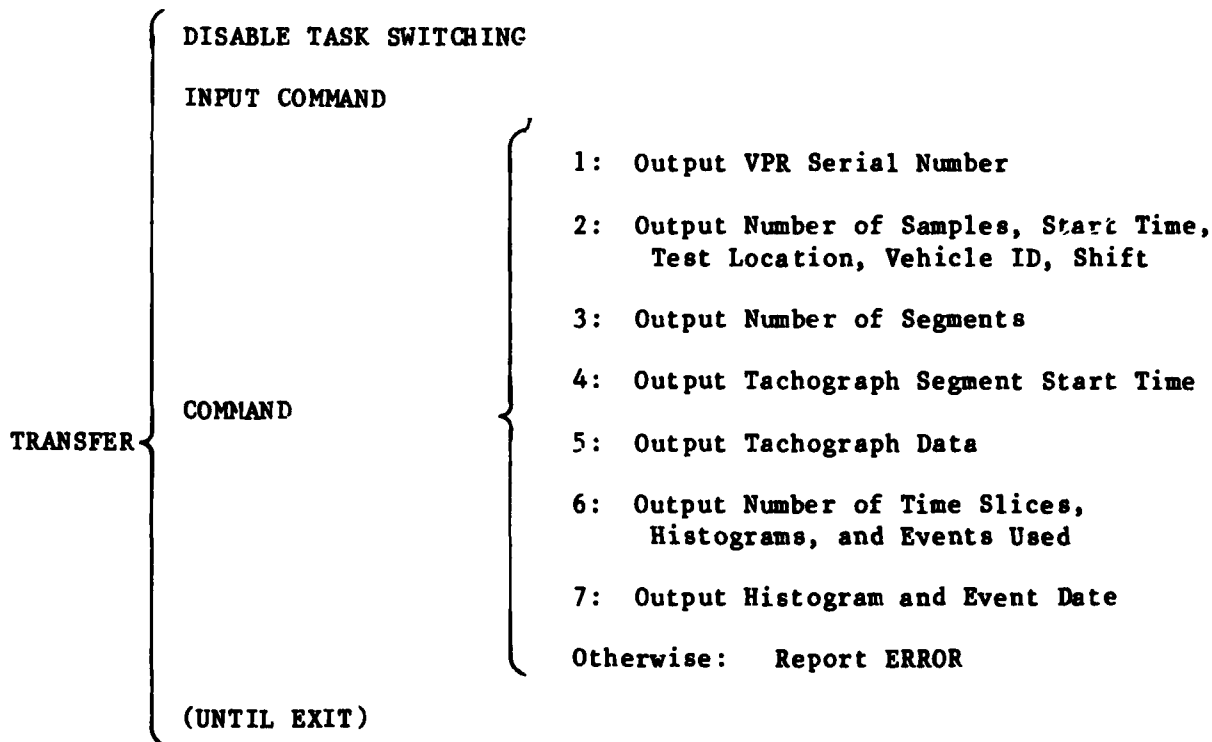


Figure 2.1-11. Warnier-Orr diagram of data transfer.

2.2 TRANSDUCERS

The VPR is a powerful system with a great deal of inherent flexibility. But the VPR, to be useful at all, must be teamed with sensors or transducers aimed at a set of parameters whose measurement provides the information required. The selection of these parameters and transducers requires more thought and planning than perhaps any other step involved in testing.

Before testing starts, a fundamental but very necessary requirement is the determination of the purpose for performing the testing and for using the VPR. The next step is to consider which measurements are most beneficial to achieving the goals proposed, and from the measurements a final list must be selected in such a manner that the number of measurements is minimized while the useful information gained is maximized. At the same time the harshness of the environment must be kept in mind and transducers that will survive that environment must be available.

A case in point is the IPT of the HMMWV. Early in the IPT of HMMWV planning the decision was made to use the VPR to monitor the vehicle and provide feedback to the tester for controlling the endurance phase of testing. To aid in selecting the parameters which would best monitor and control vehicle operations, three basic categories were considered. One category contained parameters that measured the suspension environment, a second group was composed of power train parameters. The third group included vehicle parameters that indicated the effects of non-vehicle variables (i.e., driver, course, weather). Parameters from the first two categories were refined to zero-in on items with high failure rates during DT or were suspected vehicle weak points. Of the variables considered in the third category, driver and course were the two considered to have the greatest effect on the conduct of the test. Vehicle parameters were considered which would show the variations in demands on and inputs to the vehicle by both driver and course. The final list of parameters resulted from a process of integrating and optimizing the three basic lists considered.

The following list of parameters was utilized by the VPR during IPT and FOE of HMMWV:

- a. Right rear upper control arm position.
- b. Right rear upper control arm vertical acceleration.
- c. Engine RPM.
- d. Road speed.
- e. Number of brake applications.
- f. Accumulated duration of brake applications.
- g. Exhaust gas temperatures.
- h. Absorbed power (ride quality).

2.2 (Cont'd)

The first two items, control arm position and acceleration, were chosen as a measure of severity from the suspension point of view. The position is a measure of the extension and compression of the suspension, while the acceleration yields a measure of the forces involved. Figure 2.2-1 shows the relative position of these transducers. The next four parameters; engine speed, road speed, number and duration of service brake applications are representative of the driver's controlling influence on the vehicles operation. These four parameters are operator controlled, but are influenced by variables such as gear range, vehicle load, and course. The number of brake applications and their duration provided a measure of the brake system utilization and helped characterize the operator's driving techniques. Exhaust gas temperature was selected to provide a representation of the power demand on the engine. The major contributions to this power demand were attributed to vehicle load, driving methods, and course. The last parameter listed is absorbed power, which is a numerical representation of the vertical input energy absorbed by the vehicle's operator. Road speed and surface roughness are the two primary variables that most significantly effect the absorbed power for a given vehicle. The combined measurement of all these parameters provided a quantitative sketch of how the vehicle was operated.

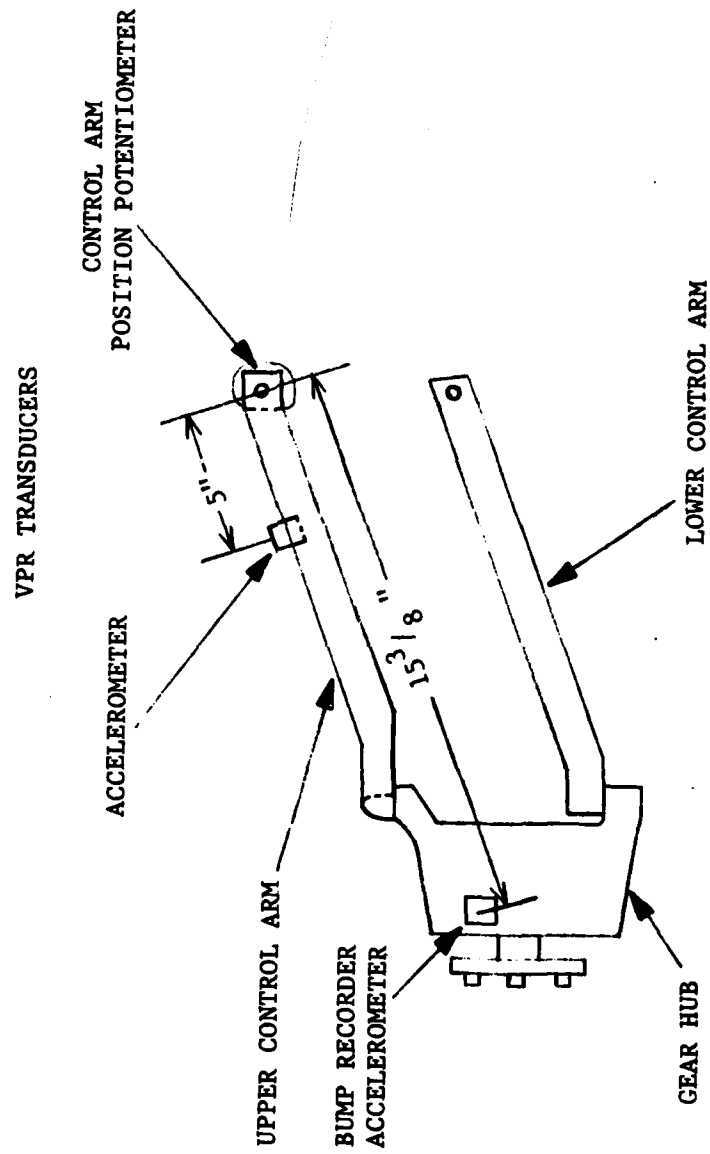


Figure 2.2-1. Control arm position and acceleration transducer placement.

2.2 (Cont'd)

The transducers used in the various measurements are listed in Table 2.2-1.

TABLE 2.2-1. TRANSDUCERS

Parameter	Transducer
Control arm position	Potentiometer, Maurey Model 112-P16-102
Control arm acceleration	Accelerometer, Statham Model 2262C-25
Engine RPM	STE-ICE (internal)
Road speed	Magnetically actuated reed switch, Mass Tech Model TR8-1111-8
Exhaust gas temperature	Chromel-Alumel thermocouple
Brake applications	Brake light switch (internal)
Absorbed power	Accelerometer (and absorbed power preprocessor)

The potentiometer and accelerometer used to measure control arm position and acceleration, respectively, are shown in Figure 2.2-2. These transducers were mounted on the right rear upper control arm, a location that provided the maximum protection attainable. The remaining transducers were mounted in locations such that photographs were not possible. The engine speed was measured using the existing simplified test equipment-internal combustion engine (STE-ICE) transducer (internal to the engine). The road speed transducer is pictured in Figure 2.2-3. This transducer is an in-line device which mounts on the side of the transfer case and allows simultaneous operation of the vehicle's speedometer. Brake applications were indicated each time the brake light switch was activated by depressing the pedal. Exhaust gas temperature was measured by a thermocouple installed in the exhaust pipe. The thermocouple was located approximately 35.5 cm (14 in.) downstream from the flange that coupled the right collector pipe and the exhaust pipe, and extended inside the pipe nominally 1.27 cm (1/2 in.) from the rear surface. Input for determining absorbed power was detected by an accelerometer mounted on the floor of the vehicle at the base of the driver's seat and processed by a special preprocessor. The electrical signals from all these transducers were input to the VPR to be conditioned, processed, and stored.

The parameters measured during the HMMWV IPT were chosen to address specific areas of concern and would not necessarily be appropriate to other tests. For example, while road speed is appropriate to a wide spectrum of vehicle testing, control arm position is a valid parameter only for vehicles with independent suspension.

Transducers are an area where further development is required. Two specific shortcomings which surfaced during the HMMWV IPT are:

a. No sensor system exists for measuring torque in rotating shafts which is applicable in endurance test environments.

b. Although the control arm position potentiometers functioned they required frequent replacement. A non-contact type sensor would be preferred.

These problems (and others which will inevitably appear) will have to be addressed and solved.



Figure 2.2-2. Accelerometer and potentiometer used to measure control arm position and acceleration.

2.2 (Cont'd)



Figure 2.2-3. Road speed transducer.

2.3 DATA RETRIEVAL SYSTEM

2.3.1 Data Retrieval Hardware

A photograph of a typical data retrieval system is shown in Figure 2.3-1, while Figure 2.3-2 is a conceptual representation.

A data retrieval system consists, in its minimum configuration, of the following:

- a. Hewlett-Packard (HP) 1000 minicomputer system with real time executive RTE-VI or RTE-IV operating system.
- b. Disk drive with a minimum of 15 M bytes available for data storage and software.
- c. Graphics terminal with hard copy unit.
- d. Printer.
- e. Sixteen hundred (1600) bytes per inch (BPI) magnetic tape.
- f. A 16 bit microcircuit interface (HP 12566-C) for data transfer.

2.3.1 (Cont'd)



Figure 2.3-1. Typical data retrieval system.

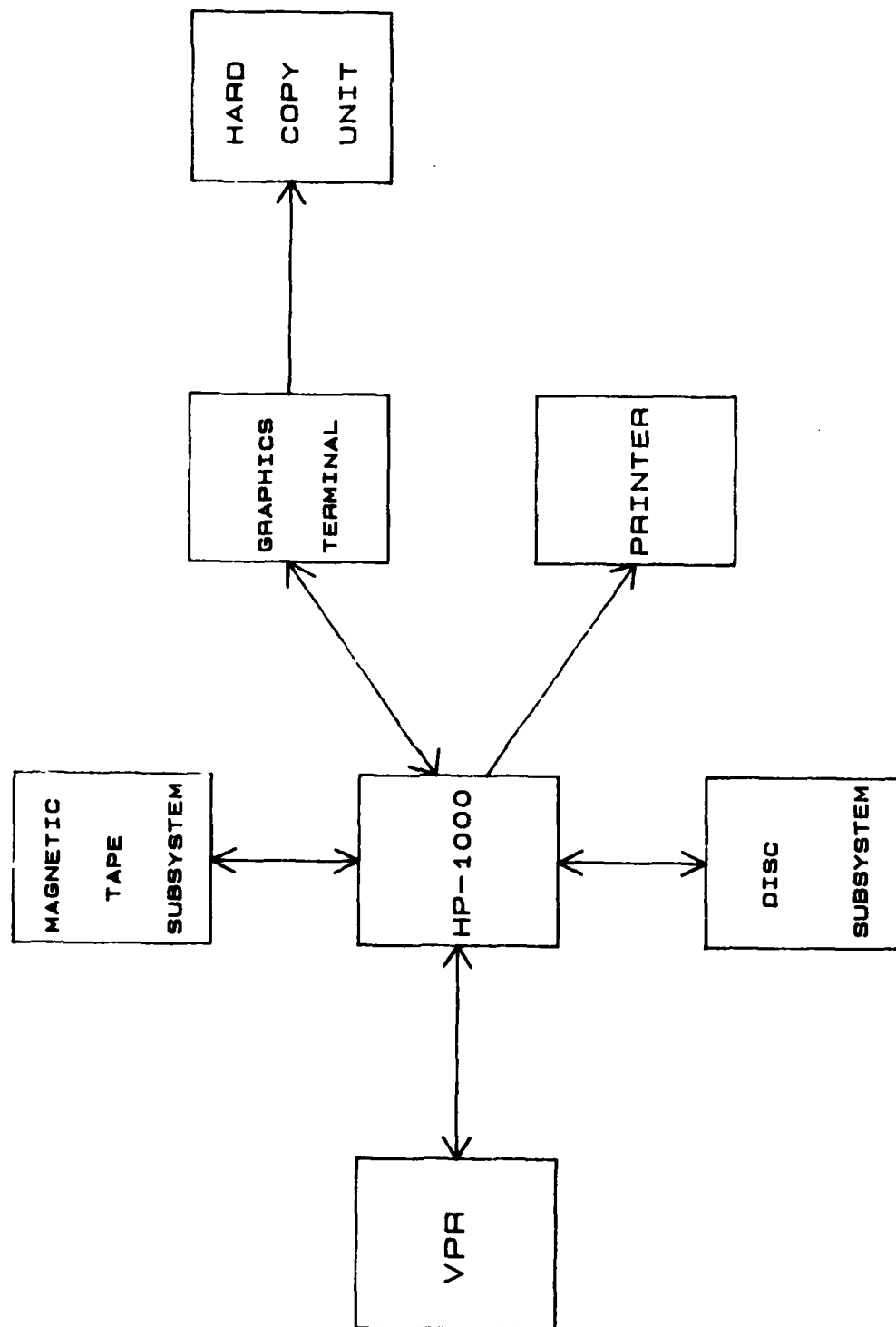


Figure 2.3-2. Block diagram of data retrieval system.

2.3.2 Data Retrieval System (DRS) Operating Software

Control of the DRS is vested in the monitor program 'VPR'. This program provides a consistent command structure for ease of use. The commands used consist of two character mnemonics with subparameters as shown in Figure 2.3-3 and the Warnier-Orr diagram in Figure 2.3-4.

Most monitor commands actually schedule a separate applications program. This scheme allows various functions to be separately tested and modified, as well as allowing additional functions to be included quickly and with minimum effort.

Monitor commands can be broken into four groups: data collection, preliminary data analysis, archival storage processing, and terminal operator utilities. Commands from the data collection group control data transfer and data directory management. Preliminary data analysis commands (covered in detail in section 3) control examination, plotting, and analysis of data. Archival storage processing commands control tape storage and retrieval along with preparation of data for entry into the Intel System 2000 data base.

VALID 'VPR' COMMANDS ARE

CL	Clear the directory
CN code	mag tape control (FMGR codes)
CM, start, stop, channel, list	plot composite histogram
CS, start, stop, list	quick-look composite
DB, start, stop, list	write data base tape
DL, start, stop, list	directory list
ED, set, list	edit directory entries
EN	find end of tape
EV, start, stop, list	process events
EX	exit VPR monitor
IN, run, channel	inspect the data
LC, list	list commands
LM, start, stop, list, optn	limit check on +90%/-90%
PM, set, channel, plotlu	plot histogram
PI, run, plotlu, start, stop, type	plot tachograph
PU	purge run from directory
QL, start, stop, list	quick-look data
RE, track, nscp	restore data tape to disk
RU, prog	run program
TP	write data to tape
TR, load, list, diagnostic	transfer data from VPR
VE, start, stop, list	verify the data

Figure 2.3-3. 'VPR' command codes.

2.3.2 (Cont'd)

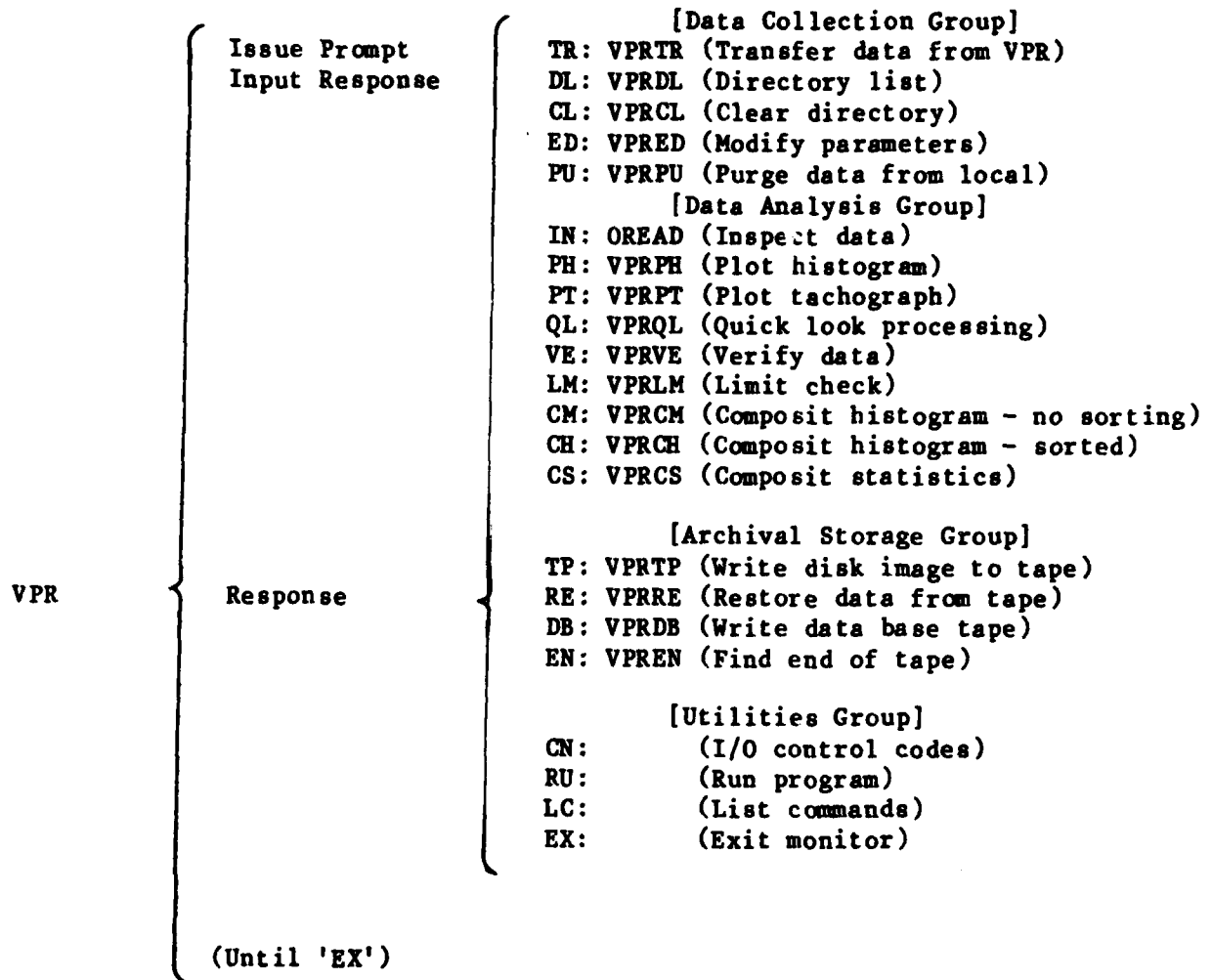


Figure 2.3-4. Warnier-Orr diagram of 'VPR'.

2.3.2 (Cont'd)

The data collection function involves transferring data from each VPR to the HP 1000 minicomputer. This is accomplished via a data cable between the two devices. The data transfer is controlled by the program "VPRTR" (fig. 2.3-5). The transferred data are stored in the form of a directory entry and a data entry. (See app B for directory and data formats.) Each directory entry has a unique set and channel number. Set numbers are assigned at the time of transfer and range from 1 to a maximum of 9600. Channel numbers are used to identify the type of data. Histogram channels range from 0 to 23. Tachograph data is given a "T" and events data an "E" instead of a channel number.

The transfer program scales the tachograph data and scales and "normalizes" the histogram data. Each VPR has a calibration file maintained on the HP 1000 system. The file contains tachograph and events scale factors and histogram minimum, histogram maximum, histogram normal minimum, histogram normal maximum, and histogram sample rate. Normalization is the process of changing histogram maximum and minimum values while maintaining the same number of histogram bins (see fig. 2.3-6). Histogram normalization is used to standardize scaling between all VPR's. Normalization is necessary for composite histograms and enhances direct vehicle to vehicle histogram comparisons.

The data collection function also entails formatting the data for systematic retrieval. The data transfer program 'VPRTR' makes a directory entry for every tachograph, histogram channel and events channel received from the VPR. Four programs are used to manipulate the directory entries. The program 'VPRDL' provides a list of directory entries (see fig. 2.3-7). The directory listing can appear on a terminal or be directed to a printer.

The program 'VPRED' allows modification of directory entry parameters. A list of VPR editor commands is given in Figure 2.3-8. All directory entries, except set and channel numbers, can be changed with program 'VPRED'. All new entries are checked by the program before changes to the directory parameter are made.

The program 'VPRPU' is used to remove (purge) entries from the directory. A directory entry is normally purged only in the case of invalid data (due to transducer failure) or lack of significance (vehicle motionless, very smooth road) to the test. A list of purge commands is given in Figure 2.3-9. Purging a directory entry does not destroy the directory entry or the data. The set number is set to -1 so that the directory entry cannot be accessed by any program. This allows purged data to be recovered, if necessary.

The program 'VPRCL' removes all directory entries. It is used at the beginning of a test or after data has been processed for archival storage.

2.3.2 (Cont'd)

The archival storage processing function involves formatting VPR data for an Intel System 2000 data base and providing local offline magnetic tape storage. Data base processing is done by program 'VPRDB'. This program produces a magnetic tape in INTEL System 2000 data base format for loading on an IBM 4341 mainframe computer (see fig. 3.4-3). The tapes contain all the job control language necessary so no preprocessing is needed on the IBM before loading the data onto the data base. Program 'VPRDB' checks each directory entry for validity and provides a listing of data rejected due to invalid directory entries. The data base tape is written entirely in extended binary coded decimal interchange code (EBCDIC) in 80-character records and can be listed on terminals and printers that use EBCDIC.

Local offline storage is provided by the program 'VPRTP'. These tapes consist of an ASCII header record and an exact copy of the data disk (see app B for data disk layout). This tape cannot be directly listed due to the fact that numbers are stored on the disk as binary representations rather than character representations, i.e., a disk image.

Program 'VPRRE' is used to restore data on a tape written by program 'VPRTP' to the data disk.

Several programs and monitor program commands do not directly access VPR data. The monitor program command 'CN' controls the HP 1000 magnetic tape unit. The tape can be spaced forward, backward, and rewound. Program 'MTEND' finds the last file on a magnetic tape. The monitor program command 'RU' allows any HP 1000 program to be executed without leaving the monitor program.

2.3.2 (Cont'd)

Establish Communications with VPR

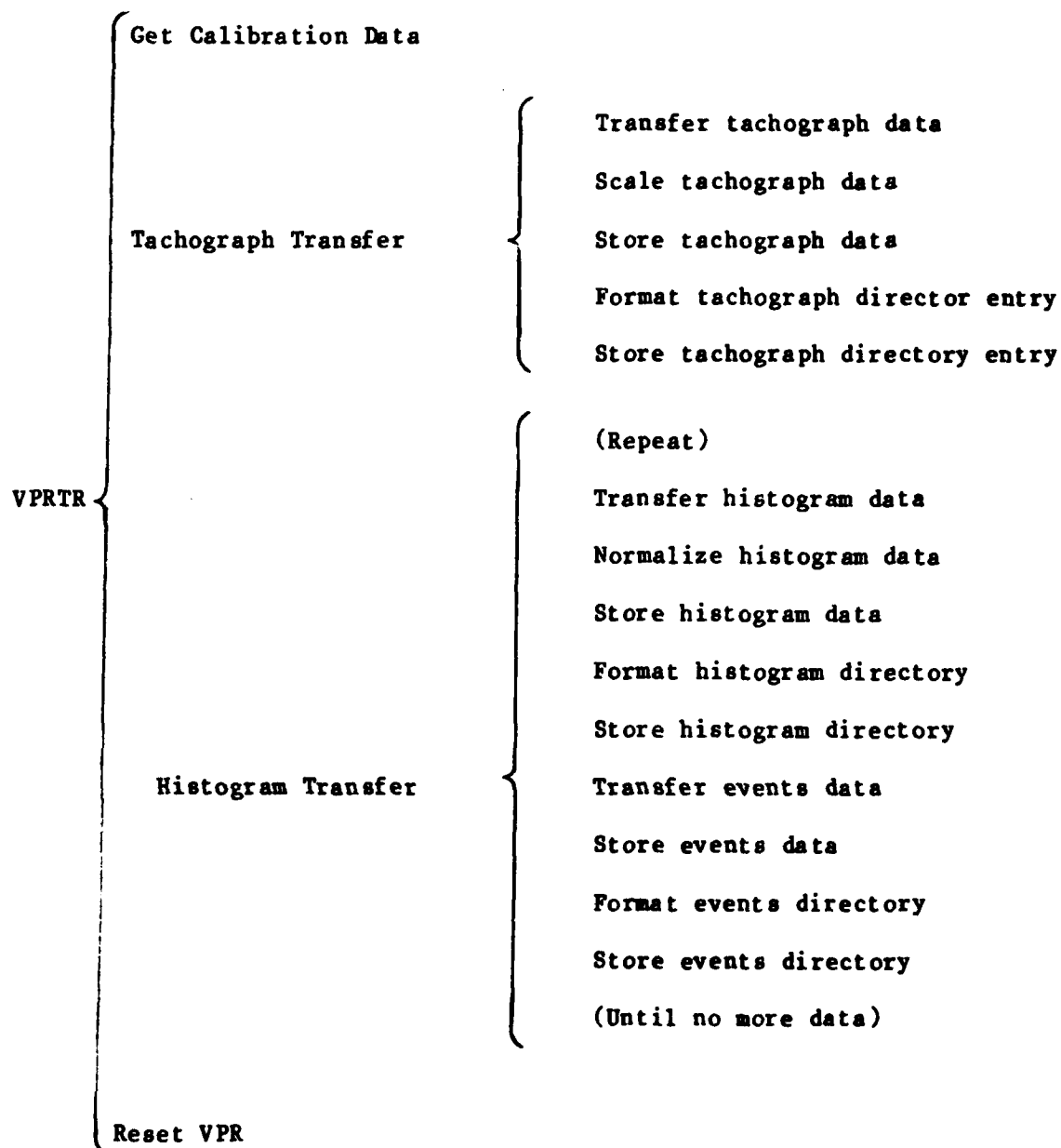


Figure 2.3-5. Program 'VPRTR'.

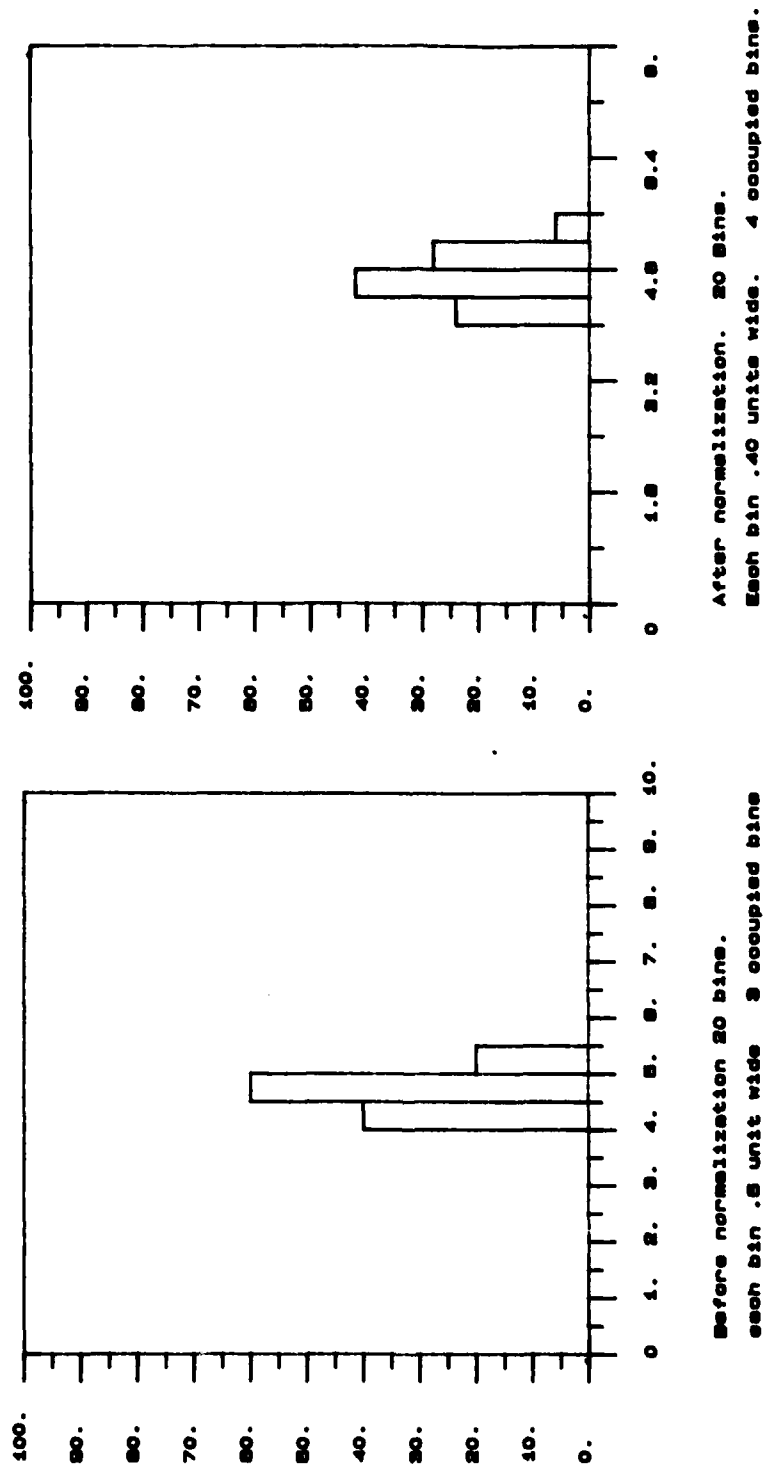


Figure 2.3-6. Histogram normalization.

2.3.2 (Cont'd)

SET	2	0/	0-17:21	CH	5E150	FKX	FK1	T1	J. MAXAND
SET	4	0/	0-17:26	CH	5E150	FKX	FK2	T1	J. MAXAND
SET	5	0/	0-17:43	CH	4E150	FKX	FK3	T1	J. MAXAND
SET	6	0/	0-17:51	CH	5E150	FKX	FK4	T1	J. MAXAND
SET	12	0/	0-17:24	CH	5E050	FKX	FK1	U1	F. SANTIAGO
SET	13	0/	0-17:29	CH	5E050	FKX	FK2	U1	F. SANTIAGO
SET	14	0/	0-17:32	CH	5E150	FKX	FK2	U1	F. SANTIAGO
SET	15	0/	0-17:53	CH	5E150	FKX	FK8	U1	F. SANTIAGO
SET	16	0/	0-17:59	CH	5E150	FKX	FK3	U1	F. SANTIAGO
SET	17	0/	0-18:7	CH	5E050	FKX	FK4	U1	F. SANTIAGO
SET	18	0/	0-18:8	CH	5E050	FKX	FK5	U1	F. SANTIAGO
SET	20	0/	0-18:34	CH	5E150	FKX	FK1	T1	T. DONALDSON
SET	21	0/	0-18:39	CH	5E150	FKX	FK2	T1	T. DONALDSON
SET	22	0/	0-18:40	CH	5E150	FKX	FK4	T1	T. DONALDSON
SET	24	0/	0-18:53	CH	5E150	FKX	FK3	T1	T. DONALDSON

Figure 2.3-7. 'VPRDL' listing of directory entries.

VALID 'VPR' DIRECTORY EDITOR COMMANDS ARE

CP,parm number	change parameters
DL,start,stop,list	directory list
EX	exit directory editor
LC,list	list commands
LD,list	list drivers
LL,list	list test locations
LP,list	list directory parameters
LR,list	list test courses
LV,list	list vehicle ID's
NS,set/run	new set/run
RU,prog	run program

Figure 2.3-8. List of VPR editor commands.

VALID 'VPR' PURGE PROGRAM COMMANDS ARE

C1,set,channel,list	purge 1 channel 1 set
E1	purge 1 events channel
EX	exit purge program
MC,start,stop,channel,list	purge 1 channel many sets
ME,start,stop,list	purge many events channel
MS,start,stop,list	purge several sets
S1,set,list	purge 1 set
RU,prog	run program

Figure 2.3-9. List of purge commands.

SECTION 3. DATA PROCESSING

3.1 OVERALL DATA PROCESSING SCHEME

The overall scheme for data acquisition and data processing is shown in Figure 3.1-1. In this scheme, several VPR's can each be linked to a DRS, while several DRS's can be linked to an overall data base. Hence, there exists a 3-level hierarchy, with various data processing tasks being implemented in each level.

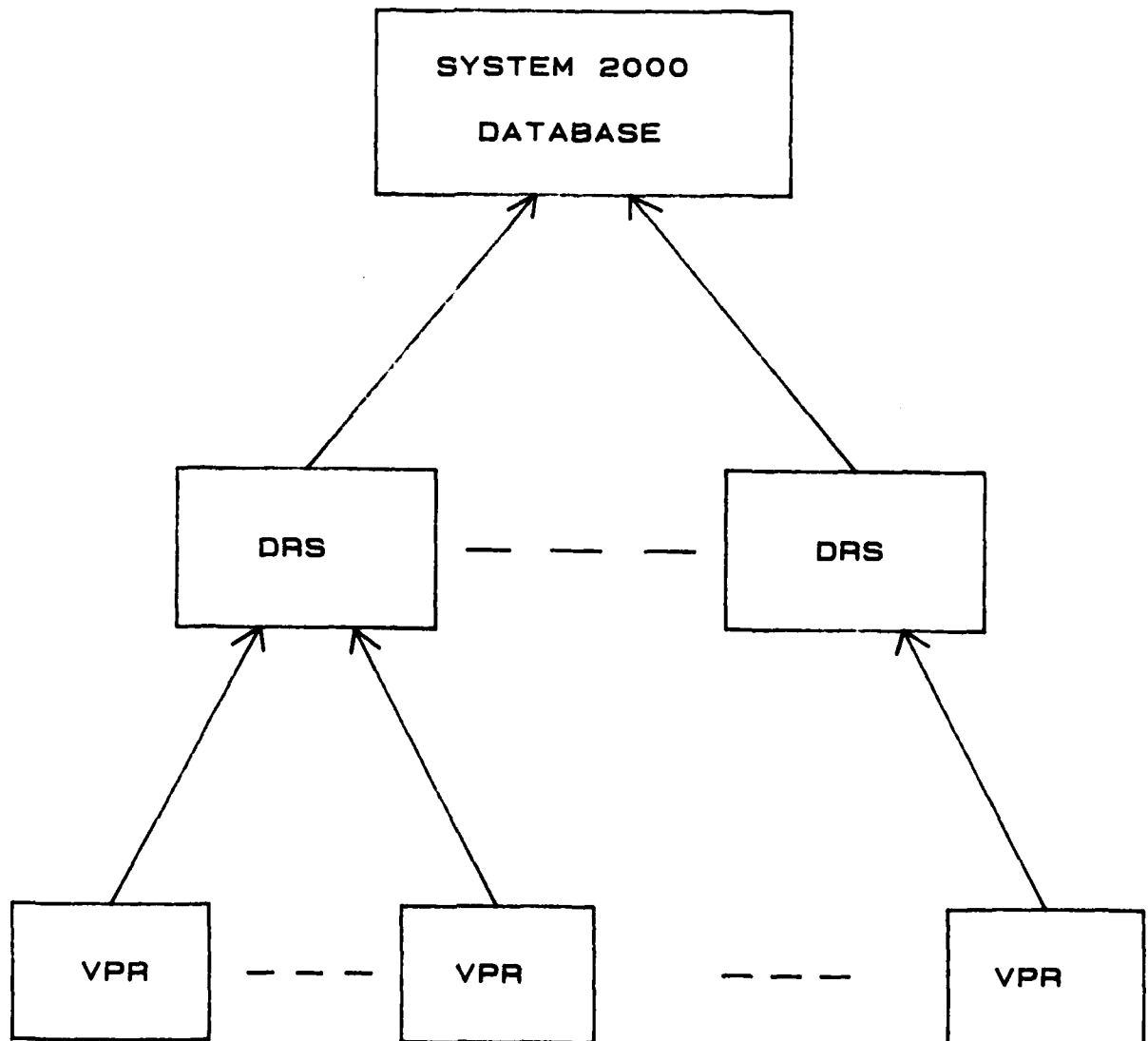


Figure 3.1-1. Overall data acquisition and processing schema.

3.2 REAL TIME DATA PROCESSING

One way to monitor a process is to record time histories pertinent to the process and at some point in time look at this recorded data (e.g., through plots or listings). For large sets of data this is tedious, time consuming, expensive, probably fruitless, and requires a large storage capability. For example, if three parameters are sampled and recorded 50 times per second and three are sampled and recorded five times per second, at the end of a 12-hour period over seven million samples would be saved. Clearly some technique which preserves the intelligence borne by these parameters, but which reduces the information to an understandable form and to a reasonable volume must be used.

3.2.1 Histogram Processing

In experiments which include large numbers of observations (or iterations of measurements) experimenters invariably resort to statistical presentations, so that results are expressed in terms of means, standard deviations, root-mean-square (RMS) values, extreme values, etc (see app C, ref 6). In the VPR the first step, which is the building of histograms, is carried out in real time. A histogram is a table which lists the number of times a measurement (or observation) falls into a given subinterval of the span of allowed values.

Histograms are closely related to the probability density function of the underlying process. This sample density function is not unique for a given data group, however, but also depends on other factors such as the number and width of the bins used and the number of data samples included in the histogram generation. Even with this lack of uniqueness, however, histograms are generally treated as sample probability density functions.

In the VPR, histograms are computed in the following manner:

- a. At the end of each data input cycle the histogram task is reactivated (if it has been started).
- b. If the maximum number of points has been reached (corresponding to maximum time) a new set of histograms is started.
- c. Using offset and scaling tables (again, tables are utilized to allow flexibility in configuration), data from each channel being processed are mapped into an integer number in the range of 0 to 63. For example, if data from a given channel ranges -1024 to +1023 (which may be -9.42 g's to +9.42 g's) data elements are first offset by 1024 and then divided by 16. Measurements which lie outside the expected range are included in the lowest or highest bin, depending upon which is closer to the measurement.
- d. Using the result found in c above as an index into an array, the array element corresponding to that index is incremented by one.
- e. When all channels have been processed, the task suspends itself.

3.2.1 (Cont'd)

When data transfer occurs, what is then transferred is a series of 64 element arrays. In the DRS are files which contain the span covered by each histogram, and hence attach physical significance to them. Also in the DRS, calculations are made using the histograms and these are covered here only to provide completeness. The sample mean is computed by:

$$\bar{x} = 1/N \sum N_j X_j$$

the RMS level by:

$$RMS = \sqrt{1/N \sum N_j X_j^2}$$

and the standard deviation by:

$$\sigma = \sqrt{1/(N-1) \sum N_j (X_j - \bar{x})^2} = \sqrt{N/(N-1) (RMS^2 - \bar{x}^2)}$$

where in these equations:

N = total number of points

N_j = number of measurements falling the the j'th bin

X_j = value (in physical units) at the midpoint of the j'th bin

Additionally, the value X_j such that a fraction p of the measurements have a value <X_j, is given by:

$$X_j \ni \sum_{k=1}^j N_k \leq p \cdot N, \quad \sum_{k=1}^{j+1} N_k > p \cdot N$$

The 10% and 90% levels can be determined in this manner.

Figure 3.2-1 is a histogram as constructed in the VPR, and Figure 3.2-2 is a plot of that histogram with physical units attached and the results of the calculations just discussed appended. (Note that in the VPR representation, occupation levels are offset by -32768, i.e., -32755 corresponds to an occupation of 13.)

3.2.1 (Cont'd)

BIN	0	1	2	3	4	5	6	7
+0	-32755	-32764	-32754	-32754	-32760	-32761	-32758	-32750
+7	-32745	-32741	-32739	-32738	-32730	-32728	-32719	-32721
+15	-32721	-32717	-32709	-32713	-32710	-32707	-32695	-32705
+23	-32704	-32693	-32698	-32713	-32713	-32728	-32735	-32743
+31	-32751	-32753	-32761	-32763	-32764	-32766	-32766	-32767
+39	-32768	-32768	-32768	-32768	-32768	-32768	-32768	-32768
+47	-32768	-32768	-32768	-32768	-32768	-32768	-32768	-32768
+55	-32768	-32768	-32768	-32768	-32768	-32768	-32768	-32768

MINIMUM VALUE = 0.0 MPH

MAXIMUM VALUE = 60.0 MPH

BIN WIDTH = 0.9375 MPH

Figure 3.2-1. VPR internal histogram representation.

8/ 8-17:32 SET 14 CH 3 ROAD SPEED

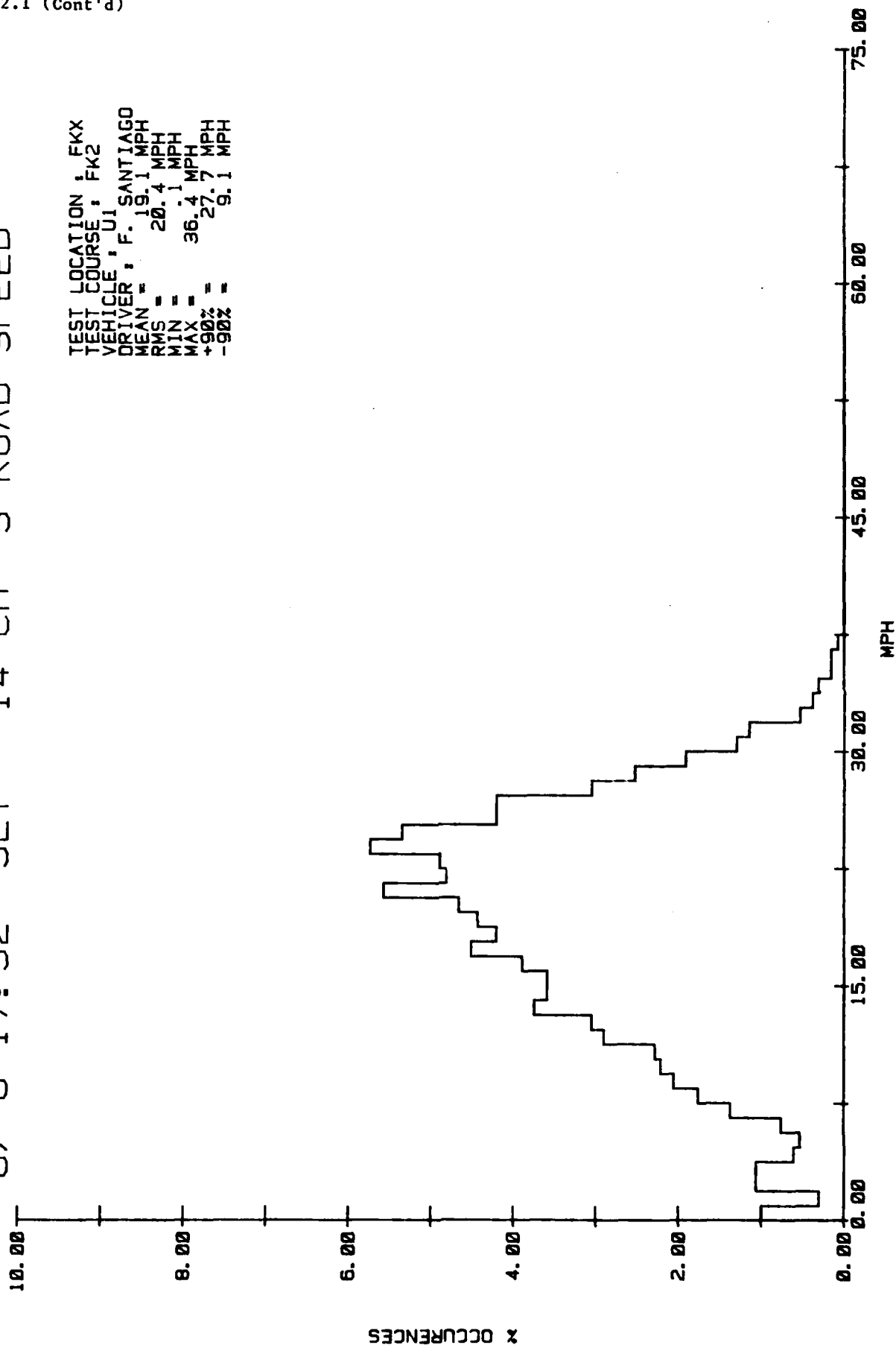


Figure 3.2-2. Histogram with physical units and the results of calculations.

3.2.2 Tachograph Processing

A tachograph is a device which records engine RPM, or road speed, or both over a 12 or 24-hour period. The recording media is a pen and ink circular chart recorder. The chart used is approximately 15.2-cm (6-in.) in diameter, which translates into approximately 1.9-cm (3/4-in.) per hour and hence, causes difficulty in reading.

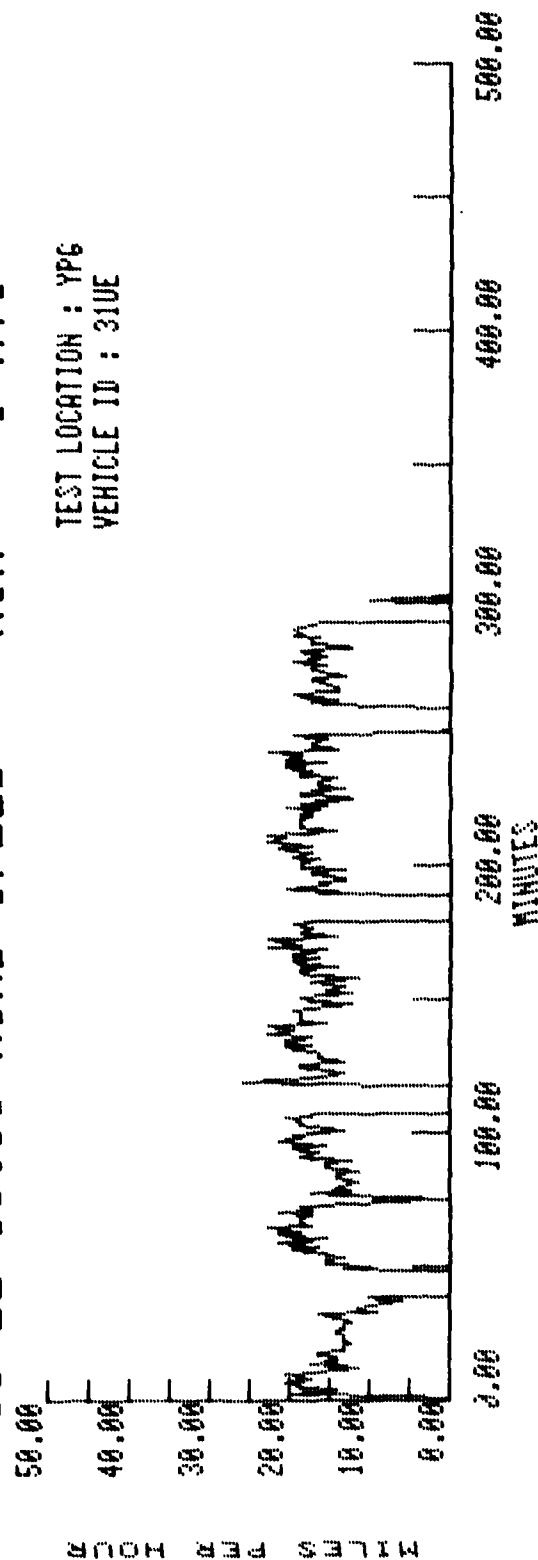
The VPR incorporates a real-time processing task which allows it to replace the mechanical tachograph. During a 12-hour time interval a reading of road speed each second would require over 43,000 storage locations; and therefore, this recording rate is not acceptable. Instead, the speeds are sampled once per second and processed in real-time to determine the average, maximum, and minimum values during each 1 minute time slice, with these data stored in memory. In this manner, the storage requirements are reduced to 720 x 3 locations for each channel for a 12-hour recording time.

The tachograph task does not execute continuously in that it requires that the vehicle operate switch be engaged. When the vehicle is shut down, the VPR samples this switch once each second and automatically starts the tachograph task when the switch is engaged. The time of day of engagement is recorded to allow synchronization.

Figure 3.2-3 is a typical tachograph plot made after data was transferred to the DRS.

10/22-05:51 ROAD SPEED RUN 1 AVG

TEST LOCATION : YPG
VEHICLE ID : 31UE



ENGINE SPEED

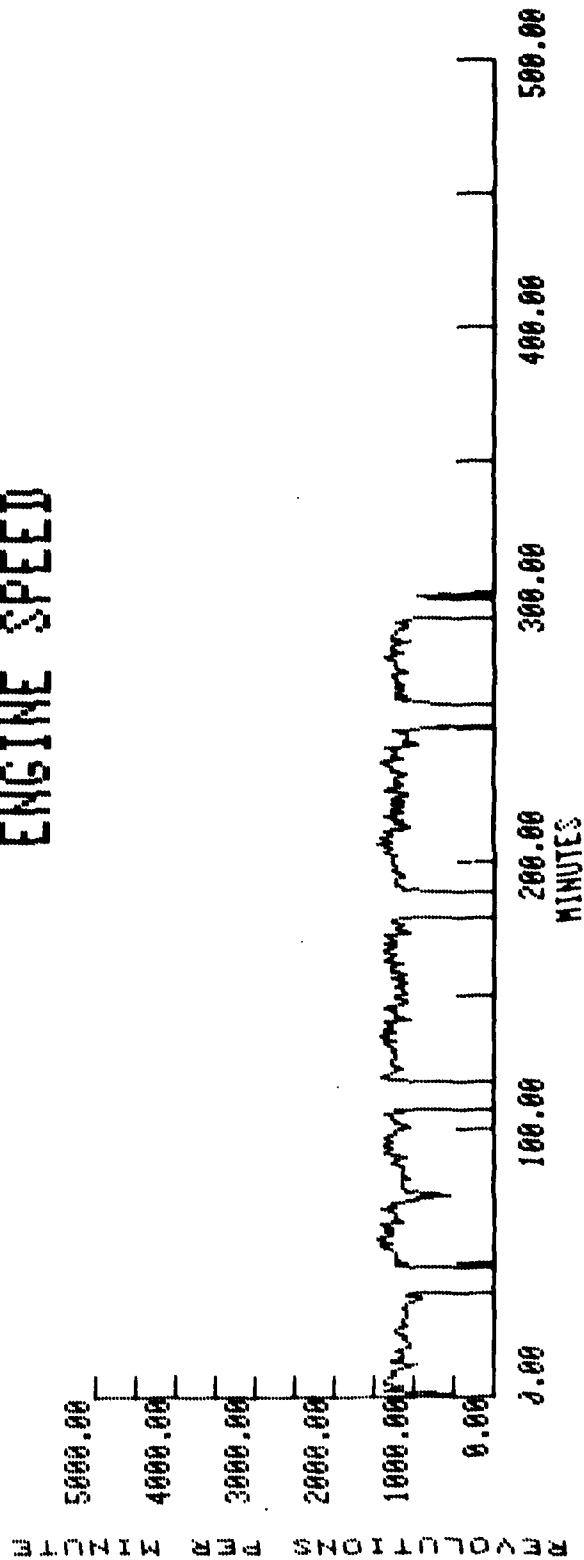


Figure 3.2-3. Typical tachograph plot made after data transfer.

3.3 DATA RETRIEVAL SYSTEM PROCESSING

Near real-time on site data reduction has been a mainstay of testing for the USACSTA for a number of years. This has traditionally been accomplished by utilizing minicomputers mounted in mobile vans (called Test Site Terminals or TST's) to control the data acquisition and reduction phase of testing. With the introduction of the VPR this situation is somewhat different. The VPR controls the data acquisition process, and executes real-time processing tasks as described in the previous section. TST's are used to collect and check the integrity of the data and to provide test operating personnel with the information needed to perform the test control function. While the programs developed to perform these operations will be discussed in depth in the following paragraphs, their general thrust is to ensure proper transducer operation, quantify vehicle performance and to validate proper test conduct and control.

Program 'OREAD' allows the data which has been dumped to the disk from the VPR to be examined exactly as it has been recorded on the disk. This is a powerful troubleshooting tool in that errors detected in subsequent processing can be narrowed to either an on-board VPR acquisition/processing problem or a software processing problem. In addition to examining the data, the data directory area may also be queried and checked. Figures 3.3-1 (Octal Presentation) and 3.3-2 (Decimal Presentation) are examples of the format of the data output from program 'OREAD'.

Program 'VPRQL' outputs the results of all the channels acquired by the VPR by course segment. For each channel the mean, the root mean square (RMS), the 10% level, the 90% level, the minimum value, the maximum value, and the total number of points recorded are all listed. The 90% level is defined as that value such that 90% of the data acquired for that channel falls below. The 10% value (also referred to as the -90% value) is defined as that value such that 90% of the data acquired for that channel falls above. In addition to the channel statistical data provided, the following header or descriptive data are output for each data set: the set number, the vehicle identification number, the load/unload/trailer condition, the date, the time, the driver's name, the calculated odometer reading, the elapsed time, the mileage for that data segment, and the course segment driven by the vehicle. Figure 3.3-3 is an example of the output of program 'VPRQL'. The data is examined at this point to determine proper transducer operation, correct data scaling, proper VPR operation, and as a preliminary check on the severity of the test to which the vehicle is being subjected.

Program 'VPRVE' provides a validity check on the data acquired. The program checks that each channel's mean, minimum, and maximum value falls within prescribed intervals. Checks are also performed on the distribution of points in the histogram bins, and the total number of points. The criteria are contained in the file 'VCHECK' which must be established before the beginning of testing. Bin checking is performed to insure a reasonable distribution of points in the histogram. Total point checking is conducted to insure that all channel's sampled at the same rate have the same number of points. Channel data which does not meet the established verification criteria are output to the console to inform the operator of the discrepancy. Figure 3.3-4 is an example of some discrepancies output by program 'VPRVE' on a VPR data set.

3.3 (Cont'd)

Two plotting routines fall into the category of quick-look processing. Program 'VPRPH' plots the histogram of any requested channel. Descriptive and statistical data, as described for program 'VPRQL', are included in the plot. Figure 3.2-2 is a plot of histograms obtained by running this program. Program 'VPRPT' plots the tachograph of any run acquired by the VPR. Figure 3.2-3 is a plot of a tachograph output by running this program.

Program 'VPRLM' is a verification check performed on the 10% and 90% levels. This program checks that the extremes of the distribution fall within the limits established during baseline testing (section 4). As such, 'VPRLM' requires a set of files corresponding to test courses and load conditions. The program matches these parameters and performs the required tests. Figure 3.3-5 is a sample output from this program.

Program 'VPRCT' is a routine designed to help the operator detect any trends in the data, e.g., a slipping position transducer. The program outputs the current reading of a given channel, plus the last five (more recent) readings. The data is stored in files (segregated by vehicle identification number and load/unload/trailer condition) for permanent record. Thus, at any time, the entire file may be listed and the trend of the channel over the entire test examined. Figure 3.3-6 is an example of how the data are stored in the trend files.

While complete test-wide statistical analyses can be performed only by exercising the data base (section 3.3), some combinatorial processing is possible in the DRS, with the constraint that the analysis be limited to that amount of data that can be stored on the DRS disk at one time.

Programs 'VPRCM' and 'VPRCH' will plot a composite histogram of VPR data. Program 'VPRCM' will plot composite data of any VPR channel, over any operator entered number of sets, regardless of test course/test course segment, load condition or driver identification. In addition to the plot, the corresponding composite statistical information is also displayed. Figure 3.3-7 is an example of the output provided by program 'VPRCM', except the composite histogram produced is only on data sets where test course/test course segment, load condition, vehicle identification and driver name are the same. Along with the plot, the corresponding composite statistical data, the test course/test course segment, the load condition, the vehicle identification and the driver name are all displayed. Figure 3.3-8 is an example of the output provided by the program 'VPRCH'.

Program 'VPRCS' will produce a composite statistical analysis of VPR data sorted by test course/test course segment, vehicle identification and driver name. The data are output in the format shown in Figure 3.3-9.

```

MODE=0 DISC LU= 19 TRACK= 0 SECTOR= 0
000001 052040 001006 012501 000031 000000 000017 000437 * T A
071463 031777 000001 000003 000002 074000 000014 046040 * 533 x L
000002 000000 001006 012506 000031 000111 100000 000002 * F I
040000 000010 000401 001404 046040 007472 000002 005670 * 0 L :
177777 000001 001006 012506 000031 000112 100000 000006 * F J
040000 000010 000401 001404 046040 007472 000002 005670 * 0 L :
000002 000002 001006 012506 000031 000113 045400 000016 * F KK
045363 031422 000401 001404 046040 007472 000002 000074 * J 3 L : <

MODE=0 DISC LU= 19 TRACK= 0 SECTOR= 1
000002 000003 001006 012506 000031 000114 000000 000000 * F L
053000 000016 000401 001404 046040 007472 000002 000074 * V L : <
000002 000004 001006 012506 000031 000115 000000 000000 * F M
074000 000014 000401 001404 046040 007472 000002 000074 * x L : <
000002 000005 001006 012506 000031 000116 000000 000000 * F N
073300 000032 000401 001404 046040 007472 000002 000074 * v L : <
000002 042440 001006 012506 000031 000117 000001 000000 * E F D
000000 000000 000401 001404 046040 007472 000002 000000 * L :

DREAD>_

```

Figure 3.3-1. Octal presentation.

```

MODE=I DISC LU= 19 TPAC= 0 SECTOR= 0
  1 21536 518 5441 25 0 15 287 * T A
29491 13311 1 3 2 30720 12 19488 * s33 x L
  2 0 518 5446 25 73 -32768 2 * F I
16384 8 257 772 19488 3898 2 3000 * 0 L :
  -1 1 518 5446 25 74 -32768 6 * F J
16384 8 257 772 19488 3898 2 3000 * 0 L :
  2 2 518 5446 25 75 19200 14 * F KK
19187 13074 257 772 19488 3898 2 60 * J 3 L : <

MODE=I DISC LU= 19 TRACK= 0 SECTOR= 1
  2 3 518 5446 25 76 0 0 * F L
22016 14 257 772 19488 3898 2 60 * V L : <
  2 4 518 5446 25 77 0 0 * F M
30720 12 257 772 19488 3898 2 60 * X L : <
  2 5 518 5446 25 78 0 0 * F N
30400 26 257 772 19488 3898 2 60 * V L : <
  2 17696 518 5446 25 79 1 0 * E F D
  0 0 257 772 19488 3898 2 0 * L :
DREAD>_

```

Figure 3.3-2. Decimal presentation.

VEHICLE PERFORMANCE RECORDER (VPR) QUICK-LOOK PROGRAM

SET	2 L	VEHICLE ID	AU03P	ODOMETER	3898
DATE	2/ 6/84	COURSE	HIGHWAY	MILEAGE	2
TIME	15:46	DRIVER K. RICHARDSON		ELPSD TIME	6.0
CHANNEL	MEAN	RMS	-90%	90%	# PTS
0	3.58	3.58	3.33	3.82	17899.
2	97.53	98.83	77.73	117.74	358.
3	53.68	57.41	26.18	84.88	358.
4	19.63	22.95	.86	32.63	358.
5	1377.23	1456.81	646.00	1842.76	358.
E	# OF EVENTS:	8	TOTAL EVENT TIME:	92 SECS	

END PROGRAM 'VPRQL'

<VPR:

Figure 3.3-3. Example of output of program 'VPRQL'.

VEHICLE PERFORMANCE RECORDER (VPR) VERIFICATION PROGRAM

SET	2	CHANNEL	2	TOO MANY POINTS IN LOW BIN
SET	2	CHANNEL	2	MEAN VALUE TOO LOW
SET	2	CHANNEL	3	TOO MANY POINTS IN HIGH BIN
SET	2	CHANNEL	4	TOO MANY POINTS IN LOW BIN
SET	3	CHANNEL	4	TOO MANY POINTS IN LOW BIN

<VPR:

Figure 3.3-4. Example of some discrepancies output by program 'VPRVE' on a VPR data set.

VEHICLE PERFORMANCE RECORDER (VPR) LIMITS CHECK PROGRAM

CHANNEL 0 :OF 4 TOTAL PASSES

1 SETS 10% VALUE IS GREATER THAN THE HIGH ALARM LIMIT
 1 SETS 10% VALUE LIES IN THE HIGH CAUTION AREA
 1 SETS 90% VALUE LIES IN THE LOW CAUTION AREA

CHANNEL 2 :OF 4 TOTAL PASSES

4 SETS 10% VALUE IS LESS THAN THE LOW ALARM LIMIT

CHANNEL 3 :OF 4 TOTAL PASSES

4 SETS 10% VALUE IS GREATER THAN THE HIGH ALARM LIMIT
 4 SETS 90% VALUE IS GREATER THAN THE HIGH ALARM LIMIT

Figure 3.3-5. Sample output of VPR.

VEHICLE AWD1E - TRAILER					
3.7529	.1415	417.9505	25.9250	2391.4277	
3.8087	.1342	425.2197	26.8156	2393.7383	
3.8232	.1311	287.5970	12.9651	1510.2825	
3.7445	.1308	285.8625	27.2375	1753.5244	
3.7987	.1306	234.9398	19.7713	1450.9468	
3.5338	.1232	329.2571	37.4695	2123.5801	
3.7796	.1275	213.2701	15.4893	1218.1672	
3.4885	.0662	0.0000	15.8020	1184.0042	
3.5041	.0336	0.0000	16.5980	1458.5945	
3.5411	.0383	0.0000	16.6817	1457.3999	
3.6316	.0421	0.0000	14.4770	1400.9861	

Figure 3.3-6. Example of data storage in trend files.

CHANL 3 SETS 2 TO 3 ROAD SPEED

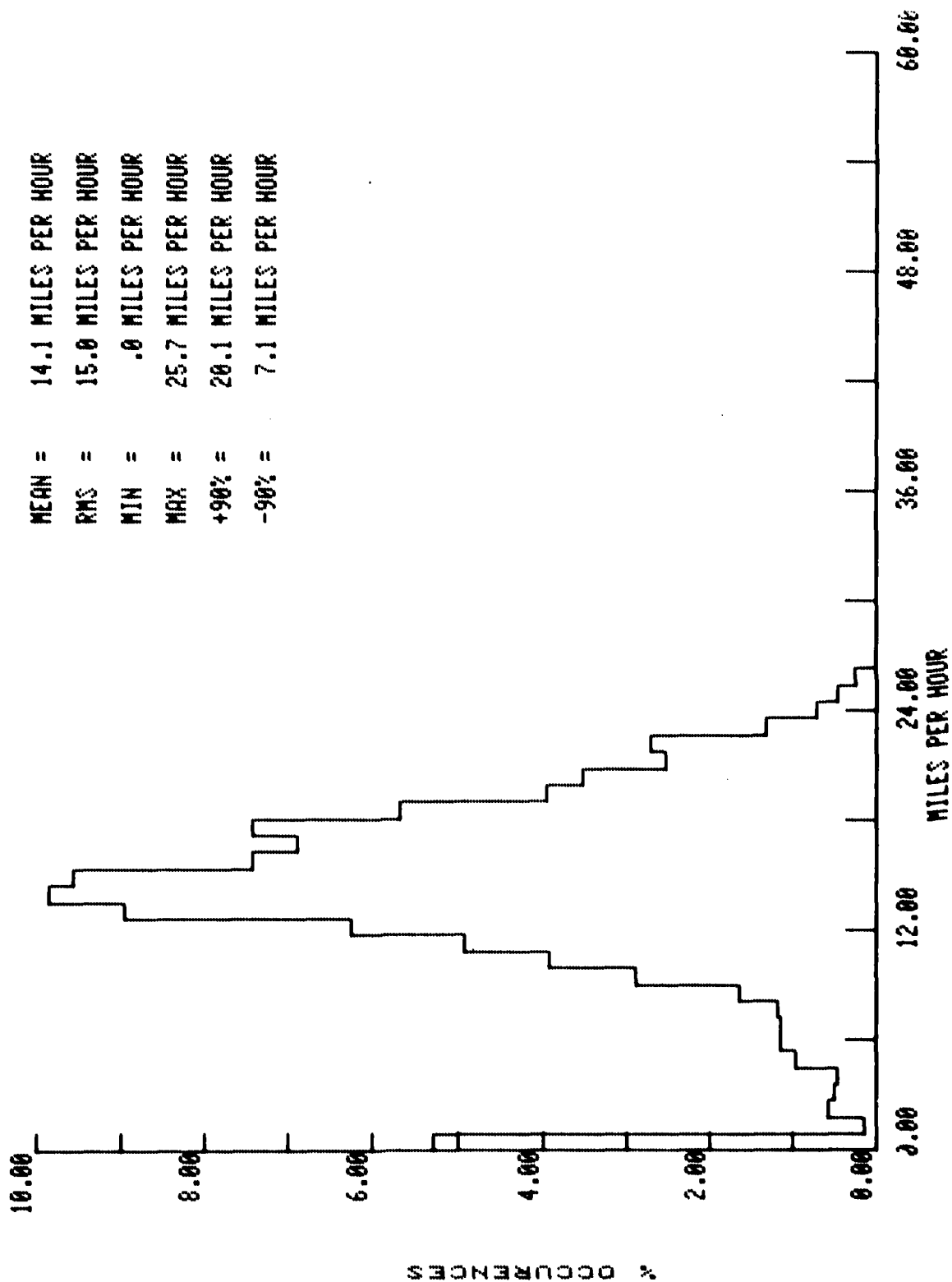


Figure 3.3-7. Sample of output provided by program 'VPRCH'.

CHANL 3 ROAD SPEED

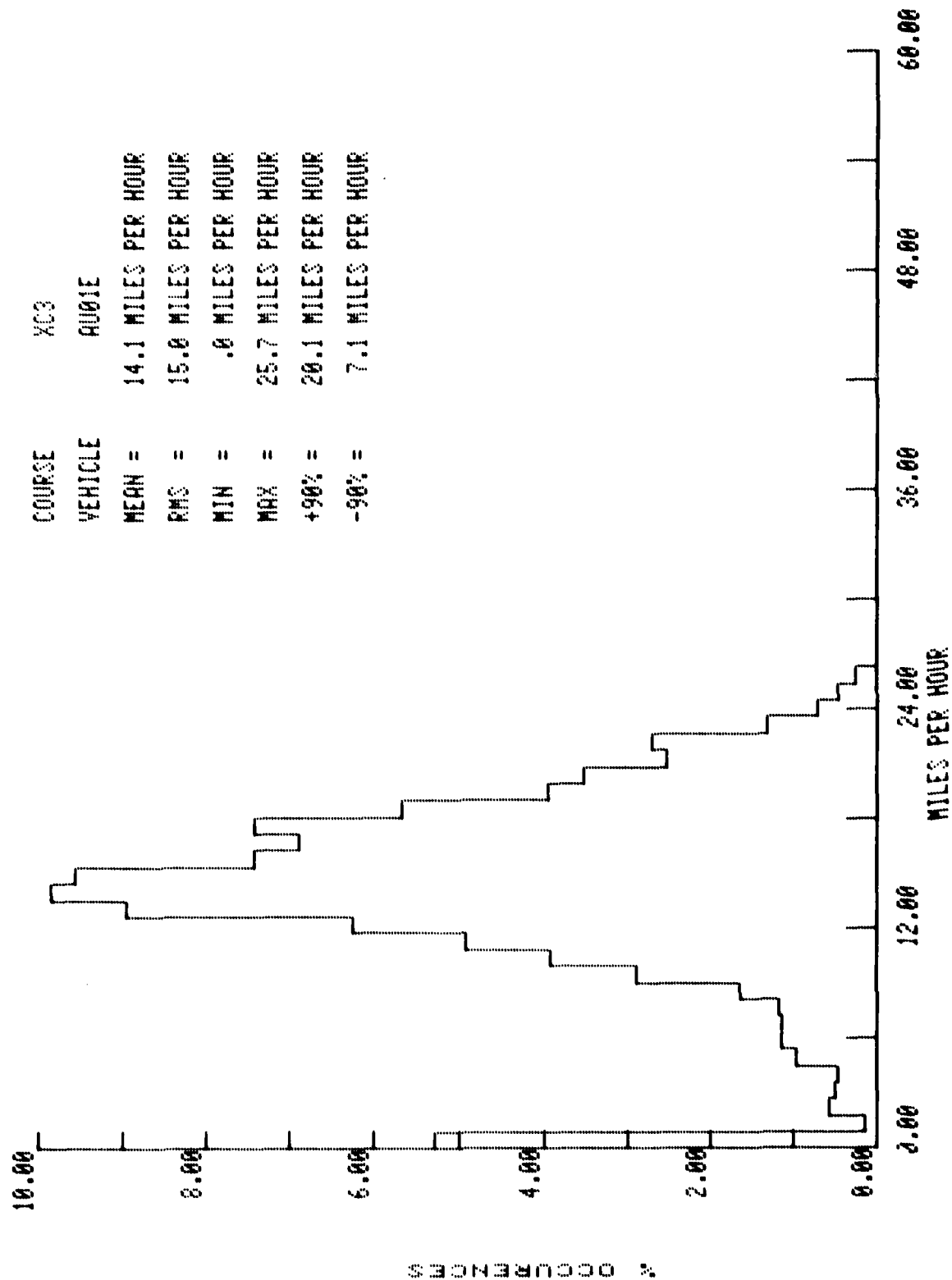


Figure 3.3-8. Example of output provided by 'VPRCH' program.

VEHICLE PERFORMANCE RECORDER (VPR) COMPOSITE STATISTICS PROGRAM

ENTER COURSE : 4
ENTER VEHICLE ID : 3
ENTER DRIVER CODE : 4
SETS 7 TO 10
DATE : 2/ 6/84 FROM 21:03 TO 22:33
TEST LOCATION : APG
TEST COURSE : C'VILLE
VEHICLE ID : AU03P
DRIVER : K. PICHARDSON

Figure 3.3-9. Output of program 'VPRCS'.

```

START ODDMETER : 3925      END ODDMETER : 3953

CHANNEL  MEAN      RMS      -90%      90%      MIN      MAX      # PTS
:         3.55      3.57      3.09      4.02      2.10      5.02      359994.
2        29.51     130.17    111.47    141.41    77.30    197.23    7200.
3        47.59      50.02     29.09     67.10     .35      85.95     7200.
4        19.63      21.39      .80      28.31     .01      34.58     7195.
5       1584.12    1653.10    712.15   2116.01   594.77   2479.14    7199.

```

95. BRAKE APPLICATIONS FOR 234. SECONDS

INSTRUMENTED DISTANCE : 95.19

END PROGRAM 'VPRCS'

<VPR:

Figure 3.3-9 (Cont'd)

3.4 DATA BASE MANAGEMENT SYSTEM

The concept of a data base varies greatly. In its simplest form a data base is simply a collection of data, but most formal data bases consist of related data organized in such a manner that access to the data is facilitated. Examples of simple data bases are library card catalogs and the referenced material, filing cabinets, logbooks, and files stored in a computer system.

There now exist many commercially available Data Base Management Systems (DBMS). All such software packages have the common goal which is the management of the data base in a manner that can be easily understood and easily implemented.

System 2000 DBMS (or S2K) forms the basis used to manage the data collected and processed by the VPR. S2K is a hierachically structured DBMS. Built into S2K are the facilities required to define, load, and update the data base as well as retrieve information from it. S2K structures data into a level 0 (or top) record and all related records below it in a tree-type structure.

Figures 3.4-1 and 3.4-2 are the schema of the data base designed for use during the IPT and FOE of HMMWV. This data base consists of five levels, with the majority of the data in the 100 records. These figures show the relationship among the records. Each record under LOCATION is considered a repeating group, i.e., the relationship of a record to a lower record can be one-to-one or one-to-many. For example, for a given vehicle at level 1, there will generally be many days at level 2, possibly various drivers and shifts at level 3, etc.

S2K provides great flexibility in data base structure. Early in the planning phase of any test, it should be determined what parameters will be monitored and what types of reports will ultimately be required. This information will allow the designer to structure the data base to enhance the systems operation. The designer also requires the types of data (character, integer numeric, etc.) and range of values in order that the picture for each can be defined.

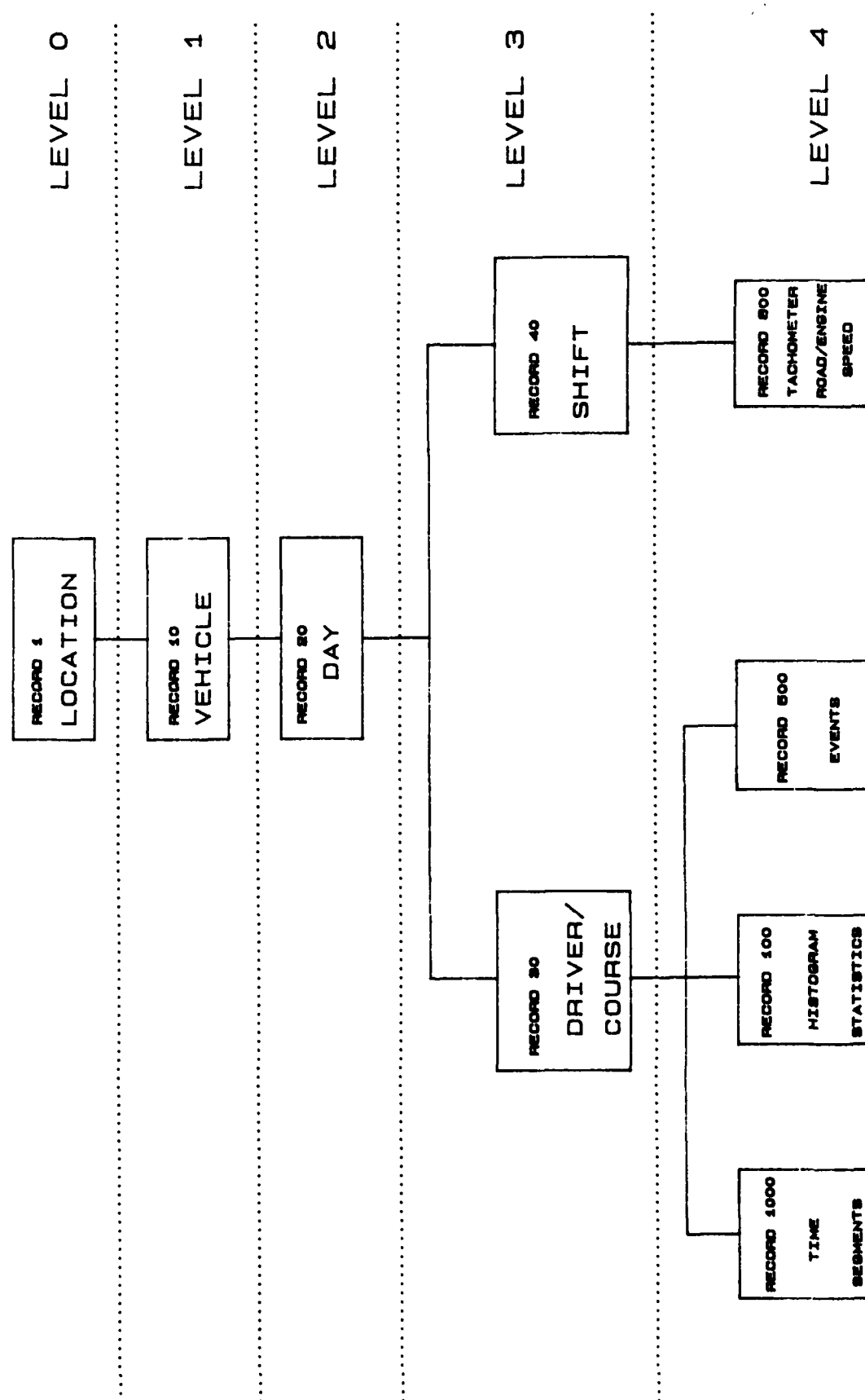


Figure 3.4-1. Data base schema.

3.4 (Cont'd)

```

1* TEST LOCATION (CHAR XXX)
2* ACCESS CODE (CHAR XXXX)
10* VEHICLE ID (RECORD)
11* VEHICLE (CAR X(7) IN 10)
20* DATE (RECORD IN 10)
21* DAY (NON-KEY INTEGER NUMBER 9999 IN 30)
30* TIME OF DAY (RECORD IN 20)
31* DRIVER (CHAR X(20) IN 30)
32* TIME (NON-KEY INTEGER NUMBER 9999 IN 30)
33* TEST COURSE (CHAR XXX IN 30)
34* LOAD (NON-KEY CHAR X IN 30)
35* START MILEAGE (NON-KEY INTEGER NUMBER 9(5) IN 30)
36* ACCUMULATED MILEAGE (NON-KEY INTEGER NUMBER 99 IN 30)
37* VEHICLE TYPE (CHAR XXXX IN 30)
38* SHIFT TYPE (CHAR X IN 30)
39* COURSE TYPE (CHAR XXXX IN 30)
100* CHANNEL (RECORD IN 30)
101* CHANNEL LABEL (CHAR X(16) IN 100)
102* MAXIMUM VALUE (NON-KEY DECIMAL NUMBER 9(7).9999 IN 100)
103* MINIMUM VALUE (NON-KEY DECIMAL NUMBER 9(7).9999 IN 100)
104* BIN 1 (NON-KEY INTEGER NUMBER 9(5) IN 100)
105* BIN 2 (NON-KEY INTEGER NUMBER 9(5) IN 100)
106* BIN 3 (NON-KEY INTEGER NUMBER 9(5) IN 100)
.
.
.
167* BIN 64 (NON-KEY INTEGER NUMBER 9(5) IN 100)
200* MAXIMUM STAT (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
210* MINIMUM STAT (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
220* PLUS NINETY (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
230* MINUS NINETY (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
240* MEAN (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
250* RMS (NON-KEY DECIMAL NUMBER 9999.99 IN 100)
260* NUM OF PTS (NON-KEY INTEGER NUMBER 9(6) IN 100)
500* EVENT (RECORD IN 30)
501* EVENT LABEL (CHAR X(16) IN 500)
502* NUMBER OF OCCURRENCES (NON-KEY INTEGER NUMBER 9(5) IN
500)
503* TIME IN ON STATE (NON-KEY DECIMAL NUMBER 9999.99 IN 500)
1000* TIME SEGMENTS (RECORD IN 30)
1001* TIME OFFSET (NON-KEY INTEGER NUMBER 999 IN 1000)
1002* ELAPSED TIME (NON-KEY INTEGER NUMBER 9999 IN 1000)
40* SHIFT (RECORD IN 20)
41* SHIFT NUMBER (NON-KEY INTEGER NUMBER 9 IN 40)
42* START TIME (NON-KEY INTEGER NUMBER 9999 IN 40)
600* TACHOGRAPH (RECORD IN 40)
601* MINUTE NUMBER (NON-KEY INTEGER NUMBER 9999 IN 600)
602* MAXIMUM ROAD SPEED (NON-KEY INTEGER NUMBER 99 IN 600)
603* MINIMUM ROAD SPEED (NON-KEY INTEGER NUMBER 99 IN 600)
604* AVERAGE ROAD SPEED (NON-KEY INTEGER NUMBER 99 IN 600)
605* MAXIMUM ENGINE SPEED (NON-KEY INTEGER NUMBER 9999 IN 600)
606* MINIMUM ENGINE SPEED (NON-KEY INTEGER NUMBER 9999 IN 600)
607* AVERAGE ENGINE SPEED (NON-KEY INTEGER NUMBER 9999 IN 600)

```

Figure 3.4-2. Detailed data base schema.

3.4 (Cont'd)

During the conduct of testing, magnetic tapes with S2K commands and data are prepared in the data retrieval system (see section 2.3.2). Data are directly transferred from these tapes into the data base.

Figure 3.4-3 is a block diagram of the overall computer system used. In practice, most access is through BATCH processing either through files over the multiple remote job entry (MRJE) link or by using a terminal through ROSCOE. A TSO terminal allows direct access. Data are retrieved by either natural language commands or by the report writer facilities. (Both are built-in features of S2K.)

An example report is one qualified by location, vehicle type, day (or date range), driver, course (or course type), load condition, shift, etc. Figure 3.4-4 is the histogram and cumulative distribution function of road speed for loaded HMMWV TOW vehicles over a specified course segment at Fort Hunter, Liggett, CA. This plot was generated by exercising the data base to generate a super histogram, with the results written to mag tape, loading the tape on the USACSTA HP3000 Series 64 and processing and plotting the data on the USACSTA IBM 4341.

This example is one of a seemingly unlimited choice of selection criteria and processing to which the data could be subjected. The DBMS provides the tools to sort and combine data, and the processing and analysis of data is an area that deserves a great deal of future attention.

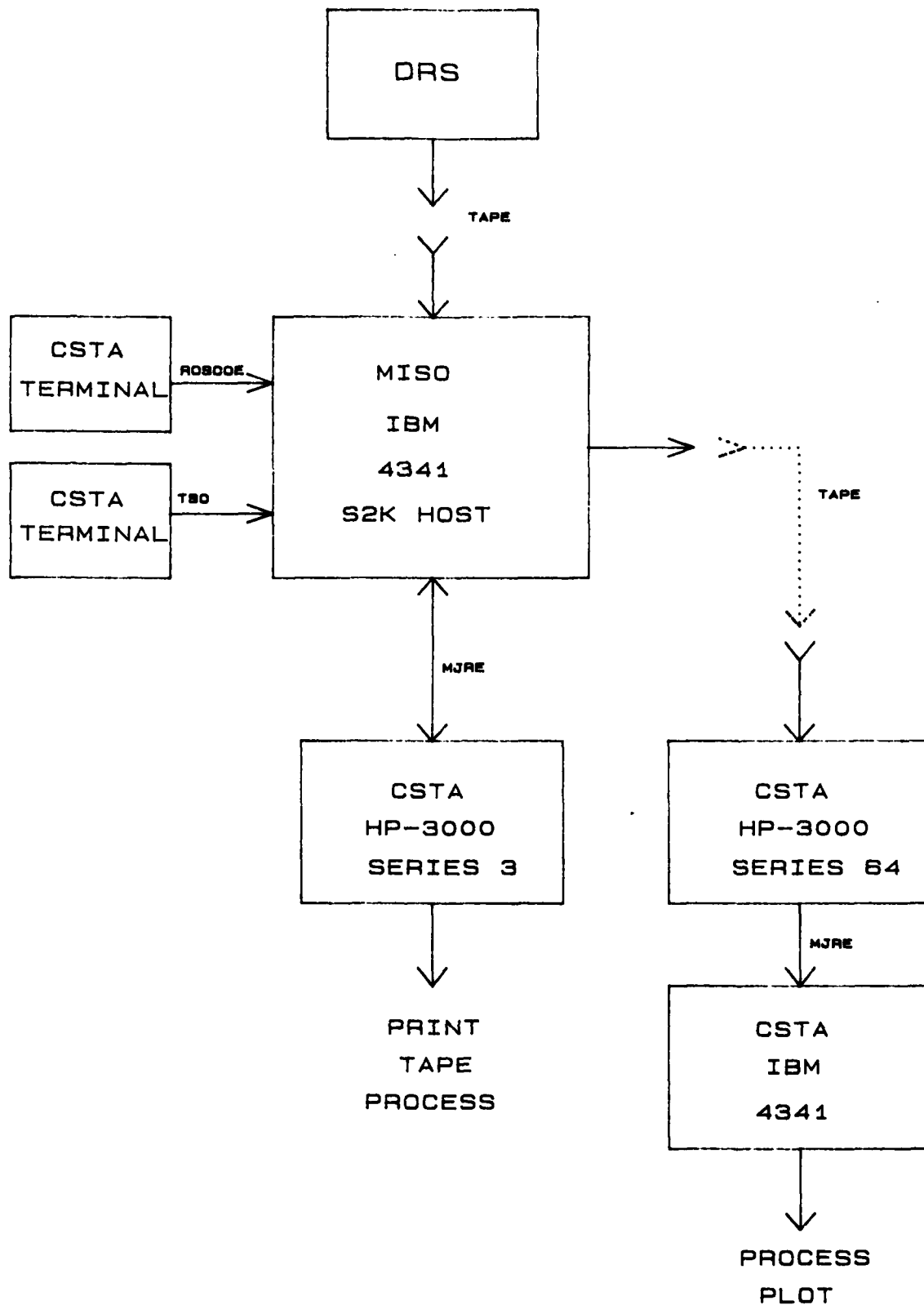


Figure 3.4-3. Overall computer system topology.

3.4 (Cont'd)

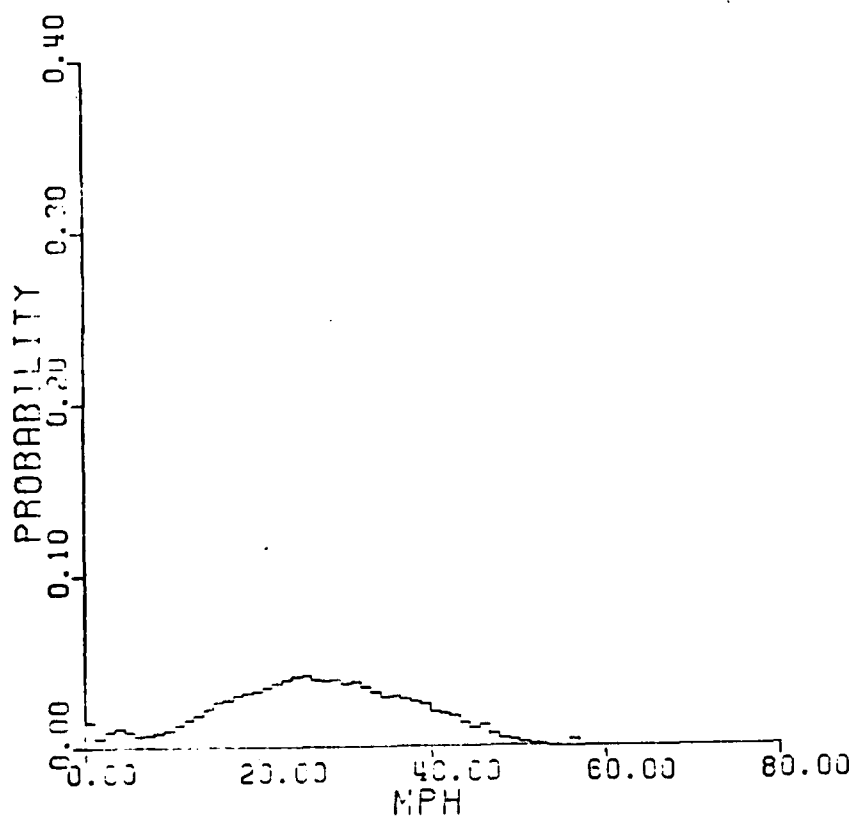
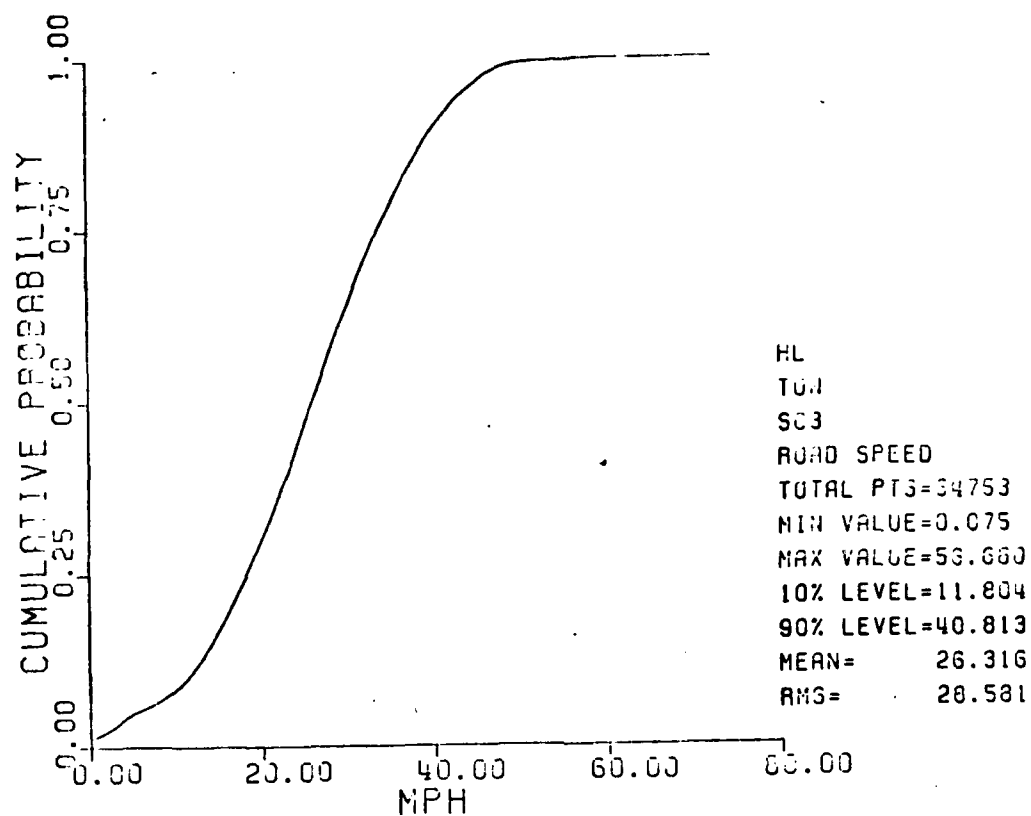


Figure 3.4-4. Histogram and cumulative distribution function of road speed for vehicles over specified course segment at Fort Hunter Liggett, CA.

SECTION 4. DETERMINATION OF OPERATIONAL LIMITS

4.1 PHILOSOPHY OF LIMITS

Any method used to establish the limits within which parameter values should remain during reliability/endurance testing must obviously mesh smoothly with the instrumentation used to monitor the parameters of interest. The VPR is a versatile monitoring system which gives a large amount of latitude in selecting a limit determination/monitoring methodology.

Two primary limit techniques were considered. The first of these, which seems to be the most straight forward, involves the following steps:

- a. Establish high and low level limits through some appropriate techniques.

- b. Program the VPR to record time histories which exceed the limits on either extreme.

- c. Perform a detailed shape (or waveform) analysis, on the data as recorded.

This technique, though quite powerful, has the drawbacks that the memory requirements are not well defined, and provides no ancillary information such as how close are the limits being approached.

The second method is based on the histogram or probability density function (PDF). Figure 4.1-1 contains the PDF as well as the cumulative distribution function (CDF) for an arbitrary random variable (ref 6).

Close examination of this figure shows that the mean value is 0, that 10% of the data have values less than -0.4, and that 90% of the data have values less than +0.4. The standard deviation of this distribution is 0.3. Figure 4.1-2 contains similar plots of hypothetical data obtained under different conditions.

4.1 (Cont'd)

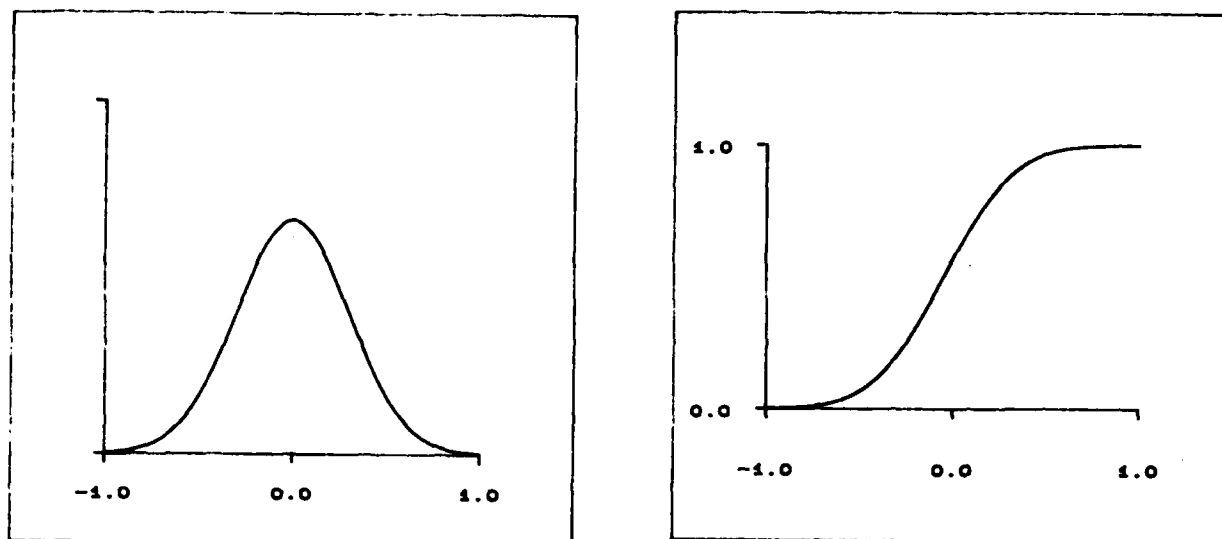


Figure 4.1-1. Arbitrary random value PDF and CDF.

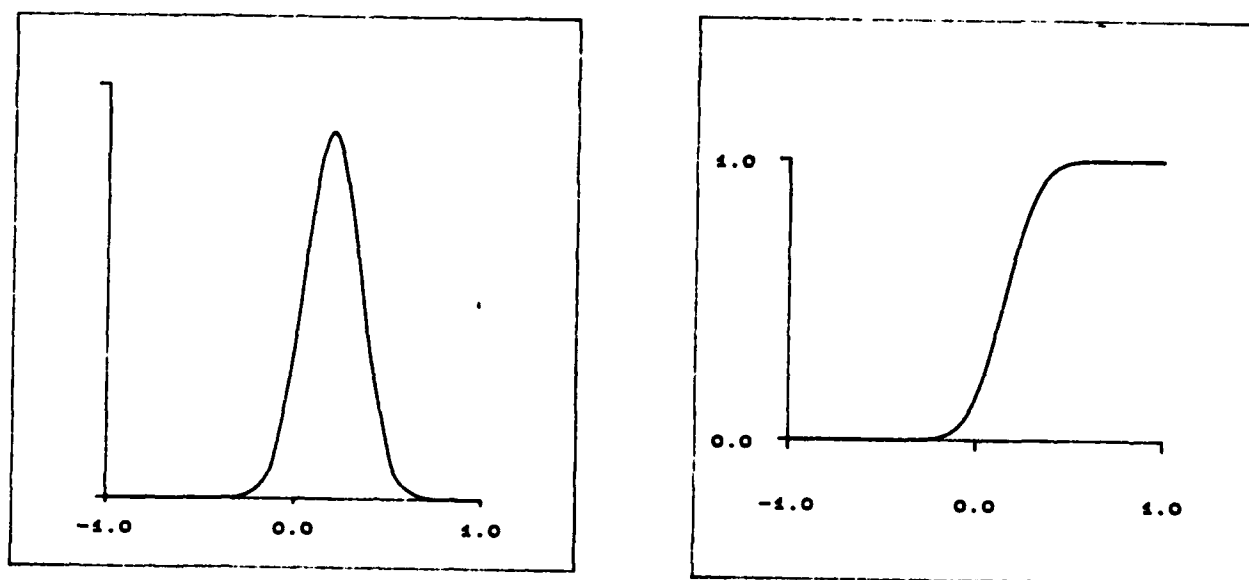


Figure 4.1-2. Arbitrary random value PDF and CDF.

4.1 (Cont'd)

In this case, the mean is 0.1, and 10% of the data have values less than -0.15, and 90% of the data have values less than +0.25. The standard deviation of this distribution is 0.1.

If these distributions were normal, (they are for convenience) the mean and standard deviation would completely describe them; however, there is no appropriate reason to assume that measurements will be normally distributed. The 10% and 90% occupation levels, on the other hand, do not depend on any data model and are generally applicable, in a more robust manner.

Figure 4.1-3 shows the approach taken toward limit determination. Each parameter is assigned 8 limit values as follows:

- a. Alarm limit associated with the low side of the 10% level.
- b. Caution limit associated with the low side of the 10% level.
- c. Caution limit associated with the high side of the 10% level.
- d. Alarm limit associated with the high side of the 10% level.
- e. Alarm limit associated with the low side of the 90% level.
- f. Caution limit associated with the low side of the 90% level.
- g. Caution limit associated with the high side of the 90% level.
- h. Alarm limit associated with the high side of the 90% level.

Messages are issued for 10% and 90% levels that fall outside of the preferred operation bands (b-c for 10% level and f-g for the 90% level).

Note that no connection is made in the above discussion between severity and the limit zones. This is so because the characteristics of individual parameters determine the relationship. For instance, the low side 10% data best describe high severity as related by control arm position, whereas high side 90% data and high side 10% data are more indicative of high severity as related by road speed.

It should further be noted that the limits defined here are not absolute, i.e., none of the limits represent values that should never be exceeded, but rather the limits serve to break the range of possible values into zones of carrying stress. The presence of alarm limit conditions should not automatically be interpreted as over or under stressing during test conduct.

4.1 (Cont'd)

MESSAGE	
—	(NONE)
—	10% HIGH LEVEL ALARM
—	80% HIGH LEVEL CAUTION
.....	10% LOW LEVEL CAUTION
—	10% LOW LEVEL ALARM
—	80% HIGH LEVEL ALARM
—	10% HIGH LEVEL CAUTION
—	80% LOW LEVEL ALARM

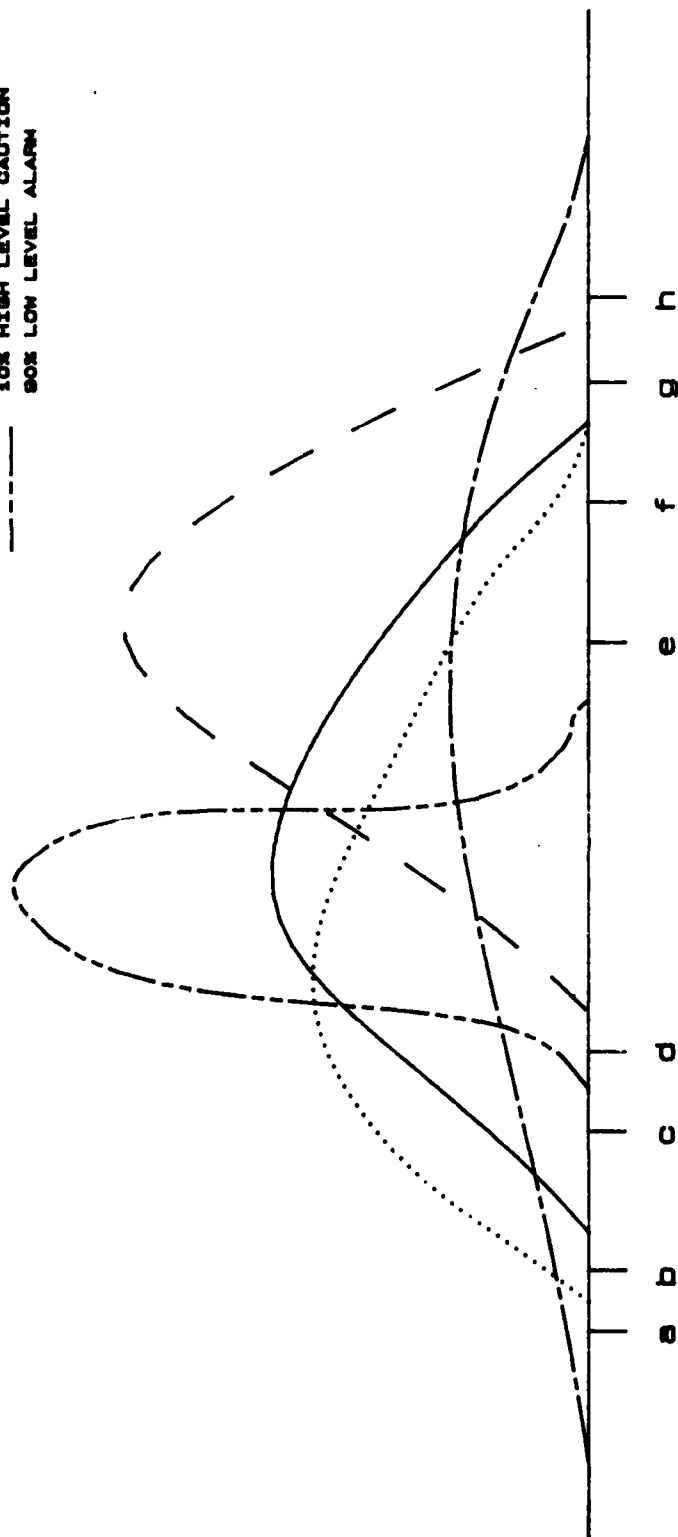


Figure 4.1-3. Limit conditions.

4.2 CALCULATIONAL DETAILS

The technique for determining and monitoring limits makes use of the VPR's histogram algorithm. This method is composed of the following steps:

a. A pretest course survey is performed using a vehicle identical (as close as possible) to the test vehicles. During this survey, several passes are performed on each test course for each of the three scenarios.

(1) Operator is instructed to drive as if an entire day of driving on the given test course is required, with no abnormal urgency (normal test severity).

(2) Operator is instructed to drive in a manner which allows the fastest negotiation of the test course, but with the constraint that full control of the vehicle and a safe posture be maintained at all times (high severity).

(3) Operator is instructed to drive as if the most important aspect of a mission is its completion (low severity).

b. Alarm limits are constructed for the 10% occupation based on the 10% levels obtained from the low severity and high severity scenarios; alarm limits are likewise constructed for the 90% occupation based on the 90% levels.

c. Caution limits are developed for the 10% occupation level roughly centered on the 10% level obtained from normal severity passes and extending one-half the distance to the 10% level obtained from the low severity passes on one side to one-half the distance to the 10% level obtained from the high severity scenario; caution limits are developed for the 90% occupation levels in a similar manner.

d. During the course of the test, the 10% and 90% values derived from the actual test data are compared against the limits so determined, and reports issued as appropriate.

The details of the limit determination procedure follows.

First, the notation used must be defined. (In the following, all reference is to one measurement parameter.)

[N90] - set of 90% values obtained during the normal severity scenario.

[N10] - set of 10% values obtained during the normal severity scenario.

[H90] - set of 10% values obtained during the high stress scenario.

[H10] - set of 10% values obtained during the high stress scenario.

[L90] - set of 90% values obtained during the low severity scenario.

[L10] - set of 10% values obtained during the low severity scenario.

MX[S] - maximum values in the set S.

MX⁻[S] - 2nd largest value in the set S.

4.2 (Cont'd)

$MN[S]$ - minimum value in the set S .

$MN^+[S]$ - 2nd smallest value in the set S

$[S]$ - mean value of set S .

Using this notation, the alarm limits are:

$$U90AL = MX[MX^-[H90], MX^-[L90]]$$

$$L90AL = MN[MN^+[H90], MN^+[L90]]$$

$$U10AL = MX[MX^-[L10], MX^-[H10]]$$

$$L10AL = MN[MN^+[L10], MN^+[H10]]$$

Similarly, the caution limits are defined by:

$$U90CL = MX[[[N90]+1/2[MX^-[H90]-[N90]]], [[N90]+1/2[MX^-[L90]-[N90]]]]$$

$$L90CL = MN[[[N90]-1/2[[N90]-MN^+[H90]]], [[N90]-1/2[[N90]-MN^+[L90]]]]$$

$$U10CL = MX[[[N10]+1/2[MX^-[H10]-[N10]]], [[N10]+1/2[MX^-[L10]-[N10]]]]$$

$$L10CL = MN[[[N10]-1/2[[N10]-MN^+[L10]]], [[N10]-1/2[[N10]-MN^+[H10]]]]$$

APPENDIX A - CORRESPONDENCE



DEPARTMENT OF THE ARMY Mr. Miller/ms/AV283-2375
HEADQUARTERS, U. S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

REPLY TO
ATTENTION OF

DRSTE-AD-M

8 MAY 1984

SUBJECT: MMT Methodology Improvement Program Directive, Vehicle
Performance Recorder and Mobility Monitoring System
(Phase I), TECOM Project No. 7-CO-PB4-AP1-007

= 17013

Commander
US Army Aberdeen Proving Ground
ATTN: STEAP-MT-M
Aberdeen Proving Ground, MD 21005

1. Reference:

- a. TECOM Regulation 70-12, dated 1 June 1973.
- b. AR 700-90, Dated 15 March 1982.
- c. DARCOM Handbook 11-4.1-82, Manufacturing Methods and Technology Exhibit P-16 Handbook, dated December 1981.
- d. Manufacturing Methods and Technology Instructional Guide for Preparing Project Status Reports (DRCMT 301), dated November 1982.

2. This letter constitutes a directive for the subject task under the TECOM Methodology Improvement Program.

3. The MIP at Enclosure 1 is the basis for headquarters approval of Phase I (FY84) of the subject investigation.

4. Special Instructions:

a. All reporting will be in consonance with paragraph 9 of the reference. The final report, when applicable, will be submitted to this headquarters, ATTN: DRSTE-AD-M, in consonance with Test Event 570/580.

b. Semiannual Project Status Reports RCS-DRCMT-301, Manufacturing Technology (MANTECH) Program, are to be provided to this headquarters by 15 February and 15 August for each year that the task is active. The information contained in the RCS-301 Report is entered into a data bank by the Industrial Base Activity (IBEA), Rock Island, Illinois, and used by DARCOM to monitor the

8 MAY 1984

DRSTE-AD-M

SUBJECT: MMT Methodology Improvement Program Directive, Vehicle Performance Recorder and Mobility Monitoring System (Phase I) TECOM Project No. 7-CO-PB4-AP1-007

progress of the program. Therefore, the information must be provided in the exact format shown in reference 1d. If the task is supported with funds for more than one fiscal year, it must be reported for each year.

c. Recommendations for new TOPs or revisions to existing TOPs will be included as part of the recommendation section of the final report. Final decision on the scope of the TOP effort will be made by this headquarters as part of the report approval process.

d. The addressee will determine whether any classified information is involved, and will assure that proper security measures are taken when appropriate. All OPSEC guidance will be strictly followed during this investigation.

e. Prior to test execution, the test activity will verify that no safety or potential health hazards to humans participating in testing exist. If safety or health hazards do exist, the test activity will be requested to provide a safety/health assessment statement to this office prior to test initiation.

f. Environmental documentation for support tests or special studies is the responsibility of the test activity and will be accomplished prior to initiation of the investigation/study.

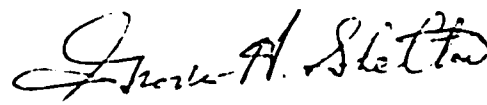
g. Upon receipt of this directive, test milestone schedules as established in TRMS II data base will be reviewed in light of other known workload and projected available resources. If rescheduling is necessary, and the sponsor nonconcurs, a letter citing particulars, together with recommendations, will be forwarded to Commander, US Army Test and Evaluation Command, ATTN: DRSTE-AD-M, with an information copy to DRSTE-TO-0, within 15 calendar days from the date of this letter. Reschedules concurred in by the sponsor can be entered directly along with a properly coded narrative by your installation/test activity.

h. The HQ, TECOM point of contact is Mr. Larry W. Miller, ATTN: DRSTE-AD-M, AUTOVON 283-2170/2375.

i. Initially, FY84 MMT funds in the amount of \$12,000 have been authorized for this investigation. Additional funds will be provided when they become available. DARCOM Form 1006 will be forwarded by the Comptroller.

FOR THE COMMANDER:

1 Encl
as


GROVER H. SHELTON
C, Meth Imprv Div
Analysis Directorate

RDTE METHODOLOGY INVESTIGATION PROPOSAL FY84 & FY85

1. TITLE: Improvement of Vehicle Test Methodology
2. CATEGORY:
3. INSTALLATION: Materiel Testing Directorate
Aberdeen Proving Ground
Aberdeen Proving Ground, MD 21005
4. PRINCIPAL INVESTIGATORS: Samuel F. Harley
Instrumentation Development
Branch
STEAP-MT-GI
AUTOVON 283-4318
5. STATEMENT OF THE PROBLEM: The Vehicle Performance Recorder (VPR) and Mobility Monitoring System (MMS), developed at APG, have the potential to become extremely useful tools in a variety of vehicle test areas, such as endurance, brake system, and cooling system testing. Although the hardware and a large body of software have completed development, the methodology to transform these real time data acquisition and processing systems into generic tools (i.e., generally applicable to a large body of test items and test scenarios) needs to be defined.
6. BACKGROUND: The VPR will be used to measure the test "stress" environment during the Initial Production Test of the High Mobility Multi-purpose Wheeled Vehicle (HMMWV). New concepts are being employed, such as continuous monitoring of several key parameters over approximately 250,000 miles of testing, and the implementation of a data base management system to allow project personnel extract meaning from the large quantity of data involved.
7. GOALS: The overall goal of this investigation is the improvement of vehicle test methodology. Specific actions toward this goal are:
 - a. Establishment of the critical parameters (i.e., those with highest information content) involved in vehicle endurance testing.
 - b. Establishment of a method to measure delivered torque during endurance testing, or alternately the determination of a suitable surrogate for torque (or engine load).
 - c. Development of a ruggedized transducer set appropriate for all types of vehicle testing.
 - d. Implementation of a data base management system applicable to all vehicle testing.
 - e. Development of suitable real-time algorithms for use during engineering performance/vehicle endurance testing.

f. Promotion of uniform test methodology throughout TECOM.

8. DESCRIPTION OF INVESTIGATION:

a. The US Army Aberdeen Proving Ground will conduct tests using field dynamometers and a variety of instrumented vehicles to evaluate the sensitivity of engine exhaust temperature to delivered power as well as the sensitivity of transmission fluid temperature to delivered torque.

b. The US Army Aberdeen Proving Ground will conduct tests to determine the feasibility of measuring delivered torque during endurance test scenarios.

c. The US Army Aberdeen Proving Ground, with contractual support, will implement a data base management system applicable to vehicle testing. Methods of tying this data base to the equipment failure data base will be investigated.

d. The US Army Aberdeen Proving Ground, with contractual support, will isolate needed real time processing algorithms (which will execute on the VPR or MMS) and develop those algorithms.

e. The US Army Aberdeen Proving Ground will investigate various parameters to determine which parameters carry the greatest importance, and will develop an appropriate transducer set to match these parameters.

9. JUSTIFICATION:

a. Association With Mission: Vehicle testing is a large part of the MTD mission.

b. Present Capability, Limitations, Improvement and Impact of Testing If Not Approved: MTD presently conducts vehicle tests, but the techniques need to be improved and expanded. In the area of vehicle endurance testing, in the past no information regarding driver or course input has been collected, which has compromised some test results. This situation has led to a DA mandate that endurance test vehicles be instrumented. Brake and cooling system tests comprise another area where new techniques should be employed. Without the implementation of this proposal the application of new instrumentation systems will be haphazard and limited by the lack of a coherent methodology.

c. Dollar Savings: Dollar savings for this proposal are difficult to project. On the upcoming HMMWV IPT, a cost estimate of \$500,000 was submitted by the vehicle manufacturer, MTD's estimate to perform the instrumentation installation, software, and data acquisition is \$280,000 using the VPR. If a unified methodology were in place, this estimate would decrease by approximately \$50,000. Therefore, cost savings ranging from \$50,000 to \$270,000 per major program could be realized.

d. Workload: Vehicle testing forms a large portion of MTD's workload.

e. Recommended TRMS Priority: 10

f. Association with Requirements Documents: Not known.

g. Other: None.

10. RESOURCES:

a. Financial

	Dollars (Thousands) FY84	
	In-House	Out-of-House
Personnel Compensation	35.0	
Travel	5.0	
Materials and Supplies	0.0	
FY84 TOTALS	40.0	

	Dollars (Thousands) FY85	
	In-House	Out-of-House
Personnel Compensation	100.0	80.0
Travel	20.0	
Materials and Supplies	0.0	
FY85 TOTALS	120.0	80.0

b. Explanation of Cost Categories

(1) Personnel compensation: Represents compensation for technical personnel assigned to project.

(2) Travel: Represents cost of traveling to other government organizations for discussions on new methodology implementations.

c. Obligation Plan:

	FY84				
FQ	1	2	3	4	TOTAL
(thousands)	0	0	20.0	20.0	40

	FY85				
FQ	1	2	3	4	TOTAL
(thousands)	50.0	50.0	50.0	50.0	200.0

d. In-House Personnel:

(1) In-house personnel requirements by speciality:

	No.	Required	Available	Total
Physicist	1	1,000	1,000	1,000
Mechanical Engineer	2	2,000	2,000	2,000
Electronic Technician	1	1,500	1,500	1,500

(2) Resolution of nonavailable personnel: N/A

11. INVESTIGATION SCHEDULE:

	CY84	FY85
	M J J A S O N D	J F M A M J J A S
In-House	- - - - -	- - - - - R
Out-of-House	- - - - -	- - - - -

Symbols - - - Active investigation work
(all categories)
R Final Report due to TECOM

12. ASSOCIATION WITH TOP PROGRAM: It is anticipated that this investigation will lead to changes in TOP's dealing with vehicle testing.

13. AUTHENTICATION:

EDWARD V. SOMODY
Chief, Methodology and
Test Management Division
Materiel Testing Directorate

APPENDIX B - ABBREVIATED VPR USER'S GUIDE

ABBREVIATED VPR MANUAL (HMM4V)

SECTION I. GENERAL

1. INTRODUCTION
2. GETTING STARTED
3. DATA TRANSFER
4. CONFIGURATION FILES
5. SOFTWARE OVERVIEW
6. DISC SPACE ALLOTMENT
7. HISTOGRAM DATA
8. TACHOGRAPH DATA
9. I/O CONFIGURATION

SECTION II. VEHICLE AND TEST SPECIFICS

1. CONTROL ARM POSITION CALIBRATION
2. CONTROL ARM ACCELERATION SETUP
3. EGT SETUP
4. FILE "HLAB"
5. FILE "VPRO00"
6. FILE "VEHID"
7. FILE "VTCORS"
8. FILE "VTDRVR"
9. FILE "VTLOC"

SECTION I. GENERAL

1. INTRODUCTION

TO SUCCESSFULLY UTILIZE THE VPR IT IS REQUIRED THAT BOTH GENERAL AND APPLICATION SPECIFIC ACTIONS BE UNDERSTOOD AND IMPLEMENTED. THIS DOCUMENT IS A CONDENSED OVERVIEW OF VPR SETUP AND USE. THE TOPICS COVERED IN SECTION I ARE UNIVERSAL IN NATURE, WHILE SECTION II IS DEVOTED TO A GIVEN TEST.

THIS DOCUMENT IS INTENDED TO BE DYNAMIC. AT THE BEGINNING OF A NEW TEST IT SHOULD BE ALTERED TO REFLECT ACTUAL USAGE AND SAVED - UNDER A NEW NAME OF COURSE. IN THIS MANNER UP TO DATE INSTRUCTIONS WILL BE AVAILABLE.

2. GETTING STARTED (COLD LOAD)

1. LOAD VPR PROGRAMS IF NOT ON SYSTEM

VPR PROGRAMS STORED ON 1/2 INCH MAGNETIC TAPE

:PU,TVPR
:ST,Tape LU,TVPR
:TR,TVPR,disc LU,tape LU

2. CHECK THE TEST LOCATION FILE (VTLOC) AND EDIT IF NEEDED. TEST LOCATIONS ARE STORED AS 3 CHARACTER IDENTIFIERS STARTING ON LINE 3. THERE CAN BE A MAXIMUM OF 10 TEST LOCATIONS. A LISTING SHOULD BE MADE FOR DOCUMENTATION.
3. CHECK THE TEST COURSE FILE (VTCORS) AND EDIT IF NEEDED. TEST COURSES ARE STORED AS 3 CHARACTER IDENTIFIERS STARTING ON LINE 3. THERE CAN BE A MAXIMUM OF 20 TEST COURSES. A LISTING SHOULD BE MADE FOR DOCUMENTATION.
4. CHECK THE DRIVER NAME FILE (VDRVR) AND EDIT IF NEEDED. DRIVER NAMES ARE STORED AS 20 CHARACTER IDENTIFIERS STARTING ON LINE 3. THERE CAN BE A MAXIMUM OF 25 DRIVER NAMES. A LISTING SHOULD BE MADE FOR DOCUMENTATION.
5. CHECK THE VEHICLE ID FILE (VEHID) AND EDIT IF NEEDED. THIS FILE CONTAINS BOTH A VEHICLE ID OF 7 CHARACTERS STARTING AT LINE 3 COLUMN 1 AND THE VEHICLE CURRENT ODOMETER READING STARTING ON LINE 3 COLUMN 40. THE MAXIMUM ODOMETER READING IS 99,999. THERE CAN BE A MAXIMUM OF 20 VEHICLES. A LISTING OF THE EDITED FILE SHOULD BE MADE FOR DOCUMENTATION.
6. EACH VPR SHOULD HAVE A CALIBRATION FILE (VPRNNN) WHERE NNN IS THE VPR SERIAL NUMBER. THESE CALIBRATION FILES CAN BE MADE BY CLONING 'VPR000' AND USING THE EDITOR TO ENTER THE NEW CALIBRATION FACTORS. CLONING IS DONE BY :ST,VPR000,VPRNNN

THE CURRENT DATE, TIME AND OPERATOR'S NAME SHOULD BE ENTERED ON LINE 1 AND A LISTING OF THE EDITED FILE MADE FOR DOCUMENTATION.

7. RUN THE VPR PROGRAM (:RU,VPR) AND CLEAR THE DIRECTORY (<VPR:CL).
8. THE VPR DATA RETRIEVAL SYSTEM IS NOW READY TO TAKE DATA.

3. DATA TRANSFER

1. TURN OFF VEHICLE ENGINE IF POSSIBLE.
2. CHECK THAT A1 AND A2 LIGHTS ARE OFF ON VPR TERMINAL. (IF ENGINE IS ON A1 LIGHT SHOULD BE LIT.) IF A2 LIGHT IS ON PRESS FUNCTION KEYS NEEDED TO "END HISTOGRAM".
3. CONNECT TRANSFER CABLE TO DATA OUT CONNECTOR ON VPR.
4. RECORD VEHICLE CURRENT ODOMETER READING.
5. ON HP1000 TERMINAL: RUN VPR PROGRAM (:RU,VPR) IF VPR PROGRAM NOT RUNNING.
6. RUN VPR TRANSFER PROGRAM (<VPR:TR,load parameter).
7. THE VPR TRANSFER PROGRAM WILL DISPLAY THE VPR SERIAL NUMBER. CHECK TO MAKE SURE THIS IS THE ACTUAL SERIAL NUMBER OF THE VPR BEING TRANSFERRED.
8. A SUCCESSFUL TRANSFER WILL END WITH QUESTION : DO YOU WANT TO CLEAR VPR MEMORY? (YE OR NO). ANSWER THE QUESTION TO END THE TRANSFER PROGRAM.
9. THE TRANSFER PROGRAM WILL RESET THE VPR (THE VPR TERMINAL WILL SHOW SOMETHING RESEMBLING "SETTING SOFTKEYS" FOR ABOUT 20 SECONDS). AFTER THE "VPR:" PROMPT RETURNS TO THE VPR TERMINAL THE TRANSFER CABLE CAN BE DISCONNECTED (REMEMBER TO RECONNECT THE RIDEMETER DATA CABLE IF IT HAS BEEN DISCONNECTED).
10. THE SET NUMBER BEFORE THE FIRST SET OF THE QUICK LOOK PRINTOUT IS THE TACHOGRAPH. PLOT THE TACHOGRAPH (<VPR:PT,tachograph set number). IF THE TACHOGRAPH DOES NOT PLOT CORRECTLY IT SHOULD BE PURGED USING THE PURGE PROGRAM (<VPR:PU FOLLOWED BY <VPR DIR PURGE:S1,set).
11. EXAMINE THE QUICK LOOK PRINTOUTS FOR BAD DATA OR SHORT (LESS THAN 1 MINUTE) DATA SETS. THESE SHOULD BE PURGED USING THE PURGE PROGRAM (<VPR:PU).
12. EXAMINE THE QUICK LOOK PRINTOUTS FOR WRONG OR MISSING PARAMETERS (DATE,TIME,DRIVER...). THESE CAN BE FIXED USING THE VPR EDITOR PROGRAM (<VPR:ED,set number).
13. RUN THE QUICK LOOK PROGRAM TO OBTAIN A CORRECTED LISTING OF THE DATA SETS TAKEN (<VPR:QL,start set,stop set,printer LU). SAVE BOTH THE ORIGINAL AND EDITED LISTINGS FOR DOCUMENTATION.
14. ENTER THE CURRENT ODOMETER READING INTO THE VEHICLE ID FILE USING THE HP1000 TEXT EDITOR (:RU,EDITR OR :RU,EDIT).
15. RUN THE TAPE BACKUP PROGRAM TO STORE THE DATA ON TAPE (<VPR:TP). THIS PROGRAM IS GENERALLY RUN AFTER THE LAST VEHICLE HAS HAD ITS VPR DATA TRANSFERRED.

4. CONFIGURATION FILES

HLAB HISTOGRAM LABEL FILE.

VCHECK LIMITS FOR THE DATA VERIFICATION PROGRAM.

VDRVR VPR DRIVER NAME FILE.

VEHID VEHICLE IDENTIFICATION FILE.

VEVNT VPR EVENTS CHANNEL LABEL FILE.

VRUN VPR NEXT RUN NUMBER.

VTCORS VPR TEST COURSES.

VTLOC VPR TEST LOCATIONS.

5. SOFTWARE OVERVIEW

MTEND	ALABL	OHIST	HLAB	VPRTB
OREAD	ASCEB	OTACH	VCHECK	DPH
VPR	ASEC		VDRVR	CRVFT
VPRCL		PLTAD	VEHID	PLYFT
VPRCM	CBUF		VEVNT	GELIM
VPRDB		RSCAL	VRUN	MTSPC
VPRDL	DELAY	RUNFL	VTCORS	CAPFT
VPRED			VTLOC	
VPREV	EDCMD	TCMIN		
VPRPH		TLABL		
VPRPT	GHLAB	TNMIN		
VPRPU	GTACH	TVER		
VPRQL	GTDAT			
VPRRE	GTRUN	VALFL		
VPRTP		VDHTE		
VPRTTR	HCON	VDRGT		
FPRVE	HVER	VDRWT		
	IASEB	VFILE		
	IBCD	VGTCL		
	IBDBN	VLSTC		
	INVPR	VNRUN		
		VPNTS		
	LDBF			
		WHIST		
		WTJCL		

VPR PROGRAMS

MTEND FINDS END OF MAG TAPE.

OREAD THIS PROGRAM READS AND DISPLAYS THE CONTENTS OF A DISC LU. THE DISPLAY MODE MAY BE SET TO INTEGER, OCTAL OR REAL. AN ASCII DISPLAY IS ALWAYS GIVEN ON THE RIGHT HAND SIDE OF THE SCREEN.

VPR THIS PROGRAM PROVIDES A CONTROL SYSTEM FOR TRANSFERRING DATA FROM THE VPR TO AN HP1000.

VPRCL THIS PROGRAM CLEARS A VPR DIRECTORY BY SETTING ALL RUN NUMBERS TO -2 AND ALL OTHER ENTRIES TO 0's.

VPRCM THIS PROGRAM WILL PROVIDE A COMPOSITE HISTOGRAM OF A GIVEN CHANNEL OVER AN OPERATOR ENTERED NUMBER OF VEHICLE PERFORMANCE RECORDER (VPR) SETS.

VPRDB THIS PROGRAM WRITES A DATA BASE TAPE IN INTEL SYSTEM 2000 DATABASE FORMAT.

VPRDL THIS PROGRAM WILL OUTPUT THE DIRECTORY(S) OF OPERATOR ENTERED VEHICLE PERFORMANCE RECORDER (VPR) DATA SETS.

VPRED THIS PROGRAM EDITS VPR DIRECTORY ENTRIES.

VPREV THIS PROGRAM WILL PROCESS THE CHANNEL CONTAINING THE EVENT(S) FOR THE VEHICLE PERFORMANCE RECORDER (VPR).

VPRPH THIS PROGRAM PLOTS HISTOGRAM DATA.

VPRPT THIS PROGRAM PLOTS TACHOGRAPH DATA.

VPRPU THIS PROGRAM PURGES SELECTED RUNS AND CHANNELS FROM THE DIRECTORY.

VPRQL THIS PROGRAM PROVIDES A QUICK-LOOK PRINTOUT OF THE STATUS OF THE CHANNELS TAKEN BY THE VEHICLE PERFORMANCE RECORDER (VPR). THE DATA IS OUTPUT TO AN OPERATOR SELECTED LIST DEVICE.

VPRRE THIS IS A PROGRAM TO RESTORE VEHICLE PERFORMANCE DATA FROM TAPE TO DISC.

VPRTP PROGRAM TO TRANSFER VEHICLE PERFORMANCE DATA FROM DISC TO TAPE.

VPRTR PROGRAM TO TRANSFER DATA FROM VEHICLE PERFORMANCE RECORDER.

VPRVE THIS PROGRAM PERFORMS THE VERIFICATION CHECKS ON THE VEHICLE PERFORMANCE RECORDER (VPR).

SUBROUTINES

ALABL THIS SUBROUTINE ASSEMBLES AN ARRAY CONTAINING THE PLOT, X-AXIS AND Y-AXIS LABELS.

ASCEB THIS SUBROUTINE CONVERTS A BUFFER OF ASCII DATA TO EBCDIC FORMAT.

ASEC THIS SUBROUTINE ACCEPTS A SECTOR INCREMENT AND RETURNS THE NEW TRACK AND SECTOR.

CBUF THIS SUBROUTINE CLEARS A BUFFER BY INSERTING BLANKS.

DELAY THIS SUBROUTINE PRODUCES A NOMINAL TIME DELAY OF $N \times 0.01$ SECONDS.

EDCMD SUBROUTINE TO LIST VPR COMMANDS.

GHLAB SUBROUTINE FORMATS AN ARRAY LABEL FOR A HISTOGRAM PLOT.

GTACH THIS SUBROUTINE GETS TACHOGRAPH DATA FOR DATABASE PROGRAM.

GTDAT THIS SUBROUTINE GETS THE TACHOGRAPH DATA FROM DISC.

GTRUN SUBROUTINE TO GET THE DIRECTORY OF A WHOLE RUN.

HCON SUBROUTINE TO CONVERT NUMBERS STORED IN BINARY AND OFFSET BY -32768 TO A 6 CHARACTER ASCII REPRESENTATION.

HVER THIS SUBROUTINE VERIFIES PROPER HISTOGRAM SET DIRECTORY ENTRIES.

IASEB FUNCTION TO CONVERT ASCII CODE TO EBCDIC.

IBCD THIS FUNCTION CONVERTS AN INTEGER BINARY INPUT INTO A 4 DIGIT BCD WORD.

IBDBN THIS SUBROUTINE TAKES A PACKED BCD WORD INTO ITS BINARY EQUIVALENT.

INVPR ROUTINE TO COMMUNICATE WITH VPR.

LDBF THIS SUBROUTINE LOADS A BUFFER WITH A GIVEN NUMBER OF SECTORS OF DATA STARTING AT A GIVEN SECTOR.

OHIST THIS SUBROUTINE OUTPUTS HISTOGRAM DATA TO TAPE IN DATABASE FORMAT.

OTACH THIS SUBROUTINE OUTPUTS TACHOGRAPH DATA TO TAPE IN DATABASE FORMAT.

PLTAD PLOTTING SUBROUTINE.

RSCAL THIS SUBROUTINE ROUNDS A NUMBER TO THE NEAREST MULTIPLE OF 2, 5 OR 10 FOR THE MAXIMUM VALUE ON A PLOTTED AXIS.

RUNFL THIS SUBROUTINE RETURNS THE NEXT RUN NUMBER FROM FMP FILE "VRUN."

TCMIN THIS SUBROUTINE FORMATS TIME WORDS FOR TACHOGRAPH TIME SEGMENTS.

TLABL SUBROUTINE TO WRITE TEXT LABELS TO H-P 2648 GRAPHICS TERMINAL.

TNMIN THIS FUNCTION CALCULATES THE TOTAL NUMBER OF MINUTES IN A TACHOGRAPH RUN.
 TVER THIS SUBROUTINE VERIFIES TACHOGRAPH DIRECTORY ENTRIES.
 VALFL THIS SUBROUTINE GETS VPR HISTOGRAM LABELS, TEST LOCATIONS, TEST COURSES, VEHICLE ID's, AND DRIVER NAMES FROM FMP DATA FILES.
 VDATE CHECKS FOR PROPER DAY OF THE MONTH.
 VDRGT SUBROUTINE TO FIND DISC DIRECTORY AND DATA LOCATION OF A GIVEN RUN AND CHANNEL.
 VDRWT THIS SUBROUTINE CHANGES DIRECTORY PARAMETERS.
 VFILE THIS SUBROUTINE ACCESSES VEHICLE PERFORMANCE RECORDER (VPR) FILES AND RETURNS EITHER ONE ENTRY OR A DUMP OF THE ENTIRE FILE.
 VGTCL THIS SUBROUTINE GETS THE VPR CALIBRATION FACTORS FROM THE APPROPRIATE CALIBRATION FILE.
 VLSTC SUBROUTINE TO LIST VPR COMMANDS.
 VNRUN SUBROUTINE TO FIND NEXT AVAILABLE RUN FROM DISC DIRECTORY.
 VPNTS THIS SUBROUTINE DETERMINES THE NUMBER OF POINTS IN A VEHICLE PERFORMANCE RECORDER (VPR) HISTOGRAM.
 WHIST THIS SUBROUTINE WRITES HISTOGRAM DATA TO TAPE IN DATABASE FORMAT.
 WTJCL THIS SUBROUTINE WRITES JOB CONTROL LANGUAGE TO TAPE FOR DATABASE.
 DPH THIS TRANSFER ROUTINE WAS WRITTEN IN SUPPORT OF THE VPR PROGRAM. IT IS USED TO DUMP TO A PLOTTER OR HARD COPY UNIT THE CONSECUTIVE RUNS AND/OR CHANNELS OF HISTOGRAM DATA.
 CRVFT PROGRAM TO PERFORM A MULTI-DEGREE FIT ON X-Y PAIRS OF DATA.
 MTSPC PROGRAM DESIGNED TO FORWARD FILE A MAG TAPE.

6. DISC SPACE ALLOTMENT

LU 19 IS THE DATA DISC

TRACKS 0 - 24 ARE DIRECTORY TRACKS

TRACKS 25 - 383 ARE DATA TRACKS

DIRECTORY ENTRIES CONSIST OF 16 WORDS

THERE ARE 3 TYPES OF DIRECTORY ENTRIES

HISTOGRAM
TACHOGRAPH
EVENTS

HISTOGRAM DIRECTORY ENTRY

WORD

1	SET NUMBER (>0)	
2	CHANNEL NUMBER 0-23	
3	MONTH/DAY IN BCD	
4	HOURL/MINUTE IN BCD	
5	TRACK (THAT DATA IS ON)	
6	SECTOR (THAT DATA IS ON)	
7	MINIMUM HISTOGRAM VALUE	REAL NUMBER STORED AS 2 INTEGERS 8 MINIMUM HISTOGRAM VALUE
9	MAXIMUM HISTOGRAM VALUE	REAL NUMBER STORED AS 2 INTEGERS 10 MAXIMUM HISTOGRAM VALUE
11	TEST LOCATION/TEST COURSE	MSB/LSB
12	VEHICLE ID/DRIVER NAME	MSB/LSB
13	LOAD PARAMETER (LOADED-L , UNLOADED-U , TRAILERED-T)	
14	ODOMETER READING	
15	DISTANCE (IN MILES)	
16	SAMPLE RATE	

EVENTS CHANNEL DIRECTORY ENTRY

WORD

1	SET
2	"Eb" (42440B) - (INTEGER - 17696)
3	MONTH/DAY
4	HOUR/MINUTE
5	TRACK (THAT DATA IS ON)
6	SECTOR (THAT DATA IS ON)
7	NUMBER OF EVENTS CHANNELS (1-4)
8	0
9	0
10	0
11	TEST LOCATION/TEST COURSE MSB/LSB
12	VEHICLE/DRIVER MSB/LSB
13	LOAD PARAMETER (LOADED - 'L ' UNLOADED - 'U ' TRAILER - 'Tb')
14	ODOMETER
15	DISTANCE TRAVELED (IN MILES)
16	SAMPLE RATE

TACHOGRAPH DIRECTORY ENTRY

WORD

1	RUN	
2	"Tb" (52040B) -	(INTEGER - 21536)
3	MONTH/DAY	IN BCD
4	HOUR/MINUTE	IN BCD
5	TRACK DATA STARTS ON	
6	SECTOR DATA STARTS ON	
7	NUMBER OF TACHOGRAPH "SEGMENTS"	
8	NUMBER OF DATA WORDS	
9	ROAD SPEED SCALE FACTOR	
10	ROAD SPEED SCALE FACTOR	REAL NUMBER STORED AS 2 INTEGERS
11	TEST LOCATION	
12	VEHICLE ID	
13	SHIFT (1-2)	
14	ENGINE SPEED SCALE FACTOR	
15	ENGINE SPEED SCALE FACTOR	REAL NUMBER STORED AS 2 INTEGERS
16	0	

The directory references to TEST LOCATION, TEST COURSE, VEHICLE ID, and DRIVER NAME are indices to the external data files:

VTLOC - Test locations.
 VTCORS - Test course names.
 VEHID - Vehicle IDs.
 VDRVR - Driver names.

Each test location has its own COURSE, VEHICLE, and DRIVER file.

The format of these files is as follows:

RECORD

1	Header
2	Header
3	ID 1
4	ID 2
5	ID 3
.	.
.	.
.	.

7. HISTOGRAM DATA

HISTOGRAM DATA CONSISTS OF 64 WORDS WHICH ARE STORED IN 1 SECTOR. THE LOCATION OF THE SECTOR IS GIVEN BY WORDS 5 AND 6 OF THE HISTOGRAM DIRECTORY ENTRY.

WORD NUMBER IN THE SECTOR CORRESPONDS TO THE HISTOGRAM BIN (WORD 1 = BIN1, WORD 2 = BIN2).

EACH WORD IS THE NUMBER OF SAMPLES IN THAT BIN - 32768. (IN OTHER WORDS 32768 MUST BE ADDED TO THE BIN VALUE TO GET THE NUMBER OF SAMPLES) 0 ~ -32768, 65535 ~ 32767.

THE RANGE, IN ENGINEERING UNITS, OF THE HISTOGRAM IS GIVEN BY THE MINIMUM AND MAXIMUM VALUES STORED IN WORDS 7 + 8, 9 + 10, IN THE HISTOGRAM DIRECTORY ENTRY.

8. TACHOGRAPH DATA

TACHOGRAPH DATA CONSIST OF:

- 1 SECTOR (64) WORDS OF SEGMENT TIMES
- 12 SECTORS (768) WORDS MAXIMUM ROAD SPEED DATA
- 12 SECTORS (768) WORDS AVERAGE ROAD SPEED DATA
- 12 SECTORS (768) WORDS MINIMUM ROAD SPEED DATA
- 12 SECTORS (768) WORDS MAXIMUM ENGINE SPEED DATA
- 12 SECTORS (768) WORDS AVERAGE ENGINE SPEED DATA
- 12 SECTORS (768) WORDS MINIMUM ENGINE SPEED DATA

THE LOCATION OF THE FIRST SECTOR OF TACHOGRAPH DATA IS GIVEN BY WORDS 5 AND 6 OF THE TACHOGRAPH DIRECTORY ENTRY.

THE FIRST 64 WORDS CONSIST OF PAIRS OF WORDS DEFINING EACH SEGMENT OF TACHOGRAPH DATA.

THE FIRST WORD OF THE PAIR IS THE STARTING MINUTE AND THE SECOND WORD IS THE NUMBER OF MINUTES IN THE SEGMENT.

THE NUMBER OF PAIRS IS GIVEN BY WORD 7 OF THE TACHOGRAPH DIRECTORY.

IF THERE ARE LESS THAN 32 PAIRS OF SEGMENT WORDS THE WORDS FOLLOWING THE LAST PAIR ARE SET TO ZERO TO FILL THE 64 WORDS IN THE SEGMENT.

THE NUMBER OF WORDS OF ROAD AND ENGINE SPEED DATA IS GIVEN BY WORD 8 OF THE TACHOGRAPH DIRECTORY. THIS SHOULD BE EQUAL TO THE SUM OF THE NUMBER OF MINUTES IN EACH SEGMENT.

THE MAXIMUM ROAD SPEED WORDS ARE STORED STARTING AT WORD 1 OF THE SECTOR FOLLOWING THE SECTOR CONTAINING THE PAIRS OF SEGMENT TIMES.

SEGMENT TIMES ARE STORED AS START MINUTE SEGMENT 1, NUMBER OF MINUTES IN SEGMENT 1, START MINUTE SEGMENT 2, NUMBER OF MINUTES IN SEGMENT 2.

DATA IS STORED WITH THE SEGMENTS "PACKED."

MINUTE 1	SEGMENT 1
MINUTE 2	SEGMENT 1
MINUTE 3	SEGMENT 1
MINUTE 4	SEGMENT 1
MINUTE 5	SEGMENT 1
MINUTE 1	SEGMENT 2
MINUTE 2	SEGMENT 2
MINUTE 3	SEGMENT 2

...
...
...

9. I/O CONFIGURATION

MICROCIRCUIT INTERFACE CARD JUMPER CONFIGURATION

TO TRANSFER DATA FROM THE VPR TO THE COMPUTER REQUIRES THAT A 1256-0
INTERFACE BE JUMPED SO THAT THE FOLLOWING JUMPERS ARE INSTALLED:

W1A
W2A
W3B
W4B
W5
W6
W7
W8
W9A
W11
W12

AD-A160 298

MOBILITY MONITORING SYSTEM AND VEHICLE PERFORMANCE
RECORDER REVISION(U) ARMY COMBAT SYSTEMS TEST ACTIVITY
(PROV) ABERDEEN PROVING GROUND MD T G BARTLETT ET AL
SEP 85 USACSTA-6169-REV

272

UNCLASSIFIED

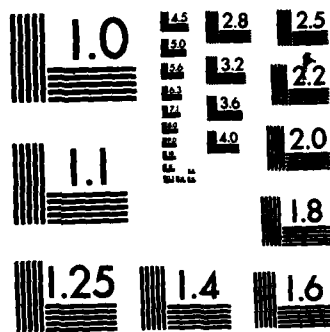
F/G 13/6

NL

END

FILMED

DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

10. "TP" TAPE FORMAT

"TP" tapes are in a disk image format based on a 16 bit integer word. Tape records are 1025 words long. It takes 6 records to store 1 disc track of 6144 words.

The first word of each record is not used. (it was once reserved for file ID).

The first record is used as a tape header.

WORD 1	- not used
2 - 32	- Header string
33 - 1023	- blanks
1024	- number of disc tracks

The total number of records in the file is given by:

$(\text{number of disc tracks} * 6) + 1$

The disc directory is stored in records 1 to 151 and data is stored in the records following record 151.

SECTION II. VEHICLE/TEST SPECIFICS

1. CONTROL ARM POSITION CALIBRATION

1. PLACE THE BALANCE ADJUSTMENT POTENTIOMETER AT APPROXIMATELY MIDRANGE
2. INSERT A 10-12 INCH ROD IN THE TRANSDUCER LINKAGE
3. USING A CALIBRATION FIXTURE, POSITION THE ROD SO THAT IT IS DOWN 2.70 INCHES FROM THE HMMWV FRAME (0 ON FIXTURE)
4. ROTATE THE TRANSDUCER HOUSING UNTIL A READING OF APPROXIMATELY -600 IS READ ON THE TERMINAL
5. TIGHTEN THE TRANSDUCER DOWN
6. WITH THE ROD STILL 2.70 INCHES DOWN FROM THE FRAME, ADJUST THE BALANCE POTENTIOMETER SO THAT -600 IS READ ON THE TERMINAL
7. TAKE ADDITIONAL READINGS (FROM THE TERMINAL) AT LOCATIONS APPROXIMATELY -2.0,-1.5,-1.0 ... 1.5,2.0 (AS MANY AS YOU CAN) INDENTS ON CALIBRATION FIXTURE
8. ENTER A FILE, "CAPnnn" (where nnn is the VPR serial number) USING THE EDITR OF AN HP1000, THAT LOOKS SOMETHING LIKE:

vehicle number VPR serial number date calibrator's initials

-1024,-2.0
-944,-1.5
-837,-1.0
-712 -0.5
-600, 0.0
-498, 0.5
-385, 1.0
-287, 1.5
-168, 2.0

WHERE THE FIRST NUMBER IS THE TERMINAL READING AND THE SECOND IS THE RELATIVE DISTANCE DOWN FROM THE 2.70 REFERENCE POINT

9. RUN THE PROGRAM 'CAPFT' (:RU,CAPFT,1,6)
10. PUT THE MAXIMUM AND MINIMUM VALUES FROM 'CAPFT' IN THE FILE 'VPRNNN'

2. ACCELEROMETER SETUP

1. MEASURE THE EXCITATION VOLTAGE V (PINS C&D OF ANALOG INPUT CONNECTOR)
2. FROM THE ACCELEROMETER CALIBRATION SHEET, GET THE SENSITIVITY S (MV/G) AND CALIBRATION EXCITATION VOLTAGE V_c
3. RUN PROGRAM 'CALAC' ANSWERING ALL QUESTIONS
4. PUT THESE VALUES FROM 'CALAC' IN THE APPROPRIATE VPRnnn FILE

3. EGT SETUP

1. MEASURE THE EXCITATION VOLTAGE V (OR USE THE VALUE FOUND WHEN MEASURING FOR THE ACCELERATION).
2. ALLOW THE VEHICLE TO IDLE A FEW MINUTES, THEN ADJUST THE RTD READING T₀ AS CLOSE TO ZERO AS YOU CAN.
3. IN THE APPROPRIATE VPR_{run} FILE, ENTER 0 FOR THE MINIMUM EGT VALUE, AND

$$1270 \cdot V / 3.69$$

FOR THE MAXIMUM EGT.

4. FILE "HLAB"
HISTOGRAM LABEL FILE

CONTROL ARM POSITION

INCHES

% OCCURRENCES

-2,8

ACCELERATION

G'S

% OCCURRENCES

-8,8

OIL TEMPERATURE

DEGREES F

% OCCURRENCES

0,300

OIL TEMPERATURE DROP

DEGREES F

% OCCURRENCES

0,100

ROAD SPEED

MILES PER HOUR

% OCCURRENCES

0,60

ENGINE SPEED

RPM

% OCCURRENCES

0,5000

7

7

7

7

.

.

24

24

5. FILE "VPRO01"

VPR001 CALIBRATION FILE 10/24/84 12:12 LJF

```
.45,.60          Road speed scale factor,engine speed scale factor
-2.262,8.478,-2.,8.,3000 Control arm travel min,max,norm min,max,sample rate
-7.98,7.98,-8.,8.,3000   Control arm accel min,max,norm min,max,sample rate
299.9,75.,75.,299.8,60   Engine oil cooler inputx,nrm min,max,sample rate
86.0,0.,0.,86.0,60       Engine oil cooler output,norm min,max,sample rate
0.0,57.6,0.,60.0,60      Road speed min,max,normalized min,max,sample rate
0.0,7680.,0.,7600.,60    Engine speed min,max,normalized min,max,sample rate
0,64,0,64,1             unused channel
0,64,0,64,1             unused channel
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0,64,0,64,1
0.2                    Event scale factor - Brake application duration
0.2
0.2
0.2
```

6. FILE "VEHID"

VEHICLE IDENTIFICATION NUMBER (USA NUMBER) FILE --(LEAVE RH COLUMN ALONE)

AU01E	0.0	1
AU02E	0.0	2
AU03P	5006.0	3
AU04P	5000.0	4
AW05E	0.0	5
AW06E	0.0	6
AW07P	5000.0	7
BLSVH	4677.7	8
USA009	0.0	9
USA0010	0.0	10

7. FILE "VICORS"
VPR TEST COURSES

HIGHWAY

BB&GRVL

BB&GRVL

C'VILLE

SEC A

XC1

XC2

XC3

CR - 1

CR - 2

CR - 3

CR - 4

8. FILE "VDEVR"
VPR DRIVER NAME FILE

K. ROBERTS
R. REEVES
M. ANDERSON
K. RICHARDSON
P. SCHRIVER
R. KUNSMAN
P. MONAHAN
S. JONES
J. WEAVER
R. ROSAS

DRIVER NUMBER

1
2
3
4
5
6
7
8
9
10

9. FILE "VILOC"
VPR TEST LOCATIONS

APG
YPG
HL
CR
COR
FKX

APPENDIX C - REFERENCES

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3. Harley, S., Harmon, R., Shrader, T., and Connon, W., Final Report, Vehicle Performance Recorder (VPR)/HMMWV Interface Verification, TECOM Project No. 5-CO-APO-DFW-203. US Army Aberdeen Proving Ground, Report No. APG-MT-6007, May 1984.
4. Bunce, P., Silicon Operating System Modules Aid Real Time Control, Computer Design, November 1982.
5. Higgs, D., Structured Programming with Warnier-Orr Diagrams - Part 1: Design Methodology, BYTE, December 1977.
6. Boeuker, A., and Lieberman, G., Engineering Statistics, Prentice Hall, Inc., 1959.

APPENDIX D - ABBREVIATIONS

ADC	= Analog to digital converter
APG	= Aberdeen Proving Ground
BPI	= Bytes per inch
C	= Centigrade
CDF	= Cumulative distribution function
CPU	= Central processing unit
CR	= Camp Roberts
DBMS	= Data base management system
DRS	= Data retrieval system
DT	= Developmental test
EBCDIC	= Extended binary coded decimal interchange code
FHL	= Fort Hunter-Liggett
FOE	= Follow-On Evaluation
g	= acceleration due to gravity
HMMWV	= High Mobility Multi-Purpose Wheeled Vehicle
HP	= Hewlett-Packard
Hz	= Hertz
IC	= Integrated circuit
LPT	= Initial production test
MHz	= Mega-Hertz
MMS	= Mobility monitoring system
MRJE	= multiple remote job entry
mV	= millivolt
OT	= Operational test
PDF	= Probability density function
FROM	= Programmable read only memory
RAM	= Random access memory
RAM-D	= Reliability, availability, maintainability, durability
RMS	= Root mean square
RTE	= Real time executive
STE-ICE	= Simplified test equipment internal combustion engine
S2K	= System 2000
USACSTA	= US Army Combat Systems Test Activity
V	= Volts
VDC	= Volts DC
VPR	= Vehicle performance recorder
VRTX	= Versatile real time executive

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