INTERACTIVE GRAPHIC DISPLAYS --- FLEXIBLE DEVICES FOR TRAINER APPLICATION

MESSRS. J. E. YULE AND E. H. SCHAUWECKER

Honeywell Marine Systems Division
California Center

The advent of computer-based training systems has resulted in expanded potential for efficient and effective training. Application of the Interactive Graphic Display can enhance this potential. Its flexibility enables a wide range of display modes resulting in more effective instruction, realistic simulation and ease of maintenance. Additionally, system design can be optimized, changes to operational hardware can readily be accommodated, and support logistics simplified.

Graphic displays have been utilized during the past ten years in diverse applications ranging from air traffic control to support of research and development activity. An example of the former is the NAS Stage A Enroute Traffic Control system currently operating at several locations, while the Advanced Sonar Laboratory Display System (ASLADS), installed at NUSC/New London, is a typical example of the latter.

Operational hardware and special purpose CRT displays are currently used for a variety of trainer needs. However, relatively few applications of graphic displays have been implemented. Its utility for the Instructor/Operator position and simulation of operational hardware for the student position has been demonstrated by several contemporary training systems.

The Instructor/Operator application is typified by the I/O console for the ground-based simulator of the Undergraduate Navigator Training System (UNTS), Figure 1. Simulation of operational equipment as well as Instructor station utility is illustrated in the Device 14E24 Sonar Operator Trainer. Characteristics of these two applications are summarized in this paper.

INTERACTIVE GRAPHICS

Interactive Graphic Displays can be generally categorized as either random scan or raster scan. The random scan or direct write display forms images on a CRT by drawing continuous vectors of any length between two program controlled locations (or characters, dots, and circles) within specified boundaries of the tube screen. Typically, the addressable locations are defined by a 1024 x 1024 matrix. Higher resolution is available but few applications justify this refinement. Random scan displays are capable of forming solid, structured, or curved line images, symbols, and characters. The image is refreshed at rates from 30 to 60 times per second to avoid display flicker. Random scan graphics are particularly effective in applications where high quality, continuous lines and images are necessary.

The typical interactive graphic system contains a display controller to access, decode, and interpret data from a refresh memory. The contents of this memory are regularly updated by the computer as the problem or situation changes. Decoded signals operate on a series of function generators that cause CRT beam movement. Typically, the controller contains vector, arc, dot, and character generators and the required hardware to control display intensity and structure.

There are various input devices enabling the user to indicate to the computer that he wishes to take some action on the display data. Keyboard depressions produce specific codes that are sent back to the computer. A light pen provides identification of the displayed data that it "sees"; i.e., the computer knows where the light pen is pointed. These devices are used to interact with the data presented on the screen of an interactive graphic display, permitting a full dialogue between user and computer. Because the data displayed on the screen are stored in a random access buffer, they can be easily updated. Periodic updating of the location information causes "movement" to occur on the screen, permitting display of dynamic data. This is not possible with other output devices.

The Raster Scan Display creates a picture in a manner analogous to conventional television. Discrete elements of a fixed matrix, usually 512 x 512 or 1024 x 1024, are sequentially addressed under computer control. Images are formed on the CRT by a combination of location and intensity signals. In the case of graphics, the result is a dotted line approximation of the various picture elements. The raster scan display has found wide application where the predominating requirement is for the display of text material or irregular approximations of continuous lines can be tolerated.

For precision, multimode display uses such as those described in this paper, the random scan graphic display is generally considered superior to the raster scan.

INSTRUCTOR/OPERATOR APPLICATION

To successfully achieve the objectives of any trainer, on-the-job performance of the Instructor/Operator must remain at a high level. As technological aspects of the problem and operational equipment become more sophisticated, demands on the skills of the instructor increase. Concentration on the trainee's progress cannot be diluted by

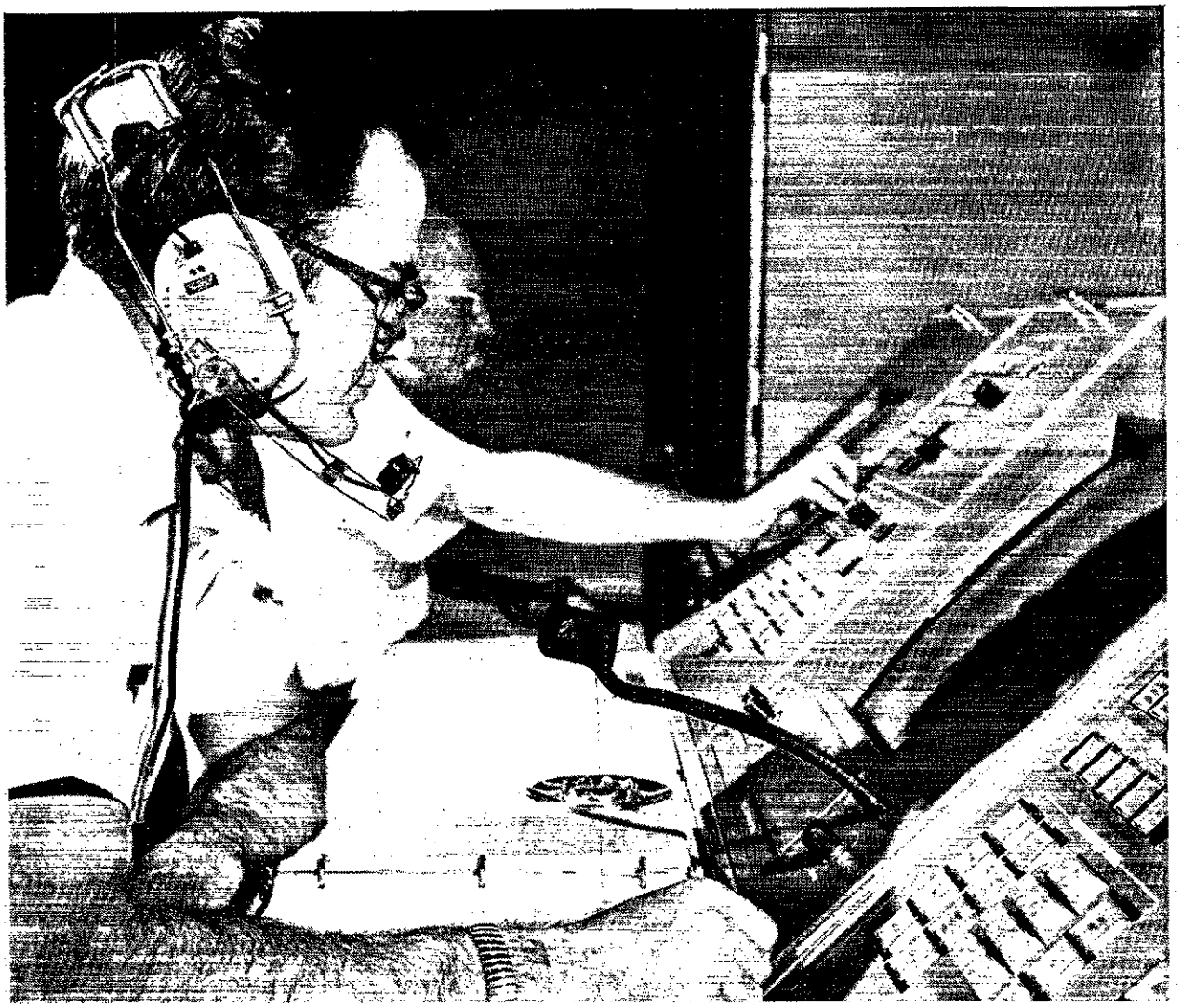


Figure 1. Instructor and Operator Consoles

inadequate information or a presentation that is not readily perceptable in a dynamic situation. The high quality image characteristics of the random scan type display assures minimum instructor fatigue during extended periods of training. As experience with the trainer grows, changes in training techniques and procedures are to be anticipated and accommodated. The inherent flexibility of the graphic display provides the potential to meet the total life requirements of many instructor and operator applications.

A noteworthy example of the utilization of random scan graphics for the Instructor/Operator function is in the console of the ground-based simulator for the Undergraduate Navigator Training System (UNTS) A/F37A-T45. This simulator is composed of 13 student complexes and supporting computational equipment. Each student complex contains instructor and operator consoles, four student stations, and computer and interface cabinets. The four student stations are arranged in a fan-shaped array, emanating from the eye-point of the instructor who needs to visually monitor all four students. The operator's console is adjacent and to the right of the instructor's console, as shown in Figure 1. All students in one complex train on the same mission. During a mission, the student is independent of other students and is able to fly anywhere over the continental United States not exceeding 70,000 feet altitude or MACH 2 airspeed.

The Instructor and Operator consoles are identical. Figure 2 illustrates major features of these stations. The graphic display on the left has a 21" rectangular CRT. The special control panel on the right functions in conjunction with the display to control mission and aircraft parameters, operating mode, and interstation communications. The Instructor and Operator displays are driven by a single display controller, the 25 millisecond refresh period of which is time-shared by the two CRTs (Instructor and Operator).

The instructor is responsible for conducting pre-flight preparation, mission selection, malfunction insertion, evaluation of student performance, and post mission critique. He works closely with the operator to ensure a coordinated realistic mission. The operator is responsible for mission control, ground control, enroute control, and functions as the pilot. An actual photograph of the operator's CRT presentation is shown in Figure 2.

The instructor and operator CRT screens are segmented into three data areas:

Lower Horizontal - Display of weather, time, and mission profile. This is displayed to both the instructor and operator.

Right Vertical - Display of student-related data to the instructor; control and aircraft-related data to the operator.

Center and Upper Left - Symbolic geoplot of aircraft, flight path, corridor, waypoints, weather fronts, and navigational and communications ground stations.

In a non-training mode, text form results of a system level diagnostic maintenance program can be displayed at either station.

The operator will occasionally function as the instructor while the instructor works with an errant student. Similarly, the instructor may assist the operator during the early and late phases of a mission where there will be more communications per student than is normally experienced. This flexibility of function between the instructor and operator demands that information needed for one role can also be selected by the other. The multipurpose console accommodates either an instructor, an operator, or one of the two performing both roles. The advantages of such a multipurpose console are:

1. Flexibility and enhanced reliability -- One console can back-up the other in case of console malfunction.

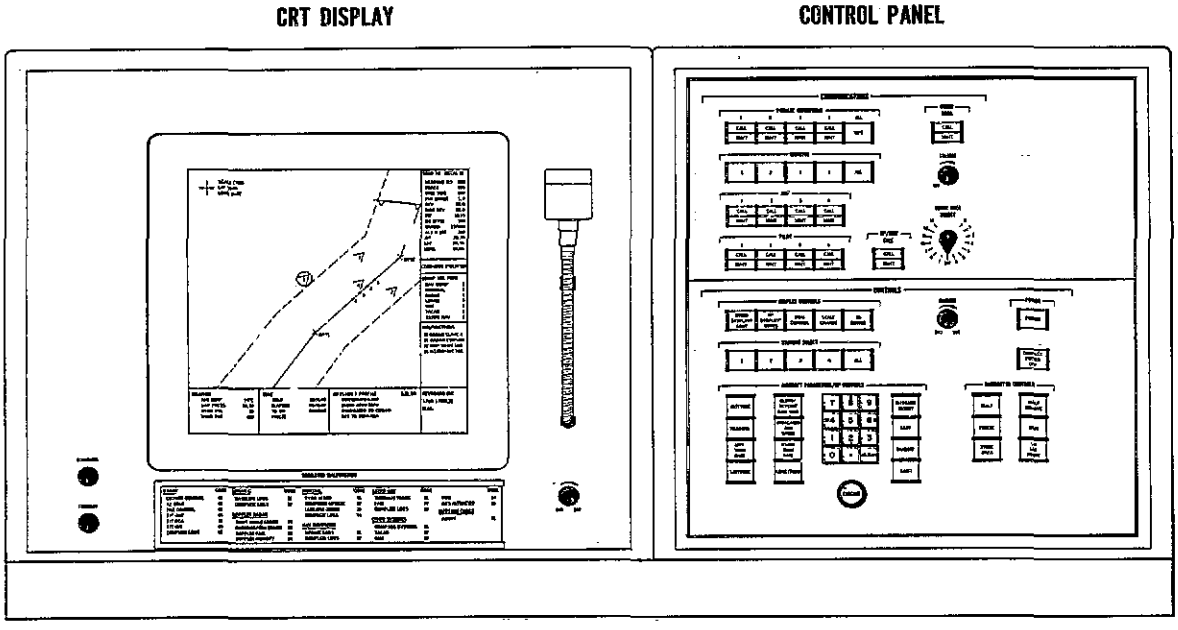
2. Cost effectiveness (less design and construction cost) -- Since there is only one multipurpose console, only one set of schematics is needed for maintenance tasks.

3. 1:2 instructor-to-student ratio -- The design allows this advantage if needed.

SIMULATION AND SYSTEM APPLICATION

An excellent example of the manner in which an off-the-shelf, standard graphic display was adapted to a trainer application is the Device 14E24 (PAIR) Sonar Operator Trainer. This system is designed to provide proficiency training of Navy sonar men through simulation of the shipboard operational AN/SQQ-23 Sonar Set. Device 14E24, which can simultaneously train two separate sonar crews, consists of two Operator (student) stations, an Instructor Console, associated interface hardware, and three H716 computers. The computers control digital simulation of audio/video sonar signals.

Two standard Honeywell S-50 interactive random scan graphic displays with six CRT monitors have been modified for this trainer. Device 14E24 design represents the first application of an interactive graphic display and data entry keyboard in an ASW trainer Instructor Console to provide problem control and display of student performance data for



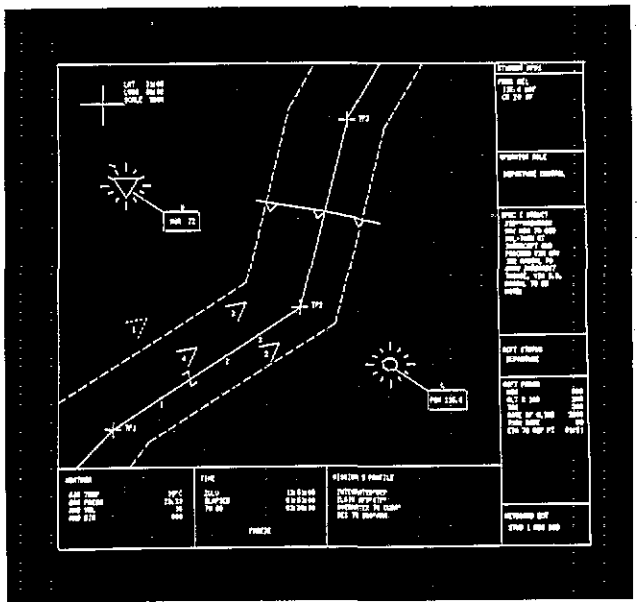


Figure 2. Instructor and Operator Console -- Layout and Display

monitoring. The student station has an interactive capability that permits the student to operate in a closed loop mode. As the student correctly responds to the problems presented, increased complexity can automatically be added.

Figure 3 depicts the trainer configuration. The instructor is situated in a position where he can observe both his displays and his student's activity. The round display functions as either an instructor display or as a repeater of the student's operational display. This allows the instructor to carefully evaluate the student and isolate the training problems on an individual basis without disrupting the activities of other students.

Device 14E24 contains two graphic display processors. During normal operations, one computer drives one processor and its three monitors while the second computer drives the other processor and its three monitors. In a backup operational mode either computer can be utilized to control the displays in two student positions plus both portions of the Instructor Console.

The design of the display system for 14E24 incorporates adaptor hardware providing capabilities not normally available in a standard graphic display. Timing studies clearly showed that a special scan mode of operation would be required. This "psuedo scan" mode gives the appearance of simulating conventional sonar scan presentations.

The system requires the display of a very complex composite image. Figure 4 shows typical types of patterns that are combined to create the desired display. An analysis of the various display subsections is listed as follows:

DISPLAY	GRAPHIC CONTENT/TIMING	DISPLAY TIME
A	173 Short Absolute Vectors/9.8 μs each	1.7 ms
B	210 Incremental Vectors with average length 0.2 inch/7.7 μs each	1.6 ms
C	400 Incremental Vectors with average length 0.1 inch/7.7 μs each	3.1 ms
D	1960 Short Absolute Vectors/9.8 μs each	19.2 ms
E	1960 Short Absolute Vectors/9.8 μs each	19.2 ms

The pseudo scan mode permits a flicker free presentation of the data tabulated above. Without this feature, the display frame period would exceed the 25 ms allowable for a 40 times per second refresh rate of the composite display. Pseudo scan also permits data compression of this type display. Programmable gain variation has been incorporated to allow for uniform display of the composite data within the physical constraints of the CRT.

B-Scan presentation is full screen consisting of 240 horizontal lines representing range with 48 elements per line. Any element in the display can be presented with high, medium, or low intensity or blanked.

The Geoplot presentation gives the instructor an overview of the problem as it has been developed. Special symbology is used to define simulated elements of the exercise. The instructor can realistically evaluate the students capability for discrimination and identification of targets.

Random scan graphics have the inherent capability to operate in the many modes required for this trainer application. A standard system was adapted to satisfy the unique requirements. Several significant changes have been accommodated through software modification since hardware design was frozen. Future growth potential can materially contribute to economical change during the life span of the system.

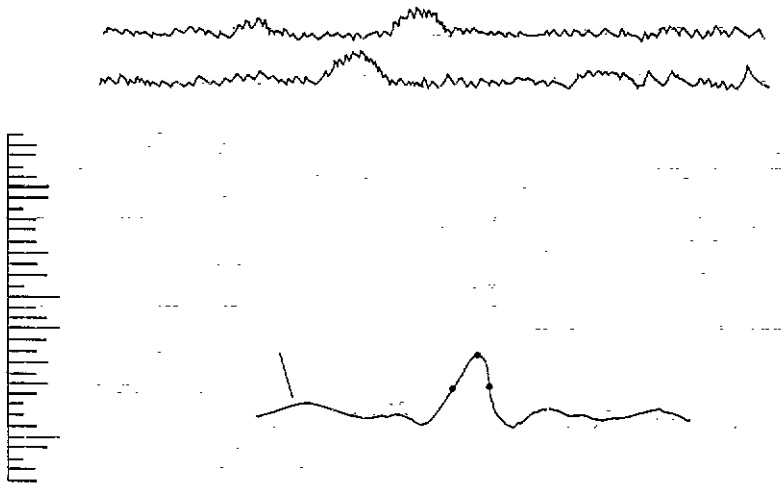
EXPANDED APPLICATIONS

The potential of random scan graphic displays as illustrated in current trainers should provoke further consideration as an effective tool in achieving economic training in many future applications.

Expanded use of interactive devices such as the light pen and track ball can simplify instructor and operator task loads in setting up student situations and identification of events. The optional color monitor can ease the instructors tasks by simplifying the observation of the performance of several students simultaneously. Replay and evaluation, particularly of dynamic tactical events, could be significantly enhanced.

The random scan display can operate in a combined mode wherein a TV-type scan background is overlayed with directly written vectors, symbols, and alphanumerics. Instructor observation of student behavior or similar features could be added to assist the instructor in evaluating the student's performance.

The graphic display has the capacity to "draw" a large amount of changing, relevant information. In-process computer aided analysis of student performance, accompanied by appropriate displayed alerting signals to the instructor, can serve to tighten the feedback



TYPICAL PATTERN TYPES

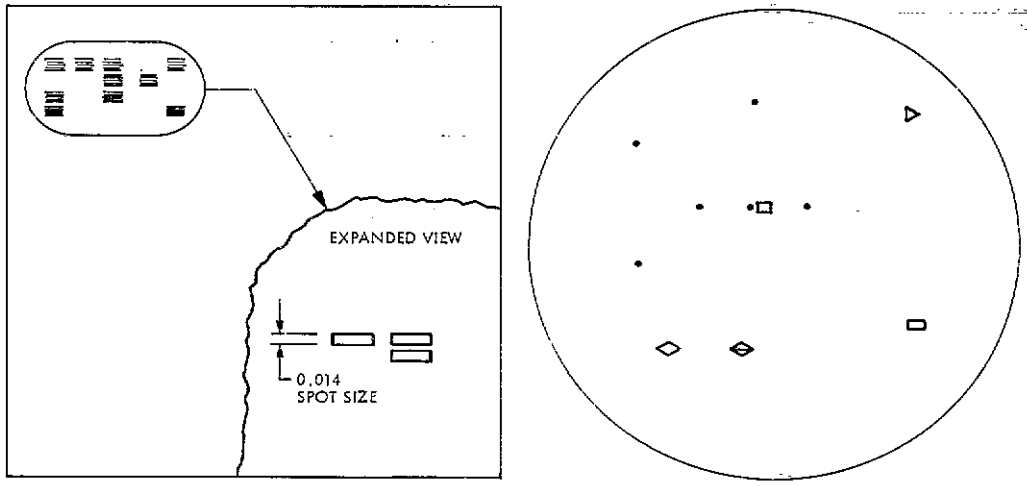


Figure 4. Device 14E24 Student Station – Simulation Patterns

ABOUT THE AUTHORS

MR. JOHN E. YULE is presently employed by Honeywell Marine Systems Division with responsibility for management of the S-50 Graphic Display Program. Prior to his present assignment, he was Program Manager of data entry system developments and design of test and maintenance equipment for Apollo, Mariner, and C5 projects. Mr. Yule received his Master of Engineering from UCLA, M.S.E.E. from University of Wisconsin, and B.E.E. from Marquette University. Mr. Yule was previously employed by Lockheed California Company as Staff Engineer with responsibility for test and logistics support of advanced reconnaissance aircraft and ASW system design. He held prior positions at Marquette University and Western Electric Company. He is a member of HKN, IEEE, SID, and is a registered professional engineer.

MR. ERWIN H. SCHAUWECKER is a project engineer at Honeywell Marine Systems Division where he is responsible for development and production of graphic display systems including the S-50 project line. Prior to this assignment, he participated in the systems and hardware design of the UFCS Mk 116 and its test equipment. Mr. Schauwecker has an M.S.E.E. from the University of Southern California, a B.S.E.E. from Ohio Northern University and is currently pursuing an M.B.A. program at the University of Southern California. Mr. Schauwecker was previously employed by Hughes Aircraft Company where he designed a modification to the AN/SPA-25 to improve its operation in high ambient environment; provided design improvements for the AN/UVA-4, AN/SVA-4; and was instrumental in the development of the 48-position rear projection readout. Other Hughes design experience included computer-controlled status display panels, a video signals simulator, and several video mapping devices which incorporated flying spot scanners. He is a member of TBII, SID, IEEE, and CSPE/NSPE.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NAVTRAEQUIPCEN IH-240
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER:

4. TITLE *(and Subtitle)*: SEVENTH NTEC/INDUSTRY CONFERENCE PROCEEDINGS 19-21 NOV 1974

5. TYPE OF REPORT & PERIOD COVERED: Final

6. PERFORMING ORG. REPORT NUMBER:

7. AUTHOR(s): Key Personnel--Naval Training Equipment Center and Industry

8. CONTRACT OR GRANT NUMBER(s):

9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Training Equipment Center, Orlando, Florida 32813

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: WA 6924

11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Training Equipment Center, Code N-423, Orlando, Florida 32813

12. REPORT DATE: November 1974

13. NUMBER OF PAGES:

14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*:

15. SECURITY CLASS. *(of this report)*: UNCLASSIFIED

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:

16. DISTRIBUTION STATEMENT *(of this Report)*: Approved for Public Release; distribution unlimited

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*:

18. SUPPLEMENTARY NOTES:

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*:
Conference--NTEC/Industry
Industry
Military
Simulation Technology
Training Device Technology
Training Methodology

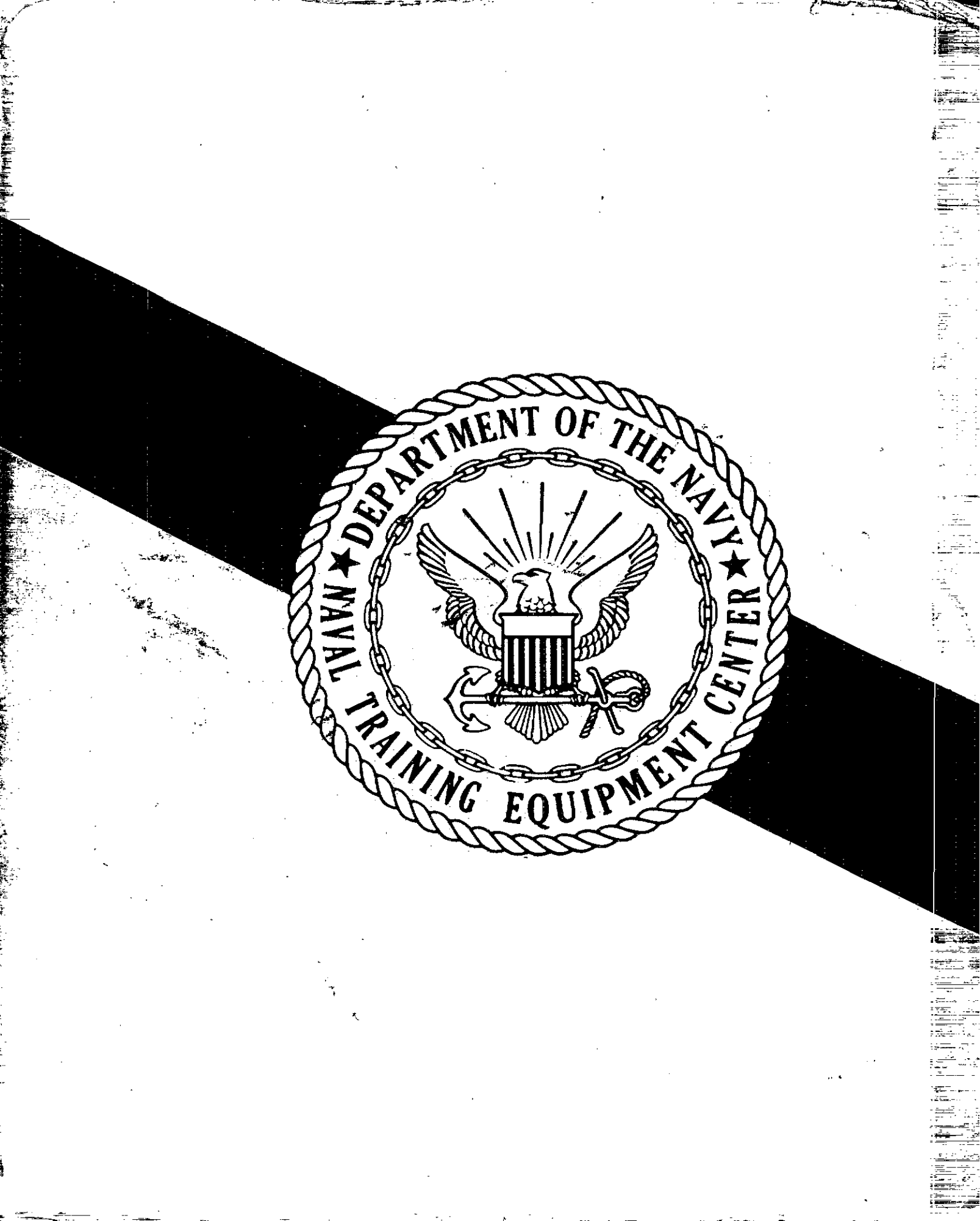
20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*:
A compilation of papers on a variety of technical and training subjects related to training device technology and training methodology. The enclosed papers were presented at the Seventh NAVTRAEQUIPCEN/Industry Conference held 19-21 November 1974. The conference theme "Training Economy Through Simulation" provides a common base for the examination and discussion of the various aspects of simulation that can and will be utilized to solve today's training requirements through the economy of simulation. The seventh conference is part of a continuing program to promote cooperation between Government and industry in

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

the procurement of training equipment, and to foster an exchange of ideas on new simulation technology.


DEPARTMENT OF THE NAVY
NAVAL TRAINING EQUIPMENT CENTER