FIELD RADAR & COMMUNICATIONS SYSTEMS BENEFIT FROM SINGLE DESIGN/MULTIPLE USE O & M TRAINERS

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Summary

Training devices have traditionally been dedicated to a single purpose: maintenance or operator training of a specified system. The success of the multipurpose field radar training devices delivered to a major training site has proven that the users are no longer tied to these limited concepts. Each training device consists of six training positions which can be used simultaneously to train any combination of: Radar Type 1 operators, Radar Type 1 maintenance, Radar Type 2 operators, and Radar Type 2 maintenance. Unique design of a single software program combined with the training exercises makes possible this multiple use, with a resulting reduction of the trainer development costs of over 40%. The trainer availability has been in excess of 99% and provides over 30,000 hours of student training time/year. This design flexibility also made it possible for the trainer to be used as an engineering tool when operational changes were desired on the tactical hardware. Operational procedures were developed on the trainer prior to specification development and implementation of changes on the tactical hardware. This greatly reduced the changes which normally occur during prime system design.

Additional multipurpose trainers are being built for systems such as a field position locating communication system, using the proven design concepts of the radar trainers. While full operational training is being conducted including simulation of complex test equipment at one or more of these training stations, advanced maintenance training can be conducted, at any or all of the remaining training positions.

A summary of the operation and maintenance training features provided by these multiple use trainers highlights the impressive potential of the single design for other training applications.

Status

Five radar trainers have been delivered and a sixth one is in final test. Due to the training requirement, three trainers were configured with the hardware for operator training only, one trainer was configured for operator and maintenance training for Radar Type 1, one trainer was also configured for operator and Radar Type 2 maintenance training. These five training devices each have six student positions with the ability to expand to eight by adding only the necessary man-machine interface hardware. The sixth trainer is for a foreign customer and will train operators and Radar Type 1 maintenance personnel. This training device will be delivered with four student positions. The number of student positions of each type was based on the number of students to be trained and the length of each training course.

Introduction

The field radar training device program required development and manufacturing of training devices to effectively and efficiently accomplish four major training functions:

1) Operator training for the Type 1 Radar Set

2) Operator training for the Type 2 Radar Set

3) Organizational maintenance training for the Type 1 Radar Set

4) Organizational maintenance training for the Type 2 Radar Set

The first two of these tasks were relatively easy to combine because at contract start it was decided a common operator position was to be utilized for both radars. In addition, the operator tasks for both radars were very similar, allowing for a single design with only slight differences based on the different performance characteristics of each radar.

The radar portions of the two systems, however, were considerably different. Although each radar contained the same basic elements, they were physically and operationally different requiring different maintenance knowledges and skills.

Cost reduction in the design of the two maintenance trainers was a challenge. It quickly became apparent that because of the physical differences, each simulated radar had to be designed to replicate the tactical hardware. However, it appeared that a savings could be achieved if portions of the software and hardware could be common.

The task analysis confirmed that a single operator position design was adequate for all trainer configurations and that separate designs were necessary for the Type 1/Type 2 Radar maintenance training positions. The analysis also identified that although the signal processors and system computers operated differently for each of the two systems, a single design was adequate because of the identical physical configuration. Figure 1 shows a summary of the common and unique hardware design elements determined by the task analysis. To meet the cost reduction challenge, a software design was created to permit use of common software for both the maintenance trainer and the operator trainer. This unique software concept was a significant departure from the traditional software design used for both tactical and training systems.

Software Concept

The traditional software design for a training device is dedicated to a single system and is hard coded to emulate that specific system.

The design concept utilized for these trainers was a change from this traditional design and represented a major risk, but the payoff of large potential cost savings made the effort an acceptable risk. The essence of this design -- labeled "Data Directed" -- was to separate the traditional software into two pieces as shown in Figure 2: 1) software and 2) exercises. The software contains the trainer functions which are common to all training tasks such as the ability to control lights, meters, displays, LED's, and sense potentiometers, switches, etc. In addition, the software contains the generic trainer functions such as performance recording, system status, student scoring, computer aided and management instructions, and exercise control. The exercise portion is the data base which contains those items that are specific to the training being accomplished. The exercise data base contains the emulation functions of the radar being simulated including the necessary operational characteristics, specific reponses to student actions, evaluation data, textual messages, grading, and instructor monitoring. Transitioning from traditional trainer software approach to this software and exercise data base required considerable design planning. Defining which items were generic to multiple systems, and which functions were specific to a given system, was a major prerequisite.

A partial result of this selection process is shown in Figure 3. An example is the turning on of a light. It is obvious that this is a generic action required on most 3D trainers. However, which light to turn on, and when, is specific to a given system and is therefore to be placed in the exercise data base. In addition, if the light is to blink, how many times or how long, will also be controlled by the exercise; the actual blinking (turning on and off) is in the software.

To display symbols, a similar software-exercise data base allocation must be performed. Each item to be displayed is modeled in software (including the ability to present the model on a CRT). The exercise data base, on the other hand, determines which model is to be displayed, where it should be positioned, and when the display should be started. The exercise continuously determines the position of all models. All trainer required functions are assigned to the appropriate software or exercise portions of the top-level design in similar fashion.

This allocation also defined requirements for an authoring language to create the data base. A form-oriented authoring language was developed for use by instructor personnel with no programming experience. Using this approach, it was possible to satisfy all functions for the four trainers in a single software design.

TRAINER HARDWARE DESIGN

		COMMON TO BOTH SYSTEMS	UNIQUE TO EACH SYSTEM
EXECUTIVE COMPLEX	COMPUTER	X	
	DISC	X	
	PRINTER	X	
	INSTRUCTOR STATION	X	
OPERATOR POSITION	WEAPON LOCATION UNIT	X	
	SHELTER POWER DISTRIBUTION	X	
MAINT POSITION	SIGNAL PROCESSOR	X	
	TRANSMITTER		X
	RECEIVER/EXCITER		X
	BEAM STEERING		X
	TRAILER POWER DISTRIBUTION		X

Figure 1. Results of Common Task Design Comparison Identifying Hardware Requirements

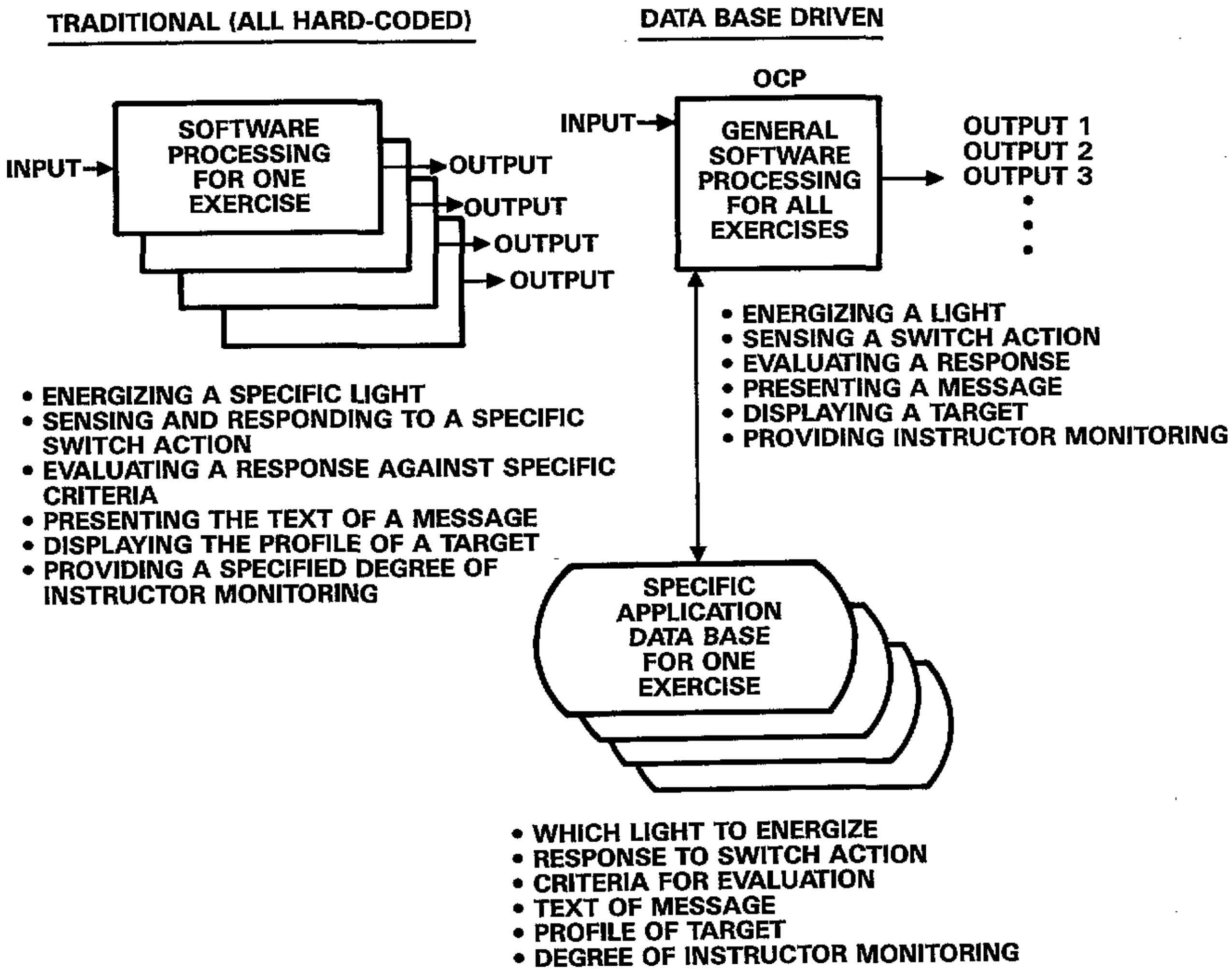

Figure 2. Comparison of Traditional Software Versus Data Directed Software Design

Function	Software	Exercise
Turn on Light(s)	X	
Identity of Light		X
When to turn on Light		X
Blinking of Light	X	
Frequency of Blink		X
Sense Switch Position	X	
Identify Switch		X
Identify Position of Switch	X	
Legality Check of Switch Action	X	
Legality Parameters		X
Actions resulting from Switch Action		X
Time to Start Display		X
Start Display	X	
Selection of Model to be Displayed		X
Model to be Displayed	X	
Position of Model to be Displayed		X
Positioning of Model to be Displayed	X	
etc.		

Figure 3. Decision Chart for Allocation of Control to Either Software or Exercise

Hardware Design

A flexible design that would support easy expansion was established as a primary hardware goal. Another goal was to maximize use of off-the-shelf hardware where appropriate. Figure 4 shows the hardware block diagram used to design the trainer. Delivery of five six-station trainers was required. Simultaneous control of eight student stations was a fundamental requirement. To satisfy the timing requirement, dual simulation processors were employed; each processor interfaces with four student positions and the other processor. The software was developed compatible with this configuration.

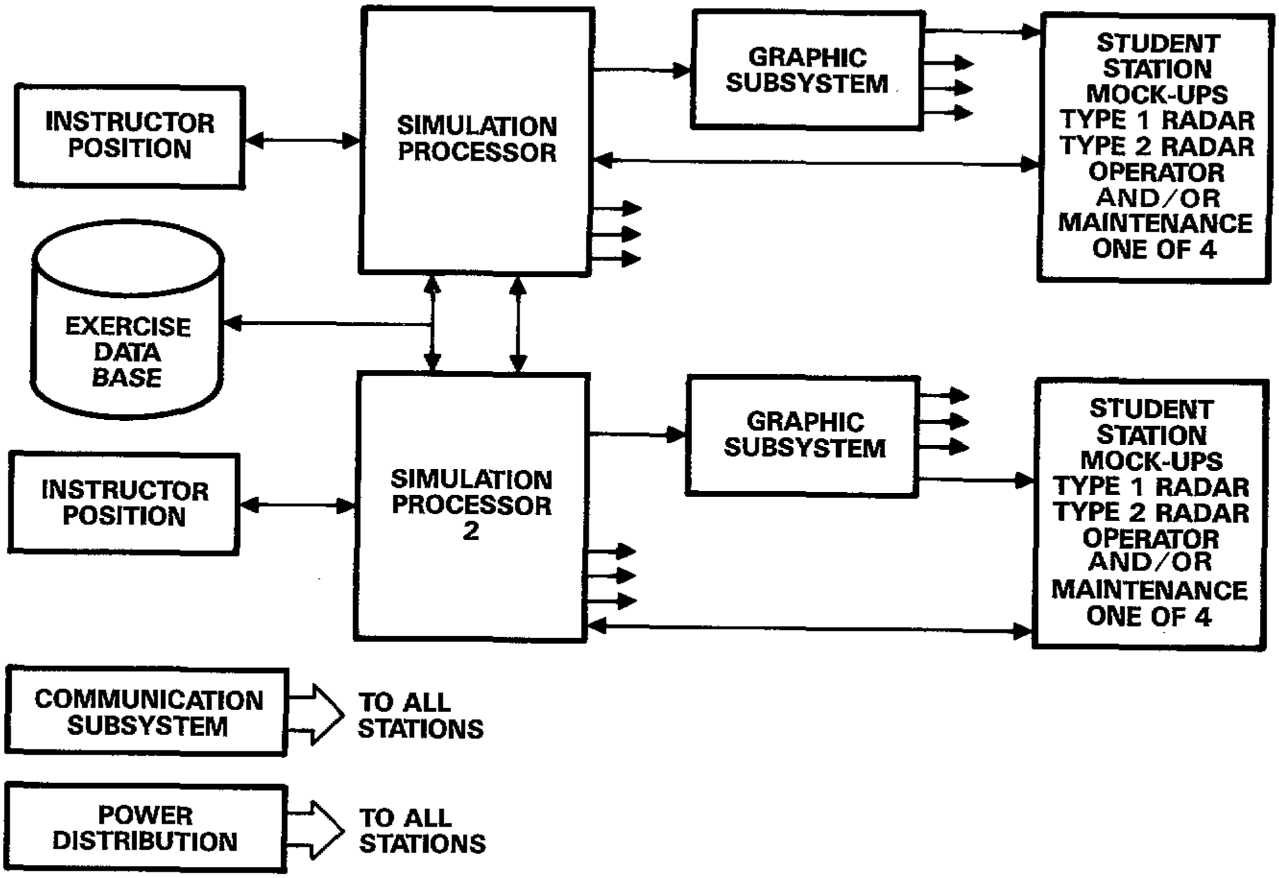

Figure 4. Field Radar Operator and/or Maintenance Trainer General Block Diagram

Figure 5 shows the training capability that can be accomplished on each of the five delivered trainers. The maintenance training limitations are strictly a result of the student station mock-ups provided.

	Operator Training		Maintenance Training	
	Type 1 Radar Operations	Type 2 Radar Operation	Type 1 Radar Maint.	Type 2 Radar Maint.
A17E11-1	x	x		
-2	x	x		
-3	x	x		
A17E12	x	x	x	
A17E14	x	x		x

Figure 5. Training capabilities of each of the five delivered field radar trainers

Benefits of Single Design

This unique design approach for hardware, software, and exercises provides tremendous advantages to the user in terms of configuration flexibility. It is possible to connect any of the maintenance trainer station mock-ups to an operator training position and conduct either maintenance or operator training. It is also possible to connect any combination of the maintenance and operator stations together and conduct simultaneous training. An example combination configuration is shown in Figure 6.

In this example, operator training can be conducted at all 8 stations in any combination of Type 1/Type 2 operator exercises. Also, using this example, Station 1 and 2 could be training Type 1 Radar operators; Station 3, Type 1 maintenance; Station 4, Type 2 Radar maintenance; Station 5, Type 1 maintenance; Station 6, Type 2 maintenance; Station 7, Type 1 maintenance; and Station 8, Type 2 operation -- all at the same time. If a station were to fail and required repair, the other stations would continue training without interruption while a special diagnostic "exercise" would be assigned to the down station to isolate the fault. Maximum training availability is achieved by fault isolation and repair of any station(s) without affecting any other station.

This design also provides ample instructional flexibility. Because each exercise is run and controlled independently, each station could run either the same or different exercises, each exercise matching each student's performance rate.

The centrally-located instructor station (See Figure 7), allows either instructor to control and monitor any of the eight student training stations. Summary data on the progress and status of all students, and detail data on one station, are available for selection by the instructor as shown in Figure 8.

Another benefit of this design is immediate and long-term cost reduction. An analysis of the cost of the design concept described here, compared with a more traditional concept revealed a cost savings of over seven million dollars for the delivered field radar trainers.

A high availability is another benefit for users. These trainers were delivered starting in 1979 and have been used continually on a multi-shift basis. During this period, the equipment has averaged over 7,200 available student station hours for training each month, with a 99.9 % availability. The system design is the reason for the high availability: when a failure occurs at a student station, only that station is down and training continues at all other stations while repairs are being made. Traditional trainer design would have required all training to be stopped while repairs were made.

Further Applications

This multiple-usage, common design concept has also been applied to the field position locating communication system trainers, now under development.

In addition to providing operator training, the communications trainer will also support maintenance skill development. Unlike the radar trainer, this trainer goes beyond developing normal organizational level maintenance skills, and features simulated frequency counters, oscilloscopes, and special test equipment as part of the training curriculum. The same software concept was used, however, because of the success of the radar trainers. Many enhancements have been incorporated including extensive CAI/CMI features and an improved authoring language.

Conclusions

High quality, fully interactive trainers are required for improved training effectiveness; however, the cost for these devices continually increases. To reduce costs, it is imperative that breakthroughs such as the design presented here be accomplished. Common design for multisystems must be considered as an alternative to new design for each new requirement.

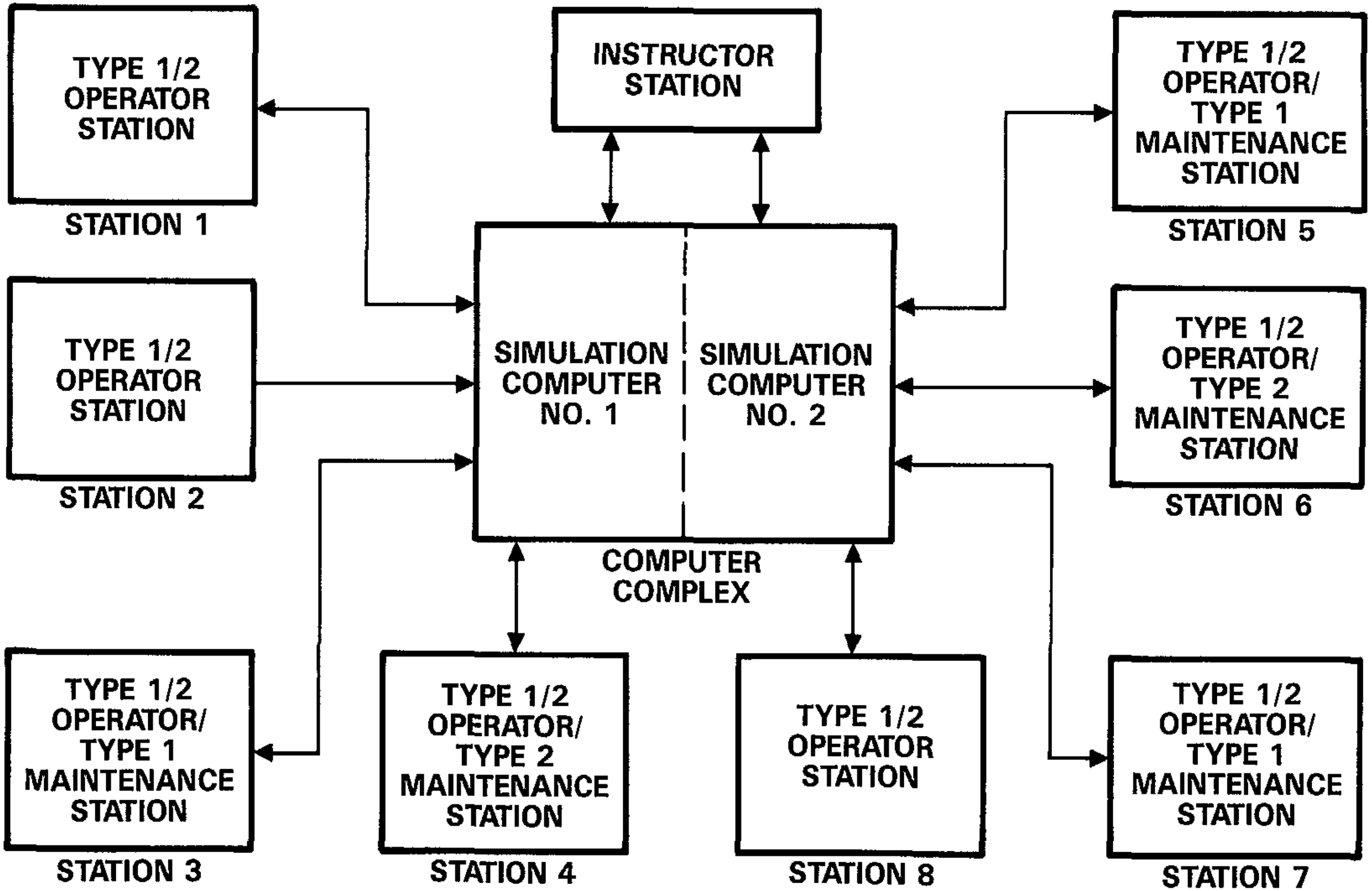

Figure 6. Flexible design allows for independent simultaneous operator and maintenance training for any system.

Figure 7. Instructor Station. The dual position instructor station can monitor and control any student station.

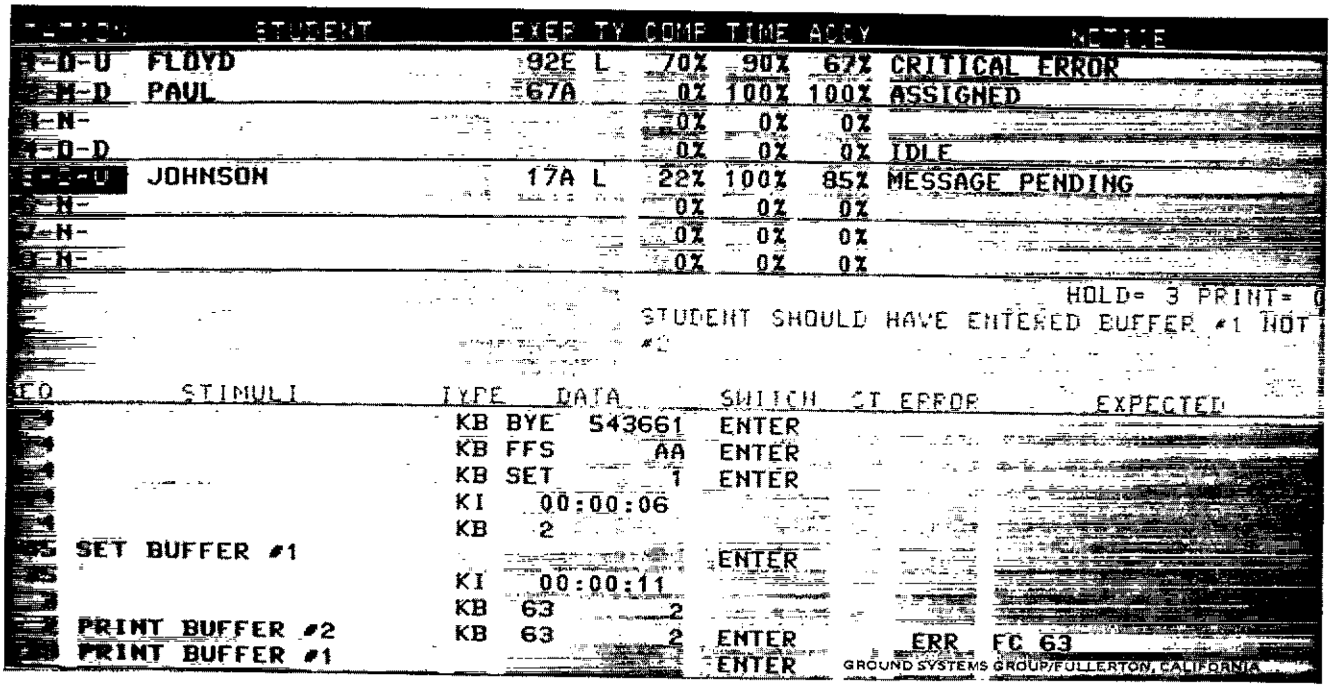

Figure 8. Instructor Display. The instructor can monitor at the summary level progress of eight students and the detail performance of one at any given time.

Biography

Mr. David J. Harbour is Manager of Simulators and Training Devices at the Ground Systems Group of Hughes Aircraft Company. He received his BS degree in Electrical Engineering from Oklahoma State University. Dave manages the Program Office responsible for on-going simulator and training device programs including Advanced Program Development. He was previously Program Manager for the Roland Institutional Training Devices and prior to that, Technical Director for the Firefinder Radar Training Devices. Prior to these assignments, Dave was responsible for the development of training material, instructional strategy, and course conduct for many defense systems.