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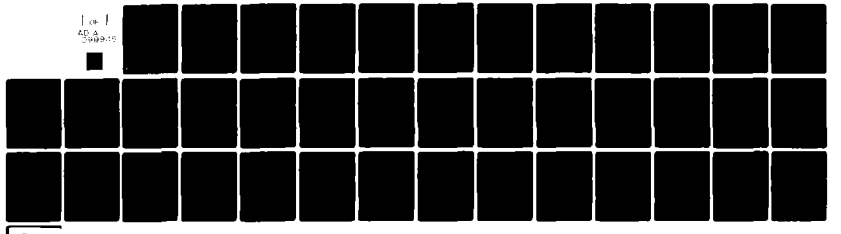

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F-16 AIRCREW TRAINING DEVELOPMENT PROJECT

Contract No. F02604-79-C8875

F-16 TRAINING MANAGEMENT SYSTEM NEEDS AND DESIGN CONCEPT ANALYSIS

DEVELOPMENT REPORT No. 12
MARCH 1981

Prepared in partial fulfillment of CDRL no. B029

by

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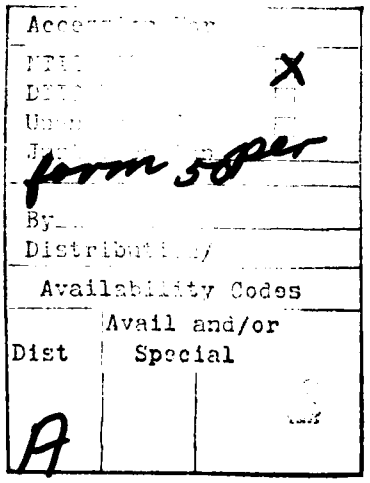
PREFACE

This report was created for the F-16 Aircrew Training Development Project contract no. F02604-79-C8875 for the Tactical Air Command to comply with the requirements of CDRL no. B029. The project entailed the design and development of an instructional system for the F-16 RTU and instructor pilots. During the course of the project, a series of development reports was issued describing processes and products. A list of those reports follows this page. The user is referred to Report No. 34, A Users Guide to the F-16 Training Development Reports, for an overview and explanation of the series, and Report No. 35, F-16 Final Report, for an overview of the Instructional System Development Project.



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DEVELOPMENT PROJECT REPORTS

Copies of these reports may be obtained by writing the Defense Technical Information Center, Cameron Station, Alexandria, Virginia 22314. All reports were reviewed and updated in March 81.

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EXECUTIVE SUMMARY

Within TAC the complexity of the weapons systems is increasingly rapid. There is also a corresponding increase in the training requirements for these systems. In order to develop and maintain an efficient and effective training program within realistic constraints of manpower and training resources, the management system should be responsive to the following needs:

1. Lifetime maintenance of the training program.
2. Standardization of the approach to modifying the training system.
3. A method of exploring varying program alternatives.
4. Quick response.
5. Early detection of problems.
6. Flexibility to meet changing needs.
7. Self-monitoring capabilities.
8. Capability to deal with large amounts of data.
9. Establishment of a historical data base.
10. Redundant management of information.
11. Operation of the system at the user level of training managers, instructors, and students.

Existing training management systems were reviewed and were found to be deficient in terms of their capabilities of meeting the above needs. For example, none of the systems have provided adequate support for the initial ISD effort, nor were they found to be adequate for long term support of an ISD project.

Based on the identified needs and the information gained by examining previous and existing training management systems, a system is described which has the potential capability of meeting the needs of the F-16 training project. This system is a mix of procedures, personnel, support capabilities, and organizational structures that will facilitate the planning, management, and implementation of the F-16 program over the life cycle of the aircraft.

CONTENTS

STATEMENT OF NEEDS

Introduction

Within Tactical Air Command, the complexity of the weapons systems is increasing rapidly. At the same time, there are constraints on critical training resources such as simulators, flight time, and qualified instructors.

There is a critical need for reliable, systematic methods to coordinate and manage the large number of training and resource variables so that personnel are trained as efficiently and effectively as possible under the existing limitations.

The training management system must have the flexibility to respond quickly and effectively to a wide and shifting range of requirements and situations. This capability is imperative in order to achieve the high standards of readiness necessary in the face of accelerating future threat.

Statement of Specific Needs

Eleven specific needs have been identified within the requirement for an overall training management system. These are the needs of a training program that continues for the lifetime of the weapons system. They are listed and described as follows:

1. Need for lifetime maintenance of the training program

An ongoing training program must be responsive to change and revisable so that quality and continuity are maintained. For the lifetime of the training program there will be changes in the operation and design of equipment, in personnel, and in the overall environment. The F-16 training program must accommodate and implement those changes.

2. Need to standardize the approach to modifying the training system

Standardization of procedures is a necessity in maintaining an effective program. In conjunction with the requirement for lifetime maintenance, there is a need to ensure that all personnel adhere to prescribed methods and practices. Experience has shown that idiosyncratic changes quickly undermine the effectiveness of any training program.

3. Need to explore the effect of varying program parameters

There is a need to know the effects of alternative solutions before commitment to a course of action. In any phase of a training program unexpected changes may occur in the available

personnel, resources, and time. A means is needed to explore the effects of alternate solutions to meet any new set of circumstances, and to ensure optimum use of available resources. A historical problem in ongoing programs has been the inability to explore alternatives in depth in the timeframes available for decision making.

4. Need for quick response

A system is needed that can respond quickly to requests for information and data collection and that can facilitate rapid revision of materials. Rapid response time in a training management system can save considerable time, effort, and money. There are two area
tant. First, throughout all phases of training, collection and analysis of data is necessary for a variety of reporting and decision making purposes. The faster the system can adapt, the less chance there is of bottlenecking or poor decision making due to lack of information. Secondly, a system is needed that can respond quickly in implementing revisions.

5. Need for early detection of problems

Sensitivity to potential and existing problems is necessary to provide optimum management in all phases of training. Early problem identification is important in two ways. It makes the problem easier to solve, and it minimizes the chance for program disruption.

6. Need for flexibility to meet changing demands on the program

The training management system must support and allow rapid expansion to meet increasing threat. It must also provide continuous operational capability within imposed constraints.

Typical problems to be met include changing student-instructor ratios and shortage of other critical resources during times of rapid expansion. During times of constant operating levels, changing constraints such as reduction of available training flights and fuel must be dealt with.

7. Need for self-monitoring system

There is a need for continually evaluating the performance of the management system against the specified operating goals and standards, and reporting all performance problems.

The management system needs to constantly evaluate the accuracy of the planning data against available real world data, and to constantly compare system performance against operating goals. There is also a need to screen data going into and out of the system to detect unreasonable values.

8. Need to effectively deal with large amounts of data

There is a need to collect, store, use, and distribute large amounts of data. These data are generated by, and required for, the operation of the training prcgram.

The functioning of an individualized, competency-based training program generates extremely large and complex data handling requirements. Without data handling capabilities it is impractical to track individual, self-paced students and maintain detailed achievement profiles.

9. Need to establish a historical data base

There is a need to establish, maintain, and apply a historical data base for prediction (projection), analysis and documentation purposes. Typically, each training problem in the past has been approached with only minimal or irrelevent historical data. The result is frequent repetition of mistakes, and the necessity to "reinvent the wheel". Without hard data, planning for each new training effort proceeds on the basis of personal recollections and intuitions.

10. Need for redundancy

There is a need to provide a high degree of redundancy in the training management system. Redundancy prevents losing important data through unforseen circumstances. The system needs to include protection against human and other errors. Loss of critical data in an ongoing program greatly reduces effectiveness, prevents reliable decision making, and weakens future planning efforts.

11. Need for the system to be operable at the user level

It is important that the training management system be usable directly by training managers, instructors and students. The F-16 training program is individualized and competency-based. There will be a continuing need for all users to frequently interact with the training management system, providing and receiving information. This interaction must be direct and must not require extensive training if it is to be practical.

STATEMENT OF REQUIRED CAPABILITIES

Introduction

The set of capabilities necessary to meet the requirements specified in the statement of needs above are evident in current training management systems. Even though these capabilities exist, this study team has found that current capabilities are deficient in three important dimensions.

First, existing capabilities have repeatedly proved inadequate for full support of the complex initial ISD effort. A variety of DOD efforts to develop information and training managemenht systems in support of instructional systems development (ISD) attest to the wide perception within the military that existing capabilities in the area leave much to be desired. At least a half dozen efforts in all branches of the service are working on this problem at the current time.

Second, existing training managment system capabilities have proven inadequate for long term support of the ISD program throughout the years following the initial effort. Needed data are ignored or not collectable within existing capabilities, and as a result, subsequent ISD efforts repeat the mistakes of their predecessors.

Third, existing capabilities are incomplete. One single system, which meets all of the needs as stated above, which can provide the support and discipline necessary to maintain a complex and sophisticated training system through years of changing weapons system characteristics and constant personnel rotations does not exist. The set of required capabilities such a system represents is addressed by isolated special purpose systems, programs, and organizational structures which attempt to deal with various pieces of the problem, but the set is incomplete and the pieces are usually not directly applicable to the F-16 needs. To acquire an optimized system, then, it is necessary to mount a dedicated effort whose ultimate goal is to create from current technology an integrated system based upon a standardized Air Force management system structure.

Statement of Specific Capabilities Needed

The capabilities of the training management system which are outlined here respond to the specific needs introduced earlier. These capabilities deal with those aspects of effective information handling and management which require continual, current, operational inputs to system managers.

1. The Training Management System (TMS) for the F-16 will provide a variety of capabilities and support functions which will allow timely, ongoing revision and update of this training curriculum and all attendant data bases. It will be self-documenting as much as possible and maintain a clear record of all revision trails. These features will enable the data base to be responsive to required revisions without loss of original quality or intent. Off-the-shelf word processing and data base management system capabilities will provide basic support functions. These will be implemented within an environment of applications programs in a time shared (real time) mode.

2. The TMS will support and encourage disciplined and standardized modification of the data base for the lifetime of the weapons system. It will contribute to the discipline and standardization of the program through built-in expectations (required interactions with the system) in terms of data requirements, and it will provide clearly specified, on-line procedures, job aids and training. Quality control and automatic reporting facilities will help ensure that standardization and discipline of revision and updates are maintained.

3. The TMS will allow planners and decision makers to explore the effect of varying program parameters. The system will allow easy access to both historical and current data bases in modes which allow the manipulation of critical program parameters for simulation (projection) purposes and for the purpose of data base update and adaptation to new data. The system will support and facilitate the generation of a wide variety of reports for planning and management purposes and provide a wide range of ad hoc computation and information retrieval functions.

4. This system will provide planners and users with quick response. The F-16 training program TMS will be operating in a real time environment for certain of its many applications. For these classes of applications (i.e., student assignments and prescriptions, etc.) a real time response is essential. Additionally the system will support a wide range of simultaneous activities and recognize and serve each of the many classes of users appropriately (students, subject matter experts, reviewers, authors, managers, administrators, instructors, proctors, etc.).

5. The TMS will provide for early detection of problems. The system will monitor every interaction affecting critical program parameters and it will immediately identify deviations from expected values. These will be accompanied by automatic reporting and program-wide dissemination of information.

6. A capability will be provided which gives a high degree of flexibility to meet changing demands on the program. The F-16 TMS will minimize dependence upon highly trained people who will be in short supply during critical periods of rapid expansion to meet emerging threats. The system will be greatly expandable or

reducible in its scope and capabilities, in a very short time, with a minimum requirement for specially trained personnel.

7. The F-16 training program TMS will provide continuous self-monitoring through explicit and published TMS performance expectations which are continuously and automatically checked. Both the expectations and the reports on system performance, generated by the self-monitoring process, will be unambiguous.

8. The F-16 training program TMS will handle very large amounts of data in short periods of time on an ongoing basis. It will be able to serve large numbers and many different types of users simultaneously with the ability of very rapid and extensive expansion if necessary.

9. The TMS will establish and maintain an historical data base for planning and reporting purposes. This data base will be maintained in a state which provides easy access to all data for a variety of planning, decision making, auditing, and reporting purposes as required. A major portion of this capability will be supplied by a highly effective, proven, off-the-shelf data base management system (DBMS).

10. The TMS will provide a high degree of reliability and redundancy. Through the use of system incorporated procedures, techniques, and job aids, and through the use of distributed processing techniques (duplicate hardware at each training site with sufficient communications to allow remote service of any site from any other sites) a degree of redundancy will be provided which will render the TMS relatively insensitive to either rotation of personnel or malfunction of equipment.

11. The F-16 training program TMS will be human engineered for easy and effective use by a wide variety of users, ranging from students and managers to high administrators, without extensive and specialized training. It can be interfaced with at the user level directly by the user himself.

EXPANDED RATIONALE

Introduction

This rationale section is provided to further explore and explain the issues central to, and surrounding, the eleven specific areas of needs identified within the F-16 training program.

Inasmuch as the F-16 effort is representative of the growing trend within the military and industry towards the application of sophisticated systems technology, particularly that incorporated into training design and development and variously identified as ISD or Systems Approach to Training (SAT), examples will be drawn from applicable military and industrial training programs using this technology to illustrate and clarify the needs identified.

For purposes of consistency this rationale will be developed in a structure parallel to that of the Statement of Needs section. It will be augmented by a support document (Appendix A-F-16 ADP Study, Background Analysis) which will contain a more general background to the whole problem of information and training management in ISD and will represent a broader perspective, which addresses the eleven areas of need referenced above, among others.

Specific Rationale for Needs

Eleven specific needs have been identified within the requirement for an overall training management system. These are the needs of a training program that continues for the lifetime of the weapons system. They are discussed with supportive rationale below.

1. Need for lifetime maintenance of the training program

An ongoing training program must be responsive to change and easily revisable so that quality and continuity are maintained. ISD is a dynamic process. Training for modern weapons systems must evolve as the weapons systems do. The training program must be kept current for as long as it is used. This often requires ongoing revisions on a large scale. For example, in one recent ISD effort in air crew training, it has been determined by the course instructors that the entire syllabus goes through a major revision once every eight months. This means that approximately 20% of the instruction changes for each class. The difficulties of maintaining so extreme a revision schedule can easily be imagined (EA-6B (ICAP) Instructional Systems Development Study Data Item 0003, Contract Number N61339-75-C-0100, Job Analysis Document, August 1975). Even in stable content areas where there

are very infrequent changes to what is being taught there should be ongoing evaluation of training effectiveness which may reveal needed revisions to how lessons are being taught. Weak lessons will need to be redone.

This evaluation revision cycle must continue even when the course has been tuned up and judged effective. Training does not take place in a vacuum. Often students enter a training program from previous training programs which contribute to the basis of assumptions about what a student already knows, and therefore about what he must now be taught. Likewise he may progress from your training program to yet another follow-on program. Changes in what is taught in any of these may require corresponding revisions within your program, even if your instruction has been effective.

2. Need to standardize the approach to modifying the training system

Standardization of procedures is a necessity in maintaining an effective program. Much money is wasted if a well-designed, systematically developed training program is revised and modified according to the personal inclination and instructional philosophy of a succession of different personnel over time. In such cases the original ISD investment can be wiped out in a startlingly short time.

ISD grew out of a perception that a systematic, disciplined approach to training development would be more efficient in producing instruction, would be easier to quality control, and if properly researched-based, would be more consistently effective than the idiosyncratic, "artistic" approaches formerly prevalent. A good ISD approach should reduce the number and extent of revisions necessary to obtain effective instruction and therefore lower costs. However, because of the extensive analysis and design required to do this, most ISD efforts still represent a non-trivial investment and it is a very visible investment, being an upfront expenditure, not hidden in the aggregate incremental costs of extra revisions over time. This investment must be protected against idiosyncratic, "artistic" changes.

As an example of what can happen one might look at the preliminary findings of a study currently being funded under DARPA Contract Number MDA-903-77-C-0265, Deliverable Item Number 002AB. Of particular interest in this study are the findings relating to the SENSO (Sensor Operator) Course. It was found that this 338 objective course had been totally rewritten from its original mediated form into a totally lecture-based course within two years of the end of the initial ISD development phase. Further, it was found that at least 20% of those changes had resulted in sufficient degradation to training effectiveness for the objectives concerned to generate fleet complaints concerning the performance levels of students graduating from the program on

these particular objectives. The conclusion of the study group is essentially that the entire ISD effort has effectively been lost and must be redone. This is by no means an isolated example.

There is a growing concern within the military surrounding this repeatedly observed degeneration of formally established training programs over time as personnel rotate and revisions are required within the course. The term "half-life" of an ISD effort is beginning to be used occasionally in the literature to describe that period of time following the initial development of a training program until half of its objectives have been idiosyncratically changed according to the personal agendas of personnel rotating through the activity.

If the effectiveness of the F-16 ISD effort is to be maintained for the lifetime of the weapons system, it is essential that all future revisions and modifications to the program be as systematically developed and as carefully quality-controlled as the initial effort. To maintain consistency of effectiveness and uniformity of instructional approach, it is also essential that these ongoing modifications and revisions to the program be carried out in a carefully considered manner, utilizing as much as possible the original techniques and procedures employed in the establishment and development of the training program. This is an extremely difficult thing to do in a "people centered" system where procedures, techniques and traditions are resident in individual personnel rather than institutionalized to some degree within the system itself.

3. Need to explore the effect of varying program parameters

There is a need to know the effects of alternative solutions before commitment to a course of action. One of the most important aspects of managing an ISD effort is planning. The F-16 ISD project statement of work reflects this important emphasis. Throughout the initial analysis, design, and development effort, there are requirements for extensive advanced planning and exploration of alternatives built into the program. Training support requirements analysis, media cost benefit analysis, generation of optimum and alternative syllabi, and other important project steps and activities are all representative of the importance placed on the generation of good planning data.

In a larger sense this emphasis is indicative of the highly analytical approach taken to training development within the Air Force as a whole. The F-16 is representative of modern training programs within the Air Force in that it represents the allocation and application of extremely expensive resources in very short supply in many cases. It is essential for effective planning within the F-16 program to be able to extensively explore the effects of a range of possible decisions at each critical decision point before committing to expensive courses of action.

This is best accomplished in an interactive environment where manipulation of critical program and data base parameters in a simulation mode is possible.

In essence, an environment is needed whereby decisions can be "made" and their consequences explored by means of systems models before the decision must actually be committed to operationally. If a range of different decisions are made, the consequences can then be compared in the interest of ascertaining what the "best" decision might be. The Air Force currently has available a range of capabilities in this general area, one good example being MODIA (Method of Designing Instructional Alternatives) developed by RAND Corporation. This type of modeling capability should be available within the context of the training management system for use by personnel on all levels of the training program, as an aid to decision making. Other available programs with similar capabilities include DOSS and L-COM. However, as a group and individually, these particular systems and subsystems would be difficult and impractical to employ in the F-16 environment on a continuing, day-to-day basis. What is needed is a modeling capability incorporating many of the solutions represented by the systems named before, but one which is integral to the overall F-16 training management system and one which overcomes some of the disadvantages, especially in terms of user orientation and expertise required, and also in terms of the hardware required, represented by the systems named.

With such a capability for exploring the consequences of alternative decisions, a wide range of decisions could be made routinely before each important decision is committed to. Currently, in existing training management contexts, planners are lucky if they can explore more than one or two alternatives, even on a superficial or general level, before a decision must be made.

4. Need for quick response

A system is needed that can respond quickly to requests for information and data collection and that can facilitate rapid revision of materials. The F-16 training management system must meet heavy requirements for rapid turnaround of information and it must quickly supply appropriate services to a wide range of users. Examples include a wide range of services, ranging from the requirements of individual students whose test data must be appropriately recorded and whose progress within the course must be facilitated, through immediate generation of instructional prescriptions and student directions appropriate to the student performance measured and the overall progress being made by each student.

Rapid response time in a training management system can save considerable time, effort and money. Given that the F-16 training program can be individualized, considerable savings can be

made in terms of training support and hardware requirements. For example, in an individualized training program, expensive pieces of media equipment may be optimally used and student requirements for these expensive items can often be fully served with fewer pieces of equipment. The difference can be most easily illustrated when one considers the difference in requirements for a large class of students proceeding in a lock- step, group progress model, all entering a lesson in the course which requires the use of equipment such as slide-tape machines. In this model all would require a machine at the same time and the total number of machines necessary could conceivably be quite large. In an individualized model however, different students would be taking this particular lesson at different times since some students would be faster than others. An adaptable training management system would be able to explore a variety of alternatives assignments for each student at each assignment point in his progress, and while making sure that full use was made of expensive equipment, it would at the same time attempt to avoid overscheduling the equipment available.

A good example of such a system is the Advanced Instructional System (AIS) for the Air Force, currently operational at Lowry AFB. One of the characteristics of this system is that at the time an assignment is to be made to a student, the system quickly ascertains whether or not needed AV and other equipment is currently available, and if it is not, provides a student with an alternative assignment (if possible) on segments of instruction for which the student has prerequisite completed, but which do not require equipment or resources which are not available. In a manually operated system it would be difficult to catalog, control and optimally respond to the mix of resource and student requirements which would be encountered, in a timely and efficient fashion.

Another important area of quick response which must be served in the F-16 training program is the area of revision and updates. The system must respond very quickly in supporting/ implementing ongoing revision and updates to training program. That is, as deficiencies are detected within the course, the system should provide as much support as possible to the revision effort required, so that (hopefully) the next group of students to encounter the deficient material (perhaps the slower students in the same class) would be given improved instructional materials. The critical issue in terms of system responsiveness is the simple fact that as training programs become more sophisticated and complex, and as the consequences of inadequate or inefficient training become more expensive, the training management system must be able to respond with needed information and services in seconds or minutes rather than days or weeks.

5. Need for early detection of problems

Sensitivity to potential and existing problems is necessary to provide optimum management in all phases of training. As ISD

efforts become more complex and larger in scope, and as the ISD models used become more sophisticated and detailed, effective management becomes extremely difficult.

Two ongoing ISD activities are offered as examples of this problem. The first is the ISD effort to support the air crew training for the SH-2F LAMPS ASW Helicopter. In this activity, now in the final phases of evaluation in both the East and West coast training squadrons, almost 900 instructional and/or performance check packages were developed and validated in eight different media/delivery modes including workbook, computer assisted instruction, simulator activities and several still and motion audio-visual formats. This effort progressed on a very fast time frame, taking a little over two years to complete the entire ISD cycle from analysis through implementation and final evaluation. A large and constantly shifting ISD team which sometimes numbered as many as fifty people (both contractor and Navy personnel) at one time, and which involved several hundred different individuals over the course of the project was required to support this ambitious and effective ISD activity. About thirty major professional role classifications can be identified on this team.

The other major ISD activity to be used as an example is the ISD effort for the P3 ORION air crew training program, now being carried out at Moffett Field. In this activity the scope is greatly amplified. For example, instead of 900 instructional and/or performance check packages, more than 6,000 are involved. The mix of media are at least as complex and the AV effort is one of the most ambitious ever undertaken on this type of effort. Almost four years will be required to complete this activity and the combined contractor/Navy ISD team will run consistently more than 100 on-board personnel with several hundred having participated at one phase or another by the end of the project.

When it is realized that each step in the ISD process requires the dedication of a different mix of these personnel and other resources, and that the production of one AV package may involve nearly 100 identifiable individual activities to be managed, the true scope of the management problem involved can be appreciated. For example, in the SH-2 activity it was observed as early as January 1976, that lesson production rates were considerably lower than those which had been projected in the planning phases. It was not until April 1976 that sufficient data could be gathered to isolate and adequately document the problem. The earlier planning figures which had been based upon full-time availability of subject matter experts (SMEs) were inadequate. In the April 1976 monthly report, a 68.1% level of SME time was documented. (Contract Number N61339-76-C-055, Data Item Number 0007, Monthly Progress Reports for January to April 1976.) Similarly in October of 1977, it was ascertained that the subject matter experts available to the P3 ISD activity were actually writing instructional materials only 39% of the time

(Contract Number N00123-77-C-0792 Monthly Progress Report for September 1977).

It is extremely important that the training management system be very sensitive to deviations from all important program parameters. Such deviations should be treated as potential problems and should be immediately reported to facilitate early detection of potential problems. This has the joint effect of minimizing chances for program disruption and maximizing the probability that the problem can be solved within the context of available time and resources.

6. Need for flexibility to meet changing demands on the program

The training management system must support and allow rapid expansion to meet increasing threat. It must also provide continuous operational capability within imposed constraints. Recent build-ups and increased demands on training systems such as Vietnam, graphically illustrate the importance which should be placed on this critical need.

The F-16 training program must support and allow large scale and rapid expansion. This implies that it should place minimum dependence upon resources which will be especially scarce at these critical times, such as highly trained and experienced personnel. A personnel intensive training program is easily expandable only by supplying more personnel with the characteristics required. At times of threat these personnel will be in great demand. A system dependent training program is expandable by increasing system capabilities. These increased capabilities can be built into the system from the time it is initiated at very low cost.

An additional measure of flexibility is the ability for the program to provide continuous operational capability when critical constraint parameters are imposed. For example, there is a need for the training program to be able to quickly and optimally adjust to decreased numbers of available training resources (shortage of aircraft, shortage of instructor pilots, shortage of fuel, etc.), and yet maintain the highest possible training effectiveness within the revised program parameters. An automated system can immediately switch to built-in alternates with a minimum of disruption and required retraining of program staff, all the while completely documenting and managing all aspects of the change.

7. Need for a self-monitoring system

There is a need for continually evaluating the performance of the management system against the specified operating goals and standards, and for reporting all performance problems thus identified. The management system needs to constantly evaluate the accuracy of the planning data against available real world data and to compare system performance against operating goals.

There is also a need to screen data going into and out of the system to detect unreasonable values. For example, if the training management system does incorporate a range of planning models which allow management personnel to manipulate critical program parameters, it should be anticipated that some optimum values of these parameters will be incorporated into the project's planning expectations once a decision has been made. In a self-monitoring training management system these "ideal" or "optimized" parameter values snould be continually checked against the real or measured values of these parameters in the ongoing data base, and differences should be reported. If, after a body of data on the parameter values has been gathered, the observed values of the paramters are significantly different from the values assumed in making important decisions, then the validity of those decisions should be questioned and some alternative paths of action should be explored. If discrepancies between assumed and actual paramter values are ignored or undetected the program could gradually find itself in increasing difficulty.

Another need for self-monitoring lies in the area of running simple checks to detect unreasonable values on data coming into and going out of the training management system. A straight forward example of this process (which has been actually observed) is the assignment of a pilot instructor or a simulation to more sessions on a given day then could possibly be met. In its simplest form this need consists of a need for such straight forward (but very valuable) techniques as eliminating all possibility of the system being provided data item "D" when only "A", "B", and "C" are possible choices. If these errors (probably representative of one of the most common class of data errors) are detected at the time they are given and called to the user's attention for correction, a lot of time and effort will be saved and considerable expense and difficulty will be avoided.

8. Need to effectively deal with large amounts of data

There is a need to collect, store, use, and distribute large amounts of data. These data are generated by and required for the operation of the training program.

The functioning of an individualized, competency-based training program generates extremely large and complex data handling requirements. Without sophisticated data handling capabilities it becomes impractical to track individual, self-paced students and maintain detailed achievement profiles. It is anticipated that the F-16 Training Program will be an individualized, competency-based training program. The implications of this are that the competencies of each student in the training program will be represented as a profile of skills and knowledges related to the task job analysis and objectives hierarchies for the F-16 pilot tasks. As each student progresses through the training program developing new competencies, his competency profile must be updated to reflect the real state of his perform-

ance. It is anticipated that the competency profile for each student will be updated almost hourly throughout the training period. It is also anticipated that the total number of competencies constituting the F-16 pilot tasks will number in the hundreds. In addition, students in the program will be progressing at different speeds and often along slightly different paths depending upon both natural ability and upon the complex of skills they bring to the training program from previous experience and/or training.

These detailed data are needed both to more adequately represent the performance state of each student for use in matching personnel to task requirements, and for purposes of isolating specific training needs, and also for purposes of pinpointing needed improvements and revisions to the training program itself. The large size of the resultant data base, the high rate of information flow, the frequent update requirements, and the necessity to interpret and report these data for a variety of program related purposes, all have very important implications in the design of the F-16 training management system. If these data are properly collected and used, the result will be a much more effective and efficient training program and a much cleaner match of personnel to job task requirements, resulting directly in performance payoff in the F-16 mission.

9. Need to establish an historical data base

There is a need to establish, maintain, and apply an historical data base for prediction (projection) analysis and documentation purposes. Typically, each training problem in the past has been approached with only minimal or irrelevant historical data. The result is frequent repetition of mistakes and the necessity to "reinvent the wheel". Without hard data, planning for each new training effort proceeds on the basis of personal recollections and intuitions.

One important finding of the F-16 ADP study group was that one of the most serious deficiencies of previous ISD efforts has been the lack of consistently collected, detailed historical data upon which to base planning and decision making for subsequent efforts. As ISD models become more and more sophisticated and as the mix of personnel and skills required to fully implement a modern ISD program becomes more complex the importance of a detailed historical data base increases rapidly.

Two recent studies serve to highlight this finding. In a report entitled "Analysis of Needs and Goals for Author Training and Production Management Systems," authored by Dr. C. Victor Bunderson under DARPA Contract Number MDA-903-76-C-0216, it was reported that a survey of major existing Navy ISD efforts found that almost no detailed historical data existed which would allow the analysis of the effectiveness or efficiency of any of the hundreds of specific techniques and procedures utilized or any of

the many different personnel structures involved. These activities uniformly were unable to report with any degree of certainty how long instructional development took or how much instructional development cost on any but the grossest of levels. Typically, time and cost determinations were made in a post hoc manner by dividing the total amount of time taken and the total amount of funds spent by the number of instructional packages developed. No information was available on any detailed sub-procedures and techniques used in terms of their costs, efficency, or effectiveness. In other words there were no data available except on the most intuitive and general level that would aid in planning for a follow-on ISD effort.

In this kind of an environment it should be clear that each ISD effort is almost doomed to repeat the mistakes of the past, especially in an environment where personnel rotation patterns almost guarantee there will not even be continuity in terms of the people involved from one ISD effort to the next.

More recently the F-16 Aircrew Training Project "Previous ISD Program Review" prepared by Allen Thompson and Dr. Andrew Gibbons for the F-16 training program found the same problem exists throughout Air Force ISD efforts, with isolated exceptions. In general it was found that the detailed historical data available are spotty and incomplete, and it is the observation of the ADP study group that such historical data as are available are inadequate to use in planning purposes for other ISD efforts attempting to avoid the mistakes of the past or to find more efficient procedures, techniques and organizational structures.

Many ISD efforts score somewhat better on the utility of available historical data in terms of student performance records. Even here, however, there is room for considerable improvement, in that often in the past student performance records were kept in insufficient detail and the linkage between measured student competencies and the specific job task requirements being taught on any detail level is somewhat obscure.

Within the F-16 training program it is hoped that historical student performance records can be kept and maintained in great detail, and that they can serve as the basis for planning and decision making in many different areas, including need for curriculum revision and updates, qualifications of student personnel for individual assignments, isolation of deficiencies and prerequisite skills taught by other training programs, isolation of specific training program-related problems (such as an instructor whose students characteristically have trouble with some training related competency area), and so on.

If the F-16 training program, in particular, and future ISD based training programs within the Air Force, in general, are to be optimally served in the future, it is extremely important that a detailed, comprehensive, constantly maintained, and easily

manipulatable historical data base be built-up on all aspects of the F-16 training program from initial analysis on through continuation training for the lifetime of the weapons system. Without this provision future ISD efforts will continue to reinvent training related wheels, with varying degrees of success and skill, and at considerable expense in terms of efficiency, effectiveness and funds.

ISD efforts should build on one another and avoid the mistakes of the past while continually contributing to the body of knowledge, techniques, procedures and organizational structures that maximally contribute to the development and implementation of effective training. It is important that this data base deal as much with how the training was developed and which procedures and techniques are most cost effective and efficient, as with the more commonly collected student performance data.

10. Need for redundancy

There is a need to provide a high degree of redundancy (and hence reliability) in the training management system. Redundancy prevents losing important data through unforseen circumstances. The system needs to include protection against human and other errors. Loss of critical data in an ongoing program greatly reduces effectiveness, prevents reliable decision making, and weakens future planning efforts.

The F-16 training management system must incorporate a high degree of redundancy. It must not be sensitive to personnel rotation or equipment breakdowns. The ideal circumstance would be that the training management system would be sufficiently standardized and flexible to allow each training site to be capable of immediately assuming part or all of the management load of any other training site in the event of unforseen personnel or equipment loss. In addition, important records must be either kept at more than one site or they must be recoverable from more than one local data base, to protect against loss of key information. It is important that the F-16 training management system be able to quickly recover from a wide range of unforseen circumstances without the loss of critical information or training effectiveness, in a minimum amount of time.

11. Need for the system to be operable at the user level

It is important that the training management system be usable directly by training managers, instructors and students. The F-16 training program is individualized and competency based. There will be a continuing need for all users to frequently interact with the training management system, providing and receiving information. This interaction must be direct and must not require extensive training if it is to be practical. The ADP study team feels strongly that the training management system to be developed should be directly usable by any of the many differ-

ent classes of users, with a minimum of training, and without the requirement for specially trained interface personnel between the system and the user. One drawback in terms of the usefulness for project planning purposes of many of the sophisticated partial management capabilities now is existence, such as the powerful MODIA program developed by RAND Corporation for the Air Force is that the sophisticated system can be used directly only by especially trained teams of personnel knowledgeable with the use of the MODIA system.

This contrasts with other potential management system elements such as the TICCIT system utilized for CAI/CMI purposes at several junior college and military installations, and the Versatile Training System (VTS), utilized at many Marine and Naval Air installations as a personnel qualification system and general training program support system. An important characteristic of each of these systems is that they assume a minimum level of systems expertise on the part of the various users and each system contains a substantial and extensive set of user aids, helps and training materials on-line, designed to maximize the amount of service that the casual user can derive from the system without outside intervention.

The F-16 training management system will provide information to a wide variety of users ranging from secretarial and clerical personnel, through a range of student, instructor, and proctor personnel, to high level administrative management and command personnel. All of these users need different kinds of information and different levels of detailed reports to properly fulfill their functions. It is important that this information be readily accessible, directly from the system, as needed by each class of user, and that interaction with the system be perceived by these users as a helpful and supportive activity rather than a threatening and punishing exercise.

The training management system will be most successful and beneficial to both the F-16 and to other Air Force ISD programs if it freely and efficiently provides the information needed for decision making, project monitoring and future planning. If information is difficult to access and requires the interface of specially trained or highly skilled systems personnel, the impact of the system will be lessened, cost effectiveness will be lost, flexibility will be diminished, and vulnerability to threat will be increased.

PREFERRED SOLUTIONS

Introduction

This section provides a functional description of the F-16 Training Management System in terms of the capabilities required to meet the needs identified. It will describe a functional continuum of alternative solutions and the position of the preferred solution recommended by the study group (on that continuum).

The specific system implications of each identified need will be outlined, followed by a summary description of the recommended F-16 TMS and support organizations. Finally a set of specific recommendations for reaching this preferred solution will be advanced.

The F-16 TMS will be a mix of procedures, personnel, support capabilities, and organizational structures whose role will be to monitor, control, document, and facilitate the planning, management, and implementation of all phases of the F-16 training program, for the lifetime of the weapons system. All of the above features must be adequate or the program goals can not be met. For example, without good procedures, no mix of personnel or organizational structures can be fully effective. Without the proper organization there are severe problems in effectively defining lines of authority, responsibility, and accountability. If adequate support capabilities are not available, needed data for management and planning will be lost or uncollectable, and needed reports and other information products cannot be supplied.

While there are no good substitutes for efficient procedures and organization, to a certain extent personnel and support capabilities can be manipulated in various trade-offs for maximum effectiveness in any given situation.

The range of possible solutions to the F-16 training management problem is wide. On one dimension the range is from an organizational structure identical to those currently used in similar aircraft training programs, to a totally "revolutionary" or radically different structure, to be designed from scratch without concern for existing practice, and to be imposed on the system from without. On this dimension the recommendation of the study group is that the F-16 training program's organizational structure should be an "evolutionary" step up from current program management structures. That is, cleaner lines of responsibility for meeting student and curriculum performance goals should be identified (more accountability) and accompanied by increased access to, and control of, the resources necessary to meet those goals (more control).

On the dimension of personnel and support, the range could run from a fully manual (personnel dependent) system to an almost fully automated (personnel independent) system. The study group recommends a system as insensitive to personnel turnover as possible, but stops short of advocating a fully automated TMS. The reason for this is that, while a growing number of DOD organizations are coming to recognize that automating ISD activities (see Attachment B) is highly desirable, some activities lend themselves much more readily to automation than others (See "ISD Task Priority for Computer Aided Training Systems Development And Management"(CATSDM) Contract Number N61339-77-C-0018, Data Item 004).

Some of the characteristics of a cost effective TMS (both from the organizational and from the support standpoints) are outlined below.

1. Because of the need for lifetime maintenance of the training program, there is a need for easy access to the training data and materials on an ongoing basis for revision and update purposes. The system implied to meet this need would posses extensive word processing and text editing capabilities, as well as the facility to automatically maintain critical data links between all interim ISD products from the task/job analysis statements which define desired student competencies, through the objective hierarchy definitions which operationally define student performances to be accepted as evidence of training success. The system would have to be able to maintain the relationship of those objectives to one another within the syllabus, through the final specification documents and instructinal materials themselves. Because of the mass of material involved and the complexity of the relationships between ISD products, and because of the importance of maintaining an audit trail for continuing revision and documentation purposes, there are strong implications for automating the relevant parts of the training management system designed to help answer this need.

Organizationally there must be a commitment to accountability and to maintaining the currency and completeness of the F-16 training program, including both the finished instructional materials themselves, and the supporting ISD documentation and interim products.

2. Because of the pressing need to standardize the approach to modifying the training system, the F-16 training management system must contribute to the discipline and standardization of procedures both for implementing and for revising and modifying the training program and materials. This is best accomplished by putting those procedures as much as possible on-line and under the control of the system, so that it may structure the interaction required by training program maintenance and revision personnel. A rich mixture of on-line interactive revision protcols and job aids, supported by on-line instructional mater-

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ials for accomplishing the procedures, will help ensure that, in spite of the passage of time and the rotation of knowledgeable personnel, program modification and maintenance will still be carried out in a well defined and disciplined manner. This will serve to prevent the rapid degeneration of training effectiveness so often prevalant when curriculum or program modification is allowed to proceed on an idiosyncratic and uncontrolled basis. The system implication is that a relatively heavy degree of automation is called for in meeting this critical need.

Organizationally the implication of this need is that curriculum and program maintenance and modification will take place under the control of a centralized organizational structure responsible for proper maintenance of the training program and charged with the maintenance of a well defined and disciplined approach to revision and update. Further, this organization must approach the problem of curriculum maintenance from an active, rather than passive, standpoint. That is, the organization must continually operate under the premise that no training program is perfect and that training effectiveness should be continually monitored both from the standpoint of meeting the previously specified objectives and from the standpoint of continually comparing those objectives to real world training requirements and updating the training program accordingly.

3. Since the training management system must allow planners and decision makers to explore the effect of varying program parameters, there is a strong implication that both historical and current data bases will be highly manipulatable on a real time basis. Since these data bases will often be very extensive and since the relationship of critical program parameters will often be extremely complex, real time simulation of program performance and modeling of alternative program decisions heavily implies a relatively sophisticated automated planning support system. A variety of training support requirements analysis and cost benefits analysis programs exist, along with a range of fairly sophisticated general modeling capabilities, which could be adapted to F-16 needs.

Organizationally the F-16 training program structure should be charged with the generation and maintenance of program contingency plans and ongoing "state-of-the-program" reports. Additionally, the organiztion should be charged with the requirement to project the effect of a range of alternative decisions before committing to any extensive or long range plans of action at critical decision points in the program.

4. Since there is a need for quick response in many parts of the F-16 training program, a system is needed that can respond quickly to requests for information and data collection, and that can facilitate rapid revision of materials. If the F-16 training program is to be an individualized, self-paced, criterion referenced instructional program there is a high probability that the

average student will require some sort of information service (test grading, instructional prescription or assignment, resource scheduling, administrative support, etc.) several times every day. In many of these cases the student will be unable to proceed until the information is provided. Similarly, other users such as instructors, proctors, program managers, or high level administrators, may have similar needs for current information and immediate service. All of these classes of users may need to be served simultaneously and some users should be given access to data and services that other users would not need and should not access. There is an extremely strong implication here for automation of the appropriate aspects of the training management system. Successful models abound, both in the military and industry, in the areas of computer managed instruction, data base management, and general automated administrative support. The F-16 training program should borrow from the best of the available models and augment existing services and functions with capabilities to be specified by the ADP planning team internally.

Organizationally the F-16 training program staff should be structured with clearly defined areas of responsibility and authority to facilitate quick and effective interface with information and decision-making outputs. In other words, in the real time, "all at once" world of a responsive, automated training management system, users should not be unduly fettered by an outmoded, cumbersome, and unnecessarily bureaucratic management organization. The F-16 training management organization should be streamlined and oriented toward quick and effective service for all classes of users.

5. Since there is a need for early detection of problems, there should be continual, ongoing monitoring of critical program parameters at every interaction between user and system, supported by automatic reporting of any discrepancy between the value of those parameters and values expected by the training management organization. It should be readily perceived that such a degree of monitoring would be impractical in any purely manual, people-based system. The implication is that a system which could effectively and efficiently meet this need would involve a considerable degree of automated support.

The organizational philosophy of the F-16 training management structure should reflect an empirical approach where mistakes and problems are anticipated, and accepted as a challenge and a focus for improvement, rather than as potentially damaging events which should be down-played or concealed. F-16 should be a model program for Air Force ISD. Uninhibited publication of its problems and mistakes are every bit as important as its successes. Without this commitment to open analysis and publication of program progress it would be all too easy for subsequent ISD efforts to proceed on the basis of a set of false assumptions, having never been exposed to F-16 program difficulties, with the result that the cycle of repeated mistakes would be continued.

6. Since there is a need for flexibility to meet changing demands on the program, the F-16 training management system must allow rapid redefinition of program parameters, evaluation of alternative training conditions, and implementation of an ongoing program optimized under the new conditions. This means the system must be able to quickly adapt to problems like the sudden unavailability of critical instructional resources (such as loss of training sorties or the unavailability of simulators or instructors), by assigning students automatically to the most effective instructional alternatives. In addition, during times of critical threat, the training management system must be able to accomodate extremely rapid growth in the numbers of students, and it must accommodate itself to changes in program parameters such as greatly accelerated training schedules. Since the most critical resources at these times will be precisely those highly trained personnel who could best serve as instructors within the course and as managers of the training program, there is a need to minimize the "people-dependence" of the F-16 training program. Here again the implication is toward automation of the training management and implementation systems. A well defined technology, both of computer managed instruction (CMI) and computer assisted instruction (CAI), exists and is being effectively utilized in a variety of military and industrial settings. These should be carefully studied and the best aspects of each technology should be incorporated, wherever feasible, into the F-16 training program.

Organizationally the system must be supported by a framework of well defined, yet somewhat redundant and very flexible personnel roles, where as much as possible of the training management load could be quickly absorbed by an influx of new personnel with a minimum of training, supported by the well defined procedures and self-instructional protocols of the training management system itself, and easily directed by a relatively small number of more highly trained personnel in leadership positions within the program. To maximize the efficiency and effectiveness of the few highly trained and experienced personnel who may be available during a time of accelerated threat, they should be supported as much as possible by ongoing monitoring and quality control functions provided by the automated parts of the training management system.

7. Since there is a need for a continually self-monitoring system which provides the training management organization with current information on the performance of the management system itself (both organizationally and otherwise), there is again an implication that the F-16 training management system should have a considerable degree of automated support. An automated information management system could constantly evaluate the accuracy of planning data against available real world data and could compare system performance against operating goals at very frequent intervals. In addition, an automated training management system could continually screen data going into and out of

the system to detect unreasonable values and instruct interacting users on problems encountered before they go on. This single feature could go a long way toward improving the quality of data used for planning and decision-making and towards enhancing the cost effectiveness and utility of the system to all concerned. Such data control and error reduction technology is well within the state of the art.

Organizationally there must be a commitment towards continual, ongoing evaluation of the performance of both the training program and the training management structure, and towards immediate and active action to remedy perceived deficiencies.

8. The need to effectively deal with very large amounts of data both in terms of ISD products, program documentation and training materials and in terms of massive amounts of student and program performance data, has been well documented. The implication of this need for the F-16 training management system is clearly one of automated support. Conventional, off-the-shelf data base management system and computer managed instruction capabilities provide a very good starting place for the definition of solutions to F-16 training program needs.

Organizationally there must be a commitment to the importance of building and maintaining substantial data bases for planning and decision-making purposes.

9. The only way to break the recurring cycle of essentially starting over with each new ISD effort is to establish a historical data base on all aspects of major ISD efforts. It is the feeling of the F-16 ADP study group that one of the greatest contributions of the F-16 training program to Air Force ISD and training could be the establishment of such a data base for the first time on a level of detail, and in a format, sufficiently manipulatable for the planning and procurement of future ISD efforts in a more efficient and effective manner. Again the capabilities for the establishment of such an historical data base exist in a well defined information management and data processing capability strongly implying automation available in large part off-the-shelf or through adaptation of literally dozens of existing DOD capabilities.

10. The need for redundancy in the F-16 training management system can easily be met in an automated or semi-automated environment by the provision of communications capabilities between similar hardware configurations at each training site sufficient to allow remote service of any site from any other site. This is a state-of-the-art, existing technology, ideally adapted to the F-16 training needs and identified as offering a high degree of reliability and service to the F-16 training program.

With well defined, on-line procedures supported by interactive protocols and system supported instruction to train new

personnel and with redundant hardware capability, the F-16 training program will offer a degree of reliability and redundancy unmatched by any previously training program. It will be insensitive to either rotation of personnel or large scale failure of training program support equipment, while offering the potential for rapid, large scale expansion of capabilities at minimum expense and with maximum effectiveness.

11. The need for the system to be operable at the user level implies that the user must be guided and helped as much as possible at every interaction with the system by the system itself. The implication here is that an automated system would offer definite advantages in terms of coaching the user, screening his data for errors or improper assumptions, and in offering immediate, on-line job aids or procedures training as needed. The technology of human engineering protocols used with automated systems has been well advanced in the areas of computer managed and computer assisted instruction. While this technology may not be properly or widely applied in other areas of automatic data processing, a considerable amount of expertise could be brought to bear in defining the user/system interfaces for the F-16 training management system to achieve maximum utility and simplicity for the user at any level. In addition, while the automated system could ensure that every user has immediate and free access to the full range of data and information to which he is entitled, the built in security capabilities of an automated information management system could protect against improper distribution of any information or data.

Organizationally the implication is clear. The F-16 training management structure must be completely committed to user service, whether that user be a student, an instructor, a proctor, a manager, or a high level administrator. All functions of the system and all actions of the management structure should be aimed toward user service.

SYSTEM DEFINITION SUMMARY

The needs identified by the F-16 ADP Study Group within the context of the F-16 Training Program, and the preferred solutions indicated to meet those needs, imply a strong degree of automated support to the overall F-16 training management system. Summarizing some of the most important of those implications for automation, the F-16 training management system ADP support hardware should be time-shared and operating in an interactive real time mode. There should be an efficient terminal distribution net and both local and remote communications capabilities to remote terminals and to other F-16 training management system computers. The hardware should be easily and effectively upward expandable. That is, the system configuration selected to meet F-16 needs should not be the "top of the line" of its hardware type, unable to effectively accommodate further growth and increased requirements. The hardware system as installed should include considerable excess capacity over that anticipated for the initial utilization. This excess capacity should be present both in terms of computer power and in terms of disk and core memory. These are extremely important, and in the long run, very cost effective considerations in dealing with the important needs for flexibility, reliability and redundancy. The system should be gracefully degradable in both hardware and software to help meet these same ends and increase the probability that effective TMS support can continue under unusal circumstances, including hardware problems. Also the hardware configuration selected should be carefully chosen with an eye toward maintainability to reduce the expense of the required spares inventory and in keeping with the redundancy and reliability philosophies. As much as possible there should be interchangeable parts between duplicate and similar units and access in a timely manner to a high level of maintenance services. Finally the hardware system configuration must be simple and reliable enough to operate and support with a minimum of full time operating and support staff (preferably none).

From a software standpoint the system selected should incorporate advanced capabilities in word processing, text editing, and both assembly and high level language capabilities. In addition there must be available sophisticated data base management systems, disk operating systems and time sharing executives in order to fill the needs identified. Also from the software standpoint there must be good data protection and crash recovery characteristics, good data logging capabilities, and in general, full capability to support and maintain a reliable multi-user, multi-function environment. Software support characteristics of the system should make it possible to implement a sophisticated modeling capability either through existing or specially created applications programs. It must be possible to construct and maintain extensive and sophisticated interactive protocols and

user training and input sequences to ensure that the system is fully usable by the full range of intended users in a rewarding and non-threatening interaction climate. And finally, because of the intended multi-user, multi-function operating context, it is extremely important that the system embody good data protection and user security techniques to avoid the loss of critical data or the accidental or intentional destruction of important records.

ORGANIZATION DEFINITION SUMMARY

The degree of automation implied by the needs and preferred solutions identified by the F-16 ADP study group for the F-16 training management system represents a considerable step forward from most existing training management systems. For this reason it may excite considerable attention and interest both within and without the program. Equally if not more important than the procedural innovations implied by this level of automation, are the implications for organizational tasking and structure implied by those needs. The most advanced automated training management system within the state of the art today would still be insufficient to meet the full training management needs for a sophisticated individualized self-paced competency based training program such as F-16, unless that program were being implemented within an organizational structure whose aims, tasking, and manpower make-up were properly defined to fully meet all the goals of an advanced ISD program, while taking full advantage of the increased capabilities inherent in the degree of automated support provided.

The F-16 training management organization should be tasked with a high degree of accountability for the on-going maintenance and revision of the training program in terms of maintaining both its currency and its effectiveness. This responsibility should be centralized and accompanied by commensurate control of resources adequate to do the job. The organization should be tasked with actively pursuing on-going curriculum evaluation and also for the on-going evaluation of the effectiveness of the supporting training management organization (i.e., itself). A major responsibility of this organization should be to publish all findings both positive and negative in terms of effectiveness of the training program and the effectiveness of the management system and organization. Without this kind of openness, an on-going commitment to clear isolation of problem areas, ISD will continue to essentially start afresh from the same base of ignorance in each new major iteration in the future.

The training organization must be responsible for generating a variety of training contingency plans to include in part, alternative plans dealing with such problems as sudden increases in the number of students, sudden decreases in the amount of training time available per class, loss of simulators or other critical equipment, decreases in the number of available training sorties, decreases in the number of trained instructors, etc. Within the training management organization, there must be clearly defined lines of authority and responsibility and the primary design parameter in establishing those lines should be the paramount requirements that, in effectively implementing any sophisticated ISD programs, all the right things must be done (i.e., do not leave out critical activities), those things must

be done right (i.e., lip service to any critical activity may be more damaging than ignoring it altogether), and user service must be facilitated (i.e., the training management organization exists to serve the many different levels of users, not the other way around). The training management organization must be committed to building and maintaining a detailed, comprehensive, historical data base for planning and projection purposes. It must be completely user oriented, and built into the training management program should be recurrent user evaluations of the training system and organization from all levels of users.

SUMMARY AND RECOMMENDATIONS

Some preliminary conclusions derived from the study group are summarized below. Most of these came directly from the needs analysis in the preceding sections.

Summary Points

1. All phases and principal activities of the ISD process can benefit from some degree of automated support. (See "ISD Task Priorities for CATSDM" Contract Number N61339-77-C-0018, Data Item 004 and "List of Candidate ISD Task Processes or Products" Contract Number N61339-77-C-0018, Data Item 001)

2. Automated support of ISD for a rapidly changing weapons system is particularly important. This support maintains the currency (external validity with the real world) and consistency (internal validity and agreement of all parts) of the training program.

3. Increased efficiency and effectiveness of the F-16 training program which results in even a fraction of one percent operational improvement will more than pay for even the most elaborate information management system being envisioned.

4. Even partial applications of the type of system being suggested will produce an observable effect in efficiency and effectiveness.

5. The complete information management needs of F-16 are not known at this time. Better functional specifications are needed to facilitate Air Force decision making. The specification process should be ongoing throughout Phases IV and V of the ISD project, at least.

6. A minimum level of effort required to generate the needed level of primary specification in a useful time frame would be about 3 man years of effort as early in Phase IV as possible.

7. For those needs which are known, there are existing systems which either address the need or which contain adaptable solutions to similar problems. (See "Analysis of Existing Programs for CATSDM", Contract Number 61339-77-C-0018, Data Item 005).

8. No existing system or useful combination of systems addresses all of the currently identified F-16 ISD needs. (See Point 7 above).

9. Useful, low risk, relatively inexpensive (although incomplete) alternatives exist. These could be pursued either singly

or in combinations while the Air Force decision making process proceeds. (See Recommendations Section.)

10. Failure to initiate interim activity such as a) the specification activity in Phase IV, b) some interim development and production managment support, and c) word processing approaches will result in a loss of full capability in the eventual integrated F-16 system. This loss of capability is due to the rapid pace of the project activities and the lead times required for many functions.

11. Potential benefits to F-16 of a comprehensive, integrated information management system include:

-- Detailed planning support of all levels.

-- Identification of inefficiencies and potential problems.

-- Optimizing use of equipment and assets.

-- Reduced life cycle costs.

-- Increased life cycle efficiency and effectiveness.

-- Life cycle contribution to program discipline, continuity, and consistency.

-- Increased flexibility and responsiveness to meet threat or changing conditions.

-- Improved information flow with increased management visibility.

-- The resulting historical data base will free subsequent programs from repeating the mistakes of the past and can guide future procurements.

12. The optimal TMS has profound implications for other weapons systems.

13. To optimize the chances for successfully meeting the TMS needs of the F-16 program anticipated in the original statement of work and verified and further defined by the study group, existing systems such as the Navy's Versatile Training System (VTS) and the Air Force's Air Force Operations Resource Managment System (AFORMS) should be viewed as foundations upon which to build the F-16 TMS. (See "Versatile Training System (VTS) Functional Description (FD) For Naval Aviation Activities, REG 31408-88-76, 15 April 1977, Naval Weapons Center, Code 31408, China Lake, California and Air Force Operations Resource Management System (AFORMS), Functional Description, 1 December 1976).

Recommendations

1. Word processing, tentatively approved for Phase IV should be maintained for the rest of the project and expanded to support production/revision.

2. While decision/approvals are being made, support for these ADP related activities during Phase IV is essential:

-- Word processing.

-- CAI/CMI source study.

-- Install/adapt some level of automated management support in Phase IV for use in supporting the large scale, complex development and production events of Phase V. (Recommend Author Management System (AMS), developed for DOD under DARPA Contract Number MDA 903-76-C-0216).

-- Automate task and goal analysis (should be integrated with the system above to start with).

-- Fully analyze existing capabilities (VTS and AFORMS recommended), write specifications for additional needed TMS modules, and contribute other information needed to support specific Air Force decision making at each phase (at least 3 man year effort in Phase IV).

3. The resulting F-16 TMS system should acquire and control its own dedicated hardware since the degree of interaction required and the amounts of data to be generated are too large to allow any chance of less than full-time, real-time service. If the acquisition of dedicated hardware and use of a time shared system is necessary, then the TMS should be guaranteed highest priority.

4. For reliability, redundancy, and long range economy purposes a "multi-minicomputer" with local terminal nets hardware approach replicated at each training base is recommended over possible alternative approaches such as distributing all services to all bases from one large central system.


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