NAVAL SUBMARINE MEDICAL RESEARCH LABORATORY

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OPERABILITY EVALUATION OF THE ISPE CONTROL STRUCTURE

by

Arthur N. BEARE and George MOELLER

Naval Medical Research and Development Command
Research Work Unit M0100.PN.001-1009

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R. A. MARGULIES
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SUMMARY PAGE

THE PROBLEM

To determine the degree to which the design of the multifunction switching system employed for system control and data entry in the ISPE submarine sonar system allowed rapid, flexible, and error-free operation of the system.

FINDINGS

The analysis was confined to controls associated with displays available in the *search* and *class-loc* configurations. All functions desired by the operators were readily accessible. Analysis of errors revealed that it is very easy to misfile information or assign resources to the wrong contact. There were a number of errors traceable to control labels that were not as informative as they might be, and one instance in which the same label was used for controls having different functions. There were three instances in which limitation of access to controls when in the *hooked* mode appeared to be counterproductive. It was suggested that the sonar threat acknowledgement functions be made more flexible. The overall operability of those parts of the control structure tested was judged to be very good, and operation of the system appeared to be very easy for men familiar with the principles of sonar to learn.

APPLICATION

The report recommends ways of correcting deficiencies noted, and the identification of problem areas will aid designers of future systems.

ADMINISTRATIVE INFORMATION

This investigation was conducted as part of Naval Medical Research and Development Command Research Work Unit M0100.PN.001-1009, "Human Factors Evaluation of ISPE Operator Performance." The present report was submitted for review on 26 February 1981 and approved for publication on 12 May 1981.

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ABSTRACT

Eight experienced FBM sonar operators participated in an evaluation of the "operability" of the multifunction switching system employed for system control and data entry in the ISPE submarine sonar system. Operability was operationally defined in terms of the availability of controls for desired functions and the number and kinds of errors associated with control usage. The sonarmen were individually instructed in system operation for three days and then participated in two days of testing in which they employed the simulated system in two multi-contact scenarios.

The analysis was confined to controls associated with displays available in the *search* and *class-loc* configurations. All functions desired by the operators were readily accessible. Analysis of errors revealed that it is very easy to misfile information or assign resources to the wrong contact. There were a number of errors traceable to control labels that were not as informative as they might be, and one instance in which the same label was used for controls having different functions. There were three instances in which limitation of access to controls when in the *hooked* mode appeared to be counterproductive. It was suggested that the sonar threat acknowledgement functions be made more flexible.

The overall operability of these parts of the control structure tested was judged to be very good. Operation of the system appeared to be very easy for men familiar with the principles of sonar to learn.

OPERABILITY EVALUATION OF THE ISPE CONTROL STRUCTURE

The acronym ISPE stands for Improved Sonar Processing Equipment, the developmental name for a system intended to upgrade the sonar capabilities of 616 and 640 class fleet ballistic submarines in service in the 1980-early 1990 time frame. The first units will join the fleet in 1982 as the AN/BQQ-8[1]. The system provides centralized digital processing of signals taken from currently installed sonar arrays, the AN/BQR-7, the AN/BQR-21, and the AN/BQR-15, thus simplifying the problem of retrofitting. In place of the collection of dedicated display units associated with the current signal processors, displays and system control are accomplished by means of three general-purpose consoles analogous to those used in the AN/BQQ-5 and 6 sonars. In addition to improved signal processing, ISPE incorporates several new features such as automatic motion analysis for all contacts. These new features, combined with the desire to exploit the flexibility afforded by all-digital signal processing, have resulted in a system that is both more capable and considerably more complicated than the combination of equipment it replaces.

The operator interface in ISPE consists of three identical improved sonar operator display (ISOD) consoles in the sonar shack and a single improved commanding officer display (ICOD) located in the control room. The ISODs are general-purpose units having two vertically arrayed cathode ray tube (CRT) displays and associated controls. The majority of operator actions are performed by means of a multifunction switching system (MFS), which takes the form of a row of ten push buttons (termed variable action buttons or VABs) below each of the CRTs. A label describing the current action of each VAB is written in the function label field at the bottom of each display. Additional ISOD controls are mounted on the console's desktop panel. These consist of a small number of dedicated switches, termed fixed action buttons (FABs), a key pad for numeric entry, and two cursor controls; a stiff stick for the vertical and horizontal data reading cursors and a set of four directional buttons for the index cursor, which is used to select items from displayed menus. The ICOD has one CRT and associated controls. It is a functioning operator console (although system software restricts ICOD access to some functions) instead of the usual simple repeater.

In June of 1978, the Naval Submarine Medical Research Laboratory was requested by OPNAV to conduct an independent evaluation of the operability of the ISPE system. Such an evaluation falls naturally into two parts: analysis of displays, which consititute the systems' output (Kinney, et al, 1980), and analysis of the controls by which the system is configured and operated.

A majority of the control functions in ISPE are implemented by means of the multifunction switching system. The AN/BQQ-5 and 6 submarine sonar systems employ a MFS system that is conceptually similar, although implemented in a somewhat different fashion. It was thought that operators has experienced difficulty in learning and operating that system. Thus OPNAV was specifically concerned with the operability of the MFS system employed by ISPE. The investigation reported here was undertaken in response to this concern.

The defining feature of a multi-function switching system is that a small number of physical input devices (e.g. push buttons) are used to control a larger number of functions. This results in a considerable saving of control panel space and may be the only practical way to manage a complex system where literally hundreds of control actions are required.

An obvious but absolutely critical consequence of the many-to-one mapping of functions onto controls is that not all functions are accessible at any one time. What is accessible may be controlled manually, by a separate selector, or it may change automatically with different options succeeding one another as controls are activated. In the ISPE system, control functions are grouped to support tasks associated with the type of information being presented on particular displays. The system couples manual selection of displays with automatic succession of controls for functions related to that display.

One important consequence of automatic succession is that the order in which functions become accessible imposes an order of activation. In many cases, this is appropriate and beneficial because it precludes out-of-sequence activation. However, many controls are not activated in pre-determined sequences, but in response to the situation with which the operator is dealing. When automatic sequencing is employed, the designer must insure that it does not place a control out of reach at a critical moment. Thus the simple availability of desired controls is a major determinant of system operability.

The evaluation reported here concentrated on two aspects of the implementation of the ISPE multifunction switching system. The first of these was the simple availability of the desired functions: that is, would the control structure allow a knowledgeable sonarman to prosecute a contact in a simple and straightforward manner? The second focus of the evaluation was to determine which elements of the control structure were awkwardly implemented or likely to result in operator error.

Approach

It was decided to test the operability of the ISPE control structure by means of a simulation. Experienced sonarmen were to use the simulated system as best they could to prosecute a number of contacts in a fairly complex situation. It was felt that their comments and the problems they experienced in the simulation would be the best indicators of potential problems to be encountered by later users of the actual system.

Since a functioning ISOD was not available, and the dynamic simulation of sonar data would, in any case, have been prohibitively expensive, a very limited simulation was used in this study. A computer program developed by NUSC, New London, simulated the succession of available controls. Displays were simulated by photographic reproduction of the line drawings presented in the Functional Operational Design (FOD) documents. Two multi-contact scenarios were developed and read to the operators in a step-by-step fashion. Operators were told of various events visible on the displays but otherwise no attempt was made to simulate sonar data. Although hardly lifelike, this form of simulation has distinct advantages. Problems in interpreting and manipulating the control structure are not masked by other problems which might overshadow them in an operational evaluation. That is, the hardware is assumed to function properly and the displays are always easy to read. The operator is free to concentrate on a single question: *Will this system let me respond as I think this situation demands?*

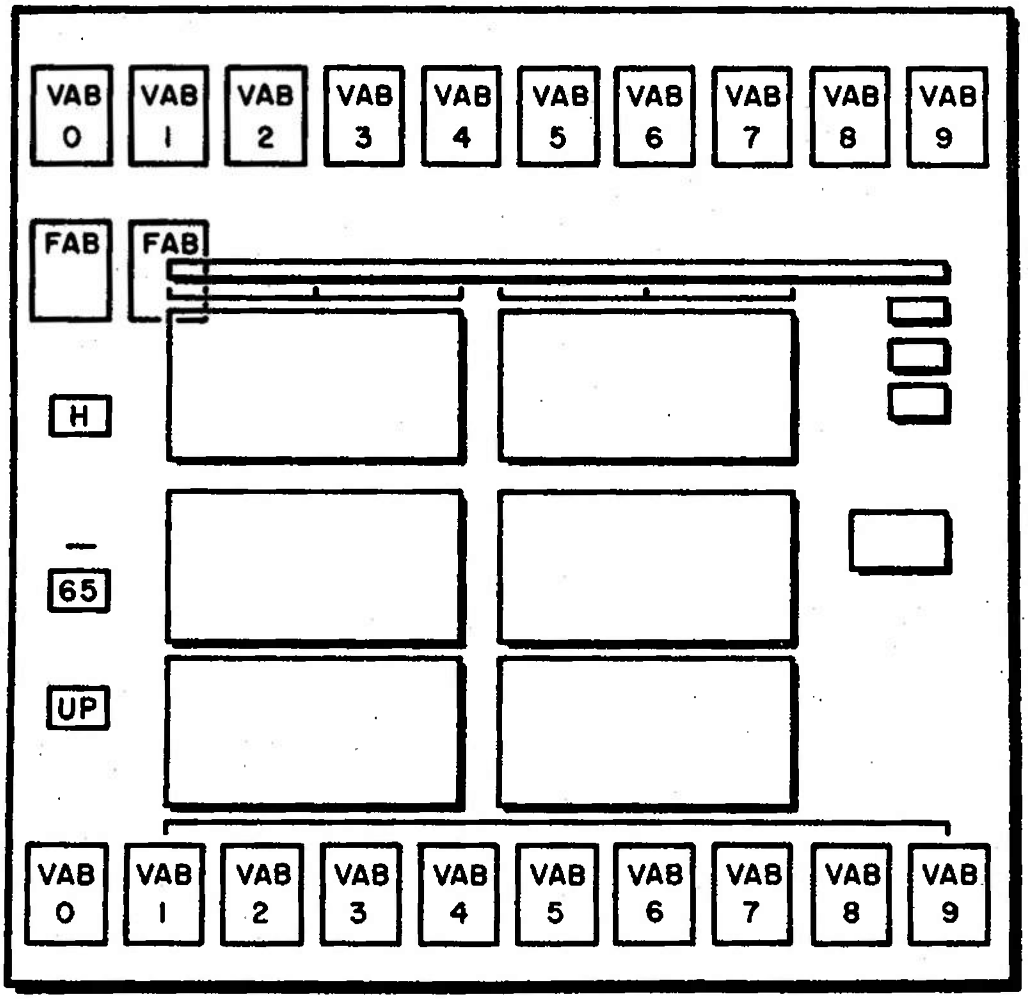
Materials

The major piece of equipment used in the evaluations was a Magnavox *Orion 60* plasma display terminal. This is a desk-top unit with a conventional keyboard and an 8.5 x 8.5 inch display surface. The display is of the dot-matrix type and is thin and transparent, which allows graphics, in the form of 35 mm slides, to be superimposed by means of a projection system behind the screen. Standard alpha-numeric characters are formed from a 7 x 9 dot matrix and are approximately 3.8 mm tall. The display provides 32 lines of 64 characters. The characters are orange: an orange filter was used to match the color of projected slides to that of the alpha-numerics. The *Orion 60* has a "touch panel" feature. Subjects could thus select a control by simply touching the appropriate label on the screen, or by pushing the associated key on the keyboard.

The ISPE control structure was simulated by means of the NUSC "Button Tree" program. This program writes the VAB labels associated with each display. When a control is selected, the labels are re-written to reflect the options that become available upon activation of that control. The program also gives those error cues the system would generate when an illegal operation is attempted, although it does not provide unsolicited cues to the operator. The VAB labels provided by this program were shortened from a maximum of 8 characters to a maximum of 5 so that all ten VABs could be printed side by side on the face of the display screen used for the simulation[2]. VAB labels for the upper CRT were written at the top of the Magnavox screen and those for the lower CRT at the bottom. The NUSC program also simulates the actions of the set of fixed action buttons (FABs). The last selected FAB was written against the left edge of the display just below the upper row of VAB labels. The "enter" and "sonar threat" FABs were produced with a line of *X*s to indicate illumination of the switch. In order to minimize display re-write time, the blanking of VABs when a numeric entry is pending was eliminated. In addition to the VAB and FAB labels, a *hooked-not hooked* indication was added to the display for the convenience of the operator.

The "Button Tree" program was executed on the UNIVAC 1108 computer at NUSC, New London. The display terminal was connected with the NUSC computer over a 300 baud telephone link. Rewriting the display required approximately one minute, sometimes much longer if the time sharing load on the computer was heavy.

Figure 1



Schematic of the display as it appeared to the subject. Current VAB labels for the upper and lower CRTs are represented by the rows of rectangles at the top and bottom of the screen. Activated FABs were written below the upper row of VABs. The small rectangles at the left edge of the screen contain (from top to bottom): the hooked-not hooked flag, a count of the control actions to date, and a marker indicating whether the drawing displayed represents the upper or the lower CRT (the *Broad Band Search* display is shown).

The display as it appeared to the subject is shown schematically in Figure 1 (facing). The rows of squares at the top and bottom represent VAB labels; the two squares below the top row of VABs (on the left) represent currently active FABs. A projected line drawing of the broad-band search display is drawn in thicker lines. The three small boxes at the left (beneath the FABs) represent (from top to bottom) the *hooked-not hooked* flag, a number showing the count of control actions so far completed, and the "upper-lower" marker (see below).

The ISPE displays were simulated by 35 mm slides of line drawings of the displays presented in the FOD. These were rear-projected onto the face of the computer terminal by a Kodak Carousel slide projector which was also controlled by the program. Since only one slide, representing one of the two displays that was "visible" to the operator at a particular moment, could be displayed, the program selected that slide associated with the last activated VAB. A marker appeared on the screen indicating whether the slide being shown represented the "upper" or "lower" display. By touching this marker, the subject could change the slide displayed to that of the other display screen.

No attempt was made to simulate the sonar data pictorially. Instead, the subject was told what was being displayed, e.g., "you have a new trace at 070° on the left data field."

Two multi-contact scenarios (presented in Appendix A) were worked out in detail for use in the operability evaluations. These were designed to provide a large variety of sonar events with which to test the flexibility of response allowed by the control structure.

The scenarios were modeled after the TRACOR "No-Fault" and "Decision-Making" scenarios developed by J. L. Bryant (1979a, 1979b), but were more complicated in that they incorporated maneuvers by own ship and several of the contacts. The detection ranges and contact characteristics were realistic, but no attempt was made to closely model the expected physical performance of the ISPE system. A further note of realism was injected by having own ship manuever so as to avoid coming within counterdetection range of the threat contact (which was never allowed close enough to be detected on broad-band).

The scenario events were translated into a list of display indications. Two versions of each scenario were prepared, one listing display indications of the displays of the *search* operator console and the other listing events on the *class-loc* console. No attempt was made to test the adequacy of controls used only or primarily by the supervisor. It was felt that operability of the supervisor's station was less critical in that it would be manned by the most experienced operators, and the time available for training and testing did not allow simulation of all aspects of such a complex system.

The scenarios were read to the subjects one step at a time by the experimenter, who recorded the subject's comments and errors.

A computer program was written to simulate the Contact Status Display (CSD). This program was updated whenever an operator assigned a tracker, correlation or classification channel, or entered classification information via the Class Menu Display. Every 15 minutes of scenario time, the simulated CSD was updated to reflect the motions of all contacts. Printouts were available to the subjects whenever they desired to see them.

Three sets of training materials were used to familiarize the subjects with the operation of the system and the action of each of the controls:

(a) A set of materials describing each display and associated controls were prepared by NSMRL project members. These described the display layout and the functions of each VAB. Subjects were instructed to read through these descriptions and to work through the controls at the display terminal, going over the material on each display until they were comfortable with the controls and their actions.

(b) A "Common Procedures" handout was made up, listing the control sequences required to perform the separate actions, such as assigning a tracker or assembling a signature, by means of which the operator may prosecute a contact. Again, subjects worked through the "procedures" handout on the terminal, pushing all of the buttons in sequence.

(c) The TRACOR Corporation had prepared a set of scripts stepping through each control action in the prosecution of a single contact (Bryant, 1979a). These "No Fault" scripts (modified to reflect the keyboard characters associated with each control on the *Orion 60*) were used as the final step in training. The experimenter read the script to the subject who (usually) attempted to perform the required actions without looking at the script, though it was consulted whenever he was in doubt.

Subjects

Nine subjects were recruited from FBM off-crews. The first of these participated in ironing out flaws in the simulation and the experimental procedures. The remaining eight participated in the simulations. All were experienced sonar technicians, averaging three to five years of at-sea experience and having an average rank of STS2(SS). Each participated in the experiment for five full days, approximately 35 hours.

Method

The timetable for the experiment is given in Table 1 (facing).

A. Training. The first three days were devoted to training. On the morning of the first day the system concept was explained and each of the displays described in detail with the aid of the line drawings in the FOD. The afternoon of the first and most of the second day were devoted to working through the materials describing the actions of the controls associated with the separate displays. All of this working through was done at the terminal, and experimentation by the subject was encouraged. The last couple of hours of the second day were spent practicing with the procedures handout. On the third day, the procedures were reviewed, again at the terminal, and the TRACOR "No-Fault" scripts for the *search* and *class-loc* (and, if the subject was quick, the *supervisor*) consoles were worked through. One of the experimenters was on hand to answer questions throughout the period of training. Display changes resulting from VAB activations were explained in detail. A frequent response to questions of how to do something was "why don't you try it

Table 1. Training and Testing Schedule

MON	AM	o	Explain experiment - goals, limitations of simulation
		a.	MFS ("Button Tree") concept, VABs and FABs
		b.	Display Select, Audio, idea of Hooking
		c.	Major displays (with FOD diagrams)
	PM	o	Leave subject to work through all explanitory material while practicing on Button Tree. Someome there to answer questions, explain how displays will look and react.
TUE	AM	o	Continue working through controls for each display
	PM	o	Step through important procedures using "common procedures" handout: emphasize Hooked manipulations
		o	(If time, begin TRACOR No-Fault *Search*)
WED	AM	o	TRACOR No-Fault *Search*
		o	Begin TRACOR No-Fault *Class-loc*
	PM	o	Finish TRACOR No-Fault *Class-loc*, begin *Supervisor* if time
THU	AM	o	Practice in areas where subject weak on Tue or Wed
		o	Scenario 2 *Search* (No prompting - should be longest)
	PM	o	Scenario 2 *Class-loc*
FRI	AM	o	Scenario 1A *Search*
		o	Begin Scenario 1A *Class-loc*
	PM	o	Finish Scenario 1A *Class-loc*
		o	Debrief - what good, what seemed hardest to learn, suggestions for improvement

and see." The training phase was thus one of active learning on the subject's part. This learning seemed to proceed quickly, thanks in large measure to the fact that all subjects were knowledgable about sonar when they came to the experiment.

Although the training program was intensive, none of the subjects could be said to have mastered the operation of all controls by the first day of testing. This undoubtedly resulted in much higher error rates than would be encountered at sea. We assume, however, that the errors of our partially trained operators will tend to cluster around those operations that are less logically implemented or simply more difficult to learn, and it is these same operations that probably would be responsible for errors at sea. The skill of the proficient operator may make initially awkward or difficult operations appear easy, but these are the ones that will trip up the under-trained, the unmotivated, or the overloaded operator.

B. Testing. The test scenarios were run on the fourth and fifth days, the search console sections in the morning and the class-loc sections in the afternoon. Scenario 2, which has fewer maneuvers by own ship and the threat contact, was run first.

The subject was given a handout describing current shipping and sonar conditions, the expected threat, and "standard operating procedures" (assign trackers to triangulate where possible; do multipath ranging if the contact is in the bow quadrant). The scenario was read to the subject one step at a time and he operated the system to deal with the situation as he thought best. Guidance was provided by the experimenter if requested. Requests for guidance, errors, and subject comments were recorded by the experimenter, who also recorded his observations of the subject's behavior. An assistant seated behind the subject entered all resource assignments to the Contact Status simulation and gave the subject an updated printout at the completion of each step in the scenario. At the conclusion of the testing sessions, a printout of all control actions was obtained from NUSC.

At the end of the last day of testing, subjects were debriefed. Notes made during these debriefings are presented in Appendix C.

C. Analysis. At the conclusion of the experiment, the experimenters reconciled their notes to the printouts of control actions. Every error, request for guidance, comment, observation, or (difficult) question concerning system operation was written on a 5 x 8 card. All together, 346 observations were recorded for eight subjects. These were sorted independently by the authors into five groups: 1) control errors or requests for guidance; 2) questions about the operation of the system; 3) comments by subject or observer; 4) those which were very difficult to classify; and 5) observations of no further interest (system questions that had been resolved satisfactorily, and notes describing difficulties or unusual occurrences, such as computer failure). The first three categories were not mutually exclusive. For example, an error could be associated with a question of system operation. The initial sorts were reconciled and reduced to four categories: 1) errors or request for guidance; 2) system questions; 3) comments; and 4) observations of no further interest.

Errors or requests for guidance were described by 133 cards. This represents a raw error rate of 3.45% of 3855 recorded control actions. Another 76 cards posed questions about system operation. These 209 cards were sorted into three categories: 1) errors or comments pointing to a need for the redesign of the man-machine interface; 2) errors suggesting areas that should be given emphasis in training; and 3) errors clearly reflecting deficient mastery of the more basic aspects of the system. Category 3 included such errors as inadvertent selection of a control or not knowing which control to select to complete a sequence. Items in this category were dropped from further consideration as it was felt that they reflected failures on the part of the individual subject instead of defects in the system itself. The remaining cards were then resorted independently by the two investigators into subgroups relating to specific control operations. Agreement on the third sort was approximately 75%. Disagreements were mostly due to the fact that an observation could fit into more than one category. Disagreements were reconciled on a case-by-case basis.

It is recognized that there is a large subjective component in these procedures. To make the evaluation as objective as possible, analysis has (with a few exceptions) been confined to problems resulting in documentable errors, *i.e.*, obviously inappropriate control activations. Nevertheless, a certain degree of subjectivity is inherent in any evaluation. In the present case, the authors' judgments were informed by familiarity with the system documentation and close observation of the subjects during the training and testing phases of the experiment. The authors are confident that the problems described below are of some generality, as opposed to reflecting simply the idiosyncratic misunderstandings of particular individuals, even when the problem only occurred for one man.

As previously noted, the simulation and testing was confined to the displays and associated controls used by operators of the search and class-loc consoles. Awkward implementations and common errors are described below, along with recommendations for reducing the likelihood of the error being committed or the time to recover if it is. The problems are loosely grouped according to the nature of the difficulty. A majority of the proposed modifications have to do with making the system more transparent or increasing the information available to the operator.

It is recognized that many of the problems described would not arise at the hands of a well trained and experienced operator. However, a significant proportion of the operators will be non-rated watchstanders or junior sonarmen who must learn the system on the job. The proposed modifications would make the operation of the system easier for the beginning operator and all are in keeping with the design emphasis on operability.

Problems relating to the assignment of contact data to the correct system file are listed in Table 2 (overleaf). A general summary of the problem is given in the *Problem Description* column. Suggested solutions are presented in the *Solution Proposed* column. The two numbers in parenthesis at the beginning of the problem description give the number of times the error was recorded and the number of

Table 2. File Errors

Problem	Problem Description	Solution Proposed
1	(8/2) Initialized tracker on second contact while still hooked to first contact.	System test for wide disparity between BCV and bearing of hooked file, and cue "cursor not on hooked file bearing."
2	(4/4) Contact tracked on DL appears on BB display, pushed "new trace at bearing" (1.1-0) instead of "hook at bearing" (1.1-1) to add BB tracker.	System test and cue: "Sierra # at bearing selected." Change 1.1-0 label to "new contact at bearing."
3a	(6/4) Pushed "new trace at bearing" (1.1-0) instead of "hook at bearing" (1.1-1) as first step in adding a second tracker to triangulate contact.	System test and cue: "Sierra # at bearing selected." Change 1.1-0 label to "new contact at bearing."
3b	(3/3) Pushes "new trace" or "new line" in attempt to gain access to a contact's file.	
4	(11/3) Subject's natural reaction to "sonar threat" is to push "hook threat" (1.3.1.1-2 OR 2.6.6-2) which creates a new file. The options reached by hooking the threat (1.2.3.1.3 or 2.6.5.1.3) do not allow a graceful recovery if the operator realizes the threat is not a new contact.	Add "return to previous options" escape to tiers 1.2.3.1.3 and 2.6.5.1.3. Change "hook threat" VAB (1.2.1.1-2 and 2.6.6-2) to "hook new threat" and add a "hook file at threat bearing" function.

individual subjects committing the error. The observations which led to the identification of the problem are presented in Appendix B.

The first problem described in Table 2 is probably the most important problem isolated during the course of the simulations. Subjects frequently neglected to drop hook when they had finished dealing with a contact. When they then began to prosecute a second contact, any trackers assigned to the second contact went into the first contact's file. This error is very serious for two reasons. It is uncertain how the additional trackers at divergent bearings would affect ongoing contact motion analysis (CMA) of the first contact. Secondly, the tracker (or other resource) assigned would be functionally useless as the data it produced would go into the wrong file. In addition, should the second contact be a new one, entering it to an old file would prevent its appearing on the contact status display, thus effectively concealing its existence. Presumably an alert supervisor would detect the absence of a new file when a new contact was reported, but if he was not looking at the contact status display a considerable time might elapse before the error was corrected.

The most obvious solution to this problem is more careful operation of the system. Operators should be trained to be aware that system performance can be seriously degraded by mis-filing of information. It is recommended that unhooking *immediately* upon completion of any hooked operation be incorporated as a standard operating procedure[3]. Maintaining hook when not actively prosecuting a contact invites file errors. This particular error would be rendered much less likely if the system were to warn the operator when the bearing cursor strayed too far from the bearing of the hooked file. It is proposed that the system test for disparity between the bearing cursor position and the bearing of the hooked file and that the cue "cursor not on hooked file bearing" appear in the cue area when the bearing cursor wanders too far afield. The proposed test should not be difficult to implement, since routines for comparing the cursor position against the file position are already a part of the software. For example, activation of "hook at bearing" currently requires the system to search the files for a contact at the bearing cursor position.

Problem 2 arises when a contact is being tracked on "difar-like" (DL)[4] and, after some delay, also appears on the broad-band (BB) display. There is no indication on the BB displays that a tracker is assigned on the DL, and the tracker symbols on the DL display do not indicate the bearing to which they are assigned. Thus, a DL contact that had been tracking in automatic target following (ATF) for a time may appear at a relatively unexpected position on the BB display[5]. A similar situation can occur in the case of a contact that is being tracked broad-band on the array that is not being displayed (e.g., the contact is tracking in the conformal array when the operator is monitoring the cylinder and towed arrays). The operator's initial reaction on seeing a new trace on the BB display is to push the "new trace at bearing" VAB. In the case described, this action would result in the creation of a second file on the same contact and also the appearance that there were two contacts where there was, in fact, only one. Again, more deliberate operation of the system would prevent this error in the majority of cases. Additional protection could be provided if the system were to test the position of the bearing cursor against the position of current files and warn the operator if he were about to create a file at the position of another current file. Since this warning would be elicited by the activation of the "new trace" VAB, activations resulting in such warnings should not also create a new file. However, since it is possible that the operator will, on occasion, have separate contacts at similar bearings, it should be possible to override the warning, perhaps by pushing the VAB a second time while the cue was still being displayed. On the second button push the new file would be created.

The present VAB label "new trace at bearing" is misleading. Subjects stated that it is a general policy to consider all DIMUS traces to represent contacts until proven otherwise. The "new trace" VABs are used solely to indicate the detection of a *new contact*. They should be so labelled. The "new line at XXX and bearing" VABs of the DL Search and Class-Summary displays are similarly misleading. They, too, are used *only* to signal a new contact. However, most contacts exhibit multiple lines, so a new line does not necessarily imply a new contact (as does a new DIMUS trace). The "new line ..." labels should be changed to read "new contact at XXX and bearing."

Five of our subjects also attempted to use the "new trace" or "new line" VABs to gain access to a file, in lieu of hooking that file (problem 3). Although these errors are plainly the result of insufficient understanding of the system, they too would be made much less likely by the provision of the system test and cue as suggested in the solution to problem 2.

A number of errors centered around responses to the "sonar threat" alert function. Although this feature is of great potential importance, it does not appear to have been as well thought out as most other aspects of the ISPE system. Acknowledgement of a sonar threat by activation of FAB 16 brings up tiers 1.2.1.1 (on DLS) and 2.6.6 (on Class-Summary). These allow the operator only 4 responses to the threat. He can hook the threat (VAB 2), thereby *creating a new file;* he can enter the threat to an existing file (VAB 4); he can acknowledge an alarm generated by the BQR-19 (VAB 6); or he can dismiss the threat as a false alarm (VAB 8).

Experience indicates that threat alerts will be triggered often; almost always by non-threat contacts and frequently by own ship. The threat alert function would be more usable if it were more flexibly implemented. For example, the present "enter to file" option (VAB 4) requires that the operator supply the file number. Response would be facilitated if the system would indicate the number of the file (or preferably the Sierra number) of the contact at the threat bearing, which could be determined by a test like that proposed in response to problems 2 and 3. Alternatively, entry of the threat line to a pre-existing file could be speeded up by replacing the present "enter to file #" VAB with one having a slightly different function: "put in file at bearing" (limitation of "enter" to mean *enter via the keyboard* is discussed in connection with Table 5 below).

The present "hook threat" VAB creates a new file. This is the only place in the system where "*hook*" creates a file instead of accessing a pre-existing one. There is no way of hooking an existing file from the sonar threat tier. Inasmuch as a threat contact may trigger several alerts, hooking the existing file directly in order to further prosecute the contact seems a desirable option.

The present "hook threat" function also has another serious flaw: when it is selected, the options then presented to the operator do not allow an easy recovery, should he realize that the contact triggering the alert is already on file. This is a notable omission in view of the availability of retrace sequences for other functions. To remedy this deficiency, a "return to previous options" VAB should be added to control tiers 1.2.3.1.3 and 2.6.5.1.3.

It is proposed that a "hook file at bearing" option be added to the sonar threat acknowledgement tiers on DLS and Class-Summary. Further, the current "hook threat" VAB should be relabelled "hook new threat", and the current "enter to file #" function should be changed to "put in file at bearing." The proposed sonar threat acknowledgement tier would be:

In addition, upon acknowledgement of the sonar threat, the system should review the contact status file and display one of two cues: "Sierra # (or file #) at threat bearing" or "no contact presently at threat bearing."

The proposed changes appear to be rather extensive; they are not. "Hook new threat" is merely a more accurate label for the present "hook threat" function. "Hook file at bearing," while new to the threat acknowledgement tier, is already implemented on the BB and Class-Summary displays. The "put in file at bearing" function is the only new one, but requires only that the system search the contact files for the one at the bearing of the signal causing the alert. The two operator cues are also selected by the results of such a search, which is similar to the search initiated by the "hook at bearing" commands.

Table 3 (overleaf) describes some features of the system which appear to be awkwardly implemented.

Problems 5, 6, and 7a are all instances of controls being inaccessible when the console is in the hooked mode. In all cases, this limitation of access when hooked appears to be arbitrary and may be counter-productive. Being unable to switch the broad-band sensor displayed while the console is in the hooked mode (problem 5) is probably

0	1	2	3	4	5	6	7	8	9
Hook New Threat		Hook File at Bearing		Put in File at Bearing			BQR-19 Acknow		Noise/ False Alarm

Table 3. Awkward Implementations

Problem	Problem Description	Solution Proposed
5	(3/3) Cannot change BB arrays displayed when hooked.	"Display Source Select" VAB should be accessible when hooked.
6	(9/4) Cannot assign a classification channel via CS when contact is hooked.	Class channel assignment tiers should be available when hooked.
7a	(3/3) LAMPAZ assignment via CS not accessible when hooked.	LAMPAZ assignment should be available when hooked.
7b	(4/2) Transfer of single lines to LAMPAZ via signature assembly tier awkward. Erasure of lines from contacts other than the one hooked reduces utility as sorting aid.	
8	(1/1) "Release indexed corr ch" (3.4.0.1-4) and "release indexed class ch" (3.4.0.1-6) VABs on CSD have automatic return to PFD top position: A nuisance when want to release both class and correlation channels.	Drop automatic return, return via "return to previous options" VAB.
9	(2/2) Harmonic comb comes up on the "off" state if the operator turned it off when last used.	Harmonic comb should always come up in the "on" state when selected.

simply a minor inconvenience, as the operator may not want to do this frequently. However, the operator should be able to assign a classification channel on the Class-Summary display when the console is in the hooked mode (problem 6). To assign a classification channel to a hooked contact or a second contact while prosecuting a hooked contact, the operator can use the Contact Status Display, or unhook to access the classification channel assignment controls on Class-Summary. In the former case, the Contact Status Display would temporarily replace either the Class-Summary or the Class-Analysis display. Either sequence is, at best, a nuisance, and could result in significant delays or errors if the system or operator were heavily loaded.

The controls on the Classification Summary Display that assign lines to the LAMPAZ (line amplitude-azimuth) display are not accessible when the console is in the hooked mode (problem 7a). Assuming that the primary function of LAMPAZ is as an aid to contact sorting, it follows that LAMPAZ should be used most frequently during classification and signature assembly. The signature assembly feature requires that the console be hooked, in which case assignment of lines to LAMPAZ is not presently possible. The inaccessibility of LAMPAZ while in the hooked mode represents an unnecessary limitation on the usefulness of this feature. The technique of transferring trial signatures to LAMPAZ directly from the Signature Assembly field has the *significant* drawback of overwriting lines from contacts other than the one hooked (problem 7b). Again, this would seem to limit the usefulness of the LAMPAZ display as a sorting aid. Although the presently implemented capability of transferring entire signatures to LAMPAZ is a desirable feature, the ability to transfer individual lines without erasing lines which may be coming from other contacts is also very desirable, and could be accomplished simply by allowing access to the regular LAMPAZ assignment controls while hooked.

The control options associated with the Contact Status Display at the supervisor's console are more extensive than those associated with the same display on the *class-loc* and *search* consoles. On the supervisor display, assignment and release of correlation and classification channels are accomplished by means of a separate control tier (3.4.0.1). Releasing of either a correlation or a classification channel on this tier results in automatic return to the top tier of the supervisor Contact Status Display (problem 8). Although this automatic return is intended to save the operator the trouble of returning via a separate button push, it is as likely to be a nuisance because one of the more common reasons for releasing classification or correlation channels through this display is to release all resources prior to dropping a tracker[6]. Thanks to the automatic return feature, the operator must access the "manage corr/class channel" tier (3.4.0.1) for each correlation and classification channel to be released. This is a case where automatic return may actually impede the operator's actions. A manual "return to previous options" VAB should replace the automatic return feature.

The status of the harmonic comb when selected by means of the harmonic comb control tiers on DLS or Classification Summary is determined by the last selected position of the "harmonic comb on/off" VAB on the harmonic comb control tier. Thus, it is possible for the harmonic comb to come up in the "off" state if the operator turned it off when it was last used (problem 9). The controls for the harmonic comb should be modified so that the comb always comes up in the "on" state when the operator selects the harmonic comb control VABs on DLS or Class-Summary.

Errors or subject comments revealed several instances in which VAB labels were either inconsistent or less informative than they might be. These are summarized in Table 4 (facing).

The most glaring instance of an inconsistent control label is "enter line at XXX" (problem 10). This control places lines directly into the contact's file from DLS, Class-Summary, and the top hooked tier on Class-Analysis. In the signature assembly mode, the "enter line at XXX" VAB (2.7.6.2-5) has a very different function: this control is used to transfer lines from one of the grams to the signature assembly field. This VAB should be relabelled "move line to signature," which is a more accurate description of its function. Also in the interest of accurate description, VAB 2.7.6.2-4, "enter lines displayed," which some of our subjects confused with "enter line at XXX," should be relabelled "put signature in file."

Five subjects had difficulty remembering that the CMA update functions were accessed via the "localization/range history" control (problem 11). Since the range history plot is only one of the functions accessed by this tier, and is in fact a part of CMA, a better label for this control would be "ranging/CMA."

Classification channel assignment sequences on the Class-Summary and Contact Status displays conclude with the processing options "full band process" (VABs 2.6.2.2-3 and 3.4.0.3-3) and "extended range process" (VABs 2.6.2.2-5 and 3.4.0.3-5). Classification channel processing is altered on the Class-Analysis Display by VAB 2.7-5, "clas ch procssng ext/norm." Since the "full" band is expected to be the processing normally assigned, it is recommended that VABs 2.6.2.2-3 and 3.4.0-3 be relabelled "normal band process."

One subject apparently thought that the "compute range" VAB (2.7.6.1-3) on the multipath ranging tier both calculated the range and entered this range to the on-going CMA (problem 13). The more limited function of this control would be more accurately indicated if it were labelled "compute trial range."

One subject remarked that the "select vernier process" (VAB 2.7-2) control label was too much like "select demon/vernier display" (VAB 2.7-3), to which it is adjacent on the Class-Analysis Display (problem 14). The function of this control would be more accurately conveyed if the label were changed to "assign vernier process."

In the interest of clarity and consistency, it is recommended that the word "enter" be reserved for controls that initiate numerical entry by means of the keypad. Another word will almost always be more descriptive of the actual function of those controls that do not initiate such input. In order to be consistent, "enter" should also appear on those controls which require numerical entry but do not have "#" as a part of the label. Table 5 (overleaf) summarizes the VAB labels

Table 4. Confusing VAB Labels

Problem	Problem Description	Solution Proposed
10	(8/6) Inappropriate selection of "enter line at XXX" (2.7.6.2-5) and "enter lines displayed" (2.7.6.2-4) in signature assembly tier. "Enter line at XXX" (2.7.6.2-5) has *different function* in signature assembly (2.7.6.2) tier and tier 2.7.6, where VAB 2.7.6-5 enters to the hooked file directly.	Change 2.7.6.2-5 label to "move line to signature" and 2.7.6.2-4 to "put signature in file."
11	(6/5) Difficulty remembering CMA accessed via "lclztn/ range history" (2.7.6-0).	Change 2.7.6-0 lebel to "ranging/CMA."
12	(1/1) Classification channel assignment sequences on CS and CSD conclude with the processing options "full band process" (2.6.2.2-3/3.4.0.3-3) and "extended range process" (2.6.2.2-5/3.4.0.3-5): The analogous control on CA is "class ch process ext/norm" (2.7-5).	Change 2.6.2.2-3 and 3.4.0.3-3 labels to "normal band process."
13	(1/1) Apparent confusion of function of "compute range" (2.7.6.1-3) and "enter computed range" (2.7.6.1-8) on CA MPR tier.	Change 2.7.6.1-3 to "compute trial range."
14	(1/1) CA "select vernier process" (2.7-2) much like "select dem/vern display" (2.7-3).	Change 2.7-2 and 2.7.6-2 labels to "assign vernier process."

Table 5. "ENTER" VABs to be Changed

VAB #	Present Label	Proposed Label
A. Inappropriate "ENTER" VABs		
1.1.1-8	Enter ping bearing	Mark ping bearing
1.1.3-8	Enter ping bearing	Mark ping bearing
1.2.3-5	Enter line at XXX	Put line in file
1.2.3.2-7	Enter fund XXX	Put fund in file
2.6.3-3	Enter cursor XXX	Use cursor XXX
2.6.5-5	Enter line at XXX	Put line in file
2.6.5.2-7	Enter fund XXX	Put fund in file
2.7.6-6	Enter line at XXX	Put line in file
2.7.6.1-8	Enter computed range	Use computed range
2.7.6.2-4	Enter lines displayed	Put signature in file
2.7.6.2-5	Enter line at XXX	Move line to signature
2.7.6.2.2-7	Enter fund XXX	Put fund in file
3.3.1-0	Enter indexed data	Record indexed datum
B. Suggested "ENTER" VABs		
3.13-0	Sea state number	Enter sea state
3.13.1-3	Towed array depth	Enter towed depth
3.13.1-5	Own ship depth	Enter own ship depth
3.13.4-0	Towed array gain	Enter towed gain
3.13.4-1	Towed array loss	Enter towed loss
3.13.4-3	Confml array gain	Enter confml gain
3.13.4-4	Confml array loss	Enter confml loss
3.13.4-6	Cylndcl array gain	Enter cylndcl gain
3.13.4-7	Cylndcl array loss	Enter cylndcl loss

that should be changed.

Table 6 (overleaf) lists several situations in which the presentation of additional or simply more accurate feedback to the operator would facilitate his responses.

There is no indication of the number of the tracker which is assigned by operator action on the BB and DLS displays (problem 15). Providing this information would lessen reliance on the Contact Status Display and facilitate handoff of the contact to the classification operator. It would also speed MTB assignment in the case where the signal was too weak for the tracker to lock on in ATF (control normally returns to the top tier when "ATF assign" is selected, whether the tracker locks on or not). It is proposed that the system be altered so that the tracker number assigned by an operator action would be displayed briefly in the cue area.

One of the responses on the present sonar threat acknowledgement tier (1.2.1.1 and 2.6.6) is "enter (the threat line) to file #." The file number may not be readily available to the operator (problem 16). The primary source of file numbers is the Contact Status Display, which may not be displayed at the time of the threat. Since the system determines the bearing of the signal triggering the threat, it should be comparitively simple to search the contact files and identify the file at that bearing (or determine that there was no file at the bearing). It is proposed that such a test be added to the operating system, and that the results of the test be displayed in the cue area as "file #___ at threat bearing" or "no contact presently at threat bearing." This addition was suggested as a part of the proposed redesign of the threat alert response tier (problem 4) and is, of course, unnecessary if that redesign is implemented.

On a number of occasions, the sonar threat alert was activated while the operator was not looking at one of the DL displays (problem 17). Acknowledgement of the alert in this circumstance results in the appearance of the cue "select DL Search." On three occasions, operators blindly followed the displayed cue when selection of Class-Summary would have been a better choice. The cue displayed should be "select DL Search or Class-Summary Display."

In a number of cases, operators attempted to activate a VAB (problem 18a) or a FAB (18b and 18c) in the interval between selection of a control initiating numeric entry and the actual entry of the required numbers. These actions result in the display of rather nonspecific error cues, either "invalid command" or "selection invalid." A more informative cue, "complete numeric entry," should be provided. It should be noted that these problems may be an artifact of the simulation used in this study: the system blanks all VAB labels when a numeric entry is pending, but this feature was suppressed in the simulation. The number of errors of this kind observed supports the wisdom of blanking the VAB labels. Since this kind of error is likely only when the operator has been distracted, displays allowing more than one kind of numeric data to be entered, such as the Class-Menu, would benefit from a more unambiguous cueing procedure than simply blanking all VAB labels. Here two VABs initiate

Table 6. Additional Information Desirable

Problem	Problem Description	Solution Proposed
15	(1/1) BB & DLS displays do not show tracker number of tracker assigned by operator action.	Display number of the tracker assigned by operator action in cue area.
16	(3/2) How does operator know file number of contact causing "sonar threat"? (Problem on DLS only)	Cue "Sierra #___ at threat bearing or VAB "enter to file at bearing."
17	(3/2) Pushed "sonar threat" (FAB 16) while neither CS or DLS was displayed: cue "select DL search" obeyed when CS would have been better choice.	Cue "select DL search or class summary display."
18a	(2/2) Attempted to activate a VAB while numeric entry is pending: cue "invalid command" not helpful.	Cue "complete numeric entry."
18b	(4/4) Attempted to drop hook (FAB 10) while numeric entry is pending: cue "selection invalid" not helpful.	Cue "complete numeric entry."
18c	(1/1) Pushed "sonar threat" (FAB 16) while numeric entry is pending on CM: cue "selection invalid" not helpful.	Cue "complete numeric entry."

numeric entry, and blanking does not indicate which one was selected. A more foolproof procedure would be to blank all VAB labels except the one initiating the numeric entry sequence.

Table 7 (overleaf) lists miscellaneous problems and observations made during the course of the simulations.

A subject was observed to activate the "enter computed range" VAB (2.7.6.1-8) on the multipath ranging display *twice* upon completion of ranging (problem 19). The effect such a spurious entry would have on the ongoing CMA could not be determined. Although errors of this kind are hardly specific to ISPE, many computerized systems can be hung up by unanticipated inputs. The system designers should be aware that such illogical inputs will inevitably occur and protect the system from undue sensitivity to them.

Although the system warns of crossing contacts (problem 20), the subjects were unable to determine the best procedure for dealing with a tracker which had been captured by a crossing contact. Specific procedures for dealing with this occurrence should be included in system operating guidelines.

The detection of transients is a relatively common occurrence (problem 21). It is unclear how information about transients can be entered into the system. Specific guidelines for dealing with transients and other untrackable signals need to be developed and made available.

The practical difference in effect upon CMA of dropping or inhibiting trackers could not be determined (problem 22a). Guidelines for selecting the appropriate action should be made available.

Sonarmen are not particularly well versed in conventional CMA techniques and the ISPE CMA function is very sophisticated and in some cases allows the operator a choice of several inputs. Effective use of these options will require detailed knowledge of their effects and the subtle distinctions among these effects (problems 22a and b). This is one of the few instances where lack of detailed knowledge of the algorithms employed by the system may lead to degradation of performance.

Experienced operators believe they can detect contact maneuvers and frequently differentiate between a target zig or a speed change almost instantaneously on the basis of displayed sonar information. In cases where the operator is actively tracking a target, it is likely that he will be able to detect and *name* the kind of maneuver executed by the contact more rapidly than the system's automatic processing algorithms. Guidance as to the best way of constraining the system solution in response to specific information developed by the operator is required (problem 22c).

In the scenarios created for this study, sonar threat alerts occurred at both the search and class-loc consoles. *Class-loc* operators were of the opinion that someone else, either the search operator or the supervisor, should be tasked with responding to sonar threats, especially in situations where they were actively engaged in tracking a contact. Clear allocation of responsibility for

Table 7. Miscellaneous Problems

Problem	Problem Description	Solution Proposed
19	(1/1) Pushed "enter computed range" *twice* upon completion of MPR; effect on machine processing uncertain.	Designers should protect against spurious entries.
20	(2/2) Difficulty in dealing with tracker captured by the louder of two crossing contacts.	A procedure needs to be established and trained.
21	(2/2) Transients. How to enter information on transients to the system needs clarification.	Need guidelines for dealing with transients and the untrackable signals.
22a	(1/1) Uncertain of differences in effect upon CMA of dropping or inhibiting trackers.	Guidance required as to exact effect of available alternatives and when each should be used.
22b	(3/3) Unsure of difference in effect upon CMA of "enter computed range" (2.7.6.1-8) on MPR tier and "enter range" (2.7.6.1.2-0) on CMA tier.	
22c	(2/2) Detects speed change in grams, unsure of whether to "enter speed" (2.7.6.1.2-3) or "enter speed" *and* "maneuver detect" (2.7.6.1.2-5) "detect speed change" (2.7.6.1.3-4).	
23	(2/2) *Class-loc* operator says "sonar threat" responses are a distraction at his console, and should be handled by someone else.	Clear allocation of responsibility is desirable.
24	(1/1) Position *(Class-Loc* or *Supervisor)* responsible for data entry via CM needs to be determined.	Clear allocation of responsibility is desirable.

handling sonar threats is desirable. Consideration should be given to allowing the "sonar threat" function to be disabled at selected consoles.

Some subjects spent a great deal of time entering classification information to the Class-Menu Display (problem 25). It was suggested that entry of this information to the system's records should be done by the supervisor. Again, guidelines allocating responsibility for various functions are desirable.

Comments

Subject comments and the experimenters' observations were recorded throughout the execution of the scenarios and in the debriefing session at the conclusion of the experiment. Selected comments are presented in Table 8 (overleaf). These fall into 3 categories: reservations about system operation, suggestions, and praise. The letter following the comment indicates the subject who made it. Comments which were either trivial or reflected an inadequate understanding of the system have been omitted. While it is not proposed that the system be modified in light of these reservations and suggestions, the authors do concur in the majority of the comments.

Discussion

1. Operability. This study was limited to an assessment of the operability of those features available to operators on the *search* and *class-loc* consoles. Subjects operating these consoles experienced little difficulty in responding to the events presented in the two scenarios. At no point did the logic of the control structure interfere with their prosecution of the contacts presented. It is concluded that the operability of those parts of the control structure which were tested is entirely satisfactory.

There is room for improvement in the implementation of some functions, however. The present control structure for the *search* and *class-loc* functions is seriously deficient in only two respects: 1) it is entirely too easy for the operator to mix the data from two contacts in one file (problem 1); and 2) the controls available for responding to threat alerts could be considerably improved (see discussion of problem 4). The proposed modifications to the threat alert response tiers would: a) bring the logic of these controls more into line with that of similar controls elsewhere in the system; and b) enhance the speed and flexibility of response to such alerts. The rest of the modifications proposed as solutions to problems encountered should make the system easier to deal with for the inexperienced operator.

2. Training. Almost everything about ISPE was new to the subjects, many of whom were from boats that had just received the AN/BQR-21. The major problems encountered were those related to aspects of ISPE operation that had no counterpart in the experience of our subjects. A primary example is the importance of the distinction between *hooked* and *unhooked* modes of operation. Most of the problems related to hooked contacts could be avoided if operators were instructed to hook a contact only when dealing actively with it and

Table 8. Selected Comments

Reservations:

1. "Entering the 'predominant signal' to Class Menu for most routine contacts is a nuisance, 99 or 98% are all the same." C.

2. Subject doesn't like the idea of DLS displays to *Conn*: "too many [routine DL] signals will cause unnecessary talk from *Conn* to sonar." E.

3. "Detection prediction ... it's never going to be right anyway - just going to give the OOD something to worry about that he doesn't need to" OOD's do not appreciate how approximate the range of the day is: they tend to think sonar is malfunctioning or goofing-off if every contact is not detected at the predicted range. D. Similar comment by E.

4. Re experience with BQR-21: "I hope ISPE is fairly fast about hooking and unhooking." D.

Suggestions:

5. "The whole business of controlling CMA might best be done on GeoSit or even a separate, dedicated display." D. Similar comment by A.

6. Re assignment of classification channels on the Class-Summary Display: "Assign class channels on the display that deals with these, not on C-S." C.

7. "In the Contact Status Log section, the Sierra number should be on the left, not the file number, and the tracker table should list Sierra numbers instead of the file numbers." E.

8. "The Contact Status Display should be visible all the time - maybe a separate repeater for this, visible from all three consoles." E.

9. Pressing "compute ratio" after "mark #2" on ratio compute tiers is an unnecessary extra step - could be done automatically when second line is marked. A.

Praise:

10. "Being a search operator would be easy to do. You could train anybody." G. Similar comment by H.

11. "That Geographic Situation - boy is that going to help me out at sea. That's going to be a lifesaver." C. Subject says he has trouble with plots, visualizing the 'big picture.' Similar comment by D.

12. CMA update function will be "good because it will teach new people what affects the CMA solution." E.

to *always* drop hook when they finished a particular operation.

Although certainly not difficult, the system of assigning files to individual contacts and then accessing those files in order to record information or assign additional resources for the prosecution of the contact needs to be thoroughly mastered. The ease with which spurious files can be created or data entered to the wrong file requires that the system be operated very deliberately, and that the operator at all times be conscious of the files associated with each contact.

The concept of resource allocation should also be stressed. Again, the concept is not difficult but it takes a while for operators of older systems to get used to assigning correlation or classification channels to a particular contact instead of simply using one basic resource with which to prosecute all contacts.

The system functions of continuous contact motion analysis and multipath ranging also were new to our subjects. The concepts are not new to sonarmen, although most have not had experience with systems having these capabilities. The CMA function should be emphasized in training, as sonarmen are not particularly well versed in conventional CMA techniques and the ISPE CMA functions allow the operator a choice of several different inputs.

The multifunction switching system employed in the control structure is in general well thought out and appeared to be quite easy to learn. On one level, the control structure is very flexible, but on another, it is very rigid. Prosecution of a single contact requires the execution of a number of logically distinct actions (data entry sequences). This system is very flexible in that the order of these sequences is largely left up to the operator. However, it is *inflexible* in regard to the execution of the data entry sequences, which must be completed (or aborted) before the operator is free to do much of anything else. Such is generally not the case with less automated systems. The necessity of completing a sequence once initiated should be emphasized. Training should also emphasize methods of graceful recovery from actions initiated by error. It is also axiomatic that operators should be thoroughly familiar with the options available, how they are related to other options (especially in regard to those which are mutually exclusive), and the paths from one part of the control structure to the next.

3. Evaluation. In general, the controls associated with the search and class-loc displays are well thought out and logically implemented. Subjects in the experiment appeared to have very little difficulty in learning to use the control structure with a high degree of fluency and flexibility. With the exception of those awkwardly implemented features previously noted, the system appears to exhibit no major operability problems.

The sonarmen participating in this experiment were generally quite impressed with the capability of the system as it was explained to them. They accepted it readily and for the most part enthusiastically. We believe their enthusiasm was well founded.

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Footnotes

1. Development of ISPE as an integrated sonar suite was suspended in December of 1980. The technology developed for ISPE survives as Towed Array Signal Processing Equipment (TASPE), which will employ a single ISOD having Broad Band, "Difar-Like" and Class-Analysis displays. The first TASPE units are to be deployed in fiscal 1985.

2. Reducing the number of spaces available for the writing of control labels necessitated the abbreviation of some terms that are not abbreviated in the actual system and the further shortening of some existing abbreviations. Shortening was generally accomplished according to the "contraction-vowels out" rule. Although no formal attempt was made to evaluate it, shortening did not *appear* to affect the interpretability of the labels. Many of the problems identified in this report are traced to *wording* of particular control labels. In some cases, shortening may have reduced the legibility of a label, but the problems identified are semantic and may not be attributed to the abbreviations.

3. Unhooking upon completion of an operation was emphasized in the "Common Procedures" training handout. All control sequences requiring hooking were concluded with activation of FAB 10, "Release Hook." Even with this emphasis, failure to drop hook was a common problem among our inexperienced operators. Although failure to drop hook should not be a problem for experienced operators, it should be remembered that a significant proportion of operators will be inexperienced, and many will come to the system without formal training in its operation.

4. To avoid the use of classified terminology, the names for functions and VAB labels used in this paper are those of the NUSC "Button Tree" program.

5. When the ISOD is configured to present both BB and DL displays, the bearing cursors on the two displays are slaved. Examination of the DL display before activating "new trace at bearing" is greatly facilitated by this feature, and should be done routinely before signaling a new contact. However, overlooking a relatively weak contact, especially if there are a number of other, stronger signals on the display,

remains a possibility, especially in the case of the inexperienced operator.

6. Correlation channels may be released through the Class-Analysis Display (VAB 2.7.6.1-4), but classification channels, while they may be *reassigned* through the Class-Summary Display, may be released only via the Contact Status Display.

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APPENDIX A

SCENARIOS USED IN OPERABILITY EVALUATION

SCENARIOS USED IN OPERABILITY EVALUATION

The scenarios presented in this appendix represent two segments of routine FBM patrols. There are two written scenarios for each segment, one describing events as they would be presented to an operator running the search console and one describing the same events as they would be presented to a man serving as the class-loc operator. No attempt has been made to model the anticipated detection performance of the system, but we did try to include a variety of contacts and common occurrences, such as transients, contacts that shut down and start up again, and maneuvers by both the contacts and own ship.

The displays were represented by line drawings (on 35 mm slides) taken from the FOD. No attempt was made to simulate displayed data. Rather, the subject was told by the person reading the scenario what was being displayed.

Each scenario was presented as a series of discrete events. These are numbered as E1, E2, etc. Below the event number is the time in the problem when the event would have occurred, had the scenarios been happening in real time. The scenario was presented in terms of four kinds of information, indicated by abbreviations in the text:

SI: (Sonar Indication) information being displayed, e.g., "Dimus trace at 072°T."

E: (Event), e.g., "Search operator reports BB contact at 072°T, 1 tracker in ATF."

D: (Direction), e.g., "Supervisor wants a second tracker on the towed array."

P: (Prompt), e.g., "remember standard operating procedure (re MPR)."

A fifth abbreviation appears in the text: RA (for reader action). This is to remind the reader to change a card which duplicated the own-ship readout at the top of the displays. These cards were changed whenever own ship changed course or speed.

SCENARIO #1A

A. GENERAL INFORMATION

1. On routine patrol, west Atlantic basin
2. Sea State 1-2
3. Water Depth 1500 Fathoms
4. Layer at 165 feet
5. No Convergence Zone
6. Own ship depth 140 feet
7. Own ship speed 6 knots on course 300°
8. Towed array scope 1800 feet

B. INTELLIGENCE REPORT

1. Type II or III to Southwest
2. Normal merchant/trawler shipping
3. US Warship in area, with SQS 26(A)/3.5-3.7 Khz

C. CURRENT SITUATION:

1. Crossing shipping lane, 2 contacts held:
   (a) one at 129°, drawing left, past CPA and opening: S-141, Class M.
   (b) one at 254°, drawing right (to cross bow at 16,000 yds): S-142, Class M.

D. ISPE PRESENTLY CONFIGURED:

1. Conformal array is DL sensor
2. Broad Band Search with cylinder and towed array

E. SONAR STANDARD OPERATING PROCEDURES:

1. Triangulate contacts where geometry and resources permit
2. Do Multi-Path Ranging on all contacts in bow quadrant (MPR only works with BB contacts)
3. Broad Band range of the day is 39 kyds

SCENARIO 1A, SEARCH

E 0 T 0	RA: P:	Put up OS Card 1A. OS Co 300° So 6 kts Hold 2 contacts, both classified as merchants. A. S-141, directly behind at 129°, 1 tracker in ATF on towed array B. S-142, at 254°, drawing towards bow, 2 trackers in ATF, one on cylinder and one on towed array.
E 1 T 5	SI: D:	New line on FRAZ, 363 Hz, Stable (will track in ATF) 316° Supervisor designates Sierra 143.
E 2 T 15	SI: P:	Notices BB trace on cylinder ITA/LTA at the same bearing as S-143 (now 310°) (will not track in ATF yet) Notice trace is stronger on the towed array. (Will track on towed in ATF.)
E 3 T 22	E:	Class Operator reports S-143 is US Frigate 1068 Class, two 4-bladed screws making 192 rpm (24 kts).
E 4 T 32	SI: D:	DIMUS trace from S-141 fades from towed array ITA/LTA. Notice tracker symbol not tracking. Supervisor says to drop track.
E 5 T 35	SI: D:	Detect new line while paging through LOFAR: 301 Hz, 194°. Will not track in ATF. Supervisor designates Sierra 144.
E 6 T 40	SI:	Threat alert at 301 Hz (Sierra 144). 301 Hz is strong enough to track in ATF.
E 7 T 40	E: RA:	Own ship turns to course 270°. Put up OS Card 1B.
E 8 T 43	SI: D:	Threat alert from another line at 294 Hz on S-144 Supervisor wants a tracker on line. Supervisor tells Class Operator to take over monitoring of S-144.
E 9 T 45	SI: P:	Notice that S-143 DIMUS trace has 2 tracker symbols with it, S-142 trace (which is weaker) has none. Supervisor will want that straightened out.
E 10 T 46	SI: D:	New trace on towed array ITA 111/249°R. Nothing on cylinder. Brings BQR-7 on BB left to resolve bearing. Designates Sierra 145. Restores cylinder after bearing resolved.
E 11 T 50	E: RA:	Own Ship turning to 180°. Put up OS Card 1C.
E 12 T 63	E: RA:	Own Ship turning to 270°. Put up OS Card 1D.

E 13 T 70	SI:	Very bright spots on S-143 trace at 232°. Spots are appropriate to 1068 Class's sonars.
	P:	You can hear echo-ranging.
	D:	Supervisor tells Search Operator to monitor S-143.
E 14 T 72	E:	Class Operator reports S-144 possible Type II, and appears to be slowing.
E 15 T 75	E:	Class Operator reports up-doppler from S-144. Own Ship turns to 300°, increase speed to 10 kts.
	D:	Supervisor informs Search Operator that now DL sensor is towed array. Directs search operator to replace towed array with conformal on BB.
	RA:	Put up OS Card 1E.
E 16 T 80	SI:	Another series of bright spots from S-143.
	P:	You can hear him echo-ranging again.
E 17 T 81	SI:	ITA trace on cylinder, 330°.
	D:	Supervisor designates at S-146.
	P.	S-146 is directly ahead of you.
E 18 T 110	SI:	Trace from S-143 fades on ITA.
	P:	Maybe he's out of range.
	D:	Supervisor says to drop tracker if out of range.

END OF PROBLEM

SCENARIO 1A, CLASS-LOC

E 0 T 0	RA:	Put up OS Card 1A.
	P:	Hold 2 contacts, both classified as merchants. A. S-141, directly behind at 129°T, 1 tracker in ATF on towed array. B. S-142, at 254°, drawing towards bow, 2 trackers in ATF, one on cylinder and one on towed array. One correlation channel assigned.
E 1 T 5	E:	Search operator reports new line on FRAZ, 363 Hz, 316°T. He has one tracker in ATF.
	D:	Supervisor designates Sierra 143.
	P:	Only this one good line so far.
E 2 T 10	SI:	More lines are beginning to show on LOFAR.
E 3 T 18	E:	Search operator reports he now holds S-143 broad band, one tracker in ATF on the towed array
E 4 T 22	SI:	You now have enough lines to get a good match with a file signature (US Frigate 1068 class). DEMON shows two 4-bladed screws making 192 rpm (24 kts).
	SI:	CMA gives 20 kts.
E 5 T 32	E:	Search Operator drops track on S-141.
E 6 T 35	E:	Search Operator reports a line on LOFAR at 301 Hz, 194°. Not strong enough to track in ATF.
	D:	Supervisor designates Sierra 144.
E 7 T 40	E:	Search Operator has assigned a tracker to the 301 Hz line in ATF.
E 8 T 40	E:	Own Ship turns to course 270°.
	RA:	Put up OS Card 1B.
E 9 T 43	SI:	Threat alert from another line (294 Hz) on S-144.
	D:	Supervisor tells Class Operator to take over prosecution of S-144. He wants another tracker on this line.
E 10 T 45	D:	Supervisor tells Search Operator to monitor S-143 and report any signs of a maneuver.
E 11 T 46	SI:	More lines are coming up on S-144 LOFAR
E 12 T 48	E:	Search Operator reports new BB contact at 021°. Two trackers in ATF (towed and conformal).
	D:	Supervisor designates Sierra 145.

E 13 T 50	E: RA:	Own Ship turning to course 180°. Put up OS Card 1C.
E 14 T 55	SI: D:	Threat alert from S-144 (from line already seen on LOFAR). Supervisor requires a tracker on that line.
E 15 T 55	SI: P: SI:	Signature lines match Type II reference signature (if still working on signature). (if not working on it) How are you coming on classification of S-144? One line is a known propulsion line, another is a known auxiliary.
E 16 T 59	SI: P:	DEMON from S-145 shows one 4-bladed screw at 170 rpm. Probable light craft, possible trawler.
E 17 T 63	E: RA: SI:	Own Ship turning to course 270°. Put up OS Card 1D. Down doppler on S-144, up doppler on S-143.
E 18 T 65	SI: SI: P:	DEMON from S-143 shifting to lower frequencies. May also notice slight up doppler on LOFAR (if watching). (if takes turn count) shaft rate now 85 rpm. That's about 10 kts.
E 19 T 70	E:	Search Operator reports echo-ranging from S-143.
E 20 T 72	SI:	S-144 lines show slight down doppler, decreasing SNR. Propulsion line shifts to lower frequency.
E 21 T 74	D:	Supervisor tells Class Operator to reassign trackers on S-144s strongest lines to towed array.
E 22 T 75	E: SI: RA:	Own Ship turns to course 300°, increases speed to 10 kts. S-144 lines on LOFAR waver, but show very little change. Put up OS Card 1E.
E 23 T 80	E:	Search Operator reports more echo-ranging from S-143.
E 24 T 81	E: P: D: P:	Search Operator reports new contact at 333°, drawing left, has 1 tracker in ATF. That is almost right in front of you. Supervisor designates Sierra 146. (After MPR) range is 33 kyds.
E 25 T 85	SI: P: SI: P:	Threat alert from S-144. (from a line already in file) If that is an old line, why did it suddenly cause a new alert? Slight up doppler, propulsion lines increasing in frequency, two new lines. S-144 has changed course.

E 26 T 87	SI:	LOFAR from S-143 shows new lines, down doppler. DEMON shows shaft rate increasing to 185 rpm.
E 27 T 90	E:	Own Ship turns to course 330°.
	SI:	Down doppler on S-144, S-143.
	RA:	Put up OS Card 1F.
	E:	Supervisor has changed DL sensor to towed array.
E 28 T 92	D:	Supervisor requests classification of S-146.
	SI:	DEMON shows on 4-bladed screw making 62 rpm - Probable Merchant.

END OF PROBLEM

SCENARIO #2

A. GENERAL INFORMATION:

1. On routine patrol in North Atlantic off the UK Gap
2. Sea State 3-4 (on 10 point scale)
3. Water Depth 800 Fathoms
4. Layer at 240 feet
5. No convergence zone
6. Own ship depth 140 feet
7. Own ship speed 6 knots on course 030°
8. Towed array cable scope 1800 feet

B. INTELLIGENCE REPORT:

1. Normal merchant/trawler shipping
2. Type II reported North/Northwest

C. CURRENT SITUATION:

1. No shipping held
2. Large number of biologicals to East and Northeast

D. ISPE PRESENTLY CONFIGURED:

1. Conformal array is in the DL sensor
2. Broad Band Search with cylinder and towed array

E. SONAR STANDARD OPERATING PROCEDURES:

1. Triangulate contacts where geometry and resources permit
2. Do Multi-Path Ranging on all contacts in bow quadrant (MPR only works with BB contacts)
3. Broad Band range of the day is 30 kyds

SCENARIO 2, SEARCH

E 0 T 0	RA:	Put up OS Card 2A.
E 1 T 1	SI:	New line on FRAZ at 318° (302 Hz, broad, diffuse and unstable). (will track in ATF)
	D:	Supervisor designates as Sierra 131.
	P:	Remember Standard Operating Procedures.
E 2 T 4	SI:	DIMUS trace on left at 098°, on right at 068/292°R (corresponding relative bearings). Can hear it.
	D:	Supervisor designates as Sierra 132.
E 3 T 5	SI:	Weak DIMUS trace on LTA of towed array 078/282°R. Not able to hear it, not enough SNR to track in ATF.
	D:	Supervisor directs replace cylindrical array with conformal array to resolve bearings. (Low SNR there too Bearing 312°T is the same as S-131 on DL.
	P:	Supervisor prefers you restore cylinder because of better frequency response.
E 4 T 8	SI:	DIMUS trace on left at 073°, on right at 043/317°R (corresponding relative bearings). Can hear it.
	D:	Supervisor designates Sierra 133.
E 5 T 10	SI:	Intermittent trace on cylinder STA 044°.
	SI:	Sounds like winch noises.
	D:	Supervisor designates as Sierra 134.
E 6 T 12	SI:	DIMUS trace from S-131 now in towed ITA fields - still can't hear it. (ATF trackers will lock)
E 7 T 16	SI:	DIMUS trace in ITA field of left display. 047°. Can hear it.
	D:	This is probably S-134.
E 8 T 20	SI:	New line on FRAZ, 301 Hz, 312°. (S-131 is at 255° now) Line strong enough to track.
	D:	Supervisor designates as Sierra 135.
E 9 T 21	SI:	DIMUS traces from S-133 weaken and end abruptly. Can no longer hear it 100°T.
	D:	Supervisor says not to drop file.
E 10 T 22	SI:	Threat alert: 301 Hz, 313°. (Line is already in file for S-135)
	D:	Supervisor tells Search Operator to acknowledge, then to continue to watch S-135 while Class-Loc works on identification.
	D:	Supervisor wants a second tracker on the towed array.
E 11 T 25	E:	Own Ship turns to course 000° (to avoid trawlers to Northeast).
	RA:	Put up OS Card 2B.
	SI:	DIMUS from S-132 stops 124°.

E 12 SI: New trace on towed array 058/302°R. (same bearing as S-134)
T 28 D: Supervisor tells to assign tracker on towed to triangulate.

E 13 SI: Strong transient (even on cylinder STA- if cylinder is still
T 31 being displayed) from S-134.

E 14 E: Lines from S-135 decreasing in SNR; lost ATF.
T 34 D: Supervisor directs Search Operator to track S-135 in MTB.

E 15 E: Own Ship turns to course 270°.
T 37 RA: Put up OS Card 2C.

E 16 E: Towed array stabilized after turn.
T 43

E 17 SI: S-134 trace on towed array stops abruptly at 072°.
T 45 (S-134 is in baffles for hull arrays)

E 18 SI: Spaced bright transient on towed array STA at 073°. Hears
T 45 noises from S-134.
D: Supervisor tells not to drop file.

E 19 SI: While paging LOFARs, notices increasing SNR from S-135.
T 47 P: MTB tracker can go to ATF now.

E 20 E: Threat alert from S-135: 300 Hz, 331° (same line as first
T 48 threat alert). (Threat gram indicates tracker already assigned)

E 21 E: Another threat alert from S-135. New frequency.
T 49 D: Supervisor requests a tracker on the towed array for this line.

E 22 SI: New DIMUS trace on cylinder (or conformal) at 130°, on towed at
T 50 140/220°R. Can hear it.
P: This is about the same place S-132 stopped.
D: Supervisor asks what it sounds like. (It sounds like S-132)
D: Supervisor says to enter to S-132 file.

E 23 SI: New BB trace on towed array ITA 157/203°R. (113°T is in
T 55 baffles of hull arrays)
P: This is about the same place S-133 stopped.
D: Supervisor asks what it sounds like. (Can't hear it)
P: Are you listening to the same array you see it on? (It sounds
like S-133)
D: Supervisor says to enter to S-133 file.

E 24 SI: Notice that tracker symbols for S-132 and S-133 are both on
T 70 one trace (i.e., the louder has captured the weaker).

END OF PROBLEM

SCENARIO 2, CLASS-LOC

E 0 T 0	RA:	Put up OS Card 2A.
E 1 T 1	E:	Search Operator has assigned 1 tracker to an unstable 302 Hz line. 318°.
	D:	Supervisor designates Sierra 131.
	P:	Must now wait 3 or 4 minutes for grams to develop - in that time other things happen.
E 2 T 4	E:	Search Operator reports new contact at 098°, has 2 trackers in ATF.
	D:	Supervisor designates Sierra 132.
	P:	Contact abeam and drawing aft - multi-path ranging (MPR) Not required at this time.
E 3 T 8	SI:	Now have usable DEMON on S-132.
	P:	One 4-bladed screw, 90 rpm, sounds like sometimes out of water. (Classified as probable trawler)
E 4 T 9	E:	Search Operator reports new contact at 073°, has 2 trackers in ATF.
	D:	Supervisor designates Sierra 133.
E 5 T 10	E:	Search Operator reports possible winch noises at 044°.
E 6 T 12	E:	Search Operator reports BB trackers in ATF on S-131.
E 7 T 14	SI:	Now have usable DEMON on S-133.
	P:	One 3-bladed screw making 200 rpm (Classed as light craft: trawler).
E 8 T 16	E:	Search Operator has new contact at 047°. One tracker in ATF.
	D:	Supervisor designates Sierra 134.
	P:	S-134 is almost dead ahead of you.
E 9 T 19	SI:	Have usable DEMON on S-131.
	P:	One 4-bladed screw making 108 rpm, that plus multiple wavering lines (classed as probable merchant).
E 10 T 20	E:	Search Operator reports new line on FFAZ, 301 Hz, 312°. Has assigned 2 trackers in ATF.
	D:	Supervisor designates Sierra 135.
E 11 T 21	E:	Search operator reports S-133 disappeared.
E 12 T 22	E:	Threat alert. 301 Hz, 313°.
	P:	This line is already on file.
	D:	Supervisor tells Class-Loc Operator to take over tracking of S-135.

E 13 T 23	SI: P:	Have usable DEMON on S-134. One 4-bladed screw making 165 rpm. (Classed as light craft: trawler)
E 14 T 25	E: RA:	Own ship turns to course 000°. Put up OS Card 2B.
E 15 T 31	E:	Search Operator reports ping from S-134.
E 16 T 32	SI: P:	Additional lines beginning to come in on S-135 gram - seems stable. Beginning to look as though he might be the Type II.
E 17 T 34	SI: D:	Lines from S-135 decreasing in SNR (tracker beginning to unlock). Supervisor orders search operator to MTB 300 Hz tracker.
E 18 T 37	E: RA:	Own Ship changes course to 270°. Put up OS Card 2C.
E 19 T 39	SI: P:	Notices slight up-doppler as OS swings bow past S-135 (now at 324). Possibly due to own ship motion.
E 20 T 43	E:	Towed array stabilized.
E 21 T 44	E:	Search Operator reports S-134 stopped.
E 22 T 45	E:	Search Operator reports echo-ranging from 073°.
E 23 T 47	SI: E:	New lines appearing on S-135 grams, getting stronger: slight up-doppler, propulsion lines increasing in frequency. Search Operator puts tracker back in ATF.
E 24 T 48	E: SI:	Threat alert from S-135: 301 Hz, 331°. (This is a reactivation of a previous alert) Additional lines appearing.
E 25 T 49	E: D:	Another threat alert from S-135 (new line). Supervisor requests restore trackers on towed array (in preparation for turning away from S-135).
E 26 T 50	E: D:	Search Operator reports new contact at 130°. Supervisor thinks it may be S-132 again; hold off on assigning new tracker.
E 27 T 53	E:	S-135 still drawing aft, bearing 345°.

E 28 E: Search Operator reports new trace at 157/203° relative.
T 55 D: Supervisor thinks it may be S-133 again; hold off on assigning tracker.
P: Contact is in baffles of hull arrays. You can't hear it with present audio selection.

E 29 SI: DEMON from contact at 130° looks like S-132.
T 56

E 30 SI: LOFAR of S-135 beginning to show slight down-doppler. (May be past CPA)
T 65
D: Supervisor is changing DL sensor to towed array.

END OF PROBLEM

APPENDIX B

ERROR AND SYSTEM QUESTION CARDS DOCUMENTING PROBLEMS DESCRIBED IN THE TEXT

ERROR AND SYSTEM QUESTION CARDS DOCUMENTING PROBLEMS DESCRIBED IN THE TEXT

The cards describing operator errors or questions of system operation raised during the run throughs of the scenarios are presented in this appendix. These were based on notes made during the running of the scenarios and tend to be cryptic. Several describe multiple mistakes, only one of which is relevant to the associated problem description.

The cards are organized by problem number. Each card is identified by a running head of the form: 61:DLS, 2S/10, D. This gives the card number (61), the display or displays where the problem arose (DLS), the scenario and event number (2S/10), and the subject having the problem or raising the question (D). The text of the card follows immediately.

Some of the cards also have notes made after the card was created, answering the question posed or further defining the problem. These notes are placed between double slashes (//) to differentiate them from the original problem description.

Abbreviations are used extensively. For the most part, the referent will be obvious to anyone who has read the text of this report. Scenarios designated "NF..." are the TRACOR "No Fault" scenarios used in training. TA stands for (sonar) Threat Alert, and AB and GM are the authors.

Problem 1

79:BB,1S/10, D. Tried to initialize tracker on new contact while hooked to S-142. IDEA: Machine should give error message if attempt to add a tracker to a file at a bearing radically different from other tracks in file.
// SOP - unhook ASAP //

80:BB,2S/2, D. When S-132 detected, pushed "initialize tracker at bearing" when hooked to S-131. Some kind of system test that warned of attempts to assign additional tracker to a contact at different bearing would help prevent this, which is probably the most common error with new operators.

100:CS,1CL/15,D. Erroneously assigned tracker to previously hooked contact (vice threat), corrected mistake by dropping and unhooking, then pushed "new line at XXX", creating a new file (threat already on file) and another error. Finally did it right (hooked threat's file) and had to go to CSD to delete erroneously created file.

105:CS,1CL/15,D. After TA, initialized tracker while hooked to previous non-threat contact. Some test for tracker approximation to others in file a must.

108:CS/CA,1CL/26,D. Problem - begin prosecuting threat while hooked to previous contact. Had to be reminded to drop hook.
// Implies train to complete processing //

222:DL,2S/19, F. Initialized tracker when new lines appeared. Two errors: (1) had not succeeded in unhooking from another contact, hence initialized into wrong file, and (2) failed to enter lines.

225:BB,2S/22,F. New BB trace - initialized tracker ... then realized still hooked from last TA. Again hung up - "complete resource processing" releasing tracker in order to release hook. Used 4 pushes to release hook, minimum possible here 2.

265:CS,1CL/4,F. Apparently (only) released tracker when goal was to release hook. Then initiated tracker to old (hooked) contact file when new line (new contact) was appropriate.

Problem 2

82:BB,2S/6,E. When DL S-131 appeared on BB, called new trace - then dropped trace, hooked S-131 and assigned tracker to that file.
// Should have dropped new file? //

93:BB,2S/3,C. Initializes new "trace at bearing" for BB trace on DL contact thereby creating new file (? check out tests and error messages for new trace and hook VABs re more than one file on same bearing).

Problem 2 (cont'd)

284:BB,2S/3,G. BB gain of DL contact. Pushes "new trace; maintain file" vice hooking. Wants to correct his mistake by dropping file via CSD but Search VABs for CSD won't let him do it. This is a very common error. Also tried to gain access to a drop file function by hooking at bearing, but there is no drop file once it's been created.

334:BB,2S/6,H. Again does new trace, etc., when should have hooked Sierra. Old contact can now be tracked.

Problem 3a

81:BB,2S/2,D. Subject wants to use "new trace at bearing" VAB as first step in assigning second tracker for triangulation.

206:BB,2S/4,F. In order to add second tracker to triangulate, pushes "new trace at bearing" on towed array instead of hooking and adding tracker and resolving ambiguity.

210:BB,2S/6,F. Created new file (new trace, etc.) on CYL when should have hooked existing file on TOW.

283:BB,2S/2,G. New Contact: "new trace, ATF", then "new trace" again (on same array - cylinder vice towed), MTB & Hook, ATF, *then* resolve bearing. Possible problem with multiple files at same bearing.

315:BB,2S/2,H. Trying to assign a second tracker. Created a second file instead.

319:BB,2S/4,H. As card 5, event 2 - Trying to put on tow as well as Cyl to triangulate. Assigned a second file instead.

Problem 3b

68:BB,2S/5,C. Trace stops abruptly. Does "new trace at bearing," MTB assign and hook" instead of simple "hook at bearing" in an effort to release the tracker.

134:CS,2CL/25,E. After TA, wants to assign tracker to TA line, but have it in old contact's file. Pushed new line at freq. and bearing (thereby creating a new file at the same bearing). [Should there be some way of warning of this?] Then had to go back and hook (but now 2 files at bearing!) and assign tracker as per original intention.

286:DL,2S/9,G. DL decreasing and unlocking; to MTB, pushes "new line at XXX, MTB & Hook".
// Makes a second file. //

Problem 4

47:DL,2S/21,E. Hooks threat (creates new file?), starts tracker. Then gets on towed array, starts second tracker, then dropped first tracker.

Problem 4 (cont'd)

// Test in CS flow charts - TBD? //

52:DL,2S/21,A. New threat line from old contact (to which hooked at time of TA). Pushes hook threat, thereby creating a new file at same bearing. Does the system have any way to sort this out, or must the supervisor? Then dropped (automatically assigned tracker on conformal) and added on towed - still in the newly created extra file.

53:DL,2S/10,A. Hooks threat (creates new file?): threat line already in file. Then released that tracker and assigned a new one on TA. Do we now have 2 files on same contact? Should we have dropped hook and then hooked S-135?
// Should have entered to file number //

55:DL,1A/8,A. Second TA while hooked to contact (new line, same contact). Pushed "hook threat" thereby creating a new file at the same bearing. There ought to be some kind of system test for this (overlapping file) thing.

105:CS/CA,1CL/15,A. TA from S-144. Pushes hook threat (now <u>3</u> files at bearing) and starts tracker. Wants tracker on towed, so goes back and drops first tracker and re-initializes, still in third file. Need some system test for existing files on threat bearing or more careful operation.
// Need "hook old threat" and "hook new threat" VABs //

107:CS/CA,1CL/10,A. Hooked to S-144 (via class channel tracker) when TA from new line on S-144. Subject acknowledges threat and hooks threat (new file, same bearing, different frequency), enters new line via C-S, then proceeds with signature assembly as planned, still hooked on threat. Do we now have 2 files at same bearing, first with 1 tracker and Sierra Number assigned, second with 1 tracker?

213: DL,2S/10,F. Treated as a false alarm the hard way: ATF ASGN followed by RELEASE TRKR.

297:DL,1S/6,E. TA from contact in file, pushed "hook threat" causing additional file at same bearing. Should have entered to file number.

304:CS,1CL/9,E. New line from contact on file, "hooks threat" vice "enter to file #".

306:CS,1CL/14,E. Subject "hooks threat" vice "enter to file" or "false alarm". Question: Does "hook threat" response have "return to previous options" escape route? Check FOD: It ought to: this is a very common mistake.

308:CS/CA,1CL/25,E. TA, "hook threat" vice "enter to file" or "false alarm". Then goes to enter new speed to CMA before assigning tracker or otherwise completing TA sequence. Then wants to drop hook, gets cue "complete resource processing", "maintain file" and drops.

Problem 5

88;BB,1S/2,D. Subject wants to change array to conformal (vice cylinder) but confused because display selection tiers not available when hooked. Finally puts tracker on conformal without displaying it (uses SNR meter to check placement).

95;BB,2S/3,C. Having to drop hook to change BB fields displayed may be an inconvenience.
// Standardize drop hook //

234:BB,2S/6,B. Hooked to contact when 21/15, wants to look at 7, can't reach "display source select" when hooked, some problem remembering to unhook to give access.

Problem 6

123:CA,2CL/4,C. Responds to report of new contact with "hook ClCh tracker" before he has assigned a class channel. His comment - should be better way of hooking - so it doesn't alter the displayed choices - in particular the option to assign a class channel to the hooked contact. Subject at this time still not clear on how or why to hook.

124:CS,2CL/2,D. Subjects hooks new contact at tracker bearing before has assigned class channel. Has to go back and drop hook before he can proceed.
// Error or AB interpretation of way system must be used. Hook limits access. //

125:CS,2CL/10,D. Operator hooks new contact to begin prosecution before has assigned Class Channel. A recurring error.

126: CS,2CL/1,D. Subject wants to hook new contact, then assign class channels. Doesn't see logic in having class channel assignment tiers inaccessible when hooked.
// Not on Contact Status //

128:CS,2CL/1,C. Responds to report of new contact by hooking at XXX & bearing. Said it seemed reasonable (it makes class channel assignment tiers unreachable) and then had to drop hook to continue.
// Move 2.6.-1,2 to right} conflict with
2.6-4 to left?} other tiers //

268:CS,1CL/9,F. System characteristic - If hooked and want to assign a class channel using Class Summary Display - "Must unhook to assign channel." Quote from data sheet.

289:CS,2CL/1,G. MTBing weak DL line, wants to assign CL-CH (to fixed beam - would CL-CH move with cursor doing MTB?) and tries to drop hook before releasing tracker. Error cue "complete resource processing" OK here.
// Go to Contact Status if want to hold hook. //

Problem 6 (cont'd)

290:CS,2CL/2,G. Told of new contact, tries "hook at tracker bearing" as first step in assigning Class Channel. Why Class Channel not available when hooked?

291:CS,2CL/6,G. Told of new contact. First step is "hook at tracker bearing" for assigning Class Channel. Second time he's done this.

Problem 7a

26:CS,NFSUP/J,D. LAMPAZ assignment for CS not accessible when hooked, yet more likely to be desirable for contact of interest (which is more likely to be hooked) than for a routine one.

132:CS/CA,1CL/10,A. Trying to get new line onto LAMPAZ while still hooked and CS hooked tier *won't let him*. Calls up signature (which has 1 line in file) and transfer signature to LAMPAZ from CA. Awfully round-about.
// Build LAMPAZ and Signature only after have several lines. //

133:CS,NFSUP/J,E. Wants to enter line to LAMPAZ when hooked on one contact and has to unhook to reach LAMPAZ tier. Note says notion of unhooking to reach certain controls still a bit shakey.
// See 132 // .

Problem 7b

113:CS/CA,1CL/4,A. CL has 4 lines on S-143. Moved first 2 to LAMPAZ via 2.7.6.2-0 about 10 minutes ago. Elects to do it again now that there are more lines. Does this operation leave the previous lines unaffected or would the machine start over fresh? Also, what will happen if he tries this with partial signatures from more than one contact. Will the machine drop lines from the first (partial) signature?
// Yes it will. //

130:CA,2CL/24,D. New line appearing on contact being tracked. Enters line to file via top tier (CS) (hooked) then to working signature with same (but having different action) VAB in Signature Assembly tier. Awkward.

131:CS/CA,1CL/12,A. Subject transfers signature to LAMPAZ almost every time a new line is added. Would this interfere (i.e., restart data accumulation) with lines that were already on LAMPAZ?
// This VAB moves temporary vector to LAMPAZ - can only have one contact on LAMPAZ. //

150:CS/CA,1CL/13,D. Has assembled signatures for 2 contacts and transferred both to LAMPAZ. Question: Does the system give any warning if the transfer of a signature is going to cause the bumping of already established LAMPAZ lines?
// NO //

Problem 8

17:CSD,NFSUP/E6,D. In 3.4.0.1 VABs to release and assign correlation and class channels result in automatic return to 3.4 or 3.4.1. This is a nuisance if both correlation and class channels, or more than one of each, is assigned.
// Room for return? YES //

Problem 9

144:CA,NFCL/Q,E. Comment: Harmonic comb on/off VAB unnecessary on this tier. If wanted harmonic comb off, wouldn't have called this tier in the first place.

148:CA,1CL/21,D. In using harmonic comb, subject has turned "harmonic comb on/off" to "on." Check FOD to see if it always comes up in the "on" position. If it doesn't, it should.

Problem 10

147:CA,1CL/2,D. In assembling signature, pushed "enter lines displayed" VAB before he had entered any lines to the signature field. "ENTER" in this and "enter lines at XXX" VAB may be too easy to confuse?

152:CA/CS,NFCL/E,C. Entering a single new line to the file when hooked and in a signature assembly mode is awkward. VAB "Enter Line" puts line on signature field, not in file. To get to file, must then "enter lines displayed" which transfers all the lines to the file (including possibly shakey ones). Since the frequency cursors are slaved on a console, it may be possible to get around this problem by entering the single line on CS if that display is available.

154:CA/CS,2CL/16,C. Additional lines on gram: hooks at tracker bearing on CS vice CLCH or CA. Then pushes "enter lines displayed" before "enter line at XXX." (Enter line at XXX confusing because enters to signature field but not directly to file as on other displays.)

182:CA,1CL/10,H. Did "enter lines displayed" vice "enter line at XXX."

186:CA,1CL/2,H. Activated "enter lines displayed" when should have touched "enter line at XXX."

273:CA,1CL/16,F. Entering lines to signature, pushes "enter lines displayed" before "enter line at XXX" which is backwards.

294:CA,2CL/15,G. Was slow to "enter lines displayed" after several "enter line at XXX." Probably needed to be reminded, but notes don't say.
// May not want to do ELD; does FOD suggest this sequence? Don't believe so. //

305:CA/CS,1CL/?,E. Subject "enter line at XXX" and moves to LAMPAZ but does not "enter displayed lines" so not on file.
// Wouldn't necessarily want to clear and fill contact file. //

Problem 11

167:CA,2CL/17,D. From hooked top tier subject uncertain how to get to "maneuver detect" VAB.

170:CA:NFCL/R,D. VAB label "update CMA" mildly misleading. "Access CMA" would be better.

171:CA,NFCL/R,A. Has trouble getting to CMA through Loc/Range History. Possible some memory problem as in #2; possibly VAB labels could be more helpful.

172:CA,NFCL/R,C. Subject has trouble remembering that you have to reach CMA update via "localization/range history". Perhaps changing the name of this set of tiers would make it a bit easier to learn.

238:CA,2CL/10,B. Subject has trouble remembering access to ZIG detect via loc-range history. IDEA: Possible change name of VAB to "contact motion analysis."

276:CA,1CL/19,F. Detects speed change on DEMON, tries to reach CMA via "sig ass" instead of "loc/range hist." Recovers promptly.

Problem 12

230:CS,CL/2,B. Class Channel assignment tiers terminates in Class Channel processing option: "full" and "extended." "Full" should be "norm" to agree with same options in CA.
// Neither self-explanatory. //

Problem 13

280:CA,1CL/25,F. In MPR, pushed "compute range; ranging complete", then went back to loc/range hist and pushed enter range. System would have required that he mark correlation peaks and compute range again. "Compute Range" VAB should say "compute trial range."

Problem 14

142:CA, NFSUP/F4,D. "Select vernier process" much like "select dem/vern displays." "*Assign* vernier process" would be better.

Problem 15

33:BB/DLS/CS,2CL/2,D. BB operator pushes "new trace at bearing" and starts a tracker. Does he know the tracker number? Then the CL operator starts to assign a CL-CH via unhooked CS. How does he know the tracker number to assign the CL-CH to? Does someone *have* to be looking at the contact status display to recover the tracker number? An alternative to this is for the CS operator to "hook at bearing", read the tracker number from the (hooked) tracker table, *un*hook, and then assign a CL-CH but it seems very cumbersome.

Problem 16

51:DL,NFS/G,D. RE: Process of entering alarm line to file: "How would you know what file you have somebody in. Maybe Sierra number would be easier (as an indexing system)."

102:CS,2CL/12,D. TA from line with tracker assigned. Wants to enter to file. How does the operator know file if he: (a) isn't hooked to the threat contact, or (b) didn't start the file himself?
// Not an error - unless judge should call False Alarm //

287:DL,2S/21,G. TA acknowledged with "enter to file #". TA when hooked to contact of interest likely, also system knows what file is at bearing of TA. "Enter to file at bearing" VAB might be quicker, save operator from looking up file number.
// May be > 1 contact at bearing //

Problem 17

11:CSD/CA,2CL/24,D. TA with CSD/CA up, pushed TA, got error cue "select DL search display" and did just that (vice selecting CS). Error cue misleading.

45:DL/CS,2CL/24,E. Configured DS(U)/CA when TA. Dropped hook on one contact then (following displayed cue) put up DLS when really wanted CS. Acknowledged alarm, then put DS(U) back. TA again and this time put up CS.

104:CS,NFCL/T,E. Called DL when wanted CS in response to cue "select DLS."

Problem 18a

37:CM,1CL/2,D. Gets several "invalid command"s when tries to enter other data before has pushed "enter" FAB on first datum. This wouldn't happen with real system due to blanking of VABs (which we suppressed). Perhaps that error supports wisdom of blanking VABs when entry pending. (Could you make a case for blanking all but last selected VAB, to remind him which he was doing if he was interrupted?)

183:CA,1CL/4,H. Incorrect response to "enter" re contact speed. Error message "invalid command" not informative.

Problem 18b

35:CM,2CL/7,D. Tried to drop hook while "enter number at index" pending on CM. Error message said "selection invalid". Not very helpful - not as good as "enter number on other display", which we have seen in other contexts.

38:CM,2CL/13,C. Tries to drop hook while enter pending. Gets "selection invalid" as error message. Not helpful at all.

Problem 18b (cont'd)

274:CM,1CL/16,F. Tries to drop hook when entry pending from "line # from tag". Error cue is "selection invalid" - not very helpful.

296:BB,1S/4,E. Tries to drop hook in middle of release tracker number (before number is entered). Error cue is "selection invalid," instead of the more informative "complete resource procession." Check sequence. S persisted in pushing drop hook, perhaps because our display did not blank and the enter FAB not as conspicuous as would be in real system. In desperation, pushed release tracker number on DLS; error cue changed to "enter # on other display", much more informative. Finally entered number and was allowed to drop hook, even though he had an entry pending on DLS, too (or did it ignore this when it gave the error cue?)

Problem 18c

34:CM/CA,2CL/25,D. Enters info to CM when TA, pushes TA and gets "selection invalid" error cue (an entry was pending on CM when TA sounded). Again, error cue displayed not very helpful.

Problem 19

277:CA,1CL/19,F. Extra VAB "enter computed range" at end of CMA entry - ? (What would ISPE do in this case?)

Problem 20

71:BB,2S/24,C. To resolve crossed trackers, drops one from weaker contact and starts a new one at the correct bearing. Would this mean CMA had to start from scratch?

228:BB,2S/24,F. Trackers merged, operator is supposed to separate. Apparently decided, after listening, that one audited first was OK. Then instead of listening to second and MTBing to correct track, operator released tracker, put new tracker in ATF on TOW.

Problem 21

99:BB,2S/18,E. Sees transient on STA at position where BB contact stopped - hooked to DL contact in MTB - elects to do nothing.
// Judgment call - should have SOP for this - others reported to Supv - probably appropriate if this (Search) console manned by rates other than sonar. //

333:BB,2S/5,H. Subject: "Need OP guidelines on maintaining log for intermittent noises."

Problem 22a

169:CA,NFSUP/W,D. Two comments on business of inhibiting tracker to CMA:
1. Is there a practical difference between inhibiting and dropping

Problem 22a (cont'd)

169:CA,NFSUP/W,D (cont'd)
a tracker?
// YES //
2. Whole business of controlling CMA might best be done on GeoSit or even a separate, dedicated display. (This last comment appears in final debrief, too.)

Problem 22b

160:CA,2CL/8,D. After MPR, chose to "update CMA", "enter range" vice "enter computed range". Not really clear on the difference in effect. Special guidance on this part would be helpful.

163:CA,2CL/4,A. With new contact in bow quadrant, does MPR and "enter computed range" and then enters range again via update CMA. Is this necessary?

165:CA,2CL/8,C. New contact almost dead ahead. Does MPR, then chooses to enter range via "update CMA." "Enter range" vice "enter computed range" (on reader's prompting). Is this a better way to do it?

Problem 22c

21:CA,1CL/0,C. When contact maneuver reflected in turn count that allows calculation of his speed, is it better for CMA operator to enter "maneuver detect", "speed change", and the new speed, or just to enter the new speed without signalling maneuver detect?
// Must start solution over.//

168:CA,1CL/19,A. Detects maneuver and determines speed for DEMON analysis. Enters contact maneuver and new speed. Is this the best way to do it or would entering the new speed alone be enough? If speed alone *not* best, a machine cue to at least consider "maneuver detect" might be useful.

Problem 23

23:CA/CA,2CL/24,C. Subjects thinks TA on every console a serious distraction, especially for CL operator.
// Agree //

109:CA/CA,2CL,D. Subject says responding to TAs while tracking a contact and working between CA and CM too much of a burden for class operator. Supervisor should do it.
// Check with Rick - supervisor enter classification data? Problem in allocation of function. //

Problem 24

1151:CA/CS,NFSUP/L,D. NUSC program will not accept VAB command to transfer signature line to LAMPAZ unless CS is being displayed. Since

Problem 24 (cont'd)

CA/CM is frequently up a large part of the time during classification, this restriction may slow down a busy operator. Is it a safety feature? // No problem, but CM should be SUPV job. //

APPENDIX C

SUBJECT DEBRIEFS

SUBJECT DEBRIEFS

At the conclusion of the week of training and testing, each subject was interviewed to obtain his evaluation of various aspects of the system and any suggestions he might have for improving it. The first four of these interviews were unstructured and the last four followed a protocol (presented on the next page). Notes taken during these debriefings are reproduced on the following pages.

ISPE Debrief Protocol

1. Were there ever instances when you wanted to do something but had a hard time figuring out how to get the system to do it?

2. Do you have any feeling that the arrangement of the control tiers *imposes* an order on the way you do things with this system? (if yes) Do you find the imposed order helpful? Annoying? Restricting? Do you think the imposed structure makes this system easier (harder) to use? Do you think the imposed structure would make this system easier (harder) to learn to use? For a new sonarman?

3. Did you find any of the VAB labels unintelligible? What (better) labels would you use? Did you find any of the VAB labels misleading in that the function they control wasn't what you thought it would be?

4. Were any functions awkwardly implemented? How would you streamline them?

5. What equipment do you use now to perform this function?
   a. Do you think it or ISPE is easier for you to use?
   b. Is there any instance where your current equipment is easier to use? What makes it easier to use?

6. Are there places where controls should be grouped together but are not? Did having to go to a different tier to operate one control ever put others that you would want to use concurrently out of reach?

7. Could you find every piece of information you wanted on the display?
   a. Were the display readouts grouped in a way that would make them easy to use?
   b. Was there anything you thought was a waste of display space?

8. Did the arrangement of the displayed readouts or data fields ever suggest an analysis you might not have thought of otherwise?

9. Would you have laid out the displays any differently if you had been the designer?

Subject A, STS2(SS)

1. Problems implementing desired actions. None, once familiar with the capabilities of each display [but this *was* a small problem - learning what each display can do for you takes a while (especially in the case of class-analysis, which does so many things) and S was often uncertain which display to select].

2. Imposition of order by the control structure. S was aware of this, but the order was "just the way the machine was," not difficult to adjust to and "seemed logical."

2a. Was this order helpful? The control structure (tiers of VABs) was *much* easier to use than an (equally versatile) array of dedicated switches would be - "helpful, as a matter of fact."

2b. Did it make the system easier to use? [The restricted set of choices] "helps to make the choice of the next action."

2c. Does the structure make the system easier to learn? "I had 3 weeks of BQR-21 operator training, and then was not comfortable with it," but was fairly comfortable with ISPE after 4 days. "Yeak, its going to be good - If you give 3 weeks training on it I'd be comfortable as a supervisor." "The control structure [should be] much *easier* [than current systems] for a new operator to learn ... he will learn faster because it *is* a step-by-step lay out." [However] for initial training on ISPE "better use people who have been to sea."

3. Were VAB labels unintelligible? No, though they were too close together on this [NSMRL simulation] screen. Making sense of the labels is easier if you already know sonar. Some of the displays' names were misleading, e.g., hard to connect "Class-Analysis" with MPR and CMA management functions and "Class-Summary" is a better name for the [hooked] Class Menu or Contact Status Display than the present "Class Summary."

4. Were any functions awkwardly implemented? Ratio compute has an unnecessary extra step in "compute ratio" after "mark #2."

5. What current equipment performs these functions? - Skipped this question.

6. Are any of the controls improperly grouped together? No.

7. Was the display layout adequate? In this simulation [he] wasn't paying much attention to the projected displays [because they contained no data]; interested in hooked or unhooked status only.

8. Did the arrangement of the display ever suggest an analysis? In general, no.

9. Would you lay out the display differently? [Possibly]: he disliked having ranging and CMA functions on "Class-Analysis." "Classification and ranging on the same thing is a mistake ... Ranging should be done by the *supervisor*." [The ranging capability is a nicety, not an

essential part of classification.] "Why does the class operator *care* how far away he [the contact] is - he doesn't. Why put *all* these functions on the class display and then have something [as simple - and error prone] as detection prediction on a display by itself - "It doesn't seem logical to me."

"Detection prediction - who cares - it's never going to be right anyway - just going to give the OOD something to worry about that he doesn't need to." ["If CMA or other ranging doesn't agree with the range of the day, the OOD will hassle sonar" - OOD's don't appreciate how approximate the range of the day is: they tend to think sonar is malfunctioning or goofing-off if every contact is not detected at the predicted range.]

Subject B, STS3(SS) (before protocol)

1. One Suggestion: Harmonic comb useful in tracking operations, possibly should be available in "loc/range history" tiers.

2. *Hooked* concept difficult, especially idea that different controls are available when hooked than when not hooked.

3. Thinks Contact Status log a great help with the large number of trackers and correlation channels available.

4. Notes no explicit use of doppler information by operator. Says programs for the Tektronix 4051 uses doppler in CMA - does ISPE? (Yes, but not in a way that lets the operator know how the doppler is affecting the CMA.)

5. Subject thinks well of the system: "It seems to have all the features you could want."

Subject C, STS3(SS)

1. Problems implementing desired actions. The hooked/unhooked status was sort of a problem [especially the idea that you had to be unhooked to do certain things, e.g., assign class channels] but that was about the only thing - "once you know it, it's all within reach."

2. Imposition of order by the control structure. The subject was aware of the structure inherent in the arrangement of the control tiers, and preferred it to the lesser structure of an array of dedicated switches.

2a. Was this order helpful? "... yeah. It more or less leads you right where you want to go ... [it's] giving you hints."

2b. Did it make the system easier to use? Yes.

2c. Does the structure make the system easier to learn? [Possibly not:] "... It's harder to learn ... because it's different from any other sonar I ever used ... the old systems [are] more straight forward - [you're] listening to one contact and one contact only. You don't put a contact into a file and leave it and come back - you have it right in front of you."

3. Were VAB labels unintelligible? Generally, no [though this S got mixed up about classification and correlation channels, possibly because of the similarity of the VAB abbreviations].

3a. Were VAB labels ever misleading? Yes. The "new line" VABs which indicated new contacts [S wanted to use these to indicate a new line from an old contact].

4. Were any functions awkwardly implemented? The subject felt that some were, but couldn't give any specific examples. As the *class-loc* operator, he didn't like having to go through "display select" every time he wanted to enter classification information via Class-Menu. He suggested a VAB on Class-Analysis to put up Class-Menu and a VAB or a FAB to replace it with whatever was being shown before, as an alternative to the present procedure of reconfiguring the console via "display select."

5. What current equipment performs these functions? Skipped this question.

6. Are any of the controls improperly grouped together? No. The system is generally well thought out and the FABs cover a lot of major contingencies [but see 4 above].

7. Was the display layout adequate? "It's hard to talk about the displays because we didn't actually refer to them that much." His general impression was that display layout was reasonable.

8. Did the arrangement of the displays ever suggest an analysis? No. "Some buttons [VABs] are kind of misleading that way - some of the things accessed [e.g., CMA entry via "localization/range history"] were *not* explicitly mentioned." [Perhaps a different VAB label, e.g., "ranging/CMA" would be a better cue here.]

9. Would you lay out the displays differently? "I've never seen [the actual control panels] so I wouldn't know ... Like I said before [4 above] a FAB for returning to the previous display [which the present display replaced] - I definitely would have included that."

Subject D, STS2(SS)

1. Problems implementing desired actions. "Basically, no, though there were occasional memory lapses - couldn't remember which display did what ... otherwise OK."

2. Imposition of order by the control structure. "Everything falls in place in the order in which you *would* do it anyway - I was satisfied with the order."

2a. Was this order helpful? "probably helpful, if anything."

2b. Did it make the system easier to use? "[It's] easy enough to learn as long as you can get the associations down between tiers - you're going to have to go by steps and that's the easiest way to learn: to go by steps." "[A] new man might have problems - just the sheer complexity of it all. He will need a pretty good handle on sonar before he'll be able to grasp - what it will do for him. If he doesn't understand sonar, he won't understand this machine ... If he understands sonar, then this machine will be no problem." [Subject said that present sonar "A" school was of poor quality: graduates "won't cut it with ISPE - can't cut it with what we have now ..."]

3. Were VAB labels unintelligible? No.

4. Were any functions awkwardly implemented? "No, everything seemed OK."

5. What current equipment performs these functions? Skipped this question.

6. Are any of the controls improperly grouped together? [Possibly] Ranging and CMA functions shouldn't be on "Class-Analysis": "Give it a separate display. For example, TMA, GeoSit, and ranging should be sort of grouped together. The search operator would handle this - it's quick and easy. Definitely gram analysis calls for its own man: we do it this way and it [by itself] still proves hectic for him."

7. Was the display layout adequate? "For the amount of information on these displays, they're arranged pretty good - I like the way part of the display will change depending on which VAB you hit." There is no waste of space. "I'm glad to see GeoSit and TTM - they're good ideas. Sonar should be able to get the big picture ... this is becoming a lost art."

8. Did the arrangement of the display ever suggest an analysis? "Not really. I knew where I was going most of the time: when I pushed a button I was ready to push the next one [in a multi-tier sequence]."

9. Would you lay out the display differently? "Other than a separate ranging display, no." "Maybe a way of recalling the last [previous] 10 minutes of a gram ..." [When reminded that the grams were 11.8 minutes, he though that it was probably adequate.] "I like the idea that you can record a display - it's good [though it will be one more thing to include in ACINT packages]."

Subject E, STS2(SS)

1. Problems implementing desired actions. "Not after I got to know it" [some problems initially - mostly remembering what display would allow a desired action] - "but that's true of anything."

2. Imposition of order by the control structure. The subject was aware of this.

2a. Was this order helpful? "... generally helpful - there's an order in things [operator actions] anyway."

2b. Did it make the system easier? [the restricted set of choices] if anything, the order was beneficial - "for operator purposes, it's excellent the way it's set up to work [now].

2c. Does the structure make the system easier to learn? "[it should be] easy for a new operator to learn. However, if they intend to teach all the system functions (*Class-loc* and *Supervisor* as well as *Search*) to new sonarmen, they [the operator-trainees] will need a better understanding of sonar principles and fire control principles than they are new being given in basic sonar school."

3. Were any of the VAB labels unintelligible? "No, not once the abbreviations [in the NSMRL simulation] were explained."

3a. Could any labels be improved? "On the Class-Analysis display, change "release signature assembly" to "signature assembly completed" [this S was hesitant in choosing this VAB even after 4 days].

4. Were any functions awkwardly implemented? "Nothing that really sticks in my mind."

4a. How would you streamline these functions? "In Class-Analysis, a VAB to jump to Class-Menu directly [to either replace C-A or put C-M on the other screen] so you could enter classification data without having to go through "display select" [and a corresponding VAB on C-M to return to C-A].

4b. Response to query about the advisability of putting ranging and CMA access on the C-A display. "It's helpful to have it in C-A [then] it's all at your fingertips."

5. What current equipment performs these functions? Skipped this question.

6. Are any of the controls improperly grouped together? No.

7. Was the display layout adequate? [the use of schematic displays in the NSMRL simulation doesn't allow proper evaluation of this question.]

8. <u>Did the arrangement of the controls ever suggest an analysis?</u> "Yes - we don't currently do ranging - seeing 'localization/range history' VAB reminds you [to do it]."

9. <u>Would you lay out any display differently?</u> "Yes. In the Contact Status log section, the Sierra number should be on the left, not the file number, and the tracker table should list Sierra numbers instead of the file numbers [to which the tracker is assigned]." [Using the present log to find which trackers are assigned to a contact requires the operator to find the file number, which he doesn't care about.] "Also, the Contact Status Display should be visible all the time - maybe a separate repeater for this, visible from all 3 consoles."

Subject F, STS2(SS) (before protocol)

"It wasn't hard at all - I had no major complications in learning the machine - being a sonar tech who knows his job, it's relatively easy to follow the functions on the machine - hard to switch from one function to another - but that's not too difficult - just a matter of practice."

o [Performance]- Depends on how well he knows his job, *not* how well he knows the machine - if he knows his job, he can use the machine with little or no difficulty; he'll be OK if he knows *sonar.* Sonar is learned at sea, by experience.

Q: Do you think ISPE will help to learn sonar?

A: Yes. Signature assembly may help to learn contacts of interest; assigning things helps to understand what each feature does for you.

o "Button Tree" easy - for a person who does know his job, say a Chief, he'll be able to operate the system with little practice.

o Subject has had familiarization with the AN/BQQ-5, but has no feeling for the difference between the Q-5 and ISPE.

o A third class just out of school - he might have trouble unless *taught* features.

Q: Could you learn the machine without learning a little bit of sonar in the process?

A: To learn the machine you would learn a bit of sonar.

o The more you know about the machine, the more you have to learn about sonar.

o Could do away with "search mode" altogether, or for that matter with the "Supervisor", too. Just have one (each) console (that) will do the whole thing.

NOTE: Subject not qualified as supervisor.

Subject G, STS2(SS) (before protocol)

1. FABs for display select would be quicker than FAB-VAB combination.

2. Set up Contact Status so trackers to be released can be selected with the index cursor vice "tracker #" VAB requiring keypad entry.

3. Problem trying to prosecute one contact when hooked to another: on search console, perhaps use "complete processing" if try to use display other than the one through which hooked (e.g., error cue if push VAB on DLS when hooked through BBS).

Final Comments:

1. *Hooked* concept a minor problem, still not certain what the point of hooking is.

2. Classification functions (complicated), will take longer to learn.

3. The system is complicated, but probably *not* difficult to operate.

4. Re CONN Display:

a. "as long as he (CONN) gets the information without us having to tell him, that's fine with me."

b. If OOD is to have one of these, he's *got* to know how to operate it - a hassle, and can interfere if sonar techs have to go out and run it for them, especially in heavy situations.

Subject H, STS2(SS) (before protocol)

(Our notes on this debriefing were very sketchy)

1. I feel that the search operator would have more to do that would require some sort of formal training before he should be allowed on the stack.

2. I also feel that a more realistic replica of the ISPE is needed.

3. How big are the system's CRTs? X-ray protection. (?)

4. Re data on screen:

a. There might be too many different kinds of info on CRT at one time.

b. Wouldn't be possible to "window" displays so that you could look more closely at a selected sub-display.

c. Still feel you could lose the picture. While telling the supervisor about what you have, you could lose track of what is happening in all the displays.

5. RLI for MTB analog tracker. [Subject mistaken: BDI meter provided for MTB.]

6. I suggest a separate joystick for audio, so that you could scan continuously on that.

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER NSMRL Report #951	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Eight experienced FBM sonar operators participated in an evaluation of the "operability" of the multifunction switching system employed for system control and data entry in the ISPE submarine sonar system. Operability was operationally defined in terms of the availability of controls for desired functions and the number and kinds of errors associated with control usage. Experienced FBM sonarmen were individually instructed in system operation for three days which were followed by two days of testing in which they employed

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the simulated system in two multi-contact scenarios.

The analysis was confined to controls associated with displays available in the search and class-loc configurations. All functions desired by the operators were readily accessible. Analysis of errors revealed that it is very easy to misfile information or assign resources to the wrong contact. There were a number of errors traceable to control labels that were not as informative as they might be, and one instance in which the same label was used for controls having different functions. There were three instances in which limitation of access to controls when in the "hooked" mode appeared to be counterproductive. It was suggested that the sonar threat acknowledgement functions be made more flexible.

The overall operability of those parts of the control structure tested was judged to be very good, and the operation of the system appeared to be very easy to learn for men familiar with the principles of sonar.