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U. S. NAVY FLEET AVIATION TRAINING PROGRAM DEVELOPMENT

Seville Research Corporation
400 Plaza Building
Pensacola, Florida 32505

FINAL REPORT OCTOBER 1976 - OCTOBER 1977

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Four specific aircraft training program development efforts (A-6E, E-2C, EA-6B, and SH-2F) were examined and compared as to methodology and procedures used. The four efforts embodied principles of the Systems Approach to Training (SAT) and/or Instructional Systems Development (ISD). Three different contractors were involved, and the programs were under the technical direction of the Naval Training Equipment Center. The four projects carried through the point in the SAT/ISD process of development of lesson

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specification documents. In addition to examining procedural and methodological differences of the four programs, the report also described the various program products and examines their utility for subsequent steps in the SAT/ISD process.

The report also examines the general model that has been evolving in a variety of NAVTRAEQUIPCEN sponsored efforts for the conduct of SAT/ISD programs. The model and its associated documentation are examined in terms of their utility for aviation training program developmental efforts.

The report concludes that these various activities have advanced the Navy's capabilities significantly for the development of more effective aviation training program efforts in the future. Several areas are suggested for further improvement of the model. These include: (1) making it more applicable to complex in-cockpit psycho-motor skills (as contrasted with cognitive skills); (2) techniques of flight performance measurement, and (3) means of enhancing the role of simulator training in the model.

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SUMMARY

This project was part of a continuing effort by the Navy to develop and implement improved procedures and methodology for fleet aviation training. The focus of concern in these efforts has been on the methodology that has come to be labeled as the Systems Approach to Training (SAT) or as Instructional Systems Development (ISD).

The present study examined the SAT/ISD programs for four specific aircraft systems, the A-6E (TRAM), the E-2C, the EA-6B (ICAP), and the SH-2F (LAMPS). Each of these efforts covered only Phase I of the total SAT/ISD process, i.e., through the step of preparing lesson specification documents. Phase II, i.e., the actual authoring of lesson materials and implementation and evaluation of the operational training system, was not included in the present examination. These four SAT/ISD efforts were conducted for the Navy by three different contractors (one contractor performed both the EA-6B and SH-2F efforts), and the Navy desired that their different procedures and methodologies be compared so as to provide a basis for future improvements in Navy aviation SAT/ISD efforts.

In addition to examining the four specific SAT/ISD efforts, the present study also examined the evolving Navy SAT/ISD model for fleet aviation training program development. That model, along with its supporting specifications, instructions, and other documentation, provides a well-organized structure for future Navy aviation SAT/ISD efforts. The comparisons of the four SAT/ISD programs and the "lessons-learned" therefrom were integrated with analysis of the model to suggest future areas for improving the model and its underlying procedures.

Results of the comparisons of the four SAT/ISD programs reveal that the three contractors used methodologies that were quite similar in an overall sense, but that there were many areas of procedural differences. Among such differences were: (1) the manner and extent of use of Navy subject matter expert personnel (SME); (2) the level of detail to which tasks were analyzed and where in the Phase I process the maximum level of detail was developed; (3) the format and level of detail in the end-product lesson specification documents; (4) the extent and clarity with which SAT/ISD procedures were described; and (5) the absolute and relative levels of effort devoted by the contractors to the various Phase I SAT/ISD tasks.

With reference to the four Phase I SAT/ISD efforts it is concluded that each would likely provide benefits to fleet aviation training programs if their Phase II programs are successfully carried out. Three areas of shortcoming of these Phase I efforts are identified. These relate to: (1) considerations pertinent to "in-cockpit" psycho-motor skills training (as opposed to cognitive skills training); (2) treatment of flight performance measurement; and (3) treatment of the use of flight simulators in training.

With reference to the SAT/ISD model, seven areas for possible future improvement are suggested. These are: (1) personnel; (2) role of the SME; (3) system constraints; (4) documentation; (5) ISD and flight skills; (6) simulation; and (7) measurement.

PREFACE

The Naval Training Equipment Center has been responsible for technical direction of a series of efforts aimed at developing improved fleet aviation training systems. These efforts have had a dual thrust: the development of specific training programs, and improvement and extension of the methodology on which training program design is based. That methodology has been labeled variously as the Systems Approach to Training (SAT) or Instructional Systems Development (ISD). The basic orientation of the SAT/ISD methodology is that of careful specification of job-relevant training objectives in behavioral terms and the systematic design of training systems based on instructional science considerations.

In pursuit of its SAT/ISD goals, the Navy has sponsored four specific efforts concerned with the A-6E (TRAM), E-2C, EA-6B (ICAP), and SH-2F (LAMPS) aircraft systems, respectively. It has also sponsored several efforts aimed at documenting and improving the SAT/ISD methodology for future applications. The present effort is part of the Navy's program aimed at improving the SAT/ISD methodology. In it, the four aircraft instructional system efforts are examined and compared, and the Navy's evolving model of the SAT/ISD process is analyzed. On the basis of results with the four aircraft programs and analysis of the SAT/ISD model, areas are identified for possible future improvements in the model and its application.

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William B. Boney
Scientific Officer

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INTRODUCTION

BACKGROUND

This report sets forth the results of a comparative analysis of four specific U.S. Navy sponsored aviation Systems Approach to Training (SAT) programs. In addition, it examines the general trends in the Navy's development of SAT procedures for fleet aviation training. The objective of the present effort was to identify from those various activities areas for improvement of the SAT methodology and its future applications by the Navy.

The purposes of the four specific SAT programs were (1) to develop cost effective aircrew training programs utilizing the SAT methodology, and (2) to evaluate a variety of SAT approaches as a means of improving future Naval Air SAT programs in terms of both their effectiveness and management. The four SAT programs cover the following aircraft systems:

- A-6E (TRAM)
- E-2C
- EA-6B (ICAP)
- SH-2F (LAMPS)

The four programs were conducted by contractor agencies working in conjunction with Navy personnel. The programs were under the technical direction of the Naval Training Equipment Center. The Navy Personnel Research and Development Center also participated in the SH-2F program. The contractor agencies involved were: (1) Grumman Aerospace Corporation (A-6E); (2) Calspan Corporation (E-2C); and (3) Courseware, Inc. (EA-6B and SH-2F).

The four programs each covered Phase I of a projected two-phase effort. In this regard, these aviation SAT programs were conceived, for management purposes, as having a logical break-point in the series of steps between the activity of development of lesson specifications and the subsequent activity of authoring/production of course materials. Thus, Phase I of a SAT effort is defined for these programs, generally, as extending from job/task analysis through the development of lesson specification documents.[1/] Phase II effort, which might conceivably be carried out by an agency different from the Phase I executor, would extend from the authoring/production step through implementation, evaluation, and quality control. The present report deals only with the Phase I activities under the four programs, though one (the SH-2F) has progressed on to Phase II. The Phase I efforts took place concurrently during the period May 1975 - April 1976.

The four programs examined were initiated in response to a Navy proposal request entitled "Systems Approach to Training." In the course of several of these programs, the term Instructional Systems Development (ISD) came to be used in lieu of the SAT designation. Therefore, in the present report the designations SAT and ISD will be used interchangeably. The term ISD has come into rather general use throughout the defense instructional community and, thus, is used here as a matter of emerging convention. Some authors view the SAT methodology as being of somewhat wider scope than ISD, but this point is not of major concern to the present examination. In the context of this report, both SAT and ISD are viewed as essentially equivalent approaches to training program development embodying certain concepts of systems analysis and with defined sequences of activities.

Aircraft Systems

For present purposes, no great amount of detail concerning the four aircraft involved is necessary. However, since the characteristics of these aircraft systems, i.e., their general mission and crew composition, do relate to the mechanics of the four SAT/ISD efforts, a brief description of each aircraft is given.

A-6E (TRAM). The A-6E is a two-man subsonic attack aircraft. The crew consists of a pilot (P) and a bombardier/navigator (B/N). The general mission is high and low altitude all-weather attack. The TRAM version (Target Recognition, Attack, Multisensor) extends and improves weapons system delivery capability, but within the same basic mission area.

[1/] Most of the formal, systematized expositions of modern instructional program development methodology begin with some form of job/task analysis activity. However, some recognize and describe certain critical activities that occur prior to the job/task analysis step. In the SAT methodology, a major activity that can occur prior to job/task analysis is that of Problem Analysis. While some elements of Problem Analysis were included in the four Phase I efforts of concern here, they did not systematically cover that aspect.

E-2C. The E-2C is a sophisticated electronic surveillance aircraft and carries a crew of five. The pilot (P) and co-pilot (CP) are seated forward, while the three remaining crewmembers--the Combat Information Center Officer (CICO), the Air Control Officer (ACO), and the Flight Technician (FT)--are seated aft in the Combat Information Center (CIC) compartment. The primary mission of the E-2C is to provide Airborne Early Warning (AEW) information in defense of a fleet force. In addition, it can perform in a variety of other missions such as Surface-Subsurface-Surveillance Control (SSSC), Anti-Submarine Warfare (ASW) Support, Search and Rescue (SAR), and others.

EA-6B (ICAP). The EA-6B is a tactical jamming aircraft that employs a variety of Electronic Countermeasures (ECM). The four-man crew consists of a pilot (P) and co-pilot (CP), who occupy the forward cockpit, and two electronic countermeasure operators (ECMO), who occupy the aft cockpit. The basic mission is to support strike aircraft and ground forces by suppressing or jamming enemy electronic activity. The ICAP version (Improved Capability) involves latest state-of-the-art electronic equipment.

SH-2F (LAMPS). The SH-2F is a helicopter, used primarily in Anti-Submarine Warfare (ASW) and in surface surveillance. It can also deliver submarine-homing torpedoes. There are three aircrew positions, pilot (P), co-pilot (CP), and sensor operator (SENSO). In addition to ASW, the SH-2F is used for other missions such as SAR and external cargo transport.

Documentation

The Phase I SAT efforts for these four aircraft systems have produced a variety of documentation including task listings, behavioral objectives, objectives hierarchies, training support requirements, media selections, lesson specifications, and a summary technical report. These documents are quite voluminous and vary somewhat in format from one program to another. While most of the documents produced were available for the present analysis, some were not. A listing of the documents examined is contained in the references section of this report.

In addition to the documentation of the four aircraft SAT/ISD programs mentioned, a variety of other documents pertinent to ISD methodology and applications was examined in the present review. These documents are also identified in the references section. The most important of these, for present purposes, are a series of documents dealing with development and implementation of a detailed ISD model, including a draft Specification for Instructional Systems Development. These items are being developed by Courseware, Inc. and Logicon for the Navy. This specification and related documents seek to codify an ISD methodology tailored specifically to the requirements of Naval Aviation operator and maintenance training.

INSTRUCTIONAL SYSTEMS DEVELOPMENT

The approach that has come to be labeled as Instructional Systems Development, or ISD, has evolved over the last 25 years or so from the efforts of many R & D groups, largely working in a military training context. It is based on use of the so-called systems approach in the solution of training problems. The ISD and SAT methodologies have been documented by many authors and will not be reviewed here. However, while many applications of SAT and ISD--generally by R & D groups--have produced impressive results, there seems to be a strong feeling on the part of some that many such applications have failed to live up to the expectations that have been developed with reference to cost effectiveness of ISD. For example, in the RFP[2/] for the recent USAF procurement of an F-16 Pilot Training System Program, it is stated (Statement of Work, p. 2-4):

> "1.2 Previous Air Force applications of ISD, while yielding worthwhile results, in many cases have fallen short of total effectiveness (p. 2) . . .
>
> "2.3 Instructional media selection has been made intuitively in the past. . . Compilation of cost effectiveness data for the variety of media options available to the instructional system designer, traditionally a conspicuous unknown in prior ISD efforts, will also be a primary component of the F-16 training system procurement. (p.3)
>
> "2.4 A major criticism that can be made of some previous ISD efforts is that these efforts fail to employ fully recent advances in training technology. Indeed, ISD efforts have been content to apply traditional aircrew training techniques rather than venture into new innovative approaches to training. (p. 3-4)
>
> "2.5 A final deficiency in previous ISD efforts which this contract seeks to avoid is the lack of total training system optimization." (p. 4)

[2/] USAF RFP No. F02604-77-09010: F-16 Pilot Training System Program. Procurement Division (LGPK), Luke AFB, AZ. 1 December 1976.

Other sources have raised similar questions about ISD's effectiveness in practice. For example, Montemerlo,[3/] building on remarks by Cream,[4/] cites various "unsupportable assumptions" as underlying the sometimes failure of ISD to fulfill the benefits expectations of training and R & D managers.

Whether one accepts the contention that ISD problems stem from "unsupportable assumptions," which would suggest a conceptually flawed methodology, or from other factors, there is general agreement that problems can result during a specific application of ISD or SAT unless there is a proper blend of personnel skills and resources. In the final report[5/] (draft) of the SH-2F Phase I effort, the author states one aspect of the personnel problem somewhat colorfully: "The Systems Approach to Training requires the marriage of academic rigor and practicality along with some of the characteristics of Waldo Pepper and P.T. Barnum."

The problems with ISD are described in somewhat more prosaic language in another of the ISD Phase I reports:[6/]

> "THE ISD PROBLEM. At the time the EA-6B ISD project was being conceived, a number of serious questions about ISD were in the minds of those concerned with Naval Air Training.
>
> "At the most general level, the problem was whether or not the Navy should continue to go with ISD as the required approach to training. . . The general feeling was that ISD provided a framework that should lead to the development of instructional programs that are effective and efficient in developing job skills. In spite of this, it was very hard to present convincing evidence that ISD is workable, effective, or efficient in terms of resource consumption. There were two reasons for this lack of certainty.

3/ Montemerlo, M.D. "Instructional System Development: Implications for Further Research." Proceedings of the 5th Symposium on Psychology in the Air Force. U.S. Air Force Academy, CO, April 1976, pp. 121-124

4/ Cream, B.W. Air Force ISD Conference. The Pentagon, Washington, DC, 3-5 February 1976.

5/ Gibbons, A.S. SH-2F (LAMPS) Instructional Design and Development: Final Technical Report, Phase I. Draft Final Report. Courseware, Inc., San Diego, CA, May 1976.

6/ Hughes, J.A., and Hymes, J.P. A Study of the Effectiveness, Feasibility, and Resource Requirements of Instructional Systems Development: EA-6B Readiness Training. Technical Report NAVTRAEQUIPCEN 75-C-0100-1. Naval Training Equipment Center, Orlando, FL, January 1977.

"First, almost all versions of ISD were seriously lacking in detailed, prescriptive guidance for conducting the various analysis and design phases which ISD requires. . . In other words, ISD approaches tended to describe broad steps or phases, but did not incorporate the detailed models, algorithms, and techniques from instructional science and technology which would make the approach really work in a standardized way in a typical training environment.

"Second, many ISD applications did not make adequate provisions for necessary resources: personnel, time, facilities, or money.

"Given these two limiting factors, it is no wonder that some casual observers were ready to conclude that ISD was a good idea that didn't work." (pp. 14-15)

This quotation highlights some of the reasons for Navy concern in these four ISD/SAT efforts with the process or methodology of ISD and the extent to which it can be used in a prescriptive manner in future programs in Naval Aviation. Thus, while all four efforts sought to produce (assuming subsequent execution of Phase II) effective training systems, each sought to examine the procedures used and to suggest ways of improving them.

It is clear, however, that despite such problems ISD and related approaches do have much to offer in the way of more effective training. While one may argue with various specifics of the method, few seriously question the strength and advisability of the general underlying concepts that are common to the various systems or applications of SAT or ISD. One measure of the validity of this assertion is the magnitude of ISD activity that abounds in military training circles, as well as that in non-military training and education. The emphasis in ISD on defining desired outcomes in specific behavioral terms, on developing the most cost effective means of achieving those outcomes, and on objective program evaluation and revision are its strength and imbue it with an aura of validity, acceptability, and common sense.

The growth of ISD activity, however, presents another set of problems of concern to the Navy in its role as a buyer of services and training products. If ISD programs are going to be procured from outside vendors, as in the case of the four aircraft ISD efforts discussed here, not only must they be based on a methodology that is conceptually sound, but the methodology must be one that is feasible of management[7/] by the procuring agency. Thus, there is a concern that the ISD procurement contracts adequately describe what is to be delivered in a manner that protects the government's interests and maximizes the likelihood that the ISD effort will be successful in producing an effective training program. It is toward this end that Navy efforts to articulate an effective ISD model, in both the technical and management senses, have been directed.

ANALYSIS OF NAVY ISD PROGRAMS

As noted, a major concern of the present report is a comparative analysis of the four Navy aviation ISD programs. The analysis is based on the available program documentation and the author's experience with similar programs. The basic intent is to provide observations and comments that will enable future Navy aviation ISD programs to be more effective and efficient and that will provide aid in the management of such programs.

Approach

The approach used is analytical examination of the four aviation ISD programs as represented in their various documentations. In addition, the proposed model and specifications for future ISD efforts are examined. Aspects of these various programs and the documentation are interpreted, compared, evaluated, and related to the views and experiences of the author and that of other researchers and practitioners, as appropriate.

[7/] The problems of managing an ISD program procured from a civilian contractor are not fundamentally different from those that would be involved in management of an in-house ISD effort by a military or civil service group. The desired end product (an effective training program) is identical, and the production process is much the same. However, for a contracted effort in-house command authority functions must be cast in contractual/legal form, specifications must be used, and various interim and final products must be defined in contractual/legal terms to insure that the process is executed as desired. It is a matter of which authority structure is used, command or legal. Functions are much the same.

Among the areas of concern in this analysis are the following:

1. Comparative analysis of the four SAT/ISD programs.
2. Utility of Phase I products for Phase II.
3. Utility of products for Navy decisions.
4. Adequacy of RFP and ISD specifications.
5. Changes to ISD methodology.

The bulk of the activity relates to the first of the above areas, which, in turn, provides input to the other four areas. Where possible, comparisons are made in objective or quantitative terms, e.g., number of hours devoted to a given activity. In many instances, however, comparisons and evaluations necessarily involve a degree of subjectivity.

In comparing the four SAT/ISD programs, the areas shown in Table 1 are examined. In some cases the information available is not complete. It must be recognized also that, while there are many common features or aspects of the various programs and the environment in which they were conducted, there are many unique or unusual aspects of each. Further, while the manner in which a given function or requirement was handled in one program might appear more or less advantageous than its handling in another program, there may have been quite adequate reasons for the differences. It is likely that some of these reasons are obscured or not present in the available documentation.

TABLE 1. DIMENSIONS OF ISD PROGRAM COMPARISON

1. Composition of the ISD Team
   - A. Number and types of personnel
     - (1) Contractor
     - (2) Navy
   - B. Qualifications
   - C. Training
   - D. Functional roles
   - E. Navy SME role
2. Task Listing
   - A. Information sources
   - B. Number of positions/tasks
   - C. Task validation procedure

TABLE 1. DIMENSIONS OF ISD PROGRAM COMPARISON (CONT'D)

D. Amount of effort

3. Task Selection
   - A. Method
   - B. Input trainee level determination
   - C. Amount of effort
4. Task Analysis (Objectives Hierarchy)
   - A. Method
   - B. Learning orientation
   - C. Format and level of detail
   - D. Amount of effort
5. Media Selection
   - A. Method
   - B. Media types
   - C. Consideration of alternatives
   - D. Amount of effort
6. Course Design (Sequence and Structure)
   - A. Method
   - B. Use of simulation
   - C. Strategies
   - D. Amount of effort
7. Lesson Specifications
   - A. Method
   - B. Format
   - C. Flight vs. non-flight
   - D. Completeness
   - E. Amount of effort
8. Measurement and Evaluation
   - A. Flight vs. non-flight
   - B. Internal evaluation
   - C. External evaluation
   - D. Amount of effort
9. Documentation
   - A. Nature of reports/documentation

B. Clarity

C. Specificity of procedures, algorithms, etc.

D. Amount of effort

10. General Factors

A. General program description

B. Program cost

C. Program quality (adequacy of methodology and execution)

D. Manageability (from Navy perspective)

E. Implications for future

Organization of Report

The report is organized into three general parts: Section I - Introduction; Section II - Results; and Section III - Commentary. The structure of the Results section will follow somewhat that implied in Table 1 and the preceding discussion, but it will depart from this as necessary for exploration or exposition of various points of interest. Due to the general characteristics of analytic studies of the present type--i.e., their lack of a rigorous scientific evaluative structure, the incompleteness of available information, the variety of circumstances surrounding the individual efforts, the subjective and interpretive nature of the evaluative statements, and similar factors--the final section is labeled as Commentary rather than the more usual Conclusions and Recommendations. As will be seen, certain conclusions and recommendations are drawn or implied, but it is recognized that other alternatives may be equally tenable. Therefore, any conclusions, recommendations, or discussions are more properly labeled as commentary. The hope is, of course, that the comments will materially assist the Navy in the future conception, procurement, execution, and management of aviation ISD programs.

SECTION II

RESULTS

OVERVIEW OF PROGRAMS

As noted in the preceding discussion, results concerning the four SAT/ISD programs will be presented somewhat in accord with Table 1, but with digression, as required. Before getting into dimensional comparisons, a brief overview description of each of the four programs will be presented.

A-6E (TRAM)

The ISD approach followed by Grumman in the A-6E effort was quite similar to that described in the USAF instructional design handbook.[8/] Seven major steps were identified for the Phase I effort: (1) determine job performance requirements and standards; (2) determine training requirements; (3) determine terminal and supporting objectives; (4) develop criterion performance tests; (5) perform media analysis; (6) plan instructional materials/methods; and (7) prepare lesson specifications. The contractor team was made up of training psychologists, educational specialists, and flight test personnel. Navy SME (subject matter expert) personnel participated principally in a review role. Approximately 700 tasks were identified for the two-man crew (pilot and bombardier/navigator), from which 373 specific behavioral objectives (SBO) were derived for training. Some 55 different lesson specifications were developed. Total ISD Phase I contract cost was $195,000.

E-2C

The approach used by Calspan in the E-2C program, which is also based on USAF procedure, is an expansion of the methodology used by the contractor in a prior ISD effort on the B-1 stratetic bomber system. Seven major Phase I activities are specified in this approach: (1) perform task analysis; (2) select tasks for training; (3) determine course objectives; (4) select instructional methods and media; (5) determine instructional strategies; (6) sequence instruction; and (7) organize objectives into unit and lesson structure.

[8/] U.S. Air Force. Handbook for Designers of Instructional Systems: Vols. I-V. AFP 50-58. Headquarters, U.S. Air Force. Washington, DC, July 1973.

The contractor team composition was similar to that described for the A-6E. Navy SMEs were used in minimal fashion in the program. The number of crewmember tasks identified could not be specifically determined from the documentation available. However, some 159 pilot/co-pilot behavioral objectives are identified, as are some 466 behavioral objectives for the other three crew positions (CICO, ACO, and FT). The P/CP course has 19 modules which contain a total of 92 lessons. The NFO/FT[9/] course has 38 modules with a total of 137 lessons. Total Phase I contract cost was $270,194.

EA-6B (ICAP)

While conceptually much the same as the two previous programs, the ISD model used by the EA-6B contractor, Courseware, Inc., was based on the U.S. Army's systems engineering of training model.[10/] The steps involved are: (1) task listing; (2) job analysis survey; (3) selection of tasks for training; (4) development of objectives hierarchies; (5) course sequencing; (6) media selection; and (7) development of lesson specifications. The contractor team consisted of an instructional psychologist, an instructional technologist, and a pilot SME. Additional professional support was provided by other contractor personnel. Considerable assistance was provided by Navy SME personnel in virtually all activities in the program. While difficult to determine precisely from the documentation, approximately 245 tasks were identified for the pilot, co-pilot, and two ECMO crewmembers. Additional elements were identified for many of these tasks. The pilot/co-pilot course is divided into 14 units comprised of 129 lessons, while the ECMO course is comprised of 17 units. The number of lessons in one ECMO unit could not be determined, but there were 129 lessons in the remaining 16 units. Cost of the Phase I contract was $216,679. However, a substantial portion of the lesson specifications was not completed within the original effort.

[9/] The CICO and ACO are Naval Flight Officers (NFO), whereas the FT is an enlisted crewmember.

[10/] U.S. Army Training and Doctrine Command. Systems Engineering of Training. TRADOC Regulation 350-100-1. Fort Monroe, VA, February 1968.

SH-2F (LAMPS)

The ISD approach followed for the SH-2F was the same as that described above for the EA-6B. The same contractor, Courseware, conducted both programs. The contractor ISD team consisted of an instructional psychologist and two instructional development technicians. A substantial number of Navy SMEs were involved, as well as a technical monitor from the Navy Personnel Research and Development Center. Approximately 183 pilot/co-pilot and 31 aircrewman (SENSO) major tasks were identified. Additional subtasks and elements were identified below the major task level, particularly for the SENSO. The pilot/co-pilot course is divided into seven sections comprised of 25 units and 64 lessons. The SENSO course has 16 sections, 38 units, and 85 lessons. Total cost of the Phase I contract effort could not be determined.

COMPOSITION OF ISD TEAMS

All four of the programs involved some combination of contractor effort with that of the Navy SMEs. Three of the contractor ISD teams apparently contained one or more persons who were SMEs in the flying content area. From the information available, no contractor SME could be identified on the Courseware SH-2F effort. One contractor (Calspan) reported having its SME attend Navy E-2C classes for a two month period to increase his subject matter expertise. The contractors apparently felt (with the possible exception of the SH-2F program) a requirement for SME in-house representation in addition to whatever input Navy SMEs provided.

Additional contractor team members are described variously as: (1) instructional psychologist and educational specialists (Grumman, A-6E); (2) specialists in the disciplines of psychology, education and human factors engineering (Calspan, E-2C); (3) instructional psychologist, instructional technologist, technical monitor, consulting and training support group, and management monitor (Courseware, EA-6B); and (4) instructional psychologist and instructional design technician (Courseware, SH-2F).

Little can be stated about the detailed qualifications and experience of the contractor ISD team personnel. All four contractors generally make some claim to having represented an instructional psychologist, an instructional technologist/technician, and an aviation SME. While this seeming congruity of staffing might be interpreted as reflecting a consensus as to personnel requirements for ISD, it must be noted that the staffing pattern was generally dictated by the RFP requirement that ". . . the contractor shall provide instructional psychologists, education specialists, systems analysts, and former military pilots/NFO with relevant experience."

Navy SME Role

Beyond this commonality of staffing and the fact that Navy SMEs played a part in all four programs, there were some wide variations in level of effort and functional roles of the various personnel. In particular, the role of Navy SMEs in the ISD efforts varied considerably. Likely, this variation reflects both the organizational and philosophical orientation of the contractor, as well as situational factors relating to SME availability, SME turnover, and squadron attitudes.

The level of Navy SME effort reported for each of the programs is shown in Table 2. As can be seen, the level of detail with which that effort can be allocated to specific ISD tasks varies from none to considerable. Therefore, lack of a specific entry in Table 2 for a given ISD task does not mean necessarily that no Navy SME time was devoted to that task in a particular program. For example, considerable SME time (1,348 hours) was devoted to the A-6E program, but no information was available as to its distribution over the ISD tasks. Also, it is likely that the extent to which these data reflect actual Navy SME effort is quite variable. The report of the E-2C program (Calspan) shows a total of only 87 man-hours of Navy SME time, but notes that this covers only direct consultation and does not involve time devoted to "independent review of supporting documentation (duration not determinable)." Only in one program (EA-6B) does the contractor (Courseware) discuss a specific procedure or mechanism for keeping track of distribution of effort over the various ISD tasks. By far, the greatest actual use of Navy SME effort was that shown in Courseware's SH-2F program.

TABLE 2. NAVY SME EFFORT[a] BY TASK AND PROGRAM

ISD Task	Program: A-6E	E-2C	EA-6B	SH-2F
1. Task Analysis	Task totals not reported	40		
a. Job Analysis			247	640
b. Task Selection				80
2. Training Objectives		19		
a. Hierarchy Analysis			208	1,392
b. Sequencing and Grouping			97	160
3. Media Selection				
4. Instructional Design				
a. Instructional Objectives		28		
b. Lesson Specifications			995	3,480
TOTALS	1,348	87	1,547	5,752

[a]Time in man-hours

TASK LISTING

The usual starting point for an ISD effort involves defining the universe of job behaviors to which the training system must respond. For this reason, a job/task analysis is performed in which all tasks required in the operational job situation are delineated and analyzed. The procedures used, the format, and the level of detail may vary, but the function is common to all comprehensive ISD efforts. The initial aspect of the task analysis is a listing of all job tasks that occur on the job.

Sources

There was considerable commonality in the manner in which operator task listings were developed in the four programs. Generally, various documentary sources were consulted (e.g., engineering documents, NATOPS, etc.) and SMEs were utilized to expand task lists by "walking through" typical missions. SME input was quite important in this aspect of the

ISD programs. The results of the task listing were usually verified, at least to some degree, by Navy SMEs who had not participated in their initial development.

Variations of note included: (1) the attendance by the Calspan SME for two months of the E-2C NFO training; and (2) the use of direct observations of task performance in ground-based devices (Calspan, E-2C). It is also of interest to note that it was necessary that the contractor redo a previous government-performed[11] task analysis in one of the programs (Courseware, SH-2F).

It is clear that SME input was required in the generation of operator task lists, but there were differences in the extent to which SME input was provided by contractor SMEs as opposed to Navy SMEs. Generally, Courseware relied relatively more heavily on the Navy SME, while Grumman and Calspan relied relatively more on the contractor SME. Related to this was the role of the instructional psychologist or technologist. Courseware seemed to use such personnel more extensively in articulating the task data deriving from Navy SME input, while the company SME for the other two contractors took a more direct role in stating the task data. While these differences reflect different ISD team organizations, it is likely that the output of this phase of the ISD process was much the same regardless of which approach was used. The critical factor was that the SME have an appropriate experience base.

Format and Level of Detail

The actual task listings were not available for the present review, with the exception of the SH-2F program, so comparisons of format and detail are difficult. Also, it is difficult to separate the format and detail of the task listing from that developed during subsequent task analysis activities such as the preparation of objectives hierarchies. In some instances, the initial listing appears to have gone to a very detailed level, while in others the initial listing was at a gross level with further detail developed later.

11/The task analysis supplied the contractor was judged to be inadequate in that it devoted great attention to minute details of equipment manipulation while ignoring higher level distinctions among major job components. In order to make the task data useful for later ISD steps, the contractor had to perform the analysis again.

On the A-6E program the contractor (Grumman) final report[12/] refers to "the generation of thousands of task statements." Consequently, a computer was used to handle the data. Grumman used three different descriptive levels: (1) major mission events; (2) the tasks comprising the events; and (3) the steps that comprise the task. For example, "Pre-Approach" is a mission event; "Contact Approach Control Agency" is a task; and "Set UHF Frequency for Approach Control" is a step within that task.

Calspan, on the E-2C program, broke the data into mission segment, task, and task elements, a categorization similar to that of Grumman. However, the meaning of these descriptors differs. To illustrate its schema, the Calspan final report[13/] describes the mission segment "Recovery." One task in this segment is labeled "Day IFR and All Night Carrier Recoveries (Case III)." Task elements in this task include items such as "Complete Approach Checklist" and "Initiate Penetration." The Calspan task element, "Complete Approach Checklist," would appear as a task in Grumman's schema, with the task then broken into steps. Thus, Calspan's "task" level is probably the equivalent of Grumman's "mission event" level, and Grumman's "task" would probably appear as a "task element" in Calspan's listing.

On the EA-6B program, Courseware defines task as "any sequence of events which has a clearly definable beginning and end point or which produces an observable product." Courseware speaks of mission phases, tasks, and subtasks. In the conduct of an ECM mission, "Launch" would be a mission phase, "Take-off" would be a task, and "Identify and Respond to Any Aircraft System Malfunctions" would be a subtask. In the SH-2F program, Courseware used a similar conception, though the task listing shows additional elements within subtasks.

The principal conclusion from these comparisons is that while terminology and format may differ, and level of detail at this initial stage in ISD may vary, the procedures used are essentially the same. The task statements are sooner or later to be refined to the level of detail required to

[12/] Campbell, S.C., Feddern, J., Graham, G., and Morganlander, M. A-6E Systems Approach to Training Phase I Final Report. Technical Report NAVTRAEQUIPCEN 75-C-0099-1. Naval Training Equipment Center, Orlando, FL, February 1977.

[13/] Sugarman, R.C., Johnson, S.L., Mitchell, J.F., Hinton, W.M., and Fishburne, R.P. E-2C Systems Approach to Training: Phase I. Technical Report NAVTRAEQUIPCEN 75-C-0101-1. Naval Training Equipment Center, Orlando, FL., December 1976.

develop specific behavioral statements of objectives and to allow analysis of the essential requirements for their instruction.

Task Validation

Once the initial task listing was developed, the programs moved to some sort of validation or confirmation of the listing. Task validation is important in ISD because the task listing (or, really, the tasks selected from the task listing) forms the basis for all subsequent training development activities. Therefore, it is essential that the listing include all significant tasks to be performed on the job and that it not include tasks that are not required to be performed on the job. Failure on the first count results in training programs that are deficient in preparing graduates for the job, while failure on the second results in programs that contain unnecessary material and are unduly costly.

The validation procedures described in the project reports varied somewhat. Grumman refers to comments and suggestions from a new group of A-6E SMEs (actually one pilot and one bombardier/navigator) who joined the ISD team after the task listing was completed. They state that this review was, in effect, a "validation" of the work accomplished.

Calspan makes no specific reference to task validation in the E-2C program, other than to a series of SME interviews "utilized at various times during data analysis to ensure that the data base was complete and valid."

In contrast, Courseware, on both the EA-6B and SH-2F programs, conducted a job analysis survey. Data were sought from operational aircrew personnel concerning (a) frequency of occurrence of the task, (b) how soon task performance is required after fleet assignment, and (c) where the task was learned. In the EA-6B program such data were analyzed from 17 pilots and 38 NFOs. The data were felt by the contractor to be adequate. In the SH-2F program, however, results were judged by the contractor to be of questionable use due to failure of Navy SMEs to complete questionnaires properly or failure to meet time schedules. The SH-2F program report notes questionnaires not filled out with care, random marking of answers, and the like.

Of the three contractors, only Courseware has made explicit the details of a validation procedure. While there can be problems in carrying out job surveys among experienced SMEs or job incumbents when the survey procedure is inadequate (as was the case with the SH-2F), most formalized ISD systems emphasize some form of task validation as an important and necessary step. While both the A-6E and E-2C programs gave some recognition to this fact, neither treated task validation as a formalized or systematic procedure. There may be operational difficulties in its implementation, but task validation is desirable and feasible in an ISD project.

Level of Effort

Comparing level of effort over the various programs that was devoted to the task listing/validation activity is difficult. As has been noted, the level of detail represented at this stage varied, and the manner in which Navy SMEs were utilized varied. As well as can be determined, however, the number of man-hours devoted[14] to activities in the task listing/validation step are shown in Table 3.

TABLE 3. EFFORT DEVOTED TO TASK LISTING/VALIDATION

Program	Contractor Professional Effort[a]	Navy SME Effort[a]	Total
A-6E	3,654	?[b]	3,654[b]
E-2C	1,740	40	1,780
EA-6B	445	247	692
SH-2F	480	640	1,120

[a]Effort in man-hours

[b]Indeterminate portion of 1,348 hours of Navy SME effort was probably devoted to this activity.

As can be seen in Table 3, the total effort devoted to task listing/validation varied greatly over the four programs. Direct comparisons of these data are difficult because of the differing degree of detail or depth

14/ As explained later in the General Program summaries portion of this section of the report, Grumman reported both "estimated level of effort" and "actual level of effort" for their various activities. All data discussed here with reference to ISD steps for the Grumman program are based on their "actual level of effort" reported. Conversions for levels of effort originally reported in man-months were made on the assumption that one man-month equals 174 man-hours. If original data were given in man-weeks, a 40-hour week was assumed. In this fashion, all programs were converted to the common man-hour metric.

to which the task listing was carried, likely differences in availability of existing task data, differences in number of crew positions analyzed, and differences in numbers of tasks characterizing a crew position. In general, it would appear that the EA-6B effort differs from the other three in terms of both amount and proportion of effort devoted to the task listing/validation step. The EA-6B program shows the least effort in this area of the four, a fact that would seem contradictory to the fact of its being the only one of the programs with a systematic task validation effort. Proportionately, only about 7% of the contractor's total professional effort was devoted to task listing/validation on the EA-6B program, whereas approximately 31%, 26%, and 14% of total contractor professional effort was devoted to this step in the A-6E, E-2C, and SH-2F programs, respectively. The reasons for these differences could not be ascertained, though as will be noted later, Courseware had a substantial number of professional man-hours on the EA-6B effort that could not be ascribed to specific ISD steps. Some of this time may have been devoted to the task listing/validation step.

While the preceding data are suggestive of some differences among the three contractors in the relative emphasis placed on this step of the ISD process, as has been noted, a variety of factors may have produced such a result. Most likely, the differences between Grumman and Calspan, on the one hand, and Courseware on the other, reflect primarily differences in the level of task detail developed in this initial step, rather than in emphasis per se. However, the approach utilized by Courseware was more proceduralized and placed relatively greater reliance on the efforts of Navy SME personnel, so there probably is some difference between the contractors' ISD procedures in this area.

TASK SELECTION

Given the definition of the job in terms of its required tasks developed in the previous activity, the next step in the ISD process involves selecting some subset of those tasks for inclusion in the training program. In most advanced training courses many of the skills and knowledges required on the job are already possessed, in whole or in part, by the trainees before they enter the training program of concern to the ISD team. Therefore, a specific selection of tasks to form the basis for the training program must be made in view of the job requirements and the trainees' entry level skills and knowledges.

Method

Much of the data or information on which task selection was based was developed in the previous task validation activity. In fact, it is difficult to separate the two activities in several of the programs. In the more formalized expositions of the ISD procedure, task selection is usually based on factors such as:

- Trainee entry repertoire
- Task frequency on the job
- Proportion of new graduates performing task
- Task criticality to mission
- Safety considerations
- Task difficulty
- Time to first performance on job
- Opportunity for training on the job

Of the four programs of concern here, only the two performed by Courseware specify an explicit procedure for selecting tasks for training. Their procedure is expressed in algorithmic form and utilizes as input data the results of the previously described job analysis survey used in the task validation process. Generally, the algorithm used in the Courseware programs operates on the basis of answers to three questions:

1. Did more than 20% perform the task on most missions?
2. Is the task critical to the mission?
3. Did more than 75% learn the task prior to RAG training?

If the answer to Q.1 is YES, Q.3 is asked; if Q.3 is YES, the task is selected to "teach in review mode," while if Q.3 is answered NO, the task is selected for "full training." If the answer to Q.1 is NO, Q.2 is asked; if the answer to Q.2 is YES, the task is selected for full training; if Q.2 is NO, the task is selected to teach in the "Fam", or familiarization, mode.

One advantage of the algorithmic expression of the selection decision process is that it permits the process to be computerized and to be handled procedurally. Also, it makes the selection procedure explicit and repeatable. The question arises, of course, as to the meaningfulness or validity or the particular algorithm chosen and the validity of the input data.

Obviously, the questions asked by Courseware here are only a portion of the pertinent questions that could be asked, but they are pertinent and comprise a manageable procedure.

While the Courseware algorithm, as any algorithm, can be questioned on the above basis, it is of interest to examine how it worked in practice. As has been previously mentioned, the SH-2F program experienced considerable difficulty in securing usable data from the task validation survey. In fact the final report of that program states that the survey data were so late that ". . . many decisions had to be made at the informal level and in the absence of questionnaire data." It further states that because of the inferiority of the data, "Through a study of prior training of the students and normal fleet instruction as it could be described by the project SME's, it is felt that the tasks selected for training constitute a list which will coordinate well with fleet training programs." Thus, it would appear that task selection in the SH-2F program was made largely through an informal judgmental procedure rather than by the algorithm.

In contrast, on the EA-6B program the algorithm seems to have been utilized smoothly with none of the difficulty encountered in the SH-2F program. Task selection required only four hours of personnel time in the EA-6B program and is described as "an almost trivial effort." The EA-6B report goes so far as to recommend that task selection not be retained as a step in ISD. Similarly, in the SH-2F final report the author describes task selection as primarily an administrative function that should be handled by the Navy.

Further examination of the results of the task selection process in the EA-6B program shows that only 2 of 172 pilot/navigator tasks and 2 of 178 ECMO (electronics countermeasures operators) tasks were not selected for training. Of the 170 pilot/navigator tasks selected, 17 were "Fam only," 25 were "review only," and 128 were for "full training." Of the 176 ECMO tasks selected, one was "Fam only," 9 were "review only," and 166 were for "full training." Viewed from this perspective, task selection made no real difference in the content of the program.

In the Grumman A-6E program, a section of the final report is entitled "Task Selection." In it, a procedure involving elaboration of the task listing through a "Task Analysis Record" form is described. On this form, for each task a variety of factors are elaborated including: (1) crewman performing task; (2) where training is given; (3) skills and knowledge required by task; (4) conditions under which task is performed; (5) cues involved in performance; (6) aircraft system involved; (7) degree of difficulty; (8) factors in task difficulty; (9) task criticality; (10) factors in performance measurement; and (11) other special factors which impact training. Some of these factors would seem useful to task selection, but Grumman says nothing about the details of how such data were used in task selection, if at all. It is not known whether all or only a portion of the tasks were actually selected for inclusion in the subsequent training program, or on what basis selection was made. Their report states that no attempt was made to assess the appropriateness of a task for Readiness Squadron training or to judge entry level skills of trainees. SME input apparently was accepted without question.

Calspan also refers to task selection, stating that, with consultation from Navy SMEs, they "selected tasks for documentation that had some expectation of occurrence and were amenable to training." They also refer to trainees' incoming skill levels, but no explanation is given as to how skill levels were assessed or to how task selection was made.

It would appear, then, that all four programs were, in fact, based on the initial task listing determined largely by SME judgment. No real selection of tasks was made, nor is there any real assessment of trainee input skill levels. The only articulated task selection procedure was that of Courseware, but, in effect, it had almost no operational influence on program content.

Level of Effort

The available data did not allow determination of amount of effort devoted to task selection for the Grumman and Calspan efforts. Their task selection efforts likely were included in the times previously given for task listing/validation.

Courseware reported only four hours involved on the EA-6B program, while on the SH-2F program a total of 80 hours of contractor professional time and 80 hours of Navy SME time are shown for task selection.

TASK ANALYSIS (OBJECTIVES HIERARCHIES)

Once tasks are selected for training, they are elaborated in terms of their component behaviors, conditions and standards of performance, inter-task dependency relationships, learning requirements, and similar factors. They are generally cast in the form of specific behavioral objectives and, thus, become the training objectives for the program. The supporting skills and knowledges required for task performance are also identified and stated as training objectives. It is in this area of ISD that there may result substantial differences in the content of training programs, for the processes of determining inter-task sequential learning contingencies and of identifying supporting or enabling skills and knowledges are analytical and judgmental in nature. Consequently, two different ISD analysts can come up with quite different program content utilizing the same input data. Such differences impact program length, media and resource requirements, and program cost.

Method

The methods employed by the various contractors in analyzing tasks and objectives differed somewhat. The goal of this level of the task analysis for all, however, was to develop the information needed for structuring the training program, for selecting media, and for preparation of the lesson specifications. In the Grumman A-6E program, the factors previously cited in task selection (e.g., cues, system, difficulty, criticality, etc.) were used in connection with the development of specific behavioral objective (SBO) statements. Objectives were also classified on the basis of eight major taxonomic categories: (1) knowledge; (2) comprehension; (3) discrimination; (4) application; (5) analysis; (6) synthesis; (7) evaluation; and (8) complex performance. The SBOs were documented on an "Instructional Systems Design Record" form that gave the task identification data, condition/constraints, performance standard, the SBO statement and ID number, taxonomic data, a criterion test statement, and test type and format. Nothing appears in this record concerning hierarchical or inter-task relationships, but hierarchical relationships were treated in the development of instructional strategies and sequences (see discussion in a later section of this report).

In the E-2C effort of Calspan, behavioral objectives were developed from the task data. The format included identifying data for each objective, as well as its criticality, difficulty, conditions and standards. In addition, it included reference to concurrent tasks that the operator must perform, as well as to interaction tasks involving other crewmembers.

As with the previous parts of the ISD procedure, Courseware had the most highly articulated system for analyzing the objectives. The tasks are analyzed in order of their complexity. Subtasks are identified until entry level behavior is reached. The hierarchical relationships among tasks, subtasks, and elements are portrayed graphically in a manner that shows the interdependencies among objectives that underlie a given task. This information is then used in the structuring of syllabi and lessons.

In developing these hierarchies, Courseware refers to "pruning" (i.e., the elimination of trivial objectives); to "summarization" (i.e., the requirement that the student state a procedure before executing it); to "behavior approximation" (i.e., not performing the actual task when dangerous, but an approximation); and to "systems introduction hierarchy structure," (i.e., the requirement that the student be familiar with basic system, subsystem, and component relationships).

Thus, while there are similarities over the programs in this aspect of their task analysis, there are also differences. In all the contractor systems, the analysis is subjective ultimately, and, thus, its utility is dependent upon the skill of the executor. Standards of performance are subjective, and in all four of these programs they seem to be based upon a somewhat uncritical acceptance of SME input, NATOPS,[15] or similar sources. Similarly, assumed hierarchical relationships between cognitive objectives and task performance are based on SME input. As has been noted, differences in the assumptions made by the course developer during task analysis have potentially large consequences in terms of subsequent program costs. This aspect of ISD is still somewhat more art than science and is worthy

[15] The question raised here is not the appropriateness of NATOPS standards to fleet operations, but their appropriateness as training program standards.

of research investigation, for it has major consequences for ultimate program cost effectiveness.

Level of Effort

As has already been noted, the available data do not lend themselves well to comparison over the four ISD programs at this level of detail. However, Grumman shows 3,045 of its total 11,658 professional hours (26%) going to development of SBOs. On the E-2C program, Calspan shows 965 of 6,581 professional hours (15%) devoted to development of training objectives. On its EA-6B program, Courseware shows 736 of 6,135 professional hours (12%) plus 208 of 1,547 Navy SME hours (13%) devoted to hierarchy analysis. On the SH-2F, 1,044 of the contractor's 3,469 professional hours (30%) and 1,392 of 5,752 Navy SME hours (24%) were devoted to objectives hierarchy development. Thus, all four programs show substantial amounts of time devoted to objectives and hierarchies. It is a time consuming activity in the overall ISD process.

MEDIA SELECTION

The importance and the cost of media in modern aircraft training programs have risen steadily in recent times. For many years, flight training programs relied principally on flight instruction in the aircraft supported by ground training consisting principally of stand-up lectures, with minor training aid assistance, and use of standard textbooks and flight manuals. Often, the relationship between ground training and that which it supported was of dubious nature. One thing ISD has purported to do is to make the relationship more truly a supportive one. Another thing it seems to have done, perhaps inadvisedly, is to stress the development of a multiplicity of media to support instruction.

In part, this increase in emphasis on a variety of media has resulted from the advantages assumed (on the basis of considerable research) to accrue from individualization and proficiency pacing of instruction. It has also derived from the developments that have occurred in instructional technology, developments that have related media types to instructional objectives types in terms of instructional or learning efficiency. As a result of these factors and the tendency of ISD systems to emphasize hierarchical structure and "cognitive-before-performatory" objective sequences (e.g., Courseware's "summarization" and "systems introduction" features), the use of various media has grown markedly in flight training programs.

The major media development of recent years has been the modern digital flight simulator. But, programmed texts, sound-slide presentations, ETV, CAI, motion pictures, workbooks, learning centers, and other media have received emphasis also. Thus, it is not surprising that selection of media is an area of considerable concern in ISD, particularly when one considers the fiscal investment that even the simpler media can represent. Not only can initial investments in media be substantial, the maintenance and updating costs for media-centered programs can be substantial. Such factors must be borne in mind by the course developer, along with concern for instructional effectiveness, as media selection decisions are made.

Method

The procedure used for selecting media to accomplish the training program's objectives, of course, has much to do with the characteristics of the ensuing program. In the present ISD efforts, media selection was constrained by a number of factors, perhaps the principal of which was its restriction generally to currently available or planned simulators or WSTs for the aircraft of concern. Thus, the media selections can be considered optimal only in the sense that they were optimized for the media already available.

In the Grumman A-6E program, media requirements for each SBO were examined with reference to three phases of instruction: (1) initial instruction; (2) practice; and (3) demonstration/test. They were examined for each of these phases in terms of two factors--stimulus characteristics necessary to present the materials, and capabilities required for optimum response. Just how this analysis was done could not be determined from the available information, but it was presumably a judgmental process by the educational specialist on the project. In any event, the WST and procedures trainers receive heavy emphasis in the Grumman analysis, as do sound-slide presentations and overhead transparencies.

Several media factors distinguish the A-6E program from the others. One is the use of the TC-4C aircraft which is an "inflight device" with several bombardier/navigator stations. In justifying the use of the TC-4C aircraft as a trainer, Grumman states that, while many of the SBOs might be taught as well in the WST, "the TC-4C provides valuable in-flight demonstration of the capability of the B/Ns to use the operational equipment under actual flight conditions."

Another media point of interest is Grumman's suggestion that "paper simulations" be developed so that the students can better learn and utilize "headwork." By headwork is meant the ability to generalize skills to new situations. While no SBOs were specifically assigned to this medium, it is an interesting suggestion that is worth exploring in view of the great stress on decision making skills in modern weapons systems.

The report of Calspan's E-2C program does not give extensive details of the media selection process. Note is taken of the emphasis on use of available media. Also, reference is made to selecting media that allow (1) student-paced instruction, (2) individualized presentation, and (3) immediate knowledge of results. Consequently, Calspan settles on the general purpose, audio-visual carrel to carry the program, along with available ground-based simulators and training devices. Of interest is their suggestion that the CPT be modified to permit use of the same slide-tape programs used in the carrel. While the carrel largely replaced classroom instruction, some classroom instruction is deliberately retained as a transition phase and to tell "sea stories."

Courseware handles media selection in a much more extensive and proceduralized manner, relying on an algorithm, exercise of which will lead to one of some 44 media decisions. While there are 44 different pathways, some of their end points are identical. Most end points list first and second choice alternatives, and sometimes more. The media selection algorithm is applied to each training objective. Input data for the algorithm are answers to five questions. These questions and their possible answers are as follows:

1. What is the required level of behavior?

a. Familiarization

b. Discriminated recall

c. Rule using

2. What is the level of content to be taught?

a. Familiarization

b. Paired associate

c. Concept

d. Rule

3. What is the size of the minimum set of critical instances needed?

a. Small

b. Large

4. What is the minimum display requirement?

a. Verbal and/or symbolic and/or static simple pictorial

b. Verbal and/or symbolic and/or static complex pictorial

c. Dynamic pictorial

d. Interactive

5. How large is the memorization component?

a. Small

b. Large

The answers to these five questions can be assigned by the instructional technologist for each objective, and the process of media selection can then be automated. In the EA-6B program, this allowed the development of four alternative media plans which were then evaluated in terms of <u>relative</u> time, personnel, and material costs. The media plans differed in terms of requirements for acquiring new media such as CAI, projectors, etc. The contractor recommended a media plan for the EA-6B that required CAI (one that would involve new procurement), as well as the existing WST, tactics trainer, and other devices.

While no problems in applying the media selection model were noted in the EA-6B report, for the SH-2F program problems were again evident. Questions as to availability of funds to support media costs apparently resulted in much lost motion in the SH-2F program media selection and resulted in the necessity for making "final" selection decisions several times.

Level of Effort

The time accounting on the Calspan E-2C program did not separate media selection from other aspects of the development of instructional objectives and preparation of lesson specifications. Grumman does break media selection out on its A-6E program, showing a total of 1,392 (12%) of 11,658 total professional man-hours for this function. On the Courseware EA-6B program, 152 (2%) of 6,135 professional man-hours were devoted to media selection, while on its SH-2F program 320 (9%) of the total 3,469 professional man-hours were involved. No Navy SME assistance was noted on any of the programs for this function.

COURSE DESIGN

Somewhere in the sequence of ISD events, the ISD analyst must make decisions as to the general structure of the course and the manner in which various portions of the instruction will be sequenced. It is largely to this end that the information on objectives hierarchies, previously discussed, was developed. Not only must consideration be given to inter-objective and inter-task relationships, it must also be given to inter-media relationships. Instructional strategies and sequences are adopted, and they, in turn, provide the organizing structure for the course. These may include concepts such as:

- Maximize hands-on instruction
- Teach first in the least expensive medium
- Teach from simple to complex
- Introduce difficult material early
- Relative emphasis of massed vs. distributed practice
- Introduce system structure before operation
- Individualization
- Self-pacing
- Proficiency-pacing

The choices and decisions made in this area have a profound effect on the characteristics of the training program, its effectiveness, its costs, and its efficiency. As was noted in the previous discussions of task analysis and media selection, some substantial differences among different ISD practitioners may arise at this point.

Method

The following exposition of the methods used in structuring the four training programs will touch only the major aspects of course structure. The particular structure adopted in a program then determines the nature of the lesson specifications that implement that structure. At a gross level, all four programs followed a similar organization, but at a finer level there were differences.

A-6E. In devising its general approach to A-6E training, Grumman chose to organize Pilot training around a phase of flight and phase of mission sequencing, whereas for the Bombardier/Navigator (B/N) training they organized around a system/subsystem orientation. They emphasize five guidelines or strategies in their program. These are: (1) provide early hands-on practice; (2) preserve task integrity; (3) consider[16/] the principles of massed vs. distributed practice; (4) introduce high skill tasks early to allow more practice; and (5) maximize use of "real" hardware to enhance transfer.

A-6E Pilot SBOs were initially grouped into six training phases: Familiarization; Visual Weapons Delivery; Tactics; Navigation; System Weapons Delivery; and Carrier Qualification. The Bombardier/Navigator training phases initially were seven in number: Familiarization; System/Subsystem Design, Theory, and Application; Airframe Emergencies and System Malfunctions; Navigation Theory and Application; Attack Theory and Application; Air/Combat Theory and Application; and Takeoff and Landing Checks. The training phases were then divided into units, which were, in turn, divided into lessons. These groupings were then reviewed by Navy SMEs and revised as appropriate. This revision resulted in a Pilot training program of six phases totaling 12 units, while the B/N program consisted of four phases totaling 10 units. Media recommendations were reviewed, and media consolidations were made to reduce the number of different media

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[16/] The report gives no indication of how these principles were considered or used.

used within a given lesson to a more manageable number. Lessons (which might be further subdivided into sessions) were then sufficiently defined to proceed with the next step in the process, that of lesson specifications. A total of 55 lessons resulted, 19 of which were for Pilot only, 17 for the B/N only, and 19 were common to Pilot and B/N training.

E-2C. Calspan distinguishes within-blocks (lessons) instructional strategy from between-blocks (lessons) strategy. The basic strategy within cognitive instructional blocks involved student-paced instruction, individualized presentation, and testing with immediate knowledge of results. For the practice or sortie (as opposed to cognitive) blocks, the strategy emphasized hands-on learning with immediate feedback. Pacing of instruction would depend on instructor evaluation of performance.

The between-blocks strategy, i.e., the sequencing of blocks, involved early hands-on experience, attention to enabling skills prior to their use in complex skills, and the interspersal of hands-on training with cognitive training. With reference to this last point, Calspan favors integration of devices and aircraft throughout the training sequence, rather than a sequential completion of cognitive, device, and aircraft training. Distributed practice is preferred in their schema to massed practice. Other important factors in the E-2C program sequencing were difficulty, criticality, and frequency of task occurrence. These latter factors, it is presumed, are based on some pooling of contractor and Navy SME judgment, though the details are not made explicit. In general, initial training is with the simplest medium (carrel or classroom), with subsequent practice occurring in the devices and aircraft.

Both Pilot and NFO courses in the E-2C program are structured around a "systems within mission context." By this is meant that systems knowledge instruction is integrated into mission training. Lessons are organized into modules on the basis of general content. The graphic schema for showing lesson and module structure allows distinction of those lessons that must be taught in a given sequence, on the basis of hierarchical relationships, and those for which ordering is optional. The resulting E-2C P/CP course has 19 modules totaling 92 lessons, while the NFO/FT course has 38 modules and 137 lessons.

EA-6B. The sequencing of instruction for the EA-6B program was a relatively simple procedure because of the considerable detail developed by Courseware personnel in previous ISD activities. Instructional units were formed by taking objectives relatively high in the hierarchy. A unit then was defined as the objectives subordinate to that level. Lessons within units were structured around medium complexity level objectives. Sequences of objectives within lessons were then determined. In addition to objectives hierarchical relationships, factors in sequencing included early hands-on training and, where independent of the hierarchy, more critical or difficult objectives being presented first. This process was carried out by contractor specialists working closely with the Navy SMEs. Following this, the unit and lesson structure was integrated with the media selections. Generally, media needs were consolidated so as to identify a single optimum medium for each lesson.

The next activity involved development of unit and lesson maps. These maps are actual diagrams of the instructional sequence along with verbal exposition of the task or action, frequently with conditions and standards stated. The maps and objectives were then reviewed by an SME not involved with their development.

Courseware notes four problems that occurred during this process, though all were apparently handled without great difficulty. The first was the fact that the training squadron had certain sequencing preferences that were independent of the objectives hierarchies and could not be deduced therefrom. Identification of such preferences (particularly if they are to be deterministic constraints) should be made early in the ISD effort to avoid having to redo the sequencing several times. The second area concerned the interaction of sequencing and media selection. Compromises in optimum media or in optimum (hierarchical) sequencing, or both, must be made. The third problem was that the time to complete the unit and lesson maps was greater than expected. The fourth problem was that SMEs were not readily available to review certain products, resulting in delays in completion.

SH-2F. The procedure used by Courseware in the SH-2F program was much the same as that described for the EA-6B program. However, several additional considerations are described that are of some interest. The general course organization involved a combination of missions, phases of flight, and equipment as organizing factors. Lessons made up units, and groupings of units were labeled as "sections." Sections were intended to require no more than two or three weeks for their accomplishment, whereas a unit was to be no longer than one week. In turn, lessons were to require no longer than one day for their completion.

Factors in defining units were comprehensiveness of scope (i.e., the unit should contain all lessons on a given topic) and the presence of a terminal testing point. Definition of lessons was based on logical test points, attention to the one day time limitation, and "nontriviality" of lessons. Major factors in the sequencing of units and lessons included resource requirements, recycle time for failed students, criticality and difficulty of the tasks/behaviors involved.

Level of Effort

It was not possible to isolate the amount of effort devoted to the strategy/sequencing function for the A-6E and E-2C programs. On the Courseware EA-6B program, 662 contractor professional man-hours and 97 Navy SME hours were reported, while on the SH-2F program the totals were 240 contractor hours and 160 Navy SME hours. While these totals represent a relatively small part of the overall program totals, the effort devoted to this activity is not inconsequential.

LESSON SPECIFICATIONS

The Phase I programs were expected to produce a complete set of lesson specifications. The Navy RFP stated on p.6 of its Specification for Systems Approach to Training, ". . . The following results are expected from this study: a. A complete set of lesson specifications shall provide the basis for the follow-on production work and program implementation. The lesson specifications will be the guidelines that will spell out in detail how each lesson should be organized and taught and what its content should include." Thus, the intent was to document the instructional program concept in a form such that someone other than the Phase I contractor, at least potentially, could carry out Phase II, including actual authoring and production of all lesson and course materials. For this reason, the lesson specifications would have to define what was to be taught, when, and how. Otherwise, the Phase II effort could inject new material, a new course organization, or a new system design concept and thereby substantially negate what had been done in Phase I.

Should the same contractor or agency perform both Phases I and II, the problem of information transfer between phases would be less critical, since there would likely be some personnel continuity over the two phases. However, since these four ISD efforts were conceived by the Navy as potentially involving different executors for Phases I and II, the question of the degree to which the lesson specifications can effect the necessary information transfer (and, in fact, enforce the system design concept) is a very critical one. The lesson specifications constitute the principal products of these Phase I efforts. If the lesson specification documents are deficient with reference to the information transfer and system concept enforcement factors, then the Navy's management concept of separable Phase I and II efforts would not be implementable.

The existence of effective lesson specification documents, as assumed in the Navy's schema, by no means guarantees an effective or good training program outcome. If the prior ISD analytical steps were improperly performed, or if the training system concept itself is deficient, effective lesson specifications will simply make it highly probable that the concept will be carried out as planned (with the consequent program being less than optimal). In contrast, ineffective lesson specifications will make it unlikely that the training system concept (good or bad) will be carried out as planned.

Format

Since the lesson specification is conceived as the basic information transfer means between Phases I and II, its format is important. There were some significant differences among the three contractors in the format used, so format will be discussed in some detail.

A-6E. The lesson specification format used by Grumman is comprised of the major sections shown below.

- Lesson Number
- Lesson Title
- Phase Number and Title
- Unit Number and Title
- Specific Behavioral Objectives (No. & Statement)
- Media (by Session for Initial Learning, Practice, & Demo/Test)
- Lesson Duration (by Classroom, Practice, & Demo/Test)
- References
- Lesson Structure

Each lesson contains a number of SBOs, and lessons may involve multiple sessions. The SBOs vary in the level of detail and the magnitude of the task described. For example, they vary from statements such as "locate and identify the X," "explain the relationship between A and B," etc., to "the replacement pilot, when ready to take off, shall release brakes, and by engaging nosewheel steering and manipulating rudder pedals maintain center of runway, call off airspeed and runway remaining information to the B/N and at an appropriate speed ease back on control stick, etc."

Primary and alternate media are shown for each session within the lesson separately for initial learning (i.e., classroom), practice, and demo/test. In virtually all areas the initial learning is in the classroom by sound/slide, overhead transparency, or slide media.

The section entitled "Lesson Structure" is one or more attached pages that contain three columns of boxes in which are listed the SBO numbers covered in each session. The three columns are titled "initial learning," "practice," and "demo/test." In addition to listing the SBO numbers, there is given a summary statement of the subject of those SBOs, e.g., "basic instruments system information directly related to After Takeoff, etc." Also shown in each box are the primary and alternate media. No information on standards of performance is given routinely, though some SBO statements may contain or imply a standard. The lesson structure sheet does not contain any new information other than indicating SBOs by session and the summary statement. The SBO ordering is the same as that in the body of the lesson specification, and the media listing is redundant.

E-2C. The format used by Calspan for its lesson specifications treats the following topics on the cover sheet:

- Lesson Number
- Module Title
- Lesson Title
- Type (Cognitive, Practice, or Sortie/Scenario
- Training Objectives
- Time
- Prerequisite Lessons
- Additional Reference Materials
- Training Devices

For cognitive lessons, a 100% standard of performance is cited, whereas for practice and sortie lessons standards are stated for each objective in supplemental sheets. These supplemental sheets for each objective in the lesson depict criticality and difficulty ratings (three-point scale) for the objective, and they then present the task element behaviors that comprise the objective. These sheets next give the performance limits and initial conditions for the objective.

A "sequence of instruction" sheet follows the cover sheet for all cognitive objectives. These sheets identify in hierarchical fashion suggested "teaching points" (enabling objectives) with a description of associated media support (e.g., a picture of the instrument panel with a specific indicator highlighted). In addition, specific notes to be included in the presentation are shown. The intent is to provide information from which a sound/slide presentation could be developed.

EA-6B and SH-2F. The lesson specification format used by Courseware is fairly elaborate. Also, certain of the terms used are unusual and require definition. Each general specification includes the following sections:

- Lesson Map
- Lesson Objectives
- Lesson Introduction

Then, for each segment (objective) within the lesson the following are given:

- Segment Designation (ID for course, unit, lesson, and segment)
- Topic
- Objective
- Media
- Level of Content
- Level of Behavior
- Generality Statement
- Figure Numbers
- Help
- Instance Spec or Practice and Testing
- Special Teaching Points
- Graphics Specifications

Then, there are additional items relating to attached figures or illustrations, security classification, and instance specifications. The instance specifications must include:

- Type Description
- Format Description
- CEA (Common Error Analysis)
- MCS (Minimum Critical Set of Instances)
- Instance Production
- Testing Criteria

As noted, many of these categories require some definition, while for others the meaning is self-evident. The "lesson map" shows graphically the hierarchical relationships of the various topic areas included in the lesson. The "lesson introduction" is intended to explain to the student why he is studying the lesson and how it relates to other information and lessons. "Segment" is simply the name given to individual objectives in the lesson. "Level of content" involves three basic categories of content: fact (identities), concepts, and rules. "Level of behavior" involves four categories: familiarization, discriminated recall, classification, and rule using. "Level of content" and "level of behavior" relate to factors in Courseware's system for defining relationships between content/behavior level and instructional strategies and media requirements.

The "generality" portion of the specification refers simply to a statement of the facts to be memorized, the attributes of a concept, or the steps or formula of a rule. In short, it is a statement of the underlying facts or material required to perform the behavioral objective of the segment.

"Help" refers to auxiliary information displays to aid student learning. By this is meant an auxiliary display such as a flow diagram, a mnemonic, an expanded generality, an algorithm, or a decision tree.

In the "instance spec," a variety of instances of the generality are outlined ("type description") with suggested "format description" for their presentation or testing. The "CEA" should specify common logical errors the student might make, while the "MCS" states the minimum number (set) of instances the student must answer correctly to pass. "instance production" should state the total number of example, practice, and test items the author must produce for each type of instance. "Testing criteria" is the passing criterion, described as usually "one MCS worth of test items correct." No information is given by Courseware as to how the MCS and testing criteria for the instance spec are actually determined.

As might be surmised from this discussion, the specification document for a single Courseware lesson can be quite lengthy. The degree of detail in the objectives and generalities often is considerable, perhaps as great as the NATOPS description. Conditions and standards are given, and the information concerning presentation and testing, at least for cognitive type objectives, is extensive.

<u>Level of Effort</u>

The preparation of lesson specifications was the culminating activity of Phase I efforts and, as might be expected, involved substantial amounts of effort. This could be inferred from the previous discussion of what comprised the lesson specifications for each of the programs. Reports of time devoted to this step confirm this expectation.

Only in the Calspan E-2C program was it not possible to identify time devoted specifically to the preparation of lesson specifications. In the A-6E program, Grumman reports a total of 1,914 of 11,658 professional man-hours (16%) devoted to the preparation of lesson specifications. In Courseware's EA-6B effort, 1,818 of its total of 6,135 professional hours (30%) were devoted to this step, and 995 of 1,547 Navy SME hours (64%) were so used. In the Courseware SH-2F program, of the contractor's 3,469 professional man-hours, 1,305 (38%) were devoted to lesson specifications, while 3,480 (61%) of 5,752 Navy SME hours fell into this category.

Courseware takes specific note of the heavy manpower requirement for the writing of lesson specifications. In their two programs, roughly one-third of the contractor's effort and two-thirds of the Navy SME effort were devoted to this task. As can be inferred from the previous discussions of the much greater level of detail that characterizes Courseware's lesson specifications, as contrasted with those of Grumman and Calspan, the lesson specification is a central part of Courseware's ISD procedure. This is reflected in the effort data. Perhaps more than any single step of the ISD process discussed, this one reflects a fundamental difference in the approach of the various contractors.

MEASUREMENT AND EVALUATION

In a strict sense, the methodologies being followed in the various Phase I efforts did not necessarily require a systematic treatment of measurement and evaluation during Phase I. These topics could be considered as a part of the Phase II effort, at least their development into operational form. At the same time, the nature of the ISD process is such as to place great emphasis on specific behavioral statements of objectives with clear definition of conditions and standards. Further, there is an explicit assumption of the hierarchical nature of learning or skill mastery, and the resultant training program sequences are built around this assumption. More specifically, these programs assume that certain skills (i.e., the ability to perform given tasks to specified standards) must be mastered before the learning of skills higher in the hierarchy can take place. There is in each of these programs, at least to a considerable extent, the further hierarchical assumption that the most effective and efficient instructional strategy generally involves a repetitive sequence of cognitive learning, followed by learning/practice in a training device or simulator, followed, finally, by learning/practice in the aircraft.

In view of these general assumptions concerning such relationships, it is reasonable that there should be a considerable stress on techniques for measurement and evaluation. Logically, management of student progress through the learning hierarchies requires an effective and efficient means of determining whether the student has achieved the various objectives.

Measurement and evaluation in a flight training program occur at a variety of levels and for a variety of purposes. The internal and external evaluation functions described in most ISD systems are examples of this, as is the day-to-day use of performance indices by the instructor to prescribe instructional experiences and to guide the student through the instructional sequence. It is worth noting, however, that there are fundamental and practical differences between the measurement of trainee performance with reference to cognitive objectives and the measurement of trainee performance with reference to complex psychomotor objectives (i.e., actual flight performance). The technology for cognitive skills measurement is relatively well developed and simple to implement in comparison with that for flight skills measurement. Thus, ability to carry out the intended hierarchical learning sequences in the flight training portion of the program, and even the simulator training portion, may be less than that for the academic portion by virtue of this factor.

All four of the ISD programs exhibit recognition of the importance of measurement in one way or another, though none really deals at length with the mechanics of a measurement system in the sense discussed here. They have, however, provided much of the basic groundwork (i.e., SBOs, conditions, standards, etc.) for later development of measurement systems.

A-6E

In the A-6E program, Grumman provides SBO statements that contain standards that vary in specificity. Generally, the parameters that would be reflected in a measurement system are there, but no discussion of the mechanics of measurement is given. There is a clear recognition of the "Initial Learning--

Practice--Demo/Test" continuum, with a statement for each session within a lesson as to the general manner in which the objectives are to be tested. For example, for a lesson within the advanced navigation unit there are three sessions. In the first, the student must use a sound/slide medium to learn recognition and identification of navigation displays and symbols. The test of this would be a demonstration in the WST. The second session might involve sound/slide presentation of parameters and capabilities of the system, with the test being a written test. Session three might require flying a navigation mission in the WST, followed by a test navigation flight in the aircraft. While there is a clear recognition of when and where measurement will take place, there is little detailed information concerning how. The problems of flight versus non-flight measurement are not discussed.

E-2C

The recognition of measurement requirements is clear in the E-2C program, with a section of the final report devoted to testing. It states, "Individual performance evaluation has been addressed as a key component in the contractor's E-2C training program." In fact, Calspan developed a preliminary data bank for test item development for cognitive objectives. Similarly, they suggest the formulation of "pocket checklists" from the evaluation criteria of the behavioral objectives "for the instructors to use while assessing student performance in practice and sortie/scenario lessons." Calspan also provides guidance as to when and where assessment occurs in the program for each objective. A proposed sequence of procedures for cognitive testing, involving pre-testing and adaptive testing, is described in some detail, and provides some suggestion of how. Other than the "pocket checklist" suggestion, there is no real discussion of the mechanics of flight skill measurement.

EA-6B and SH-2F

In the reports of these programs, particularly the EA-6B, there is a recognition of the total system context for ISD and the role of testing in that system. There is discussion of the production of tests and of quality control as specific steps in ISD. The testing information derives from the lesson specification documents which, as has been noted, are quite detailed.

Both the testing of individuals and the internal and external evaluation functions are noted. The lesson specification presents suggested test item formats (usually a sample item), the various item types to be represented in that format, the minimum critical set (i.e., the number of each item type that the trainee must get correct to be considered as passing), and the number that must be prepared of example, practice, and test items (instance production). The stress is almost completely on cognitive testing, and Courseware does present a great deal of information in the lesson specification that is pertinent to cognitive testing. Flight skill measurement is not treated directly.

Level of Effort

It was not possible to determine the amount of effort devoted specifically to the topic of measurement/evaluation by the various contractors. Their efforts in this direction were subsumed under the basic task analytic activities and the development of lesson specifications.

DOCUMENTATION

The four programs produced a considerable volume of documentation. The general nature and numbers of documents were determined by contractual requirements, so there was little difference in the number of deliverable items from one program to the other. As can be surmised from the information already presented, though, there were some major differences among the programs in the details of the content and format of the various documents produced. While it is not the function of the present report to evaluate the quality of the documentation of the three contractors in either an absolute or a comparative sense, a few descriptive statements can be made describing the general nature of documentation for the programs.

The general documentation required under the various contracts was as follows:

- Work Plan Report
- Quarterly Progress Reports
- Task Listing

- Development of the Behavioral Objectives
- Training Support Requirements
- Lesson Specification Documents
- Preliminary Technical Report
- Final Technical Report

Not all of the above documents were available for the present review for all programs. The bulk of this review was based on the final reports, lesson specifications, and behavioral objectives documents, though even some of these documents were not available for review.

The differences among the programs with reference to format and detail in such documents as task listings, behavioral objectives, and lesson specifications have already been discussed. In general, the Courseware documents present the greatest detail and Grumman the least. Most of the documents are written with reasonable clarity and precision, though some of the lesson specification documents were in rough form (handwritten) as originally prepared by the SMEs and have likely benefited from subsequent editing and sharpening.

Each of the reports has areas in which procedures used are not clearly specified or are not mentioned at all. This is to be expected as a function of the differences in approach used and the extent to which the contractor has had previous opportunities to develop his procedures and approach.

Much of the reason for Courseware's having produced a greater volume and detail of documentation results from its having available an already well developed and articulated procedure. In addition, their use of explicit algorithmic approaches for many aspects of the ISD effort contributes to the detail of the documentation.

Level of Effort

Obviously, much of the effort that went into the various documentation items was covered under the previously discussed topics such as lesson specifications. In terms of the effort devoted to the documentation per se in those areas, none of the contractors reported it separately. With reference to the final report itself, only Grumman reported the level of effort involved.

They have reported 783 and 696 hours for the instructional psychologist and educational specialist, respectively, devoted to the final report. This 1,479 hours represents about 13 percent of the total effort reported by Gruman. If Grumman's experience is at all typical, a fairly significant portion of the total cost of these Phase I efforts was attributable to the final report documentation. Considering the dual purpose of these efforts--i.e., both the development of training programs and the advancement of the ISD technology--this is not surprising.

GENERAL PROGRAM SUMMARIES

The previous discussion has presented the various programs in a somewhat fragmented fashion, seeking to examine them with reference to the major functions performed in the Phase I ISD efforts. It has not been possible to make pointed comparisons of the programs in many areas, because the information for such comparisons was simply not available. Program procedures and products have been described and compared where possible, and level of effort devoted to the various activities has been presented where available. In an effort to provide a somewhat more integrated view of the level of effort, the following tables present hours by function as given in the final reports of the various programs. These data have generally been presented previously in this report in the various sections dealing with the ISD functional activities or steps. In examining these overall program presentations, the reader must recognize that the programs differed in size, complexity, number of tasks, number of crew positions, nature of aircraft and systems involved, and in many other ways. Thus, it is difficult to make meaningful evaluative comparisons of the amount of effort devoted to a given ISD function from one program to another.

A-6E

As noted previously, Grumman's ISD team consisted of an instructional psychologist (IP), educational specialists (ES), and contractor and Navy SME personnel (SMEc and SMEn). Table 4 shows the distribution of effort (labor hours) of these personnel by ISD program activity. In addition, the total time of support personnel (SP) reported for the program is shown. Of considerable interest is Grumman's reporting of "estimated" and "actual" hours spent on each of the activities. Table 4 shows both sets of hours.[17/] Grumman was the only contractor to present estimated (presumably the level of effort estimates contained in their proposal) and actual program level of effort data. It is presumed that the other contractors' presentations of hours are actual times devoted to the various activities.

In examining Table 4 several things of interest can be noted. Most obvious is the extent to which the actual professional effort was underestimated by Grumman. The ratio of total "actual" professional effort to total "estimated" is 1.54. The task analysis step required almost twice as much effort as estimated, while the SBOs and final reporting took about 1.5 times as much as their estimates. The largest relative change was for media analysis which required 4.0 times the estimated level of effort. Interestingly, in the Grumman program only the lesson specifications step required less actual effort (by about 10% percent) than was estimated.

The original Grumman estimated levels of professional effort showed about one-fourth the effort to be devoted to each of the steps, task analysis, SBOs, and lesson specifications. The actual effort shows almost one-third devoted to task analysis and one-sixth to lesson specifications, with SBOs remaining at about one-fourth of the total.

[17/] The times shown in Table 4 are given in hours, whereas they were reported in Grumman's final report in terms of man-months. Hour conversions were made on the basis that one man-month equals 174 hours.

TABLE 4. ESTIMATED AND ACTUAL EFFORT (HOURS) BY ISD FUNCTION: A-6E PROGRAM

	Estimated Hours by Personnel Type			Actual Hours by Personnel Type				
ISD TASK	IP	ES	SMEc	IP	ES	SMEc	SMEn	SP
1. Work Plan & Quarterly Reports	87	87	-0-	87	87	-0-	Individual Task Totals Not Given	Individual Task Totals Not Given
2. Task Analysis	783	609	522	1,566	1,044	1,044		
3. SBOs	348	1,566	87	1,044	2,001	-0-		
4. Media Analysis	-0-	348	-0-	696	696	-0-		
5. Lesson Specifications	348	1,740	43½	348	1,566	-0-		
6a. Final Report (Prelim.)	348	348	43½	696	522	-0-		
6b. Final Report (Final)	87	174	-0-	87	174	-0-		
TOTAL EFFORT	2,001	4,872	696	4,524	6,090	1,044	1,348	2,610
TOTAL CONTRACTOR PROFESSIONAL EFFORT		7,569			11,658			

E-2C

The detail shown by Calspan in reporting its E-2C effort by task is not as great as that for the A-6E program just discussed. Only four task categories are distinguished, and professional man-hours are not allocated by contractor personnel types. In contrast, however, Calspan does report administrative and support man-hours by task, and times are reported separately for ISD steps for Pilot position and ISD steps for the NFO/FT positions. Also, while Navy SME time is allocated by task, it includes only "consultation time, not including independent review of supporting documentation" by Navy personnel. The E-2C program time data are shown in Table 5.

TABLE 5. EFFORT (HOURS) BY ISD FUNCTION: E-2C PROGRAM

ISD TASK	Professional Effort		Admin. & Support Effort
	Contractor	Navy	
1. Planning	224	-0-	204
2. a. Pilot Task Analysis	603	40	250
b. NFO/FT Task Analysis	1,137	-0-	447
3. a. Pilot Training Objectives	603	10	130
b. NFO/FT Training Objectives	362	9	202
4. a. Pilot Instructional Objectives	1,157	10	315
b. NFO/FT Instructional Objectives	2,495	18	361
TOTALS	6,581	87	1,909

While the categories of ISD tasks differ from those used in the Grumman listing, it is of interest to note that the proportions of contractor professional effort devoted to planning and to task analysis are quite similar for the two programs. In each case, the task analysis takes a little more than one-fourth of the total contractor professional effort. Calspan's fourth category--instructional objectives--would seem to encompass Grumman's media analysis and lesson specification categories, and perhaps the final reporting.

As can be seen in Table 5, Calspan devoted almost three-fourths again as many man-hours to the NFO/FT ISD effort as to the pilot ISD effort. It will be recalled that there are three NFO/FT crew positions involved (CICO, ACO, and FT), so this ratio of effort is understandable.

In discussing the distribution of time over the various ISD tasks, the Calspan final report presents some important cautions concerning interpretation. They note the cumulative nature of the various tasks, i.e., the learning or experience carry over from one task to another, and observe that this makes it difficult to conclude from any such data that a given ISD step or task will require "X" hours. They also note that labor distribution is affected by such factors as prior availability of data, SME availability within the contractor team and from the Navy, computer modeling and availability, and quantity and quality of an existing training curriculum and supporting equipment. These observations are well worth bearing in mind with reference to the data contained in the present report.

EA-6B

Courseware reported its effort in somewhat finer detail than did either Grumman or Calspan. The major time category additions used by Courseware include task selection, hierarchy analysis, and sequencing and grouping of objectives. Time distribution by task for the EA-6B program is shown in Table 6. On the EA-6B effort, Courseware reported a sizeable number of hours devoted to a variety of activities related to the program, but which are not explicitly allocated to the ISD steps. This would include activities such as direct program technical management, internal reviews, graphics support, and the like. These hours are shown in Table 6 under the task heading of "Other." The columns headed IP and IT refer to Instructional Psychologist and Instructional Technologist personnel, respectively. Additional personnel headings in the table include Management, Technical (mostly graphics), and Support (secretarial). SMEc and SMEn refer to contractor and Navy SME personnel.

TABLE 6. EFFORT (HOURS) BY ISD FUNCTION: EA-6B PROGRAM

ISD TASK	IP	IT	Mgmt.	Tech.	Sup't.	SMEc	SMEn
1. Job Analysis	212	100	Individual Task Totals not available	Individual Task Totals not available	Individual Task Totals not available	133	247
2. Selection of Task	4	-0-				-0-	-0-
3. Hierarchy Analysis	136	365				235	208
4. Sequen. & Grouping	115	258				289	97
5. Media Selection	152	-0-				-0-	-0-
6. Lesson Specification	459	752				607	995
7. Other	1,242	181	523	454	2,871	372	-0-
TOTALS	2,320	1,656	523	454	2,871	1,636	1,547

It should be noted how the "Other" allocations were derived for the various personnel categories in Table 6. Courseware reported the individual totals for ISD Tasks 1-6 as shown in the table, describing them as "on-site" personnel hours spent. In addition, they report "total project-related hours spent by on-site contractor personnel." For the IT, for example, total hours were 1,656, whereas the IT's ISD tasks amounted to only 1,475 hours. This 181 hour difference was attributed to the "Other" category for the IT in Table 6. In similar fashion, "Other" totals were derived for the SMEc and IP categories. In the IP's case, however, to the difference of 91 hours was added some 1,151 additional hours reported by Courseware as project hours by "off-site" professional personnel, but not otherwise allocated by function.

As can be seen from Table 6, the relative distribution of time by task in the EA-6B effort differs from that of the two previous programs. Most notable, probably, is the lesser relative emphasis on task analysis activities (i.e., the job analysis, task selection, and hierarchy analysis tasks) in the EA-6B program and the relatively large amount of time in the "Other" category. Various possible reasons for this difference have been discussed previously, but it was not possible to identify the actual causes.

SH-2F

Time data for Courseware's SH-2F effort are shown in Table 7. The same ISD task categories as in the preceding table are used here, except that there is no "Other" task category. There was no separate reporting of on-site and off-site effort, nor were any personnel categories reported other than those shown in Table 7.

TABLE 7. EFFORT (HOURS) BY ISD FUNCTION: SH-2F PROGRAM

ISD TASK	IP	IT	SMEn
1. Job Analysis	160	320	640
2. Selection of Task	40	40	80
3. Hierarchy Analysis	348	696	1,392
4. Sequencing & Grouping	80	160	160
5. Media Selection	80	240	-0-
6. Lesson Specification	435	870	3,480
TOTALS	1,143	2,326	5,752

Again, there is reflected a difference in emphasis from the other programs. In the SH-2F program about half of the contractor's effort went into the task analytic activities (i.e., Tasks 1, 2, and 3). It is extremely difficult to equate task categories from one contractor to another, so comparisons are tenuous. It might be assumed, however, that there is some commonality of meaning of these ISD task categories for the two programs conducted by the same contractor. If this is so, then the difference in task analytic requirements between the SH-2F (46 percent of total contractor professional effort) and EA-6B (19 percent of total contractor professional effort) programs is rather striking. However, the previous statements concerning the multiplicity of factors that might relate to such differences should be noted even when the same contractor is involved.

Overview

In an effort to provide an overview perspective of the manner in which professional effort was applied in the four programs, some assumptions will be made here concerning the essential equivalency of certain of the ISD task categories across the programs for descriptive or expository purposes.

In reviewing the various categories of effort reported by the contractors, a "lowest common denominator" set of categories was developed. These categories of effort of ISD tasks are as follows: (1) Work Plan; (2) Task Analysis; (3) Development of Training Objectives; (4) Development of Training Program and Lesson Specifications; and (5) Other Activities. These categories, for present purposes, will be labeled as "Effort Categories." Table 8 shows the manner in which the various steps or activities reported by the contractors have been assigned to these effort categories.

Some of the differences among the programs in terms of what constituted a given ISD activity have already been discussed. For example, one contractor may have included activity within its "Task Analysis" category that was not performed until later by another contractor (e.g., Courseware's hierarchy analysis). Another important factor that should be kept in mind is the amount of Navy SME effort that was available to each of the programs and how it was applied. In spite of these complications, the schema represented in Table 8 is of utility in examining the four programs. In Table 9 are shown the numbers of contractor professional hours and the percentages of total contractor professional effort they represent for each of the five effort categories. Navy SME total hours are shown in the table as an effort category since it was not possible to distribute them across effort categories for all programs.

The data display in Table 9 is colored somewhat by the relatively large amount of time in the "Other" category for the A-6E and EA-6B programs. If one assumed that those hours were distributed over the other four effort categories in proportion to the hours already in those categories (a perhaps questionable assumption), the apparent lesser proportion of effort on task analysis in the EA-6B program would not be so pronounced, and conversely the proportion of effort in category 4 would increase. Even so, it is reasonable

TABLE 8. ASSIGNMENT OF CONTRACTOR TASKS/ACTIVITIES TO SUMMARY EFFORT CATEGORIES BY PROGRAM

EFFORT CATEGORY	ISD PROGRAM A-6E (Grumman)	E-2C (Calspan)	EA-6B (Courseware)	SH-2F (Courseware)
1. Work Plan	Work Plan	Planning	Not shown. May be contained in "Other."	Not shown. May be contained in "Other."
2. Task Analysis	Task Analysis	Task Analysis	Job Analysis; Task Selection	Job Analysis; Task Selection
3. Training Objectives	SBOs	Training Objectives	Hierarchy Analysis	Hierarchy Analysis
4. Training Program and Lesson Specifications	Media Analysis; Lesson Specifications	Instructional Objectives	Seq. & Grouping; Media Selection; Lesson Specifications	Seq. & Grouping; Media Selection; Lesson Specifications
5. Other	Final Report	Not Shown	Other	Not Shown

TABLE 9. CONTRACTOR PROFESSIONAL EFFORT BY CATEGORY AND PROGRAM

EFFORT CATEGORY	A-6E		E-2C		EA-6B		SH-2F	
	Hours	% of Total	Hours	% of Total	Hours	% of Total	Hours	% of Total
1. Work Plan	174	1	224	3	NS	NS	NS	NS
2. Task Analysis	3,654	31	1,740	26	449	7	560	16
3. Training Objectives	3,045	26	965	15	736	12	1,044	30
4. Trng. Prog. & Lesson Specifications	3,306	28	3,652	55	2,632	43	1,865	54
5. Other	1,479	13	NS	NS	2,318	38	NS	NS
TOTALS	11,658	100	6,581	100	6,135	100	3,469	100
Navy SME Effort	1,348	100	87	100	1,547	100	5,752	100

to conclude that the EA-6B program devoted proportionately less effort to categories 2 and 3 (task analysis and training objectives), and proportionately more effort to category 4 (training program and lesson specification development) than did the other three programs. The extent to which this reflects a real systemic difference in approach or procedures is conjectural. One could advance many reasonable hypotheses to explain such an outcome other than differences in approach (e.g., prior existence of task data, nature of aircraft and crew jobs, etc.). However, the previous description of procedures used in the various ISD steps for the different programs suggests that the EA-6B effort was the most highly proceduralized in its execution and made the greatest use of Navy SME resources. Thus, the time distribution data are probably indicative of fundamental systemic differences in the ISD approaches used in the various programs. The long-term implications of such differences for training program effectiveness cannot be determined at this point, and even after completion of Phase II of the various programs, it would be extremely difficult, if not impossible, to identify the specific factors that might underlie training effectiveness differences.

SECTION III

COMMENTARY

INTRODUCTION

The previous section has described the four Phase I SAT/ISD programs in terms of the various tasks or activities performed and the general manner in which they were carried out. As has been noted, the Navy had two general goals in embarking on these efforts: (1) the development of effective training for the four aircraft of concern; and (2) the advancement of the general SAT/ISD methodology. The ultimate test of whether the first of these goals has been achieved must await the completion of the ISD process during a second phase of the various programs, i.e., the completion and institution of the instructional systems developed, and the evaluation of those instructional systems operationally in terms of their cost and training effectiveness. Only the SH-2F program has progressed to Phase II, and even here it will be some time before evaluation data eventuate. At the present time, any evaluation of the Phase I efforts must, necessarily, be based on their products, products that are intermediate or enabling activities or steps in the overall ISD process.

With reference to the second goal area, that dealing with advancement of the SAT/ISD methodology, there are "lessons learned" in these four efforts that are worth noting. While one may argue that these lessons are somewhat limited by virtue of the Phase II efforts' not having been completed, nevertheless future Navy training development efforts can benefit from examination of these programs. It must be kept in mind, however, that the four programs were conducted in response to the Navy's general conception of SAT methodology as stated in the early 1975 RFP. Changes have already taken place in the Navy's conception of SAT and ISD, both as a result of these four programs, and as a result of other SAT/ISD R&D efforts. In particular, efforts being conducted for the Navy by research personnel of Courseware, Inc., and Logicon have developed a very detailed model of the SAT/ISD process for specific use in the development of fleet aviation training programs. This model aims at identifying all major events or steps for virtually all agencies that might be associated with a given SAT/ISD effort. It extends from the initial identification of a potential requirement for a training development effort by fleet or other Navy personnel, and the identification of funds to support possible action on any such development, to the external quality control evaluation of the implemented training program. The product of this recent Courseware-Logicon effort is much more detailed than the procedures documented in the four SAT/ISD programs described here and, in fact, provides guidance both for the conduct of an ISD effort and for its procurement and management by the Navy. At the same time, the model is fundamentally the same procedure used by Courseware in its EA-6B and SH-2F programs discussed in this report.

In this commentary section of the report, an effort is made to examine all of these various efforts in terms of their implications for improving future Navy aviation training development efforts. The framework for the comments made is necessarily subjective and is based on the experiences of the author and his professional colleagues over a number of years of aviation training and simulation research and development activities. It also reflects, perhaps in a selective fashion, the considerable body of literature dealing with the systems approach to training and/or with instructional systems development.

Goals of ISD

In any such review of programs or methodologies as the present one, it is appropriate to have some idea of the general goals of those programs or methodologies. In the case of ISD, the general goal is the development of more cost effective training programs than would be the case without ISD. In aviation training, in particular, the desire for cost effective training is of special concern to DoD because of the critical part aviation forces play in our national defense and because of the high levels of cost associated with aviation training. Aviation training is one of the most costly types of military training because of: (1) the difficulty of the skills involved and the consequent years of training required to develop combat mission-capable personnel; (2) the extremely high quality of the personnel resources required to operate and maintain aircraft; and (3) the high hourly operating costs of the increasingly complex aircraft that comprise the current inventory. Add to these factors concern over availability of fuel and concern for the environment, and it is not surprising that development of means of reducing aviation training costs while maintaining necessary combat readiness is one of the most critical problem areas among all the services. ISD has been pursued because of its seeming potential for maintaining or improving the quality of training at least possible cost. It is with reference to this general cost effectiveness goal or potential that the comments here are presented.

THE FOUR SAT/ISD PROGRAMS

The principal question of concern with reference to the four specific SAT/ISD programs examined (i.e., the A-6E, E-2C, EA-6B, and SH-2F) is the extent to which they have moved toward the goal of more cost effective training. Clearly, all four represent systematic approaches of some thoroughness. For this reason, if no other, they would likely result in programs that are more effective than those existing for the four aircraft, assuming that Phase II efforts are carried out. However, this question warrants further examination.

Phase I Adequacy for Phase II

Each of the programs has produced Phase I products that would, at least in theory, allow the conduct of Phase II. The documentation of the EA-6B and SH-2F programs contains the most detail and is more than adequate to allow authoring of actual lesson materials, at least for cognitive skill areas. Very little information transmission loss would occur between Phases I and II of these programs due to the breadth and depth of the documentation. It should be noted, though, that less than half the required lesson specifications were produced in the EA-6B program and that many of those for the SH-2F were in need of much further development. Therefore, when it is concluded here that Phase I products of these two programs are more than adequate to most Phase II needs, a qualifying assumption concerning their completion is required.

The documentation for the E-2C program also seems complete and adequate for most Phase II needs. It is somewhat less detailed than that of the EA-6B and SH-2F programs, and it would likely require somewhat more effort to author the Phase II materials, but the essential information is there. The flow of instructional events in the program that would be developed in Phase II is clear and easy to follow in the Phase I materials.

The A-6E program documentation would likely be the most difficult to use in Phase II. While it gives a clear exposition of the objectives to be covered in the various units and lessons, it provides relatively little information concerning details of the lesson materials that would aid in future authoring. It is likely that the Phase I products are adequate for the carrying out of Phase II, but Phase II personnel would have to consult secondary references (which are cited in the lesson specifications) extensively in order to transform the Phase I program concept into an operational form.

The major common shortcoming of these four Phase I efforts, in terms of their adequacy for Phase II, is their relative degree of orientation toward cognitive skills, as opposed to orientation toward actual in-cockpit flying skills. None of the programs really addresses how the training will be conducted in the cockpit of the aircraft or the simulator. The emphasis is more on the cognitive aspects of flying than it is on what to do, what to look for, how to instruct, and how to evaluate in the cockpit. Thus, to the extent that achieving the ultimate ISD goal of increased cost effectiveness in training is dependent on these "in-the-cockpit" factors, these Phase I efforts are less than optimal in their utility for Phase II.

Perhaps the second major common shortcoming is in the area of performance measurement and evaluation. The Phase I products do not adequately address this area in the manner required for development in Phase II of a measurement system insofar as flight skills are concerned. The criticality of the measurement area to any training program, but especially to an individualized program based on assumed logical hierarchies of objectives, has been mentioned. While the means for meeting necessary cognitive skill measurement requirements could probably be developed reasonably well in Phase II from the Phase I information, little is said in the Phase I documents concerning the problems of in-the-cockpit measurement of complex perceptual-motor flight skills. Therefore, developing an effective flight skill measurement system during Phase II would require a considerable effort. The specification of standards of flight performance provided in the Phase I documentation would be useful in this regard, but the question of a flight performance measurement system concept is not addressed at all. This is a matter of some import.

Skills and Cost Effectiveness

As has been stated, aviation training managers are properly concerned with cost effective training. The basic determining factors in the high cost of flight training are the number of aircraft hours flown per trainee and the cost per flight instructional hour. For aircraft of the complexity of the four examined here, these hourly flight instructional costs can be $1,000 or more. Thus, it is imperative that the number of flying hours in the program be held to the minimum necessary for each trainee to attain required skill levels and, correspondingly, that each cockpit hour yield as much instructional benefit (i.e., training effectiveness) as possible. This should be the goal of the instructional system developer, but it is imperative that he not compromise the attainment of necessary proficiency levels in seeking to reduce costs.

It follows that the flying program must receive primary attention in an ISD effort if cost effectiveness is to be maximized. It is for this reason that the relative lack of attention to in-the-cockpit instructional experiences in the four Phase I efforts is of concern.

Numerous research efforts over the past decade have demonstrated that the single greatest impact on flight training program cost effectiveness has been achieved through effective use of flight simulation. The flight simulator, when combined with an effective synthetic training program, has allowed significant reductions in required flight hours, in many cases virtually to the point of eliminating the requirement for aircraft time. Therefore, when a state-of-the-art flight simulator is available to the ISD team, it should be the basic medium around which the course is organized. Only in this way will maximum cost effectiveness be realized in a flight training program.

It is noted, too, that those programs that have shown the most significant benefits from the use of simulation have been based on proficiency-pacing principles. The concept of "train to proficiency" is well established in terms of its advantages. For an ISD effort truly to build on this strategy or approach, the focus must be on in-cockpit flight skills, and flight performance measurement must be treated effectively as a critical and integral part of the overall instructional system.

Stated differently, concentrating emphasis on in-the-cockpit flight skills, as opposed to emphasis on cognitive skills, is necessary to significant increases in cost effectiveness in aviation training. This is not meant to imply that cognitive skills are not of importance, but merely that an ISD effort must concentrate attention on the most critical area, the flight skills area, if cost effectiveness is to be maximized, and the program should make maximum use of simulation commensurate with cost effectiveness considerations.

As was noted in the previous section, the four ISD efforts examined devote much more attention to the cognitive area than to the flight skills area (both aircraft and simulator). Therefore, their Phase II efforts may not achieve the degree of cost effectiveness desired and possible, though all would likely show significant gains over present programs if carried through Phase II.

Another aspect of this facet of the problem is worth noting. The ISD procedures used in each of the four programs were fundamentally very similar. All assumed an hierarchical structure of skills and their learning to some degree and, as a consequence, tended to an iterative instructional sequence of "cognitive-then trainer-then aircraft." It is logical that one should learn the cognitive enabling skills first in the classroom (or in a carrel, or from a programmed text, etc.) before those skills are used in the cockpit. However, it has been our experience that many such "enabling" items can best be learned directly in the cockpit context when and as they are needed in the flight mission performance. Thus, in some programs the classroom has been virtually eliminated as the locus of instruction in favor of the procedures trainer or simulator. Not only does this provide a true functional context for the instruction, with attendant benefits to both learning and retention, it results in the elimination of much material that was previously felt to be essential based on usual assumed hierarchial relationships. As a result, such programs have much smaller and simpler media requirements.

The suggestion that this functional context approach changes the nature of required enabling objectives may seem strange. However, building a hierarchical structure to support a cognitive analogue of the cockpit tasks can be conceived as a different process from building a hierarchical structure in the cockpit. The cockpit context itself provides a cue-response support directly that must be synthesized if the structure is completely cognitive. Because of the fundamental implications these points have for the design and operation of flight training courses, this is an area that warrants investigation. The implications for cost effectiveness are considerable.

THE ISD MODEL

The basic purpose of this report is to identify areas in which change may improve Navy SAT/ISD programs in the future. As noted, significant changes and improvements in the ISD process conceptualization have been made over the past three years as a result of a variety of Navy and non-Navy efforts. The emerging Navy ISD process model, along with its implementing procedures and instructions, is a well-formulated, well-stated, and complete approach. Much serious thought and effort have gone into its development. It offers promise for significant improvements in Naval aviation training programs and for the production of predictable results. Further, it provides a means for more effective management of ISD programs.

For the first time, perhaps, the full cast of agencies and personnel in the ISD process is described in the model. If ISD is to work to maximum effectiveness, it requires the working together of numerous agencies from the CNO on down to the training squadron and the contractor(s) involved. The conception is that of an effort in which many agencies must work together to produce the final product. Therefore, responsibilities and authority must be identified; the various steps in the process must be carefully described and their inputs and outputs must be stated; the nature of the process must be specified; and the framework for managing and evaluating the effort must be made clear. The model does these things explicitly.

What, then, are some of the directions the Navy might take to improve application of the model to future training programs? In seeking to respond to such a question, the present effort is reacting to several "models" or sets of ISD procedures as these were manifest in the four ISD programs examined and in the subsequent model development by Courseware and Logicon. So, in this context the areas for possible future improvement are based on a conglomerate view of all these efforts. To refer on this basis to the model may be presumptious, but the general direction of SAT/ISD evolution in the Navy is clearly discernable from the 1975 SAT/RFP, the four SAT programs with their considerable documentation, and more recent Courseware-Logicon model development (along with an ISD specification), even though these latter documents may not be yet considered as official Navy position.

Future Improvements

The following suggested areas for future improvement of the model and Navy SAT/ISD programs can be ascertained, in part, from the various observations about the four ISD programs made in the preceding Results section. Others derive from evaluation of other documents and the general direction of SAT/ISD evolution previously mentioned. No attempt will be made to identify all the sources from which these suggestions derive due to the magnitude of the material reviewed and its areas of redundancy and uniqueness.

Personnel. It is clear from the reports of the four ISD programs and from the subsequent articulation of the ISD model and specification that all parties recognize the criticality of personnel to effective ISD. It is a labor-intensive process, and a variety of types of personnel and skills are required for its successful execution. Two of the principal types of personnel required are those knowledgable in the areas of ISD and instructional psychology and those knowledgable in the operational job area of concern, i.e., the SME. The model should specify the required nature of qualifying training and experience for such personnel.

With reference to the SME, the model needs some further definition of their characteristics and qualifications for the various functional roles they may fulfill. For example, execution of a task selection algorithm might require input from a variety of SMEs. A fleet maintenance SME who has had no contact with maintenance training would likely be in no position to evaluate trainee entry level behavior, while a fleet maintenance supervisor SME might not be able to provide valid data concerning the frequency with which a new fleet aviation mechanic will perform a given task.

With reference to the other personnel type, the ISD/psychology "expert," the model is moving toward a detailing of required training and/or experience. While it is desirable that unqualified instructional design personnel not be utilized, it would appear unwise to move strongly in the direction of rigidly specifying the necessary academic qualifications of professional personnel. Effective knowledge of human learning and of aviation training is not confined just to those with the Ph.D. or Master's degree in instructional psychology. It is suggested here that the quality of past training development products of the professional--i.e., his demonstrated capability, his innovativeness, the cost effectiveness of his programs, etc.--is much more critical than his academic qualifications. To be unduly restrictive in statement of professional personnel qualifications not only will reduce the numbers of personnel available to work on Navy programs, it will not necessarily increase the quality. Many, or perhaps most, of the personnel who have pioneered ISD and have been effective practitioners would not fit the mold of the instructional psychologist that seems to be evolving in the Navy ISD model.

Role of the SME. There is no question as to the importance of the SME's role in the ISD process. His input is a necessity. The evolving model recognizes this, and it also recognizes the need for SME training for his ISD role. The SME role is particularly influential in defining and selecting tasks to be trained and in specifying task interdependencies and sequential relationships. As previously suggested, the SME has a variety of roles to fulfill. Review of the four SAT/ISD programs suggests that SME input was accepted in a somewhat uncritical fashion. The model would benefit if it provided more clearly for a "challenge and response" to SME input by the instructional developer. In particular, the need for each of the enabling objectives needs to be challenged, as does the nature of the task and objectives hierarchies. This is not to suggest that the SME input is invalid, but that means are required to insure that each aspect of the resultant program is functional and necessary.

Examples of SME input in need of challenge include statements of trainee input skill levels; statements of what is and should be taught in UPT, at the RTS, and in the fleet; and statements as to standards of performance that should be required during and at the end of readiness squadron training. Areas such as these, and particularly the enabling objectives content of the program, have a marked influence on the ultimate nature and cost of the program. Therefore, such inputs must be subjected to careful scrutiny and validation. The model should highlight this validation process. In fact, the model should emphasize "challenge and response" with reference to all activities. One of the real strengths of the ISD procedure is the iterative nature of its analysis, justification, and revision activities. Without the challenge in the total system framework, the ISD process will be reduced to stereotypy and will largely lose its effectiveness.

System Constraints. Closely related to the challenge and justification idea is the handling in the model of system constraints. Clearly, the system approach requires that the instructional designer recognize the realities of funding and resource constraints in the design process. While the ultimate program must be "real world" and live within necessary constraints, it should not be based on an overly submissive acceptance of constraints. Who is to be the advocate for new equipment, better simulators, more flying hours, etc., if it is not the ISD team? Resources should flow from requirements, not vice versa. For example, the draft ISD specification suggests that the maximum number of flights to be contained in the syllabus will be determined by constraints identified in the problem analysis, rather than by the nature and extent of the training requirements. While such fixed factors may ultimately be the deciding ones, they should not be the starting point for a syllabus or program.

Documentation. Review of the proposed ISD procedures reveals a large number of contract deliverable documents. Specification of deliverable items is necessary to effective management of ISD programs by the Navy. Documents should serve a functional purpose in an ISD effort, so the purposes and users of the various documents must be identified. The model generally does a thorough job in this regard. The point that warrants future examination is the required number and types of formal deliverable documents for Navy management purposes, and determination of items that must be prepared as intermediate products, but which do not warrant formal document status. Preparation of a document as a contract deliverable item takes time and effort and, hence, costs money. If a "working paper" format is sufficient in some instances for the purposes to be served, time, effort, and money will be saved. This aspect of the model and specification warrants future study and refinement.

Another aspect of documentation relates to the need for the degree of detail and graphic illustration of such items as objectives hierarchies, lesson maps, and lesson specifications. A given ISD practitioner may view this detail as necessary to downstream work in Phase II efforts, whereas another practitioner might find it less useful. It is an empirical question as to the utility of the types of information produced in the various Phase I efforts examined here. The question is not whether Contractor A would find the Phase I information <u>he</u> generates to be useful in Phase II. Rather, it is whether Contractor B would be able to use effectively in Phase II the Phase I information generated by A. In the only systematic examination[18] of the utility of various ISD products of which the present author is aware, it was found that in the Army's systems approach to training (a procedure not fundamentally different from current ISD models) many documentary products were produced for which there was no real need or use. A more recent investigation[19] within the USAF Tactical Air Command of its ISD efforts also suggests that documentation is a continuing problem for ISD teams. The question of the utility of various documents to the ISD process should be investigated further, and the results of such investigation can be integrated into the Navy ISD model to improve it in the future.

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[18] Ricketson, D., Schulz, R., and Wright, R. <u>Review of the CONARC Systems Engineering of Training Program and its Implementation at the United States Army Aviation School</u>. HumRRO Consulting Report. HumRRO Division No. 6 (Aviation), Fort Rucker, AL, April 1970.

[19] Hagin, W., and Gerlach, V. "Training for ISD Teams." Presentation on Symposium, <u>Improving Military Instructional Systems Development (ISD)</u>. American Psychological Association, San Francisco, CA, August 1977.

ISD and Flight Skills. As has been noted in earlier observations, the in-cockpit flight skills must be the focal point of an ISD effort for pilot training. Much of the procedure involved in most ISD models, including the evolving Navy model, has derived from instructional psychology research largely related to cognitive skills. The ISD procedures have not been as well developed or articulated for in-cockpit skills learning. As a result, much remains to be done to develop such procedures for the in-cockpit training situation. The logic of ISD methods seems appealingly applicable to the development of more effective training, whatever the type of skill involved, but, in fact, as a technology, ISD is not as well developed for the cockpit application as it is for the non-cockpit aspects of flying. The point here is not that ISD is inappropriate to the cockpit, but that further research and development is necessary to make it as effective for the cockpit setting as it has been for the non-cockpit setting.

Simulation. More than any other single development, the modern flight simulator has favorably affected both the effectiveness and efficiency of flight training programs. However, to use the simulator to greatest cost effectiveness requires more than treating it as just another training medium or treating it essentially the same as an aircraft. The question is how to maximize the training capabilities of the simulator in a given training setting, i.e., how to use the simulator to maximum effect as a learning environment. Simulation has received a great deal of attention in aviation training, and the evidence is overwhelming that the manner in which the simulator is used is crucial to cost effectiveness outcomes. Because of such factors, and because of the centrality of simulation to flight training, the ISD model and specification should highlight simulation and seek to insure that ISD efforts treat simulation appropriately. It is contended here that the four programs examined did not use simulation to maximum effect, though all did rely on it extensively. The model would benefit by a better articulation of how to use simulation to maximum effect.

The comments previously made to the effect that ISD researchers have not developed their technology as well for application to cockpit skills as to cognitive skills are pertinent here. The simulator presents a whole-task environment in which complex perceptual-motor skills can be presented, practiced, and tested with real-time decision making and temporal integration demands present. The "how-to secrets" of doing this most effectively have not yet been reduced to a prescriptive procedure for routine application. As noted, the state-of-the-art here is much the same as that for aircraft training development.

All of this is not to say that nothing is known about effective simulation (or aircraft) training. A great deal is known, but it is not as procedurally documented as what is known about effective non-cockpit training, nor is it as easily prescriptive. While we have dwelt somewhat on the similarity of the state of affairs with reference to aircraft and simulator training, this is not meant to suggest that the simulator should be used in the same manner as the aircraft. There are differences between the two media that must be recognized and used positively in training program design.

The ISD model provides for simulation and recognizes it as a highly important aspect of flight training. It would be better if it could provide the full recognition and detailed guidance concerning effective use of simulation that the subject warrants. This reflects not an oversight of the ISD model, but a deficiency in our state of knowledge concerning simulation, or, at least, the adequacy with which that knowledge has been documented. Thus, improvement of the ISD model in this area is dependent upon the accomplishment of the R&D activities necessary to development and statement of the required procedural guidance.

Measurement. The technology of flight performance measurement has received much less attention over the years than it warrants. The needs in this area are becoming even more evident as the analytical approaches of SAT/ISD are applied on an ever wider scale. The emphasis in these approaches on careful statement of desired behavioral outcomes, with specified conditions and standards statements, highlights these measurement/evaluation deficiencies. ISD will do less than the desired good if the student's progress through the carefully engineered task-learning sequences cannot be managed properly because of inadequate measurement. This is clearly an area in which technology base advancement is required and in which the ISD model can be improved. While the general need for measurement is recognized in the model, the difficulty of its effective accomplishment is not, nor are the differences between flight and non-flight measurement.

Another aspect of this question is also of interest for future model advancement. The general concept or strategy of training that most ISD programs support, at least theoretically, is that of an individualized, proficiency-paced program. Research studies have shown individual student flight time variations of 100% or more when this strategy is effectively used. The emerging Navy ISD model would permit such individualization, but it does not emphasize it. To do so assumes the measurement technology necessary to effective management and control of individualized training. Individualization also makes considerable use of diagnostic testing sequences for development of individual training prescriptions. Thus, there are a variety of reasons why measurement is a critical need for ISD-based programs, reasons that go far beyond the usual concern for qualification standards for the individual student. Measurement warrants more attention in the model and in technology base programs.

SUMMARY COMMENT

The Navy has moved forward significantly with the programs discussed in this report. Previous SAT/ISD model developments have been aimed at more generalized applications, whereas the series of programs discussed here have been aimed at a much more restricted application, aviation training, and have sought to target more clearly the specifics of effective instructional system development in aviation. One problem with the more general models in application is that each area of application presents some unique problems that may render the general model less useful than desired. While aviation has many commonalities with other training content areas, it has many critical uniquities as well. Because of this fact and because of the high cost and importance of aviation training, the development of an aviation-specific ISD model is justified.

The ISD model envisioned by the Navy would cover both operator and maintenance personnel for fleet aviation systems. Consideration of the unique aspects of the flight skill acquisition process, as discussed above, might suggest that the inclusion of maintenance skills within the same model/specification as covers pilot/aircrew operator skills will continue the types of application problems cited for the more general models. This question warrants further consideration by the Navy.

In this examination of specific SAT/ISD efforts and of the emerging ISD model, several areas for future research and improvement of the model have been identified. The most important of these are: (1) the measurement/ evaluation area; (2) the cognitive vs. flight skill questions; and (3) the role of simulation. These three areas, in particular, are of high import with reference to the cost effectiveness of ISD and, as such, represent areas of major potential gain in model improvement.

A further word is in order concerning the last of the three areas mentioned, simulation. In examining various pilot training ISD efforts conducted by a number of different agencies, both government and contractor, two general categories can be identified: (1) those programs in which the use of simulation is dominant and in which other media play a relatively minor role; and (2) those in which simulation is used in somewhat more of an adjunctive role with other media playing a relatively greater role. These two types of programs differ not in terms of the presence of simulation, but in its manner of use and in the magnitude of the other media requirements. To overstate this distinction, perhaps, the one can be characterized as simulator-centered, and the other as media-centered. This dimension has considerable potential effect on the cost effectiveness of an ISD effort. Both categories of programs have essentially the same simulator cost (though they differ in the extent and manner of its use), but the costs associated with the non-simulator media can differ significantly. Heavily mediated programs are costly to produce, and they are costly to maintain and update. Further, it is contended here that they will contain content not required in the simulator-centered program and that they can differ significantly in terms of training effectiveness as well. Therefore, as the Navy seeks to develop and improve its aviation ISD model further, this dimension warrents additional research to provide proper orientation of the model. At present, for reasons previously discussed concerning the limited extent to which procedural guidance on this point exists or has been articulated, the model is relatively more media centered and less simulator centered than would be desired.

Finally, the question must be raised concerning innovation and progress in the area of training technology. Obviously, the point of developing process models and specifications of procedures and products is to maximize the likelihood of effective application of the latest and most advantageous technology. At the same time, models and specifications must not constrain new ideas or alternative approaches to the point that inhibits progress or that results in stereotypic iteration of effective, but sub-optimal, procedures and approaches. Instructional Systems Development, as a technology, has not reached the point at which it should be so firmly cast that further change is not desired. The Navy ISD efforts have advanced both the technology and its application significantly, and it is recommended that the areas identified in this report be pursued as a means of continuing that trend. Considerable gains have been made, but much remains to be done.

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