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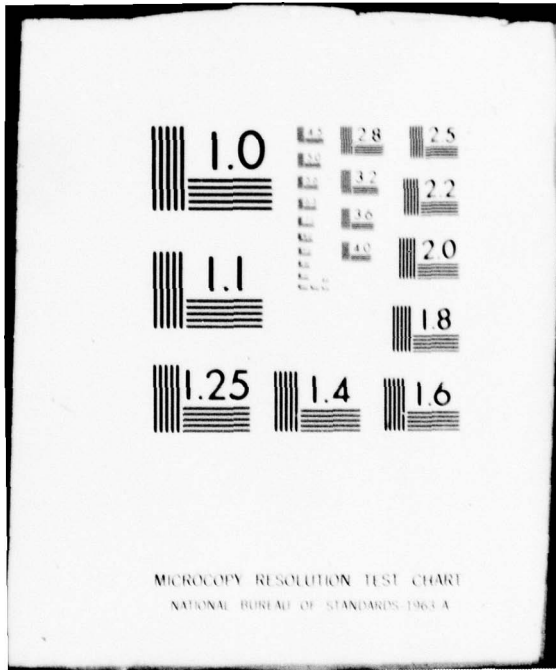
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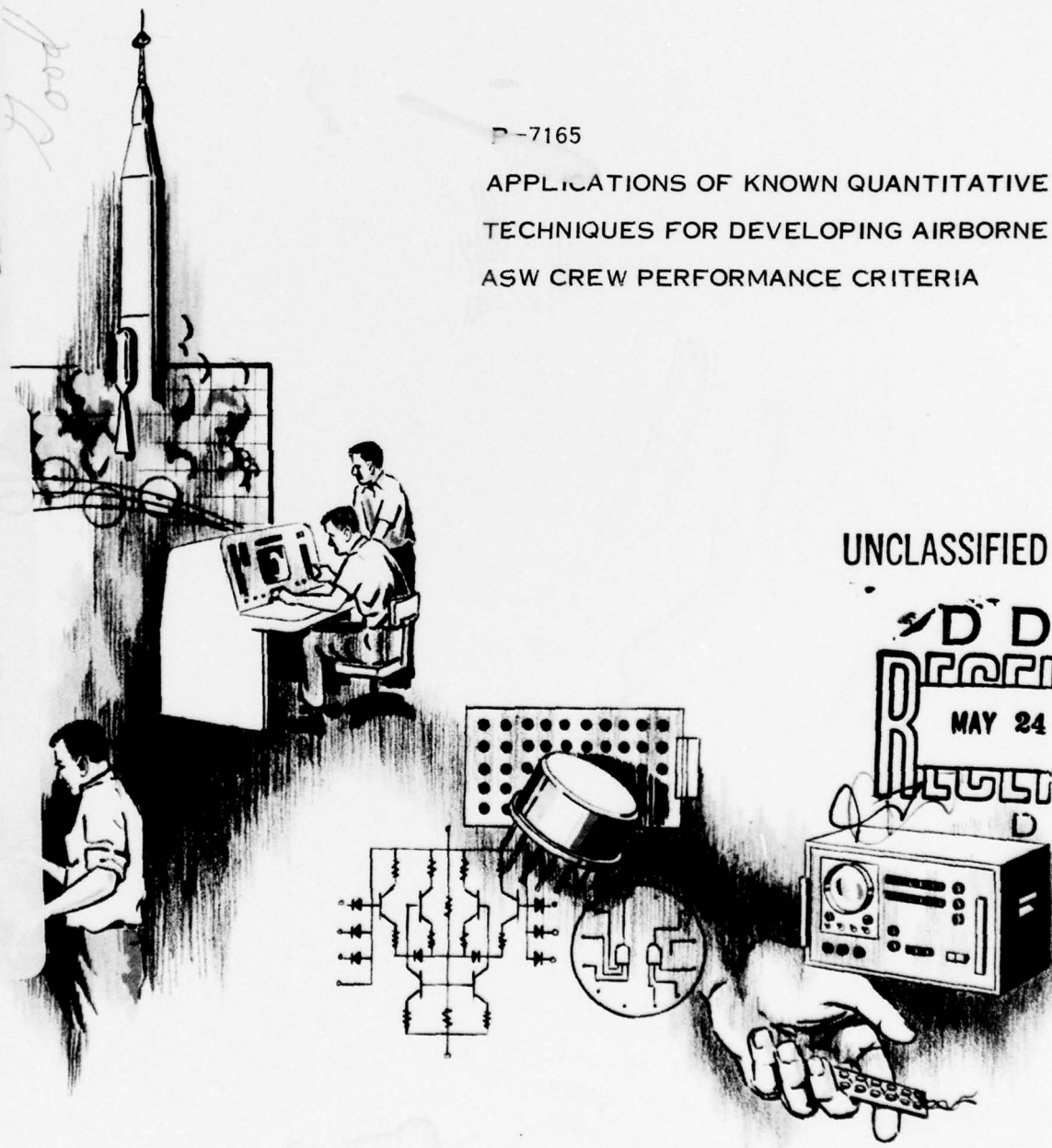
P-7165

APPLICATIONS OF KNOWN QUANTITATIVE
TECHNIQUES FOR DEVELOPING AIRBORNE
ASW CREW PERFORMANCE CRITERIA

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6 APPLICATIONS OF KNOWN QUANTITATIVE TECHNIQUES FOR
DEVELOPING AIRBORNE ASW CREW PERFORMANCE
CRITERIA

10 T.P. / Enderwick,
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ABSTRACT(P-7165)

This is a proposed research plan for a 12-calendar month period. There are five specific airborne ASW research problems discussed briefly followed respectively by five research tasks designed to develop the needed answers. The objective of this research, as well as research outlined for the four following years, is an operational crew proficiency measure.

While the setting of this research is in airborne ASW, many of the findings will be generalizable to other areas of Naval operations. For example, the information indexing model used during this past year originated in the broad area of Naval Intelligence and not where it is or will be applied, viz., airborne ASW. To be sure, the operational airborne ASW will benefit from many of the research results which naturally follow when pursuing a particular objective as the overall crew proficiency measure.

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I. INTRODUCTION

For the first eighteen months under Contract Nonr 4441(00), a performance prediction model was developed and tested in two laboratory tests of student performance on a simulated ASW task. The logic behind the basic performance prediction model may be summarized as follows:

First, in many practical situations, military commanders are forced to decide upon an adequate course of action based upon facts supplied to them by an array of "information systems," e. g., aerosurveillance systems. Second, an experienced commander is able to judge reliably and validly the value of various types of information, i. e., how much help each type is in leading him toward a successful course of action. Third, by use of standard psychological scaling techniques, these judgments of information utility can be converted to quantitative indices for various types of information. Fourth, by multiplying the scale utility value of each type of information by the number of items of that type available, and, by summing these products across all types of items, an overall utility index can be compiled which is highly correlated with decision adequacy -- a performance measure. Specifically, performance is assumed to be a linear function of this information utility index.

Previous Results

Results of the two initial experiments, which are shown in tabular form in Tables 1 and 2, can be summarized as follows. First, subjects were found to have a satisfactory amount of agreement concerning the relative value of information supplied to them. Further, the extent of agreement increased as they gained more experience on the task. Second, as predicted, performance in both experiments was found to vary as a function of the utility of the information provided to subjects at the start of the problem -- with utility being computed on an a priori basis assuming the model to be an accurate predictor of performance. Third, as tables 1 and 2 indicate, performance was found to vary as a linear function of the utility of the information provided, a finding which supports the model's descriptive validity.

TABLE 1 RESULTS OF FIRST LABORATORY EXPERIMENT WHERE ATTEMPTS WERE MADE TO USE THE MODEL TO PREDICT PERFORMANCE OF ROTC STUDENTS IN A SIMULATED ASW GAME. (NUMBERS IN PARENTHESES SHOW THE COMPONENT OF VARIANCE BEING ANALYZED; AN ASTERISK SHOWS SIGNIFICANCE BEYOND THE .01 LEVEL).

SOURCE	df	ss	ms	F
INFORMATION UTILITY CONDITIONS:	(7)	(242,453)	(34,636)	(4.438*)
PREDICTED BY MODEL	1	159,040	159,040	20.377*
QUADRATIC TREND	1	22,958	22,958	2.941
RESIDUAL TREND	5	60,455	12,091	1.545
ERROR	120	936,595	7,805	-
TOTAL		1,179,048		

TABLE 2 RESULTS OF SECOND LABORATORY EXPERIMENT WHERE ATTEMPTS WERE MADE TO USE THE MODEL TO PREDICT PERFORMANCE OF ROTC STUDENTS IN A SIMULATED ASW GAME (NUMBERS IN PARENTHESES SHOW COMPONENT OF VARIANCE BEING ANALYZED; AN ASTERISK SHOWS SIGNIFICANCE AT THE .01 LEVEL; DOUBLE ASTERISK USED TO INDICATE THAT FOUR df WERE USED TO TEST EFFECTS OF A POSSIBLE CONTAMINATION FACTOR.)

SOURCE	df	ss	ms	F
INFORMATION UTILITY CONDITIONS:	(3)	(13,583.71)	(4,527.93)	(12.537*)
PREDICTED BY MODEL	1	11,628.91	11,628.91	32.202*
QUADRATIC TREND	1	827.12	827.12	2.291
RESIDUAL TREND:	1	1,126.68	1,126.68	3.120
ERROR	72	26,003.37	361.16	-
TOTAL	75**			

Past Year's Work

As far as the model goes, the purpose of last year's work was twofold: First, to show how the model could be applied in a practical ASW airborne performance situation to predict behavior of tactical coordination officers (TACCO's). Second, to validate the model's performance predictions using data gathered on a complex simulator which presented a much more realistic environment to the subject than was the case in the laboratory task. To further test fleet applicability of the model, performance of actual experienced aircrews was studied as they attempted to solve problems on the ASW Tactical Trainer in Norfolk, Virginia.

The method of application was to define the output of each of n separate sensors available to ASW aircrews as the "types of information" of interest. Further, the ASW task was divided into various phases. Scenarios were devised to obtain judgments concerning the utility of various sensor outputs at various stages in the problem sequence. Paired comparison information utility scales were devised to provide the necessary data to insert into the model.

The experimental demonstration used the same scenarios and, to a sizeable extent, a number of the same aircrews used in gathering the scaling data. Twenty-seven aircrews participated. Each was assigned three problems involving a conventional target and three problems involving a nuclear target. For each type of target, one of the three problems was run under conditions where the team was given a package of information high in information utility, another problem was run using a package of starting information of medium utility, and the third was run using a package of information of low utility. Information presentations were randomized and counterbalanced to prevent criterion contamination. Numerous performance criteria were used, the basic one being the percent localization uncertainty remaining at successive five minute time periods after initiating the problem*. Problems were terminated after 30 minutes.

* This was a function of the amount of the initial search area remaining at various stages in the problem.

Table 3 shows an analysis of performance scores on the simulator. Performance was found to vary as a function of the utility of information provided, the elapsed problem time, and as an interaction of these two variables. The type of target involved was shown to have no effect alone or in combination with either other main variables.

TABLE 3 RESULTS OF ANALYSIS OF PERFORMANCE OF ASW AIRCREWS ON TASKS IN THE ASW TACTICAL SCHOOL SIMULATOR AT NORFOLK.				
SOURCES	df	ms	F	P
BETWEEN PROBLEMS:	(167)			
TARGET TYPE (A)	1	151.310	1<	P>.005
INFORMATION UTILITY (B)	2	25,542.965	23.99*	P<.005
AxB	2	2,429.660	2.28	P>.05
ERROR	162	1,064.580	-	-
WITHIN PROBLEMS:	(840)			
ELAPSED PROBLEM TIME (C)	5	57,965.628	228.24*	P<.001
CxA	5	521.972	1<	P>.05
CxB	10	2,560.380	10.08*	P<.005
CxAxB	10	411.670	1.62	P>.05
ERROR	810	253.97	-	-

Figure 1 shows rather clearly the nature of the main effects. First, the greater the utility of the initial information provided, the better the performance. Second, the longer the elapsed problem time, the better the performance. Third, both of these trends were clearcut until the last stage of the problem where the three curves tended to converge. This probably was an artifact produced by the standard routine of having an aircrew circle a located target at this stage and prepare to attack. In other words, the localization task was essentially over when only five percent localization uncertainty remained.

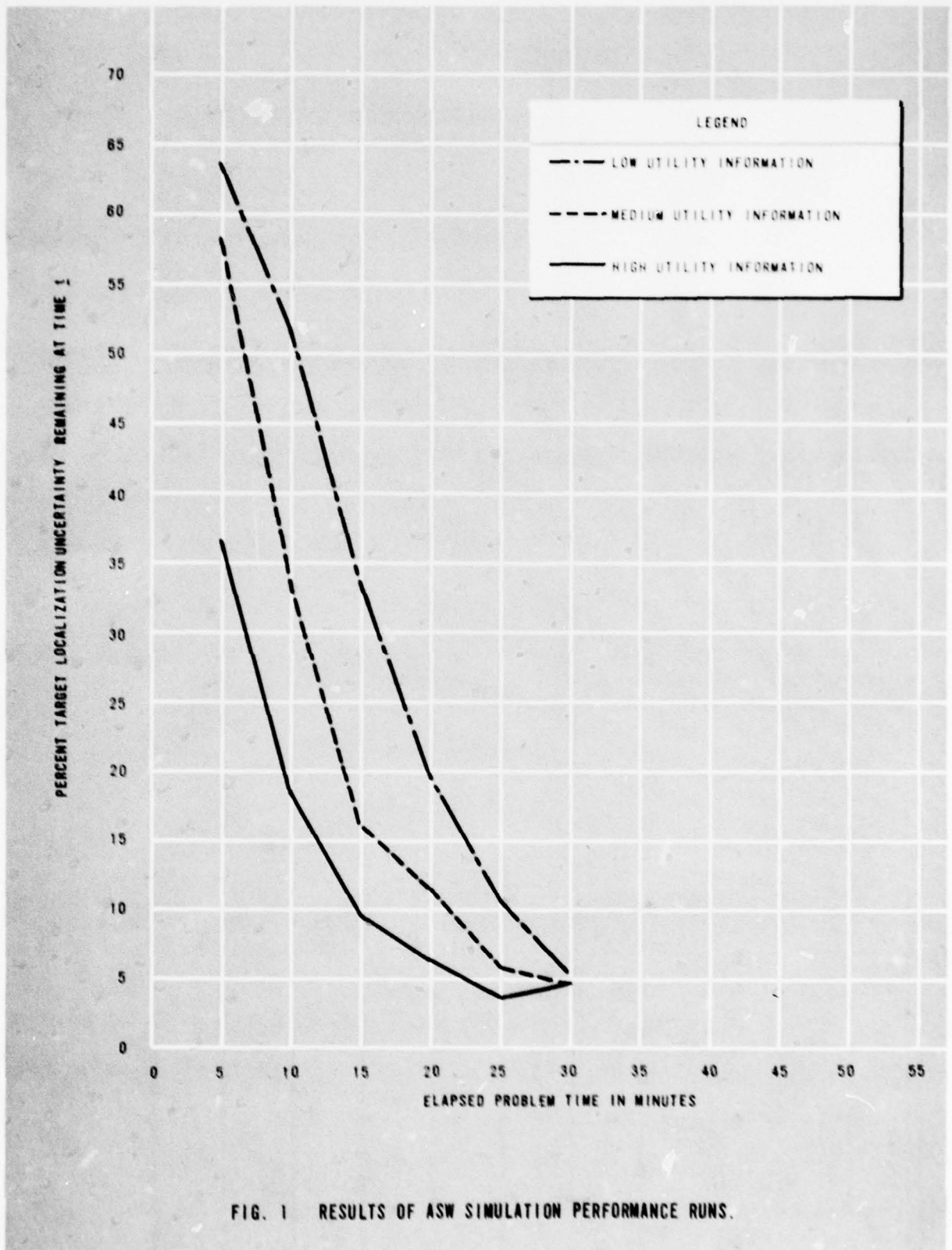


FIG. 1 RESULTS OF ASW SIMULATION PERFORMANCE RUNS.

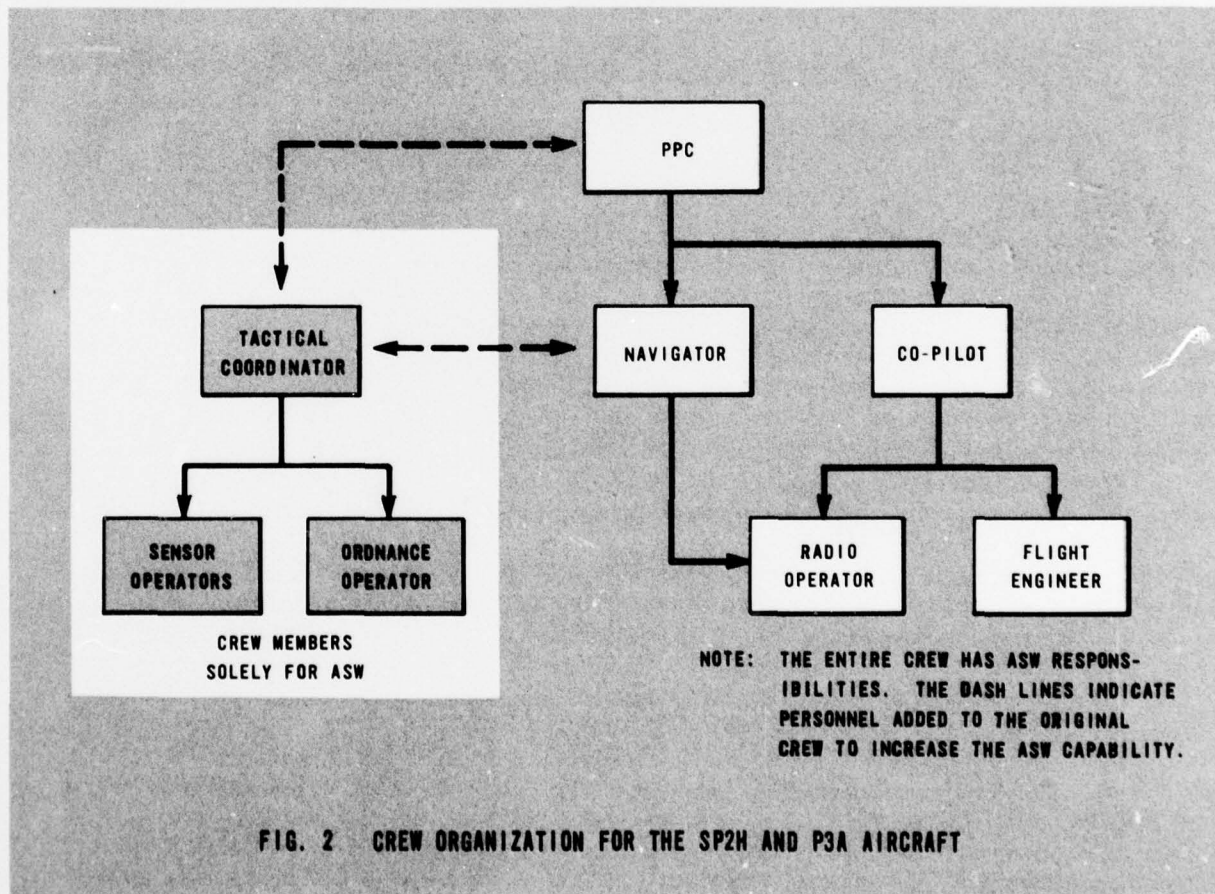
Table 4 shows the amount of performance variation associated with information utility that was predicted by the model. The significant linear trend ($F = 46.993$ for 1/162 df) and no significant residual trend provides an encouraging demonstration of the models' descriptive power.

TABLE 4 COMPARISON OF PERFORMANCE WITH PREDICTIONS GENERATED BY MODEL USING ASW AIRCREW DATA (NUMBERS IN PARENTHESES SHOW THE COMPONENT OF VARIANCE BEING ANALYZED; AN ASTERISK SHOWS A SIGNIFICANCE LEVEL BEYOND .01)

SOURCE	df	ss	ms	F
INFORMATION UTILITY:	(2)	(51,085.93)	-	-
PREDICTED BY MODEL	1	50,028.09	50,028.09	46.993*
RESIDUAL	1	1,058.78	1,058.78	1<
ERROR	162	172,462.84	1,064.58	-

II. RESEARCH PROBLEM AREA

The categorical problem is that of evaluating ASW crew performance as an integral unit for such activities as deployment and performance of the individual crew members for the purpose of identifying training problems. To be explicit, this proposal is concerned with this problem only for the SP2H and P3A aircraft crews who basically have the same organization. The crew organization as depicted in Figure 2 is given as an aid for discussion and is not official.



The PPC (Patrol Plane Commander) is responsible for safety of the crew and aircraft as well as the successful completion of the missions assigned to the crew. However, when on an ASW mission, the PPC is not in a position to adequately evaluate and coordinate the tactical activities of

the ASW crew and fulfill his responsibilities as the pilot in command. In view of this, either explicitly or implicitly, authority to coordinate and direct the tactical problem is delegated to the TACCO (Tactical Coordinator) who is a NFO (Naval Flight Officer) specially trained in airborne ASW tactics.

The members of the crew within the dash lines of Figure 1 are solely concerned with ASW, with the TACCO being the key information user and subsequent decision maker. Crew members outside the dash lines would constitute part of a fixed-wing crew for any aircraft comparable to the SP2H or P3A; however, they do, in fact, play an integral part in executing the ASW problem. The PPC, of course, pilots the aircraft from point to point, and the navigator aids the TACCO by keeping a graphic record of the ASW problem as it develops.

This past year's effort has been focused upon the TACCO's position since he is the principal ASW decision maker and his position was appropriate for evaluating the information indexing model. While the present indexing model was satisfactorily evaluated, there remain several research problems directly related to the TACCO being an information user. The proposed effort is again primarily concerned with the TACCO and his responsibility; however, other crew members are necessarily considered because of their interaction with him. Further, once this key position has been soundly studied, attention will then be concentrated on other crew positions, keeping in mind the primary program objective of an integrated crew proficiency measurement instrument.

Figure 3 shows a tentative block diagram of a proposed research program designed to reach the above objective. While the program goal will remain the same, the results of each year's effort will, of course, call for more modification of the plan. Thus, the research problems and time schedule are tentative depending upon the results of subsequent research tasks and development in ASW research in general. The remainder of this proposal will describe the problems and subsequent research tasks for fiscal year 1968 as shown in Figure 2.

It will be noted that the problem arrangement in Figure 2 is somewhat out of alphabetical order. This was done to simplify the diagram flow. The problems are lettered as they will appear within this proposal.

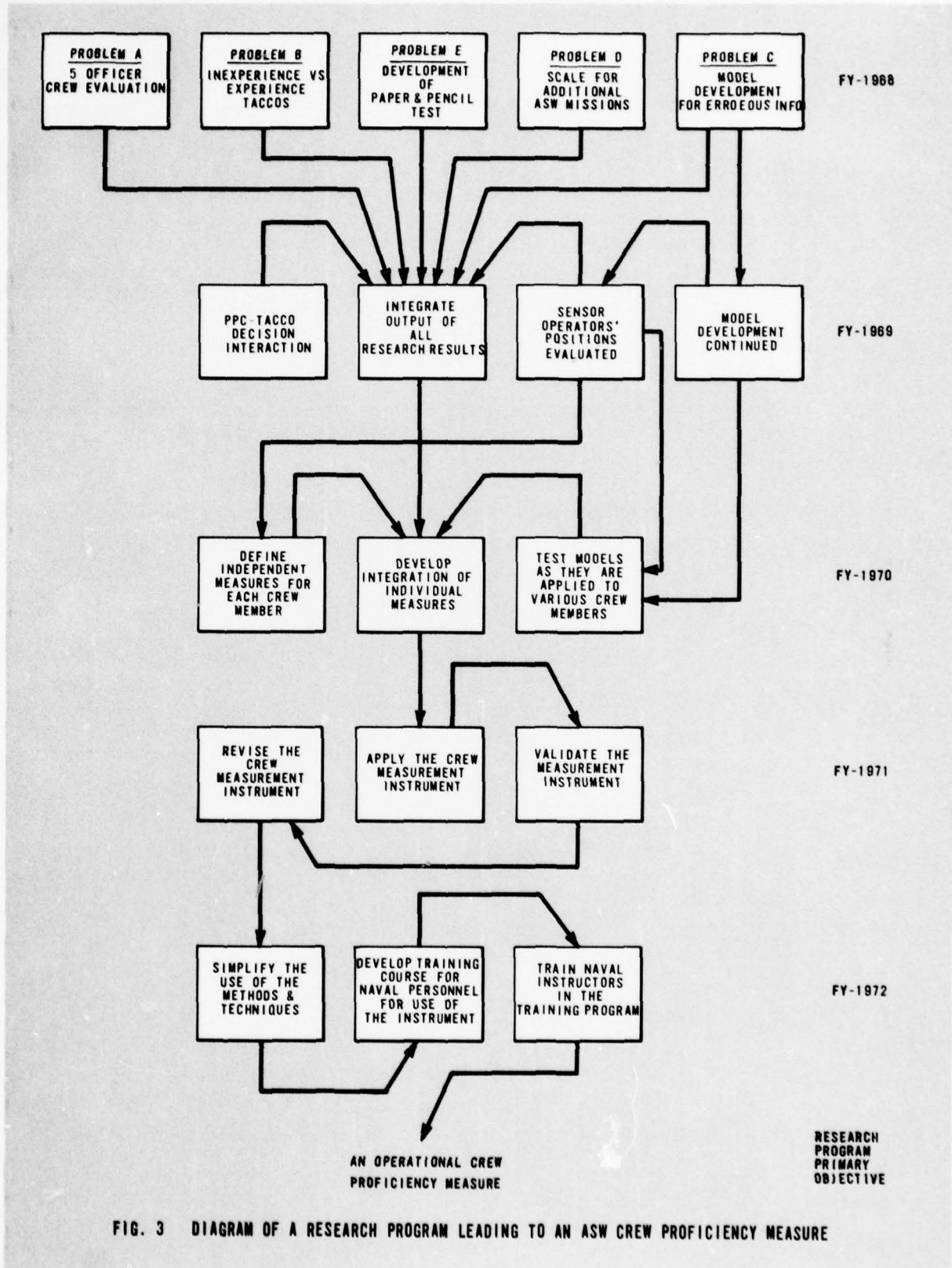


FIG. 3 DIAGRAM OF A RESEARCH PROGRAM LEADING TO AN ASW CREW PROFICIENCY MEASURE

The five problems and corresponding tasks are discussed individually with time for completion estimate for each. However, this should not be viewed as actual man-months per task. The actual man-power required for each task will be shown in a separate man-power allocation chart for the entire research effort. This chart, biosketches, and fiscal information will follow the technical discussion of the research.

III. PROPOSED RESEARCH

Problem A

The discussion to this point has been concerned with the SP2H and P3A crews as they are presently organized. Currently, a new concept in crew organization is being considered and will be evaluated by members of the VP-44 squadrons. This evaluation will be concerned with the two-TACCO configuration concept. Work has been undertaken by squadron personnel to develop a preliminary experimental approach. To date, two discussions as to the experiment have been held between VP44 and the project F/R 97 personnel from HRB-Singer. The task is far from simple, in view of these circumstances. It is here proposed that HRB-Singer collaborate with VP-44 personnel throughout the various stages of the evaluation program.

The two-TACCO concept is to be evaluated by means of the P3A trainer at VP-44 and possibly by controlled exercises. The former usually presents numerous problems, and the latter is likely to be even more difficult to control. It is strongly recommended that HRB-Singer personnel provide technical support on the evaluation in the same fashion as has been the case in F/R 97.

Briefly, as the name implies the two-TACCO concept requires two TACCO's per crew. One TACCO would be the man who turns the knobs, views the scope, and otherwise keeps the information up-to-date. A second TACCO would be senior of the two and the principal decision maker directing the crew's activities. Essentially, what is presently the TACCO's job would be divided between two NFO's. The question is whether two TACCO's are, in fact, better than one TACCO in a crew. If two TACCO's are better than one, then to what degree is this the case?

As a means of obtaining quantitative data concerning the above questions, the P3A trainer at Air Development Test Center at Patuxent River, Maryland, and the similar trainer at NAS Brunswick, Maine, show considerable promise. They also have good face-validity. It is recommended that controlled ASW exercise requiring any special arrangements outside of VP-44 be postponed and be based upon the simulator results. The simulator verification of the two-TACCO concept is briefly described in the corresponding task.

Task A

To evaluate the two-TACCO concept, four distinct steps are required. Each of these steps will be briefly described with an estimate time period required for completion.

First, the experimental design must be worked out in detail. This step includes identifying operationally the independent and dependent variables. For example, what type of information will be made available and how much of the target area is reduced in a given time estimated? Also, included here are such problems as selecting the appropriate statistics in view of the research questions, scheduling the subjects on a least-interference-basis, and scheduling the use of the simulator at Patuxent River or Brunswick. It is anticipated that it will take five calendar months to complete this step.

The second step is the data collection. This may be done either in Brunswick or Patuxent River, depending upon the availability of either of the two identical trainers and assignments of the air crews involved. Unlike the ASW Tactical Trainer in Norfolk, Virginia, only one crew at a time can man the P3A trainer; thus a longer data collection time will be required. Two calendar months would be allowed for this step.

Step three is one of data reduction and analyses. While the data reduction would have been started during the data collection period, it would continue well beyond that time. In view of the anticipated complexity of the data and subsequent analyses, this step would take three calendar months to complete.

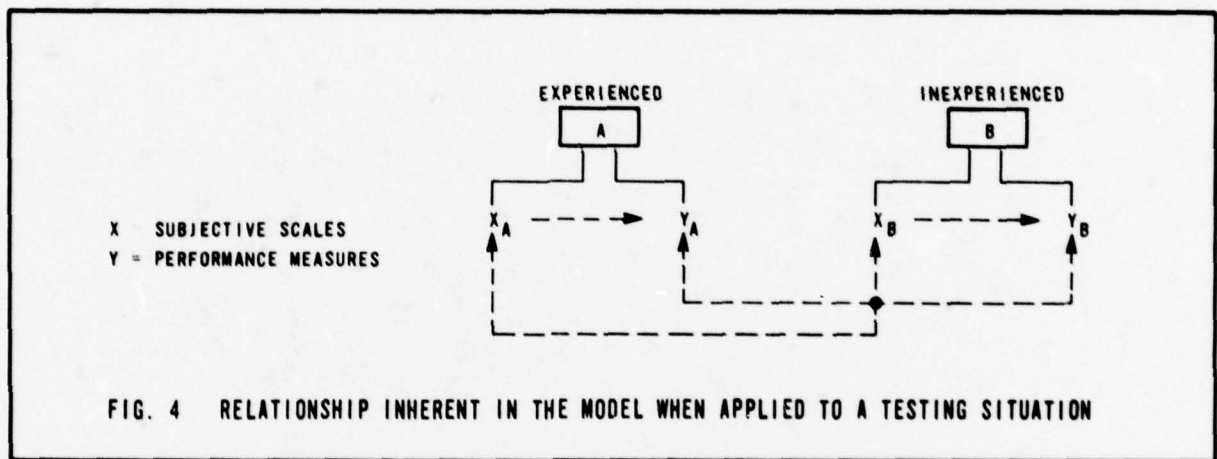
The last step of the proposed research for evaluating the two-TACCO concept is that of developing the appropriate comparison for making substantial recommendations concerning the present and future airborne ASW crew configuration. This step would require approximately two calendar months.

Problem B

A primary assumption of the information indexing model evaluated this year was that the experienced and successful TACCO's could make valid judgments concerning the relative usefulness of items of information. While this assumption received substantial support which reasonably answered any questions about the experienced judge, it left a second question completely unanswered. The question of prime importance, for a testing situation is, can an inexperienced

but trained TACCO also make such valid judgments? One would expect a different set of scales and performance scores from inexperienced men than those obtained from experienced men. This question was not evaluated in the ASW trainer. There are several relationships which need viewing to complete the investigation of the indexing model for use in testing situations.

Figure 4 graphically illustrates the relationship inherent in the indexing model when it is to be applied to the testing situation. The relationship



$X_A \dashrightarrow Y_A$ was evaluated during the past year, leaving three other relationships to be investigated. These relationships

$$\begin{aligned}
 X_B &\dashrightarrow Y_{B'} \\
 X_A &\dashrightarrow X_{B'} \\
 Y_A &\dashrightarrow Y_{B'}
 \end{aligned}$$

will be relatively simple to evaluate since the preliminary technical work had been completed while evaluating the $X_A \dashrightarrow Y_A$ relationship. To evaluate the other relationships, a sizable number of inexperienced TACCO's were necessary. Such a group, unavailable during the past work, is now available and it is proposed that the research be completed.

Before the scales are used in a testing situation, it would be desirable to have the following relationships exist:

$$\begin{array}{l|l} X_A \approx Y_A & X_A \neq X_B \\ X_B \approx Y_B & Y_A > Y_B \end{array}$$

Of course, the $X_A \approx Y_A$ relationship has been shown to exist, and the groups of new NFO's in VP-44 will make it possible to complete this investigation of the indexing model in its present form.

Task B

As mentioned previously, the scales and performance data for the experienced TACCO have been collected and analyzed. In anticipation of possibly investigating the remaining relationships the data collecting instruments for the scaling data were given to VP-44 personnel who administered them to the new group of NFO's in that squadron. Having completed this initial step, four steps remain and will be briefly described.

The first step consists of reducing the scaling data obtained and subsequently developing the scales. The scaling procedures will be facilitated by the use of computer programs already in existence. However, because of computation center turn-around time, etc., this step is estimated to require 1-1/2 calendar months.

Step two involves re-establishing the ASW simulator problem to be used again in the ASW Tactical Trainer. The use of this trainer is essential for control purposes. At the present time, Task Group Delta of AIRWINGSALANT, has been allotted available trainer time for such experimental purposes. This step ends with the collection of performance data. The time required would be one calendar month.

Once the performance data has been collected, data reduction follows for the analyses. These analyses would be the same as those performed on the data obtained from the experienced TACCO's; e.g., the AOV with orthogonal polynomials would be employed to estimate the correspondence between the judged values and the performance scores. The data reduction and initial analyses would take 2-1/2 calendar months to complete.

The last step of this task is the establishment of the comparisons as discussed above, e.g., $X_A \rightarrow X_B$ and $Y_A \rightarrow Y$. This, of course, would require statistical analyses. At least two calendar months would be used to evaluate and compare all the essential relationships as they pertain to testing and an additional period of time of approximately two calendar months would be required to prepare the report.

Problem C

While the results of the past year's work indicate that the model has shown considerable promise and some direct applicability to fleet ASW problems, it has not been expanded to handle the following cases: One, a situation where commanders get a mixture of information -- some of which is valid and some of which is false -- and then must decide what to do without knowing the true validity of the data. Second, situations where there is multistage information handling; e.g., a sensor operator uses a series of cues to arrive at an interpretation which is then passed along to a TACCO who combines this interpretation, with others made by other sensor operators to arrive at a decision. This second situation is depicted in diagrammed form in Figure 5. If both cases could be adequately described by a behavioral prediction model, a good portion of actual ASW crew performance could be predicted and simulated.

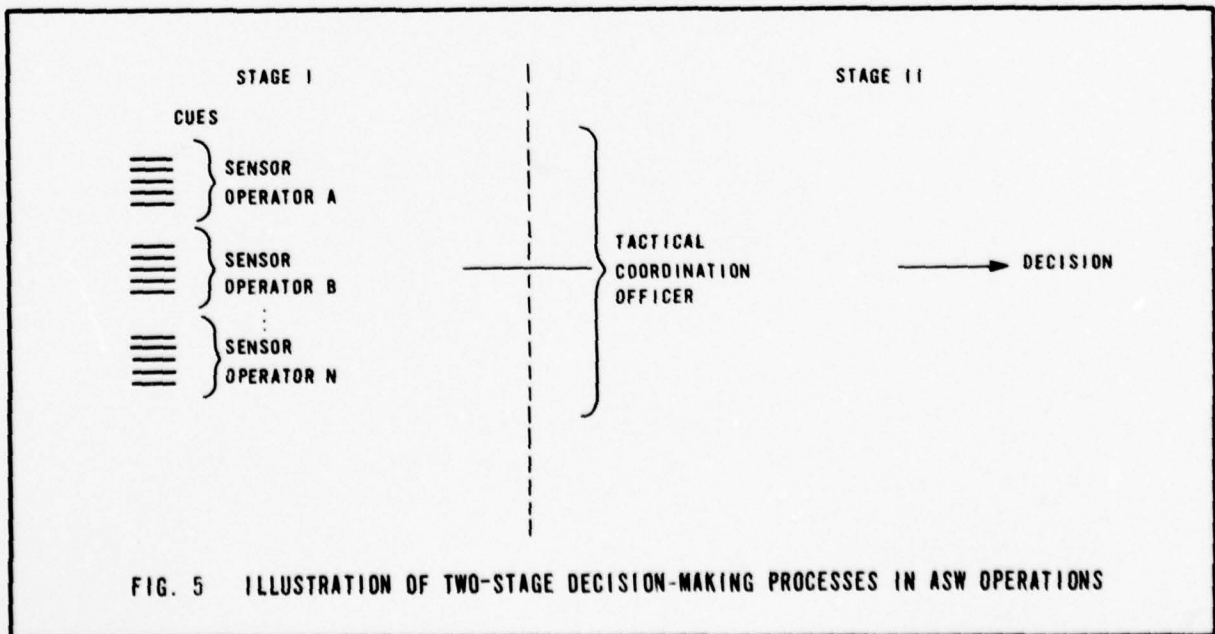


FIG. 5 ILLUSTRATION OF TWO-STAGE DECISION-MAKING PROCESSES IN ASW OPERATIONS

Task C

It is suggested that work be undertaken this year to expand the model to take account of the first of these problems.

This case would be concerned with extending the model to take account of a mixture of correct and erroneous information, and will benefit from work done on related contracts to other agencies. First, assume that the decision-making (or risk) situation is symmetrical; e.g., the cost of having erroneous information of type *j* is proportional to the value of having correct information of type *j*: Second, assume that the entire set of possibilities can be described by a matrix similar to the one shown in Figure 6. Also, assume that the entire set

		SENSOR OPERATOR REPORT			
		NUCLEAR SUBMARINE	CONVENTIONAL SUBMARINE	SURFACE CONTACT OF MILITARY INTEREST	TARGET OF NO MILITARY INTEREST
TRUE STATE OR AFFAIRS	NUCLEAR SUBMARINE	CORRECT REPORT	WITHIN CATEGORY MISIDENTIFICATION	DIFFERENT CATEGORY MISIDENTIFICATION	OMIT ERROR
	CONVENTIONAL SUBMARINE	WITHIN CATEGORY MISIDENTIFICATION	CORRECT REPORT	DIFFERENT CATEGORY MISIDENTIFICATION	OMIT ERROR
	SURFACE CONTACT OF MILITARY INTEREST	DIFFERENT CATEGORY MISIDENTIFICATION	DIFFERENT CATEGORY MISIDENTIFICATION	CORRECT REPORT	OMIT ERROR
	TARGET OF NO MILITARY INTEREST	FALSE ALARM	FALSE ALARM	FALSE ALARM	CORRECT REPORT

FIG. 6 A SAMPLE CASE DESCRIPTION MATRIX OF SITUATIONS WHICH CAN ARISE IN ASW TARGET DETECTION AND CLASSIFICATION.

of erroneous reports can be grouped into the following four categories: cases where one target is classified as another similar type; e. g. , a nuclear submarine is classified as a conventional submarine (misidentification within a category); cases where a target is misidentified as one falling into a different category; e. g. , a nuclear submarine misidentified as a surface vessel of military interest; third, errors of omission when a target is not detected or identified at all; and fourth, false alarms, or cases where something of no military interest is classified as a target.

All of these situations are shown in Figure 6. Note, however, that this matrix covers only the detection and classification aspects of ASW operations. Another crucial task is localization. During localization, it may be that the matrix collapses into one having only three cases: an accurate sensor report is received, no sensor report is received, or a false alarm is given. During the localization phase, it is doubtful that misidentification errors have a chance to come into play; therefore, this view appears to be reasonable. If it is found to be so, after discussions with operational personnel, some interesting consequences result.

First, as has been noted in previous research by McKendry, Harrison, Birnbaum and Sadacca (1967), the least costly erroneous report concerns target misidentifications of various types. By disregarding this type of error entirely, it is probable that not too much descriptive power is lost. Therefore, a single equation can be used to describe behavior during the detection, localization, and classification phases of ASW operations. Development of a preliminary expanded version of the basic model is given below in a form which assumes that only the three cases enumerated above need be considered.

Sample Model Expansion

In the present version of the model, to find the utility of correct information in a single message, one uses equation (1)

$$u_i = \sum_{j=1}^n k_j \alpha_j \quad (1)$$

where

- U_i = worth of information contained in the j^{th} message
- n = the number of mutually exclusive collectively exhaustive content areas found in the message
- k_j = number of items in the j^{th} content area
- α_j = average perceived value of information in j^{th} content area.

To compute the value of correct information in a group of messages, use equation (2)

$$U = \sum_{i=1}^{i=N} u_i = \sum_{i=1}^N \sum_{j=1}^n k_{ij} \alpha_{ij} \quad (2)$$

where

- U = worth of information contained in a group of messages
- N = number of messages.

To take account of net worth resulting from costs associated with erroneous items of information, the following terms need to be added:

- ϵ_j = the cost associated with a false alarm error for items of the j^{th} category in a single message
- l_j = the number of false alarm errors in the j^{th} category in a single message
- τ_j = the cost associated with an error of omission for items of the j^{th} category in a single message
- m_j = the number of omit errors for the j^{th} category in a single message.

Since the terms are negative (they detract from the worth of the message), the net utility of a single message (\bar{u}_i) becomes as follows -- which is a modification of equation (1)

$$\bar{u}_i = \sum_{j=1}^n k_j \alpha_j - \sum_{j=1}^n l_j \epsilon_j - \sum_{j=1}^n m_j \tau_j \quad (3)$$

Collecting terms and simplifying, the expression becomes

$$i = \sum_{j=1}^n k_j \alpha_j - \sum_{j=1}^n (\ell_j \epsilon_j + m_j \tau_j). \quad (4)$$

To compute the net utility (\bar{U}_n) of N messages the expression becomes as follows:

$$\bar{U}_N = \sum_{i=1}^N \bar{u}_i = \sum_{j=1}^N \sum_{k=1}^n k_{ij} \alpha_{ij} - \sum_{j=1}^N \sum_{k=1}^n (\ell_{ij} \epsilon_{ij} + m_{ij} \tau_{ij}) \quad (5)$$

These expressions could be written to permit estimations to be made when one knows only the probability of a correct item of information of the j^{th} type to occur (π_j). For example, the single message equation now becomes

$$U_i = \pi_i \alpha_j - [(1 - \pi_j) (\epsilon_j + \tau_j)]. \quad (6)$$

While this development could be expanded further, and the expressions themselves could be simplified in the process, the above material should illustrate one promising line of development.

To accomplish this work the following steps would be taken:

First, after visits to Norfolk, Virginia, and a review of the operational ASW flight trainer at Brunswick, Maine, the initial constraints upon the model would be formulated (1 calendar month).

Second, when these constraints are reviewed, as well as others gained in staff discussion, a trial version of the model would be formulated (1 calendar month).

Third, this version would be field checked to insure that it described adequately the operational ASW environment (1 calendar month).

Fourth, an experiment would be planned to test the model using ROTC students as subjects (2 weeks).

Fifth, the first model validation experiment would be run and results would be analyzed (2 calendar months).

Sixth, a second smaller experiment would be planned and run to answer questions remaining after the first experiment (2 calendar months). Technical reports would be issued after steps five and six.

Problem D

The current study under Nonr 4441(00) concentrated on one crew member, namely, the TACCO, and involved just one type of operation; the open ocean search initiated by a SPA.* The TACCO is the key member of the airborne ASW team and his ability to adroitly execute his duties in prosecuting a target can determine the success or failure of the crew.** The information indexing was applied to the TACCO's information-processing task, i. e., the task of taking information, as it becomes available, and determining successive courses of action for the crew to follow. The relative usefulness of any information, however, is directly related to a particular problem to be solved; and in this case, it was the open ocean SPA question. While this operation is certainly a representative task of the airborne ASW activity, it is not the only one; e. g., the barrier type of operation requires one or more aircraft to monitor a stretch of water between two points of land, thus providing a protective screen. The problem, then, is one of developing additional scenerios for other types of missions, collecting appropriate judgments, and developing the corresponding scales. While this involves three steps for each type of mission, considerable overlap in their accomplishment can be realized by proper planning and scheduling. Following through in this endeavor takes advantage of the work completed during the past year. This is true since considerable time and effort was necessary to determine the constitution of meaningful items of information pertaining to present day airborne ASW operations. The work proposed would constitute the application of the model to cover the entire spectrum of airborne ASW situations encountered by the TACCO's. In summary, a more complete

* SPA = SOSUS-probability area.

** This assumes that the target submarine is within the range of the sensors and the physical conditions are as such as to permit detection, etc.

range of item values would be available to apply to test construction and to the analyses of ASCAS's.

Task D

There are three other types of ASW missions in addition to the SPA mission. The objective of this task is to obtain scales for each of the remaining missions.

The first step in this task would be the careful development of scenerios for a

1. Barrier operation
2. HUK Force
3. Convoy escort.

This step would require 4 calendar months to complete.

Once the scenerios were developed and approved by Task Group Delta, data collection instruments would be formatted and produced, and arrangements would be made to revisit the squadrons to obtain the data. This preparatory step would take 1/2 a calendar month.

The actual data collection would require 2 calendar months. It is anticipated that HRB-Singer project personnel would visit each of the squadrons on the Atlantic Coast to administer the questionnaires.

The final step would result in a catalogue of scales for various ASW situations. Leading to that end product would be the reduction of data and subsequent scale development for each scenerio. This step would take 3 calendar months to complete. Such a catalogue of scales would be useful when ASW tests were to be developed. Test development is the topic of the final problem area.

Problem E

One of the possible uses of the information scales, developed during the pervious year, is in the area of test construction. Employment of these scales for that purpose was demonstrated by converting the actual scaling data collection instrument into a paper-and-pencil-type of problem-solving test. To accomplish this the pair-comparison formats were removed from the various critical points of the scenerio. At those same points, combinations of sensor information were introduced which were relevant to the tactical situation of the scenerio. The various combinations employed were similar in value of usefulness according to the derived scales. Insofar as a tactic will bring only certain sensors into target range while excluding others by one means or another, only certain combinations of information could occur for a particular tactic. Such obtained combinations, of course, can also be scored by using the utility scales.

Certainly the scaling data collection instruments and subsequent scales from Task D of this proposal can also be developed into a paper and pencil test, but this alone would not be making full use of the scales and ancillary information. It is proposed here, additional steps be taken toward construction of a variety of tests related to airborne ASW. Such test s can be used for many purposes, for example, there can be tests for selecting personnel, for evaluating training and for on-the-job proficiency measures. Specifically, the objective would be to evaluate the recent research in test construction and apply relevant finding to tests for airborne ASW.

Task E

To accomplish this under Task E consists of several essential steps leading to prototype ASW tests based upon research findings.

First the research of test construction would be reviewed taking particular note of item selection techniques, test formats and relevant validity studies. This review will require approximately one calendar month.

The second step would be the study of the research findings, including the scales of Task D, with the idea of making full use of the most advanced testing technology in airborne ASW. Approximately two calendar months would be allotted to this step.

Finally, prototype tests would be constructed as well as guidelines for their construction. This step would be the final preparation phase and require one calendar month.

PROJECT SCHEDULE: TASK BY MONTH

TASK	CALENDAR MONTHS											
	1	2	3	4	5	6	7	8	9	10	11	12
A												
B												
C												
D												
E												

PROJECT SCHEDULE: MAN HOURS/MONTH/TASK

TASK	MAN HOURS/MONTH											
	1	2	3	4	5	6	7	8	9	10	11	12
A	93	77	124	123	123	225	225	123	124	197	197	226
B	93	295	152	151	151	51	51	98	99	-	-	-
C	250	350	350	250	300	300	300	138	-	-	-	-
D	-	-	88	88	88	52	51	229	229	253	253	226
E	207	78	88	88	88	124	123	-	-	-	-	-
TOTALS	643	800	802	700	750	752	750	588	452	450	450	452

MANPOWER ALLOCATION CHARTS - P-7165

IV. PROJECT PERSONNEL

The following individuals will be responsible for the successful completion of this research program, Dr. James M. McKendry, Mr. Thomas P. Enderwick and Dr. Paul C. Harrison. Each of these men have been directly involved in the development of, or experience with, the techniques which will be applied during the course of this study and thus, will be the co-principal investigators. All other members of the research team will be assigned from among the personnel described in the biosketches which follow.

MANION, RAYMOND C., Research Psychologist

EDUCATION: M. S. in psychology, University of Utah, 1966; B. A. in psychology, University of Redlands, 1958; candidate for Doctoral degree, The Pennsylvania State University.

EXPERIENCE: HRB-Singer, Inc., 1966- , Research Psychologist, development of programmed instruction materials for the United States Army and the United States Air Force; development of strategic and tactical intelligence training materials; preparation of materials for military system evaluation during the Operational Evaluation. --- Peat, Marwick, Mitchell Company, 1966- , Consultant, Consultant in the area of vocational education: design curricula, determine selection criteria, select evaluation tools and techniques, develop experimental design, etc. --- Appalachia Educational Laboratory, Inc., 1966- , Consultant, Consultant in the area of educational research: design, prepare, review, and evaluate programs for educational research, especially as they relate to vocational education, school dropouts, counseling and placement, and experimental design. --- The Pennsylvania State University, 1965- , research with programmed instruction, computer-assisted instruction, and other areas of instructional media; statistical inference; school dropouts; vocational education; curriculum of higher education; and educational system modeling. --- Ordnance Research Laboratory, The Pennsylvania State University, 1965-1966, development of maintainability, training, and technical publication requirements and technical monitoring of these programs for a major United States Navy ASW weapon system; prepared work statements and other materials for purchase requests; prepared contract materials; served as technical advisor during contract negotiations; developed and delivered narrative and graphic materials for formal program presentations; established the format and graphic materials for periodic management level program briefings; prepared materials for computerized reporting using PERT and other management information systems; scheduled, planned, conducted, and reported on periodic maintainability, training, and technical publication meetings; participated in Industry-Government (including DOD) level planning and specification preparation for maintainability; developed materials for evaluating and comparing contractor efforts. --- American Institute for Research, 1964-1965, design of a computer model for storing, processing, and retrieving human factors data for the United States Air Force and NASA; curriculum development for instructor training courses for the Bell Telephone Company; development of a guide for designing, conducting, and evaluating Poverty Program educational research; development of programmed instruction materials for the United States Army; study of human behavior in bomb shelters during a disaster in terms of management and group behavior for the Office of Civil Defense; performed educational research in vocational education for the Ford Foundation to determine knowledge areas for job retraining and to develop curriculum requirements for a vocational school; consulted on the factor analytic design of experimental problems. --- University of Utah, 1959-1965, conducted research in the area of concept formation and statistical inference; worked with measurement devices in the area of creativity; developed computer routines in machine language to compute factor and regression analyses; designed, conducted, and evaluated a survey to measure the educational television audience for KUED-TV and Granite School District in Salt Lake City, Utah. --- United States Navy Personnel Research Activity, 1963-1964, performed human factors analyses of new weapon systems (during early R&D) to

MANION, RAYMOND C., (Cont'd)

determine adequacy of design and maintainability, and to predict personnel selection, manning, and training requirements. Conducted personnel performance evaluations on weapon systems during the Operational Evaluation; performed job and task analyses for both operator and maintenance technicians. --- Granite School District, 1962-1963, elementary school teacher, conducted research with programed instruction and pupil counseling. --- Redlands City Schools, 1958-1959, elementary school teacher. --- San Bernardino Probation Department, 1958, performed psychological counseling in the field of juvenile delinquent rehabilitation; developed curricula for vocational education courses. --- California State Department of Corrections, 1957-1958, designed, performed, and analyzed penal research designed to evaluate rehabilitation programs and the rate of recidivism; conducted personality assessment; participated in group counseling.

MEMBERSHIPS: American Psychological Association, American Educational Research Association; National Education Association, Society of Sigma Xi.

HONORS: Cum Laude in Psychology, University of Redlands, Redlands, California, 1958.

PUBLICATIONS: "A Study of Personality Changes Occurring in Inmates at the California Institution for Men, Chino, California, Resulting from Intensive Treatment and Time"; Chino, California: California State Department of Corrections, 1958; "Description and Maintenance Task Analysis, Torpedo EX-10"; San Diego: United States Navy Personnel Research Activity, 1964; (CONFIDENTIAL) "Selection and Prerequisite Training Requirements, Torpedo EX-10"; San Diego: United States Navy Personnel Research Activity, 1964; (CONFIDENTIAL) "The Role of Human Factors Data in Aerospace System Design and Development"; Wright-Patterson Air Force Base: Aerospace Medical Research Laboratories, 1965; "Research on Improved Computer Methods for Handling and Using Human Factors Task Data"; Wright-Patterson Air Force Base: Aerospace Medical Research Laboratories, 1965; "The Community Action Program as an Area for Research"; Pittsburgh: American Institute for Research, 1965; "Response Dimensions in Attitude Measurement, " (Paper delivered at the national American Psychological Association convention, 1965.); "The Validity of a Questionnaire Designed to Predict Educational Television Viewing Behavior"; Salt Lake City, Utah: University of Utah, 1966.

HURST, PAUL M., Staff Psychologist

EDUCATION: Ph. D. in psychology, The Pennsylvania State University, 1955; M. A. in psychology, The Pennsylvania State University, 1954; B. S. in biology, Bucknell University, 1951.

EXPERIENCE: HRB-Singer, Inc., 1960- , Staff Technical Advisor for Behavioristics Laboratory, Project Director for experimental analysis of task-induced stress; development of simulated operational data processing task for study of effects of task and training variables on performance under high levels of operator pacing; mathematical modeling and experimental design for study of decision making; consulting for experimental design and gaming techniques employed in the study of effectiveness of certain elements of the U.S. Navy to accomplish specific missions to be conducted within time frame 1963-1970; development of system performance criteria for assessment of operator and technician contributions to the effectiveness of naval systems. --- Institute for Research, 1960- , Staff Psychologist, Co-Principal Investigator for mathematical modeling, criterion development, and experimental design for study of decision making. --- U.S. Navy Electronics Laboratory, 1958-1960, Operations Research Analyst, head of team of Navy officers and civilian scientists charged with design for man-machine and partially automated subsystem and system tests of the Naval Tactical Data System; responsible for experimental design aspects including drawing up specifications for various operational tests of the system. --- St. Lawrence University, 1956-1958, Assistant Professor of Psychology, teaching and research in experimental psychology, statistical methods, and decision theory. --- Idaho State College, 1955-1956, Instructor in Psychology, teaching of experimental and general psychology. --- The Pennsylvania State University, 1954-1955, National Science Foundation Fellow; 1952-1954, Graduate Assistant, teaching of introductory psychology and assisting with instructional film research program.

MEMBERSHIPS: Phi Sigma, Phi Eta Sigma, Pi Mu Epsilon, Phi Beta Kappa, Psi Chi, Phi Kappa Phi, Pi Gamma Mu, Sigma Xi, Operations Research Society of America, American Statistical Association, Psychometric Society, American Psychological Association, American Association for the Advancement of Science.

PUBLICATIONS: "Task-Induced Stress: A Literature Survey"; "Display Problems in Aerospace Surveillance Systems. Part I. "A Survey of Display Hardware and Analysis of Relevant Psychological Variables" (with L. Crumley and others); (Ph. D. thesis) "Prediction of Decisions: A Test of the Efficiency of Alternative Models" (Abstract); "Predictions of Decisions from a Higher Ordered Metric Scale of Utility"; "Estimation of Tracking Uncertainty from Photographic Study of SPS-29 Radar Returns"; "Reports on Test Sets 1.1, 1.2, 1.6.10 and 1.6.16 of Experimental NTDS" (with W. H. Hockstra); "Learning Sets, Kinescope vs Film"; "Relative Effectiveness of Verbal Introductions to Kinescope Recordings and Training Films"; "Role of D-Amphetamine in Variability of Behavior in Learning and Decision-Making Theory," (Ph. D. Thesis); "Prediction of Decisions: A Test of the Efficiency of Alternative Models," (abstract); "Predictions

HURST, PAUL M., (Cont'd)

of Decisions from a Higher Ordered Metric Scale of Utility"; "The Effects of d-Amphetamine on Risk-Taking"; "Errors in Driver Risk-Taking"; "Measurement of Subjective Gap Size" (with K. Perchonok and E. L. Seguin); "The Effect of Lane Closure. "

SMITH, DENNIS E., Staff Mathematician

EDUCATION: Ph. D. in mathematical statistics, The University of Wisconsin, 1966; M. S. in mathematical statistics, The University of Wisconsin, 1964; M. S. in mathematics, The University of Wisconsin, 1963; B. A. in mathematics, Wabash College, 1960.

EXPERIENCE: HRB-Singer, Inc., 1966- , Staff Mathematician, validation and evaluation of stochastic models applied to traffic studies and logistics; development of sampling plans for evaluating potential monitoring systems; investigation of validity of inferences based on incomplete or inaccurate data. --- University of Wisconsin, 1962-1966, National Science Foundation Fellow, Department of Statistics, programming (CDC 1604) of problems connected with thesis research. --- AC Electronics (General Motors), 1962, Analyst, analysis of reliability and quality control problems. --- Armour Research Foundation, 1961-1962, Assistant Mathematician, programming for the IBM 7090. --- Boeing Aircraft, 1960-1961, Associate Engineer, programming for the IBM 704 and IBM 7090.

MEMBERSHIPS: Institute of Mathematical Statistics, Phi Beta Kappa.

PUBLICATIONS: "Investigation of Rejection Rules for Outliers in Small Samples from the Normal Distribution," (Ph. D. Thesis).

PAPAY, JAMES P., Psychologist

EDUCATION: B.S. in psychology, The Pennsylvania State University, 1966;
ASW Orientation Course, ASW Tactical School, Norfolk, Virginia, June 1967.

EXPERIENCE: HRB-Singer, Inc., 1966- , Psychologist, initially engaged in research for the purpose of estimating driver information requirements for decision making at highway interchanges (through simulation, controlled road tests, and insitu testing); assisted in design of stimulus materials and establishment of data reduction and analyses; currently involved with the application of programming techniques to statistical analyses; the application of experimentally evaluated behavioral models in a military operational setting (details classified).

MEMBERSHIPS: Psi Chi.

HARRISON, PAUL C., JR., Staff Psychologist, Manager of Humetrics Branch

EDUCATION: Ph.D. in psychology, The Pennsylvania State University, 1963; M.S. in psychology, The Pennsylvania State University, 1959; B.S. in industrial psychology, The Pennsylvania State University, 1958; industrial student, Lehigh University, 1951-1953.

EXPERIENCE: HRB-Singer, Inc., 1966- , Staff Psychologist, Manager of Humetrics Branch; 1963-1966, Senior Research Psychologist, information requirements for photo interpretation, image interpreters' training, counter-insurgency studies; design, development and evaluation of experimental training programs to enhance interpreter skills where infrared sensors are the prime sources of information; assisted in the investigation of performance of interpreters on infrared imagery under various acquisition parameters; supported construction of programmed materials for training of photo interpretation skills via computer assisted instruction techniques; development of methodology for evaluation of human factors contribution to performance of naval systems; assisted in development and evaluation of ASW information systems; design and analysis of human factors research; design and evaluation of display techniques with emphasis concerning interface problems; task analysis methods and procedures; development of middle-management training program syllabus. --- The Pennsylvania State University, 1962-1963, Instructor, elementary statistics, psychology of learning, psychology of sensation and perception; 1958-1962, graduate research and Teaching Assistant; psychology, motivation and morale in industry; assisted in laboratory course in experimental psychology; assisted in small group teaching research; assisted in design, construction, and operation of laboratory to study the development of speech in Mynah birds; 1960-1961, National Science Foundation Fellow, computer programming trainee in Computation Center; 1957-1958, Undergraduate Research Assistant, group leader in small group teaching research program (Ford Foundation); 1956-1958, Statistical Clerk. --- U.S. Army, 1953-1955, Cryptographer.

MEMBERSHIPS: Sigma Xi, Phi Kappa Phi, Pi Gamma Mu, Psi Chi.

PUBLICATIONS: "Variability of Response in a Determined Turning Sequence in the Metal Worm (*Tenebrio Molitor*): An Experimental Test of Alternative Hypotheses"; "Establishing a Discriminant Vocal Operant in the Mynah Bird (*Bracula Religiosa*)"; "Differential Effects of Two Training Schedules on Learning, Attitudes, and Later Performance"; (Ph.D. thesis) "A Decision Making Theory of Occupational Choice"; (M.S. thesis) "Assessing Human Factors Requirements in the Test and Evaluation Stage of Systems Development. Vol. I, Technical Report"; BuNavPers, Contract NOnr 4203(00); "Assessing Human Factors Requirements in the Test and Evaluation Stage of Systems Development. Vol. II, Application to OPTEVFOR Operations"; BuNavPers, Contract NOnr 4203(00).

McKENDRY, JAMES M., Staff Psychologist, Technology Consultant to Systems Behavior Laboratory

EDUCATION: Ph. D. in psychology, The Pennsylvania State University, 1961; M.S. in psychology, The Pennsylvania State University, 1960; B. A. in psychology, University of Alabama, 1954.

EXPERIENCE: HRB-Singer, Inc., 1966- , Staff Psychologist, Technology Consultant to Systems Behavior Laboratory; 1963-1966, Branch Manager, Humetrics Branch, Behavioral Sciences Laboratory; 1958-1963, Staff Psychologist, decision making, predecisional activities and human data processing; systems analysis problems for command-control and information gathering systems; man-machine interface problems in computer utilization; design and analysis of human factors research; equipment design considerations for operation and maintenance; derivation of human factors and training requirements in various Naval Weapons Systems; Project Director on approximately ten projects. --- The Pennsylvania State University, 1957-1958, Graduate Research and Teaching Assistant, Department of Psychology. --- U.S. Army, 1954-1957, Airborne Infantry Platoon Leader, Armored Infantry Company Commander and Executive Officer. --- University of Alabama, 1953-1954, Research Assistant on project surveying personnel and training practices of southern industries.

MEMBERSHIPS: Psi Chi, Sigma Xi, American Psychological Association, Psychometric Society, Human Factors Society, Institute of Electrical and Electronic Engineers, American Association for Advancement of Science.

PUBLICATIONS AND TECHNICAL REPORTS: "Predicting Dominance Leadership Relations by Varied Metrical Techniques"; "Decision-Making Behavior in a Three-Choice Uncertain Outcome Situation Involving Differential Pay-Offs and Triple Events"; "The Design and Evaluation of Maintainable Packaging Methods," (1960) Ergonomics, 3, 255-272; "Volumetric Requirements for Hand Tool Usage," (1960) Human Factors 1, 156-162; "Techniques in Designing for Maintainability," (1960) Electric Design, October 26, 36-41; "Assessing Maintainability," (1960) Electronic Industries, October, 78-80; "Designing Maintainable Circuits," (1961) IRE Trans, Prof. Group on Human Factors in Electronics; 2, 93-97; "Equipment Design Considerations for Improving Maintenance Procedures," Electro-technology, 70(1), 93-95; "Factors Affecting Perceptual Integration," (1963) J. Appl. Psychol. 47, 5, 293-300; "An Experimental Investigation of Equipment Packaging for Ease of Maintenance," (1960) NAVTRADEV CEN 330-1-1; "Description of Training Device Technicians' and Engineers' Estimates of Circuit and Systems Maintainability," (1960) NAVTRADEV CEN 330-1-2; "Anthropometry of One-Handed Maintenance Actions," (1960) NAVTRADEV CEN 330-1-3; "Maintainability Handbook for Electronic Equipment Design," (1960) NATRADEV CEN 330-1-4; "Task-Induced Stress: a Literature Survey," (1961) WADD Ozalid Report, Contract No. AF33(616)-7892; "Data Processing in Human Systems," (1961) Crumley, L. M. et al. Display problems in aerospace surveillance systems, AFESD-TR-61-33; "Instructional Devices in Maintenance Training," (1962) NAVTRADEV CEN 1105-1-1; "The Enhancement of Fire Control Technician Proficiency by the Use of Training Device," (1963) NAVTRADEV CEN 1105-1;

McKENDRY, JAMES M., (Cont'd)

"Methodology for Determining OPINTEL Information Requirements for U.S. Naval Forces, 1962-1968," (1963) Report 352-R-1; "An Information Indexing Approach to Information Requirement Problems," (1964) Report 567-R-1; "Utility of Information as a Predictor of Decision Adequacy," (1964) Report 567-R-2.

McKENDRY, MARGARET S., Senior Research Psychologist (part-time)

EDUCATION: Ph.D. in psychology, The Pennsylvania State University, 1963; M.S. in psychology, The Pennsylvania State University, 1960; B.S. in psychology, The University of Alabama, 1954; A.B. in liberal arts, St. Mary's College, 1952; State Certifications as (1) secondary school teacher in English, French, and science, (2) psychological examiner, and (3) school psychologist.

EXPERIENCE: HRB-Singer, Inc., 1963- , Senior Research Psychologist (part-time). --- U.S. Army Education Service in Europe, 1955-1957, Instructor (part-time). --- The Pennsylvania State University, Dept. of Psychology, Graduate Research and Teaching Assistant. --- U.S.P.H. graduate fellow, 1958-1961. --- The Pennsylvania State University, 1960-1961, Division of Counseling (during summers); 1961-1962, Peace Corps Training Project, Selection and Training Research Associate. --- Inter-University Committee for Post-Graduate Study in Foreign Service Areas, 1963, Executive Secretary.

MEMBERSHIPS: Psi Chi, Sigma Zi, American Psychological Association, American Council on Measurement in Education, Society for International Development, American Association of Social and Political Science, American Association for the Advancement of Science, Philippine Sociological Society.

PUBLICATIONS: "Effect of Intellectual Capacity on the Development of Perceptual Abilities"; "Effects of Generalized Level of Aspiration and Sequential Dependencies on Decision-Making"; "Characteristics of Peace Corps Volunteers"; "Careers in International Development"; "Social Change in Developing Countries"; and "Attitudinal Impact of Social Change in the Philippines."

ENDERWICK, THOMAS P., Research Psychologist

EDUCATION: M. A. in general experimental psychology, Bucknell University, 1966; B.S. in experimental and industrial psychology, The Pennsylvania State University, 1961.

EXPERIENCE: HRB-Singer, Inc., 1961- , Research Psychologist, TARTAR and Mark 68 Fire Control systems maintenance training study, including training literature review, task analysis, survey research concerning training techniques in relation to job performance, and development of performance specifications for training devices; maintainability and display-control problems in the design of equipment and systems; study and analysis of search behavior in varying environments; development of task requirements for man-machine systems; development of multicriteria for work involving technical, social, and environmental factors in overseas locations; supervision study of effects of utility on perceptual filtering; Project Director on the modification of VISTA, an experimental instrument for the study of binocular rivalry; study and identification of psychological variables associated with confinement under stress; recruitment and selection of personnel, Acting Personnel Manager; conduct of experimental research on the effects of levels of complex stimuli on judgment and performance related to such judgment; Project Director, application of an information indexing model to derive performance criteria in ASW. --- The Pennsylvania State University, Crystal Research Laboratory, 1958-1961, Chief Draftsman, responsible for drafting activities which included engineering design, development and improvement of crystal research equipment, as well as publication drawings concerning crystallographic research. --- The Pennsylvania State University, Ionosphere Research Laboratory, 1957-1958, Electrical and Mechanical Draftsman, work included schematic wiring diagrams, training aids, and the development of an antenna box for the nosecone of a missile. --- Jurguson Gage and Valve Company, Massachusetts, 1956-1957, Mechanical Draftsman, duties included working on details, layouts, subassemblies, assemblies, and bills of material for liquid level gages and valves. --- U.S. Navy (Reservist), USS Taconic AGC-17, 1954-1956, assigned to Intelligence of AMPHIBGRUP 2 and 4, Atlantic Fleet, as topographic draftsman; 1954-1955, seamanship, ship's company; 1955-1956, Leading Petty Officer in photo-interpretation room, assigned to Intelligence Section of the Flag Aboard Ship, duties included supervision of the development of maps and beach sketches; the entire photointerpretation process, from the development of the films to the finished beach sketches, was carried out aboard ship.

MEMBERSHIPS: National Security Industrial Association, ASW Advisory Committee, Associate Member of American Psychological Association.

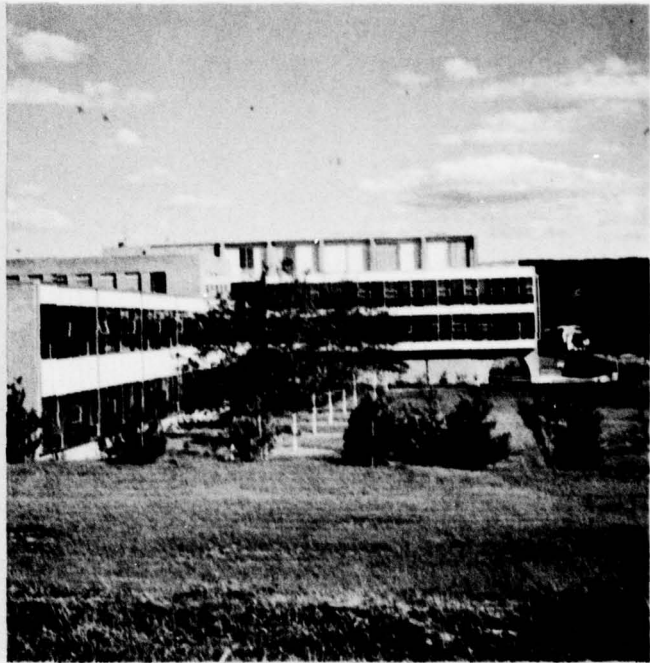
PUBLICATIONS: "An Experimental Study of the Effects of Delayed Auditory Feedback on Stutterers and Nonstutterers While Playing a Musical Instrument" (B.S. thesis); "A Proposed Redesign of a Human Nutrition Calorimeter"; "The Application of Signal Detection Theory to the Measurement of Group Influence Upon Individual Group Members"; "Instructional Devices in Maintenance Training"; "Maintainability and Maintenance Training"; "The Enhancement of Fire Control

ENDERWICK, THOMAS P., (Cont'd)

Technical Proficiency by the Use of Training Device"; "Factor Affecting the Reliability and Validity of Judgmentally Derived Information Utility Scales"; "A Measure of Utility Values as a Function of Method in Judgment Complexity" (M. A. thesis).

FACILITIES

HISTORY and EXPERIENCE



Continuing the services they had performed during World War II, three staff members of The Pennsylvania State University founded a consulting partnership in 1946 and began work on a single Air Force contract. In 1947, as the scope of their activities increased, it became advantageous for Messrs. Haller, Raymond and Brown to incorporate. During its early growth, the company's principal technical interest was performing operations research studies in electronic countermeasures.

The most significant single event in the company's history occurred in 1958 when the assets of Haller, Raymond and Brown, Inc., were purchased by The Singer Company. The company name was changed to HRB-Singer, Inc., and we now form a subsidiary of our parent organization. We function as an operating element of Singer's Technical Products Division.

Today, the solution of technical problems remains the basis of our business. Literally hundreds of research and development projects are advancing the science and technology of reconnaissance, data processing, human factors, systems study and analysis, and applied physics. More than 1,100 scientists, mathematicians, engineers, consultants, and support personnel form the core of our business energy.

Future goals are to extend our ability to satisfy our customers' information requirements and to expand our systems development and production capabilities.

We define an Information System as a combination of people, equipment, and facilities which organizes functional data into forms which can be utilized by decision-makers.

An Information System reaches a productive stage after data are collected, recorded, transmitted, stored, processed, and analyzed. The pertinent information then is utilized to provide the basis for a military or business decision.

HRB-Singer performs every function -- from collection through utilization -- in the transformation of data into productive information.

Within this structure of an Information System, we may participate in any phase of the System's evaluation -- feasibility study, system design, prototype development, production, and system operation.

To achieve optimum solutions we draw upon many academic disciplines which allow us to advance a wide range of technical approaches. Each approach is a coherent body of knowledge used to attack and solve a specific problem and is closely matched to the operating environment.

OUR BUSINESS IS HELPING DECISION-MAKERS SOLVE THEIR INFORMATION PROBLEMS. These decision-makers, our customers, include the Department of Defense and many other government agencies, such as FAA, the State Department, and the Department of Commerce; industrial firms; and educational institutions.

OUR PRODUCTS ... METHODS AND EQUIPMENT ... COMPRISE INFORMATION SYSTEMS

ORGANIZATION

HRB-Singer, Inc., is a subsidiary of The Singer Company and functions as an operating element of the parent organization's Technical Products Division. Reflecting the Singer concept of operating decentralization, the company maintains a high degree of operational autonomy.

HRB-Singer's products are primarily defense-oriented. Although utilized by all military and industrial members of the defense community, our capabilities also extend to nonmilitary government agencies, private industry, and educational institutions.

Established working relationships with our parent company enable us to elicit their financial, legal, and manufacturing resources. Concurrently, we administer the technical aspects of our business including research, development, and manufacturing.

MANAGEMENT

At HRB-Singer, management responsibilities are discharged by engineers and scientists, many of whom hold advanced degrees, and who are also thoroughly trained in managerial techniques.

Reference to our current organization chart shows the company's overall technical and operational activities under the jurisdiction of the Executive Vice President who administers the planning and performance of research activities, systems development, and production. He also directs the growth and application of the company's technical capability in all areas of research, development, and manufacturing.

Marketing, Administration and Management Services, and Finance offer administrative and logistical support to the technical group. Each contributes to the effective and efficient functioning of HRB-Singer's professional staff.

TECHNICAL ORGANIZATION

HRB-Singer's organization is designed to take maximum advantage of the company's varied technical capabilities. Disciplines having compatible interests and backgrounds are grouped into operating elements identified as technical laboratories. The laboratory structure groups personnel, facilities, and business interests into identifiable and related entities, each responsible for performing technical project efforts.

The Opsearch Lab expands upon the company's past work in inventing and applying new techniques and methods to the analysis and design of information systems. Its primary objective is to bring a systems approach to the problem areas in information systems science.

The Behavioristics Lab specializes in life sciences research and development applicable to HRB-Singer's information systems activities. It is also responsible for the development and application of methods to measure the requirements and performance of manned systems.

The Processor Lab develops electronic signal processing, analysis, and display equipment. Its activities include automatic signal recognition, data translation, and storage, coding and telemetry equipment development and aids to data analysis.

The Receiver Lab is responsible for the design and fabrication of special electronic receiving and distribution equipment ranging from the modules that comprise receivers to complete VHF and UHF receivers. The Lab's discipline encompasses the design and development of black boxes saleable as special products.

The Antenna Lab is organized to design and produce microwave receiving systems and components, plus those receiving and telemetry antenna systems used from VHF into the microwave region. Efforts also are directed to the design and fabrication of RF power generation equipment.

The Systems Lab possesses the capability to design, develop, and integrate large, specialized electronic systems. Within its framework, the Lab specializes in project management, system equipment design, feasibility determinations, documentation services, cost control, and mechanical services.

The Support Lab is concerned with the efficient operation of various electronic data collection and analysis systems located throughout the world. It is also charged with the responsibility of assigning HRB-Singer personnel qualified to operate and maintain these systems in the field.

The Development Department expands infrared technology and competence in these areas of performance: (1) development of airborne, infrared surveillance equipment and techniques; (2) image-interpretation services; (3) design, fabrication, and implementation of advanced, rapid film-processing systems; (4) research and development of advanced imaging devices utilizing electro-optical techniques.

Prime mission of the Intelligence Systems Department is to collect, analyze, and evaluate tactical and operational technical data. Activities range from studies of advanced research techniques in data collection to the fabrication of special-purpose equipment, each for accomplishing the assigned task. Examples of equipments developed include transistorized signal simulators and signal-reduction and analog-producing devices.

Manufacturing provides the facility to produce, in quantity, highly-complex electromechanical equipment such as custom-built individual components, subassemblies of major systems, or complete one-of-a-kind systems. Manufacturing is composed of three groups (1) production; (2) engineering services; and (3) manufacturing services.

Production has manufactured in quantity such items as RECONOFAX* airborne infrared thermal-mapping systems; radar weather transponders; audio selector units; transistorized pulse multicouplers; and broadband RF amplifiers.

Engineering services include product design, value analysis, industrial planning, and assembly and testing.

Manufacturing services embody fabrication and processing, drafting, quality control, electronic equipment maintenance, and material procurement.

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FACILITIES and SUPPORT SERVICES



HRB-Singer's main facilities are located at Science Park, a 240-acre tract adjacent to The Pennsylvania State University, in State College, Pennsylvania.

Laboratories are maintained for advanced research and development of complex electronic and electromechanical systems and subsystems. Individual technical groups within the Company operate research and test facilities necessary in the performance of their projects.

MICROWAVE AND ANTENNA LABORATORY - equipped for preliminary design and development projects from VHF through K-band, it includes:

MICROWAVE ANECHOIC CHAMBER - reduces microwave reflections to a minimum and makes an excellent model test range.

OUTDOOR ANTENNA RANGE - permits testing from two transmitting towers and a roof-mounted rotator.

MICROWAVE TEST BENCHES - make standing wave, impedance, and transmission line-loss measurements.

RFI SHIELDED LABORATORY - permits radio frequency instrument development without radio and electrical interference. A mobile lab measures complex signal environments under actual operating conditions.

ELECTRONICS LABORATORY - provides a facility for testing sophisticated electronic equipment to environmental specifications.

MACHINE COMPUTATION SERVICES CENTER - in addition to various card-handling equipment, this laboratory contains a 1620 digital computer which helps perform technical information activities and methodology studies.

DEVELOPMENT LABORATORY - equipped to develop complex electromechanical equipment. One outstanding example is RECONOFAX,[®] HRB-Singer's infrared photo-mapping system.

RAPID ACCESS DEVELOPMENT LABORATORY - conducts advanced studies of rapid film processing techniques.

PHYSICS LABORATORY - equipped with all the apparatus needed to perform a wide range of investigations, this laboratory includes the following:

OPTICS LAB - provides facility for prototype development of replica paraboloids, metal and replica epoxy reflecting units, and finished metal mirrors.

ELECTRO-OPTICS LAB - allows study and development of solid state image intensifiers and converters. Using laser as the primary light source, light modulation techniques are investigated.

ACOUSTICS LAB - high efficiency, low power transducer systems utilizing audible and ultrasonic frequency ranges are a specialty. Noise and other sonic studies also are performed.

Other special instrumentation efforts include infrared detection and indication systems for monitoring and inspection purposes. Instruments using nuclear radiation for measurement have been devised in HRB-Singer's hot lab.

INFRARED TEST TUNNEL - used to design and test infrared systems' components and subsystems, this 200-foot tunnel enables accurate tests to be conducted under controlled conditions.

AIRCRAFT FACILITIES - two company-owned aircraft, laboratory space, and a photo-processing area are located at nearby University Park Airport.

FABRICATION AND PROCESSING - consists of the machine shop which performs sheet metal, welding, assembling, machining, balancing, and casting operations; metal plating, painting, and finishing; and an etched circuitry section which designs, constructs, and assembles printed circuit boards.

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OUR PRODUCTS ... METHODS AND EQUIPMENT ... COMPRISE INFORMATION SYSTEMS

SUPPORT SERVICES

TECHNICAL PUBLISHING - publishes all technical reports, manuals, and other collateral material relating to customer project and internal information requirements.

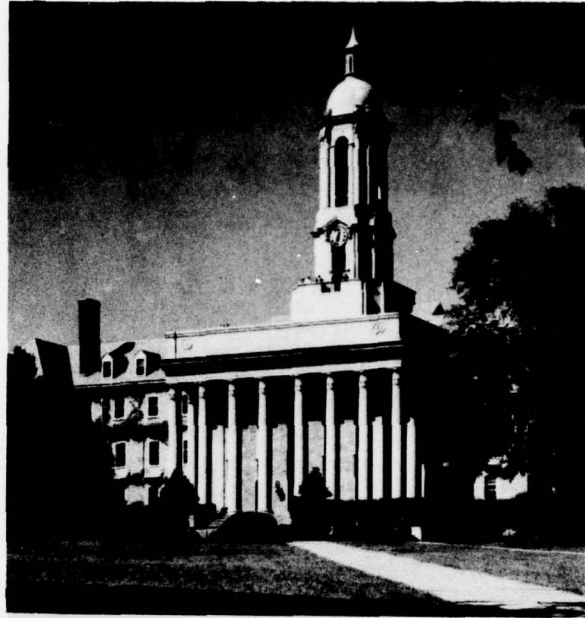
TECHNICAL INFORMATION CENTER - procures, processes and circulates written material pertinent to the Company's research and development activities.

QUALITY CONTROL - begins with production planning and continues throughout the fabrication process. This includes incoming, inprocess and final inspection procedures conforming to customer specifications.

APPLICATIONS ENGINEERS - located in Washington, D.C.; Dallas, Texas; Dayton, Ohio; Fort Monmouth, New Jersey; Rome, New York; and a European field office in Munich, Germany. These field men provide direct customer liaison.

THE PENNSYLVANIA STATE UNIVERSITY - neighbors our Science Park facilities and maintains laboratories, specialized equipment and technical libraries which are available for use by HRB-Singer personnel. The University also has scientific, technical and management personnel who are available for consulting in special academic disciplinary areas.

To execute University-industry cooperation, the Commonwealth Industrial Research Corporation serves as the focal point in promoting such relations. A nonprofit corporation, CIRC facilitates Pennsylvania's economic development through the utilization of Penn State's strengths in science, engineering, technology, social science, and management.



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ELECTRONICS LABORATORY

The Electronics Laboratories provide facilities for testing sophisticated electronic equipment to environmental specifications.

MICROWAVE AND ANTENNA LAB

This laboratory is organized to design and build microwave receiving systems and components, receiving and telemetry antenna systems from VHF into the microwave region, and RF power generation equipment. To do this work, the lab is equipped with a microwave anechoic chamber, an outdoor antenna test range and microwave test benches.

The anechoic chamber reduces microwave reflections to a minimum and makes an excellent model test range for airborne antenna systems. It can operate at frequencies down to 2300 megacycles.

The outdoor antenna test range permits testing from two transmitting towers and a roof-mounted rotator. RF generation equipment, mounted on a 50-foot steel tower, supplies the signal forces for antenna pattern measurements.

Microwave test benches make standing-wave, impedance and transmission line-loss measurements. A complete range of test equipment, including spectrum analyzers and noise measuring equipment, is available through 12,000 megacycles.

RECEIVER LAB

Equipped for design, fabrication, alignment and test operations, the Receiver Lab maintains more than a dozen sweep frequency equipment combinations -- sweep frequency generators, oscilloscopes, signal generators and power meters -- used daily in the development of broadband amplifiers, multicouplers, filters and receivers.

In addition, the lab contains specialized instruments such as a Hewlett-Packard Model 342A Automatic Noise Figure Meter; a Rohde and Schwarz Type ZDU Diagraph; a General Radio Type 1607-A Transfer Function and Immittance Bridge; and an Empire Devices Model NF-105 Noise and Field Intensity Meter.

The lab also has temperature chambers for environmental testing and a shielded screen room in which low-level radio frequency measurements may be conducted.

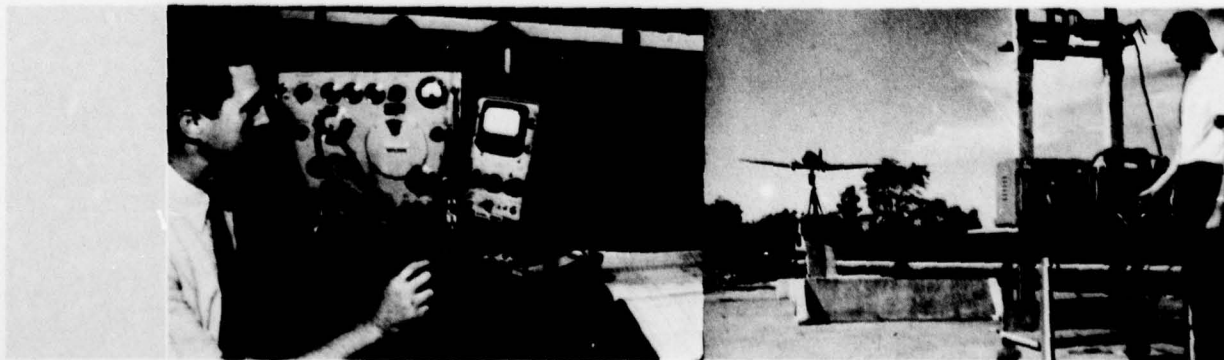
PROCESSOR LAB

The facilities of the Processor Laboratory consist of a general electronics laboratory; electronics instrumentation to develop signal identification, processing, analysis and display equipments; an underwater instrumentation laboratory; and a VLF/ULF observatory.

Electronic equipment located within this facility encompasses the usual complement of oscilloscopes, signal generators, frequency counters, power supplies, and recording instruments.

To develop underwater instruments a thermometer calibration facility, accurate to $\pm 0.003^{\circ}\text{C}$, is maintained; pressure testing facilities are leased from nearby Pennsylvania State University; and a tank suitable for testing scale models of underwater instruments is utilized.

In the area of VLF/ULF, a field station is used to receive and measure phase and amplitude changes of VLF signals, geomagnetic micropulsations and galactic radio noise. Available equipment includes frequency standards, VLF receivers, phase and amplitude comparison instruments, antennas, and field-strength measurement and recording instruments.



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RFI LABORATORY



SHIELDED ENCLOSURE

HRB-Singer possesses a wide variety of equipment and facilities to measure, test, and evaluate radio frequency interference. Newest addition is a large (11' x 28' x 9') solid-shielded enclosure. Zinc-clad steel walls, heavy-duty line filters, and honeycomb ventilators permit test engineers to work comfortably, virtually isolated from outside radio interference. Four smaller enclosures enhance our quick-reaction capability to any type or size system.

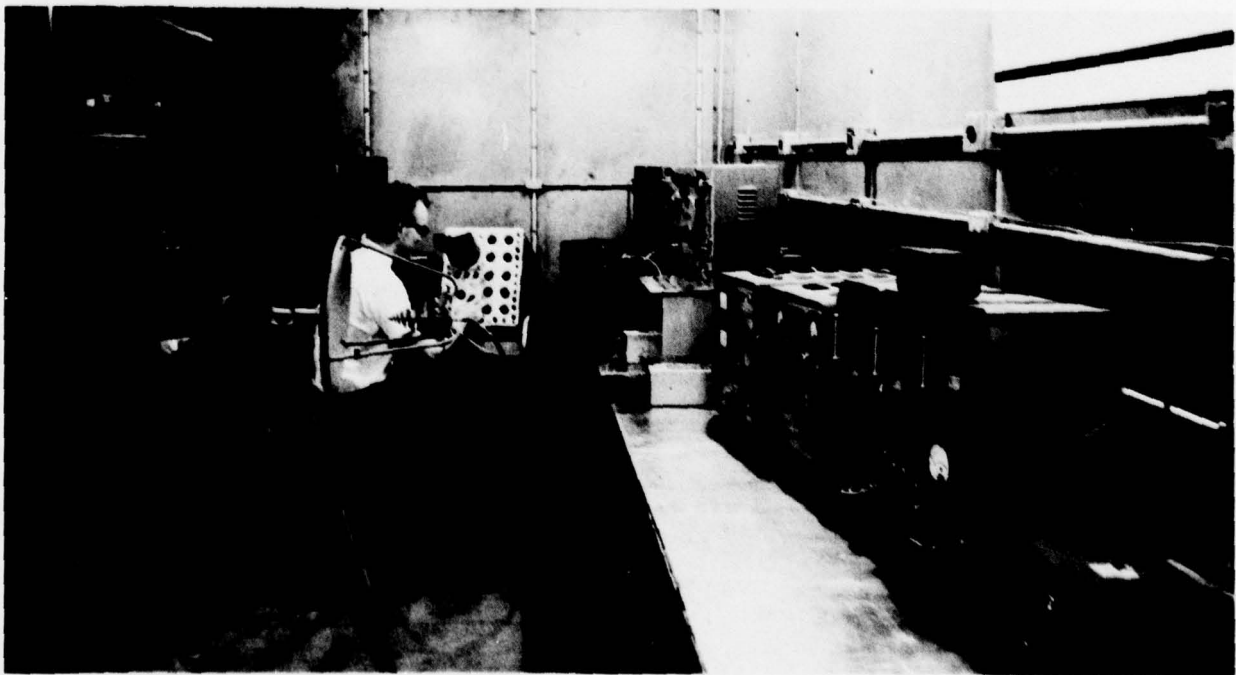
Our complement of certified interference test equipment permits complete coverage of the following specifications: MIL-I-6181D, 26600, 16910, and 11748. We also test in compliance with Federal Standard 222 (NAG-1A/TSEC).

MOBILE LAB.

Installed in a twenty-eight foot semitrailer, a complete RFI mobile laboratory measures complex signal environments under actual operating conditions. The laboratory is completely self-powered and its integrated custom-built, solid-shield enclosure operates in high-power signal density areas. It is equipped to perform: MIL-STD-449B Spectrum Signatures; MIL-E-6051C Weapons System Compatibility; radiation hazard and power contour measurements; and environmental search and analysis.

SCREEN ROOMS

In addition to the large, shielded enclosure and the mobile laboratory, double-insulated screen rooms provide the environment necessary to perform exacting measurements.



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PHYSICAL SCIENCES LABORATORY



The Physical Sciences Laboratories are equipped with apparatus needed to perform a wide range of investigations in acoustics and optics.

ACOUSTICS LAB

A fully instrumented anechoic chamber is used to investigate both solid- and air-borne sounds. Detection and analysis equipment is utilized to study noise, its cause and reduction, as well as to develop specialized sonic and ultrasonic devices. Additional equipment is available that generates and detects acoustic signals in the audio and ultrasonic range at low and high powers.

OPTICS LAB

The optical facility specializes in making and testing special optical elements. The lab includes equipment that can "lap" and polish flat elements up to ten inches in diameter and vacuum-coat pieces up to eighteen inches in diameter. Other special test equipment, including a Ronchi tester, a circle-of-confusion tester, an optical dividing head and a reflectance tester, supplements standard optical instrumentation. The lab also has the capability to electro-form and/or replicate optical elements of any shape or figure.

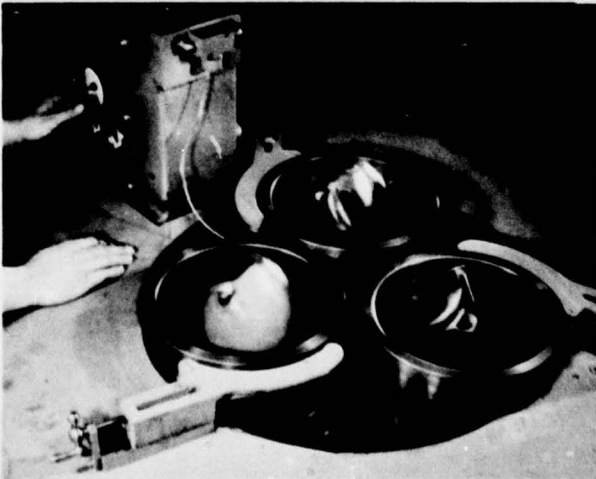
ELECTRO-OPTICS LAB

The electro-optics lab is equipped primarily for studies and experiments in the visible and near-infrared regions, particularly with solid-state components. Continuous and pulse lasers are included in the list of laboratory equipment.

For various optic and photometric measurements, instruments such as a Spectra brightness spotmeter, a scanning Micro-densitometer, calibrated (NBS) lamps, and a Perkin-Elmer monochromator with quartz and NaCl prisms are available. The lab also contains a precision thermopile, optical benches, a Weston photometer, a photometric light source (2870°K) and other standard optical pieces and equipment.

OTHER LABS

Other facilities in the Physical Sciences Laboratories include a research shop, a glass shop equipped with a 24-inch lathe and annealing furnace, a microscopy laboratory and a well-equipped chemistry laboratory. The microscopy lab is equipped to take photomicrographs and includes both a binocular microscope and a Leitz (Dialux-Pol model) microscope. The chemistry lab is used for routine analyses and special tasks related to the company's project work.



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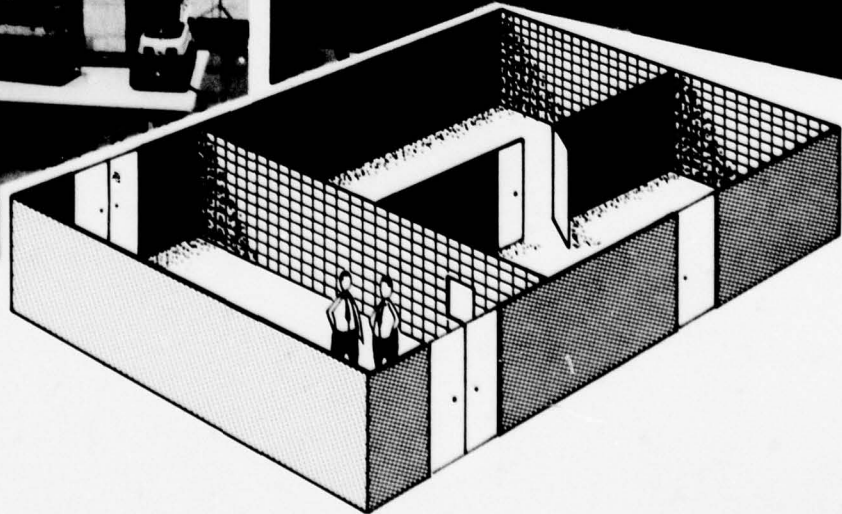
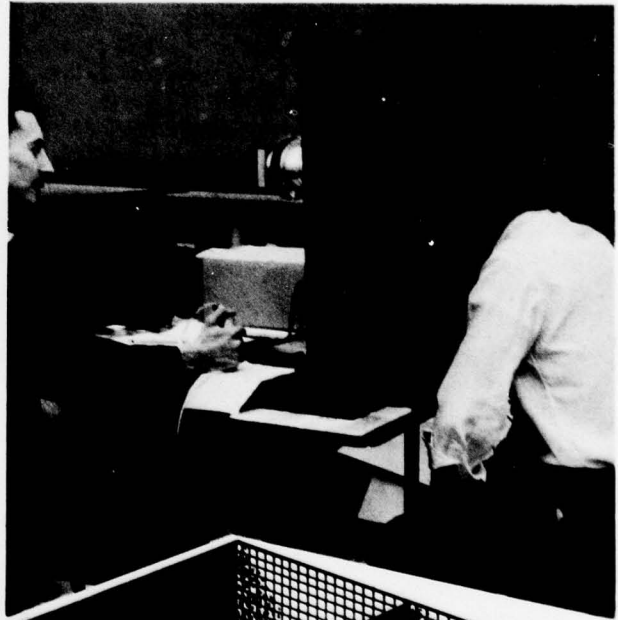
HUMAN FACTORS LABORATORY

Specially designed and built, the Human Factors Laboratory provides an area of about 650 square feet in which a wide variety of experiments can be conducted under various environmental conditions.

Among the features of the completely enclosed laboratory are sound-shielded walls and semi-indirect illumination which may be varied over a wide range. Air conditioning permits high illumination and heat-producing equipment to be used during studies under a controlled temperature environment.

Movable sound-shielded partitions can be easily erected to divide the area in half or to produce two rooms, one of which is three fourths the size of the entire lab. A one-way mirror is included in the partition. Conduits are run through the exterior walls with outlets in both rooms. This permits an experiment to be conducted in one room while observers and recording equipment are out of sight in the second room.

Laboratory equipment, stored in another room, includes multichannel recorders; physiological monitoring equipment; interval timers; sound level and spot meters; photographic and projection equipment; console and equipment mock-ups; and simulators and display devices. This allows complete use of the lab for experimental purposes.



OUR PRODUCTS ... METHODS AND EQUIPMENT ... COMPRISE INFORMATION SYSTEMS

MANUFACTURING SERVICES

Manufacturing Services provides skilled physical and mechanical support to HRB-Singer's manufacturing and development capabilities.

Machine Shop

A modern machine shop is equipped to fabricate pilot models and manufacture close-tolerance electro-mechanical hardware. Included in the array of machinery are various types of milling machines; lathes, including two gap-bed lathes; universal-type tool and cutter grinders; sheet metal forming equipment; AC and DC arc-welding equipment; a Heliarc Process; a consumable electrode-type gun; and gas welding equipment.

Various drill presses, band saws, cutoff saws and other instruments permit precision layout alignments and fabrication. An MSO jig-boring machine, designed with special-developed optical projection equipment, guarantees a setting of .00002 inch, positioning accuracy of .00012 inch, a fine-boring capacity of 7-1/2 inches, and a maximum boring depth of 12 inches.

DESIGN DRAFTING

Design-draftsmen prepare layouts, sketches and schematics for prototype preproduction or production items. Generally, the section is assigned to projects on a job-duration basis. If required, drawings comply to applicable military specifications or industrial contract requirements. The facility can reproduce prints by either the diazo- or the moist-type process. Microfilm and vandyke reproducibles can also be provided.

ETCHED CIRCUITS

Printed circuit boards are mass-produced or custom-built for experimental equipment work. From the original master design, the etched circuit facility can manufacture conventional circuit boards or small-module printed circuits.

Only the finest material and latest equipment is used to produce quality boards that meet all military specifications:

1. A double-faced photographic printer provides two-sided circuitry.
2. A screen-process press gives extremely accurate registration and sharp line definition when single-sided boards are mass-produced (approximately 50 impressions per hour).
3. Spray etching equipment can etch boards up to 19 inches by 22 inches in size. Double- and single-sided boards are produced in small quantities by adjusting the holding rack in the etching equipment.
4. Automatic feed equipment mechanically inserts eyelets into the printed board. Microminiature eyelets, a new feature, are also inserted automatically.
5. All printed circuit boards are gold-plated. This low-cost plating limits tarnish problems and increases the durability of solder joints.



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MANUFACTURING SERVICES

METAL FINISHING

Each production item is coated or plated with appropriate protective materials. This protects the component, enhances its appearance, and improves its operational characteristics.

1. Gold-Plating

Deposited to a specified thickness, gold produces a hard, mirror-bright finish. A Jet-Plater consolette, completely automatic for high-speed quality work, plates with precision either critical electrical and electronic parts or pilot models. Maximum plating area is 12 square inches.

2. Silver-Plating

Special tank facilities are designed for silver-plating. This custom process provides mirror-bright finishes, ranging from flash to heavy deposits. High quality work and consistency reduce rejects to a minimum. Maximum plating area is approximately 15 inches by 21 inches.

3. Nickel-Plating

This plating facility, also specially-designed, produces a bright smooth, protective nickel coating. Specific thickness can be obtained. Maximum plating area is 15 inches by 21 inches.

4. Copper-Plating

Like the gold, silver and nickel platers, the

copper electroplater is specially-designed to provide a smooth, bright deposit, free from harmful agents to protect against corrosion.

5. Passivation

The passivation process removes from stainless steel foreign matter which promotes the natural tendency of the stainless steel surface to oxidize. Various sizes up to 12 square inches can be processed.

6. Anodizing and Alodining

Anodizing provides a clear or black, protective, nonconductive coating with dielectric properties for aluminum and aluminum alloys. Maximum size is approximately 22 square inches.

Alodine, primarily an iridescent paint base, is applied to aluminum parts when conduction and corrosion resistance is required. Alodine can also be used to touch up areas where rework has removed the original coating.

7. Other Features

Small metal parts can be plated economically with silver, nickel and copper in quantities up to 10,000. All types of brass, steel, copper and certain aluminum alloys, excluding castings or porous alloys, can also be plated. In addition, all types of spray-painting facilities are available. Every coating must pass rigid inspection and conform to customer specification.



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QUALITY ASSURANCE

At HRB-Singer, Inc., Quality Assurance begins with production planning and continues throughout the production process. Quality Assurance conforms to: Specification MIL-Q-9858A "Quality Control System Requirements"; MIL-C-45662 "Calibration System Requirements"; and USAF Specification Bulletin NR515 "Control of Non-Conforming Supplies." We also have operated under the more detailed requirements of MIL-I-45208 "General Specification for Inspection Requirements."

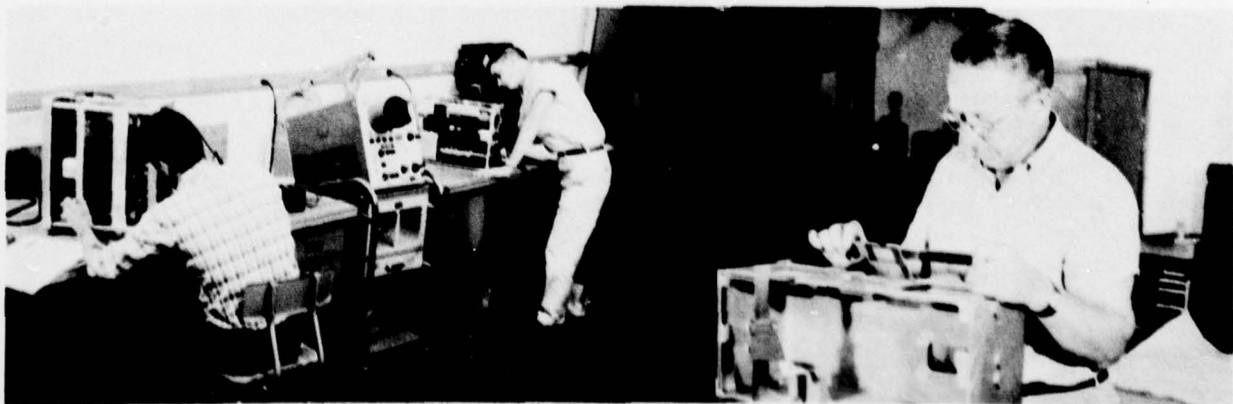
Our Quality Assurance System has been evaluated and accepted by all branches of the Department of Defense.

Resident inspection services are provided by Headquarters, Defense Contract Administration Services Region, Defense Supply Agency, Philadelphia, Pennsylvania.

Typically, the areas of responsibility from contract inception to completion are as follows:

1. REVIEW CONTRACTUAL REQUIREMENTS ... then advise the Engineering, Purchasing, Contracts, Production, Packaging and Shipping Departments of these requirements.
2. MONITOR ALL PURCHASE ORDERS ... placed with sub-contractor's to conform with contractual terms.
3. PERFORM VENDOR SURVEILLANCE ... as required, to establish vendors' own quality control capabilities.
4. INSPECT ALL PROCURED MATERIALS ... to fulfill established requirements.
5. EVALUATE VENDOR PERFORMANCE ... and inform the Purchasing Department of such performances.
6. GENERATE INSPECTION PLANS ... compatible with production operations.
7. MONITOR ALL DRAWINGS AND CHANGE NOTICES ... for errors and completeness so that process changes are incorporated at proper levels.
8. REVIEW MANUFACTURING OPERATIONS SHEETS
9. PHYSICALLY MEASURE ALL FABRICATED PARTS ... and verify conformance to drawings and specifications to assure interchangeability.
10. FUNCTION AS A MEMBER OF THE VALUE ANALYSIS GROUP
11. PROVIDE LIAISON BETWEEN CUSTOMER AND GOVERNMENT REPRESENTATIVES
12. INSPECT ALL ASSEMBLIES
13. CLOSELY SUPERVISE ELECTRICAL TEST PERFORMANCE ... to complete contractual requirements.
14. CONTROL CALIBRATION AND MAINTENANCE SCHEDULES ... for all measuring equipment.
15. COMMUNICATE INFORMATION ... to the engineering, production and reliability groups.
16. PROVIDE MATERIAL REVIEW BOARD SERVICES ... for all contracts.
17. INSPECT ALL PACKAGING AND SHIPPING ... to fulfill contractual requirements.

Examples of the documents necessary to discharge these responsibilities are included in the Quality Control Manual S-33 and HRB-Singer's Workmanship Standards Manual QC-5. Copies of these detailed manuals are available upon request.



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AIRCRAFT OPERATIONS

HRB-Singer owns and operates two aircraft, a Cessna 310B and a tri-gear Beechcraft G-18S. The Cessna, with a service ceiling of 20,000 feet, seats three people including the pilot; the Beechcraft, which has a service ceiling of approximately 23,000 feet, seats nine people plus the pilot and co-pilot. Both aircraft are equipped with oxygen systems for high altitude work.

Both planes are modified to carry multisensor airborne gear for use in infrared and visual photography. Test, data collection, and demonstration flights are conducted locally and throughout most of the United States.

Airport facilities are located at nearby University Park Airport. The company-owned hangar, 4480 square feet, is used for aircraft storage and all maintenance, including engine changes. An electronics laboratory and a photo-processing area also are located in the hangar.



OUR PRODUCTS ... METHODS AND EQUIPMENT ... COMPRISE INFORMATION SYSTEMS

PUBLICATIONS

HRB-Singer, Inc., maintains a complete publications facility which publishes all manuals, technical reports, and other collateral material relating to customer project and internal information requirements.

Experienced technical writers and editors, technical illustrators, artists, composers, proofreaders, photographers, and lithographic printing specialists blend their talents to produce documents that meet the most stringent military specifications. These requirements include: MIL-M-10953 (Signal Corps); MIL-M-16616 (SHIPS); FAA-R-638 (FAA); and MIL-T-9941 (Air Force). Military Standards, such as MIL-STD-12, MIL-STD-15, and MIL-STD-16, are referenced.

Six sections comprise our integrated publishing operation: the technical writing and proofreading sections are supervised by the technical editor; technical illustrating, photography, composing, and reproduction are responsible to the production manager. Both the technical editor and the production manager report to the publishing manager, who supervises the publications facility.

Publications is completely equipped to operate effectively and efficiently. It also is important to note that the facility operates day and night when necessary to meet project deadlines and satisfy customer requirements.



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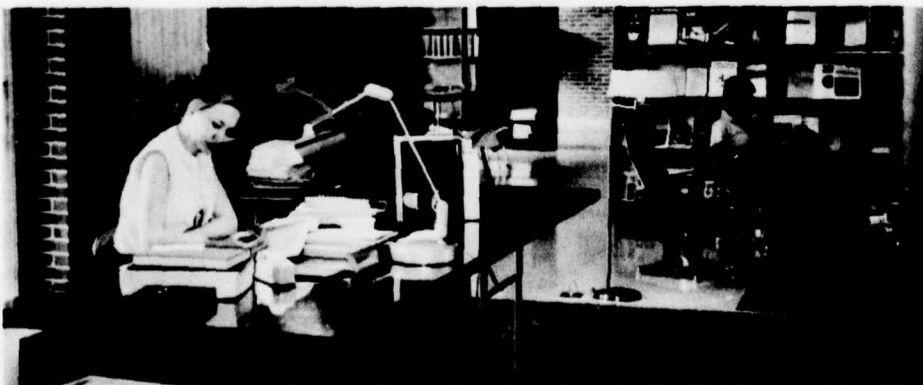
TECHNICAL INFORMATION CENTER

HRB-Singer's Technical Information Center is composed of the Technical Library, the Document Control Center, and the Mail Room.

Technical librarians procure, process, and circulate books, periodicals, reprints, and other published material pertinent to the Company's research and development activities. They collect reference data, preserve important abstracts and indexes, maintain military specifications files, and keep a temporary vertical file of all current, salient subject matter. These resources are supplemented by The Pennsylvania State University libraries through an active interlibrary loan program.

Document controllers process, distribute, circulate, and store original technical documents and correspondence. They also maintain records of the Company's technical publications.

Mail Room personnel process and distribute incoming and outgoing mail. They also regulate business communications through Western Union and the latest teletype, Bell Telephone's Model #33.



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MACHINE COMPUTATION SERVICES CENTER

HRB-Singer maintains an in-house data processing facility to support management information requirements and project work, including simulation of electronic equipment characteristics and environments, gaming, data reduction, provisioning, statistical analysis, and numerical solutions of mathematical problems.

The Center is equipped with a System 360, Model 30 computer with 65,000 bytes of core memory, one disc drive, four magnetic tape drives, an 1100 lines per minute high-speed printer, and 1000 cards per minute reader/500 card per minute punch capability. A 30-inch digital plotter is connected on-line to the computer.

Additional card-handling equipment includes key punches and verifiers, sorters, accounting machines, a collator, an interpreter and a reproducing/summary punch.

Use of this equipment helps the Company control costs and improve products in project areas such as: (1) simulation of electronic equipment characteristics and environments, (2) gaming, (3) data reduction, (4) provisioning, (5) statistical analysis, and (6) numerical solutions of mathematical problems.



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