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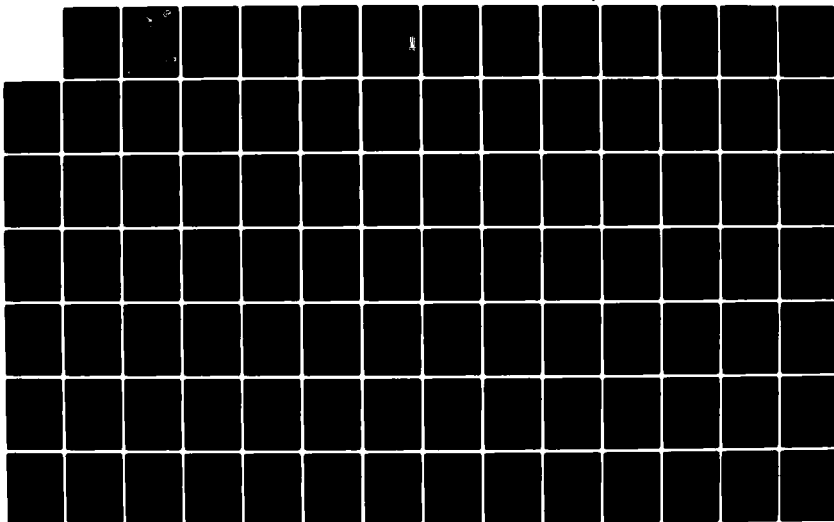
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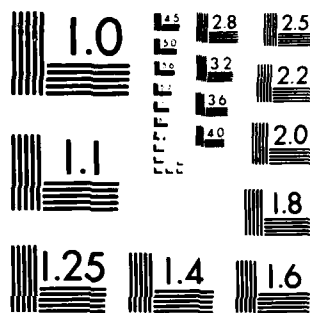
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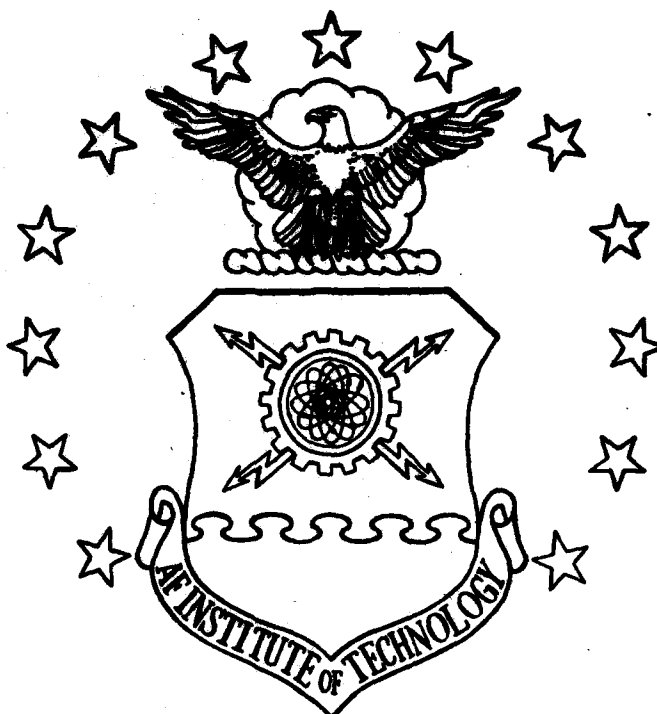
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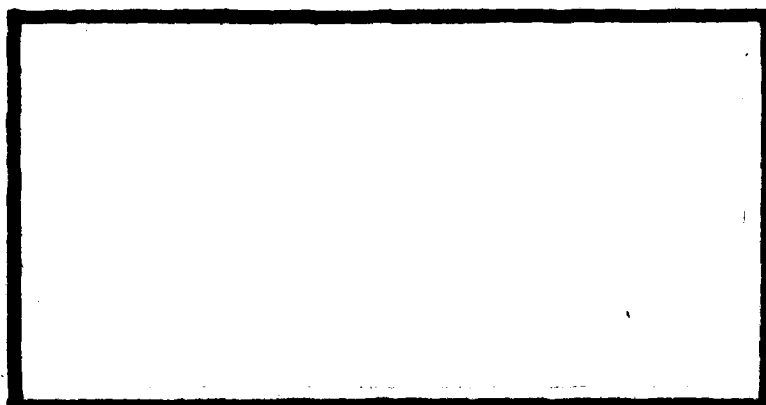


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A PROTOTYPE MODEL FOR THE DEVELOPMENT  
OF TRAINING SYSTEMS AND THE ACQUISITION  
OF AIRCREW TRAINING DEVICES FOR  
DEVELOPING WEAPON SYSTEMS

William E. Goetz, Captain, USAF  
Nelson O. Perez-Otero, Captain, USAF

LSSR 18-82

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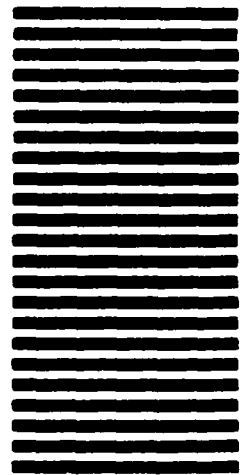
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The authors review the current method used by the Air Force to develop Training Systems and to acquire Aircrew Training Devices (ATDs), and they identify six limitations or problem areas. A review of Army and Navy ATD acquisition systems, as well as current literature, found no existing system which addressed all problems in existing systems. The authors develop a prototype system model for training and ATD development with proposed changes in four areas: (1) management and personnel which includes centralization of decision making, development and retention of training development expertise, team concept, and collocation; (2) information availability which includes access to prime contractor information and Generic Data Base (GDB) technology; (3) contracting and delivery strategies which include scenario development, Pre-Planned Product Improvement, and using actual equipment or reduced fidelity ATDs for early training; (4) Training System (TS)/ATD Development Model which includes a graphic representation of the process to develop TS and ATD requirements. The authors validate the system model via expert opinion. Five of the six limitation areas were judged to be significantly improved by the system model.

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A PROTOTYPE MODEL FOR THE DEVELOPMENT OF TRAINING  
SYSTEMS AND THE ACQUISITION OF AIRCREW TRAINING  
DEVICES FOR DEVELOPING WEAPON SYSTEMS

A Thesis

Presented to the Faculty of the School of Systems and Logistics  
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the Requirement for the  
Degree of Master of Science in Systems Management

By

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Captain, USAF

Nelson O. Perez-Otero, BS  
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September 1982

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This thesis, written by

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and

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has been accepted by the undersigned on behalf of the faculty of the School of Systems and Logistics in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS MANAGEMENT

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## CHAPTER 1

### INTRODUCTION

#### OVERVIEW

Three weeks after the Japanese attack on Pearl Harbor, the Army Air Force (AAF) only had 9,000 trained pilots; in less than three years the Flying Training Command trained more than 190,000 pilots. It was during this period of urgent growth that the first widespread use of aircraft simulators appeared. The crude Link Trainers of WW II started the Air Force on the road to the multimillion dollar mission simulators of today (13:73-75).

The use of aircrew training devices (ATDs) -- modern versions of the WW II Link trainer -- increased along with the cost of modern aircraft and aviation. Strong incentive for increased ATD use came from 1973 Congressional pressure to reduce military flying hours by 25% (12:5-1). The goal of simulator builders became to reproduce the flying environment so precisely as to replace actual flying hours with simulator hours.

[Simulator] effectiveness is directly and proportionally related to the realism produced by the training system in the sense that the simulator experience must transfer to the ultimate goal of combat effectiveness [23:54].

As ATD's realism increased, costs skyrocketed to such heights as to make large volume buys of ATDs impossible. Today accessibility to the limited number of ATDs is a new problem.

It does the Air Force little good to own the world's most realistic and sophisticated simulator if there are not enough of them to provide all of its crews with sufficiently frequent access [23:54].

Can the Air Force continue to provide effective training for new and more costly aircraft while maintaining ATD costs at levels under that of the "realistic" ATDs of today? If so, how?

#### PROBLEM STATEMENT

An ATD's configuration is ultimately driven by the weapon system's performance and physical characteristics, as well as user maintenance, training, and operational concepts. These data, along with other supporting weapon system (W/S) program and contractor engineering data, are used by the training developer to develop training objectives, the base line against which the evolving ATD is developed and tested (43:3). In an ATD program supporting a weapon system under development, the data upon which the training analysis hinges are constantly changing and typically are not frozen until the weapon system's ultimate configuration is determined. Given this acquisition environment, this thesis studied two problems in the ATD development process:

1. ATD acquisition and training personnel needed a better way to develop training and ATD requirements for developing weapon systems.

2. ATD acquisition personnel needed a better process to transform ATD requirements into performance specifications.

The following highlighted the need to study this area:

1. Delivered ATD systems were ineffective leading to increased flying time in order to meet required proficiency levels (34:3).

2. ATDs were rarely delivered prior to the weapon system's Initial Operational Capability (IOC) date as required by regulations (12:5-2).

3. Engineers were forced to work with poorly identified requirements (21) leading to system specifications that did not satisfy training requirements. In addition, without adequate direction, the engineer tried to meet all specifications totally resulting in an ATD which is excessively expensive and has excess capabilities ("goldplated") (54).

4. At an ATC/AFSC/HQ USAF workshop on acquisition and Instructional Systems Development (ISD) (the mandated method for analysis of training requirements), ATC made the following statement:

. . . the methods developed by ATC in 1973-77 to permit ISD application no longer meet system acquisition schedules. In particular, training equipment identification is being required by system program offices before sufficient data exists to permit ISD analysis. ATC is uncertain how to proceed [25:Atch.2].

5. In 1980, at a workshop on the Front End Analysis (FEA) problem, one of the participants voiced the following concerning ATD requirements for weapon systems under development:

With the occurrence of frequent changes in equipment design, how can we get data on actual equipment to simulator designers so that appropriately designed training devices and simulators are developed and fielded in a timely manner [34:3]?

This sample of the problem's effect on the acquisition of training systems, the rising cost of simulation systems for training (23:56,59), and comments by the current Deputy Secretary of Defense, Frank C. Carlucci, that the DOD should examine the acquisition process for improvements provided the initial motivations for this thesis (2:9).

#### BACKGROUND

Four background subjects relevant to the thesis are reviewed in this section. First, the current conceptual framework used to develop ATD training requirements, ISD, is discussed. Second, the acquisition setting, called the weapon system acquisition process, is reviewed. Third, the structured programming concept is discussed in general as a method of viewing complex systems. Fourth, the current method Aeronautical Systems Division (ASD) uses to procure ATDs is reviewed.

### INSTRUCTIONAL SYSTEMS DEVELOPMENT. Air Force

Regulation (AFR) 50-8 requires that all Air Force training and education programs are developed and conducted in accordance with the ISD process.

ISD is defined:

ISD is a systematic but flexible process used to plan, develop, and manage education and training programs. When used properly, the ISD process helps managers plan and use training resources effectively. The ISD process identifies training requirements; translates those requirements into valid learning objectives; selects the proper training strategy; develops effective training delivery systems; and provides quality control. Using ISD makes sure that people get the knowledge, skills, and attitudes needed to do their Air Force jobs [45:1].

The ISD process is further defined as the five step process shown in Figure 1-1. ISD starts with an analysis of the job (Step 1) and proceeds through the remaining steps. Of particular interest is Step 4 which includes the first point where training media -- including ATDs -- are identified. The validity of the process is then reviewed. (20:39-53; 45:1-2 to 1-3).

ISD-type processes are validated by their success in military and industry applications. Mager Associates, Inc. developed and marketed an ISD-type process called Criterion-Referenced Instruction (CRI) with success. A partial list of organizations using CRI (Figure 1-2) include both civilian and military organizations with large and diverse training tasks (24:6). In addition, Mager's promotional literature includes customer comments such as:

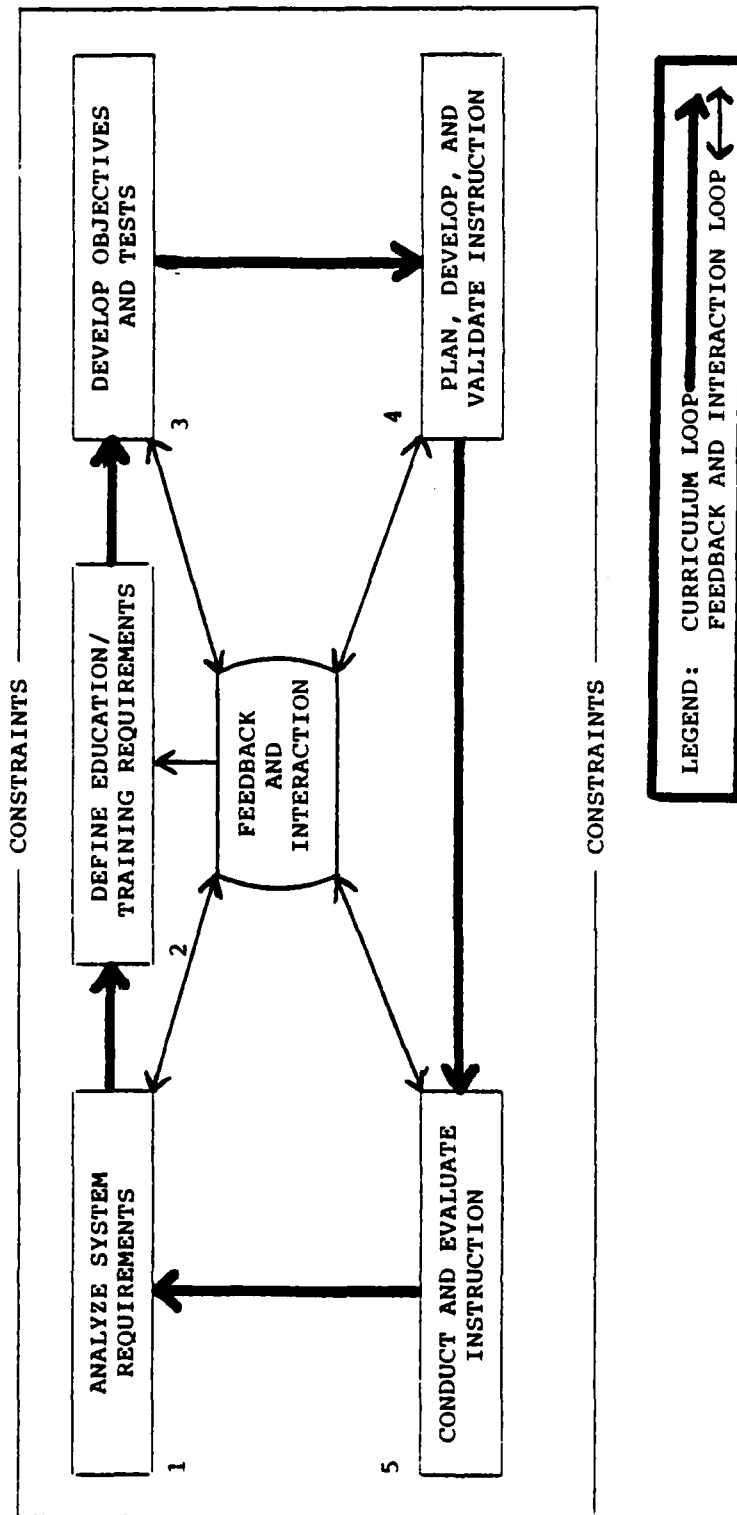


Figure 1-1. Model for ISD (45:Figure 1-1).

Xerox  
Rank Xeros (UK)  
Gulf Oil Canada  
Cii Honeywell Bull (France)  
Bell Telephone Co.  
U.S. Air Force  
Scandinavian Airlines  
Air Canada  
South African Broadcasting Corp.  
Crocker Bank  
U.S. Army  
Hongkong & Shanghai Banking Corp.  
Continental Telephone Service Corp.  
Technicon  
United Telecom  
Royal Canadian Mounted Police  
Pet Foods, U.K.  
Mitsui Machinery Sales (UK) Ltd.  
Center for Disease Control

Figure 1-2. Some Organizations Currently Using CRI  
Materials and Procedures (24:6).

I have found the application of the Criterion  
Referenced Instruction to have these benefits:

- Makes the instructional developer's job easier...
- Reduces development costs...

These two benefits have had a recognizable impact  
on our ability to deliver a higher quality training  
program to a client division in less time than we have  
experienced in the past.

Arlan L. Tietel  
Learning Systems Supervisor  
Education, Training and Development Department  
3M Company [24:5].

The ISD process establishes the environment in which train-  
ing developers must operate.

Systematic instruction in the Air Force began in 1970 and has evolved into a current set of ISD documentation. In 1970, the Vice Chief of Staff, USAF, directed a "systems approach" to military training (5:396). That directive evolved into current Air Force directives:

1. Air Force Regulation (AFR) 50-8: States the requirement to use ISD in all training related matters and assigns responsibilities (45:i-4).

2. Air Force Manual (AFM) 50-2: Summarizes the ISD process (44:i).

3. Air Force Pamphlet (AFP) 50-58, Volumes I - VI: States the "how-to" of each ISD step and sub-step (42:Vol.I,i).

4. Others: Other directives dictate ISD's use in training related activity. Of special interest is AFR 50-11 which regulates ATD development, acquisition, and use. AFR 50-11 states that ISD must be used for ATD requirements process and certification (46:1,8,9).

The acquisition process is discussed in several of the above publications. AFR 50-8 states that Air Force Systems Command (AFSC) has primary responsibility for acquiring ATD's concurrently with new weapon system acquisition (45:2-3). AFM 50-2 warns the reader of possible ISD/acquisition problems:

All the parts of a complete weapon/support system are usually not in the same stage of development at the same time. Thus, while there may be much information available on some subsystems, there may be other subsystems developing more slowly for which very little information is available. This is a problem in designing the instructional system since you may have to make instructional planning decisions before all of the information is available. To the extent that data have been gathered and analyzed in applying the ISD process at any given time, you have a more solid basis for making instructional planning decisions. As the weapon/support system develops and more of the design becomes firm, more information will be available. Use this to update the instructional planning decisions [44:2-3].

And:

If you fail to identify these items [with long lead-times like ATDs] until course development is complete, that will hurt the ability of the instructional system to provide qualified personnel in a timely manner [44:3-6].

The ISD process provides the framework within which current ATD acquisition takes place, and the ISD/ATD processes takes place in the larger weapon system acquisition process.

WEAPON SYSTEM ACQUISITION. The system concept goal is to design, produce, and manage the weapon system as an integrated unit instead of a series of individual efforts. Therefore, the total weapon system includes several subsystems such as the:

1. aerospace vehicle,
2. support equipment,
3. facilities,
4. technical data,

5. supply,
6. maintenance,
7. personnel,
8. training.

All subsystems are developed concurrently with the basic airframe with the goal of having all subsystems ready when needed to support the aircraft. The training system, along with its ATDs, is one of a major weapon system's subsystems (11:30-33; 26:3). A five phase process is used to take the entire weapon system from conceptualization to deployment.

The five phase system acquisition process is "essentially a logical flow of activity representing an orderly progression from concept formation to final operational deployment [26:6]." An overview of each phase is found in Figure 1-3 (11:44). Each successive phase is designed to develop increased confidence, to reduce risks in the acquisition, and to provide incremental commitments of resources to the project. In addition, decision milestones provide information about and direction to system decision makers. And as discussed by Gladney and Jeas, the amount of information about the system increases as the acquisition process moves through each phase (15:81).

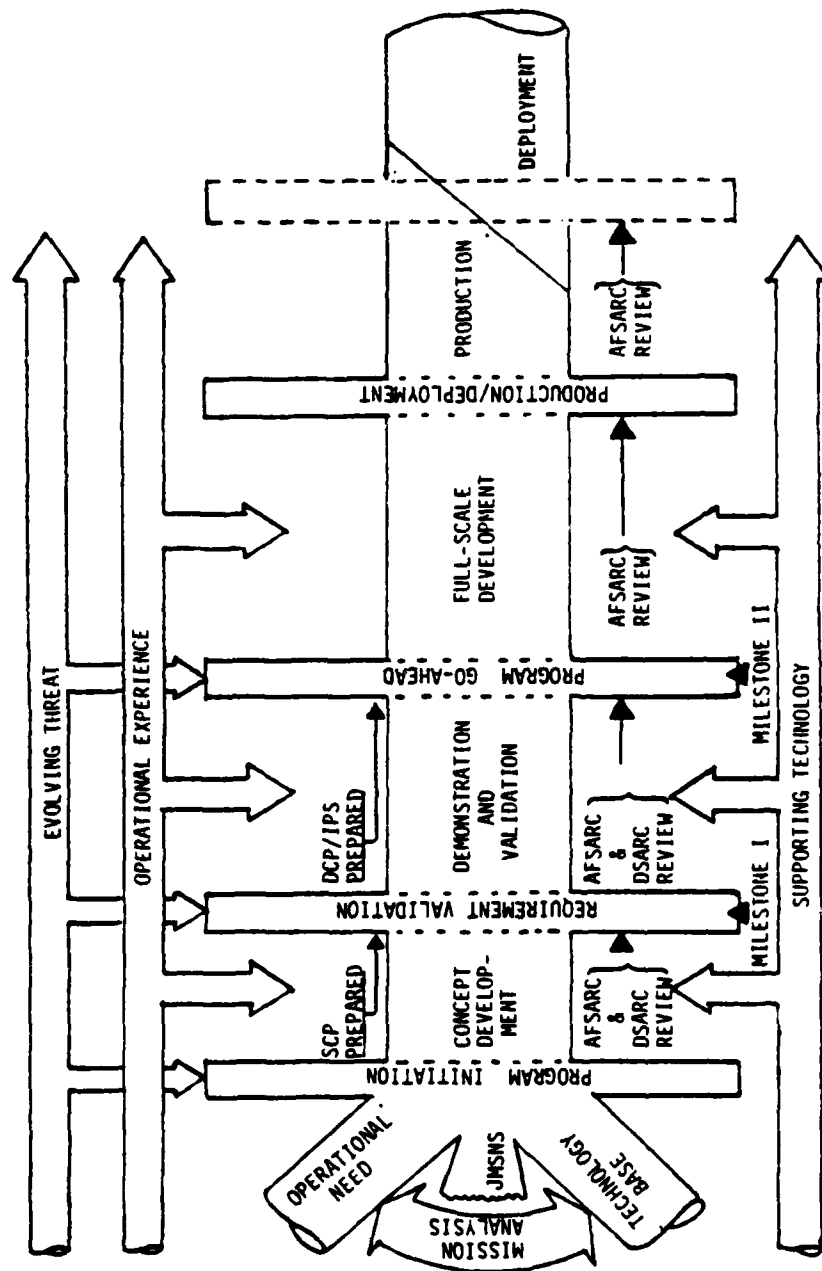


Figure 1-3. Major System Acquisition Life Cycle (11,44).

STRUCTURED ANALYSIS. Very quickly in our review of the ATD acquisition problem, similarities became apparent between what ISD people needed and computer programming people had. While ISD provided training developers with a methodical way to analyze existing weapon systems (starting with the task analysis), they needed a satisfactory tool for weapon systems under development. Computer programmers had developed an approach called Structured Analysis (SA) to "attack" large, complex problems. This approach may be useful in developing training systems and ATDs.

Since SA is essentially a systems approach, Victor Weinberg (52) built on several systems-related terms. SA is the analysis of systems which Weinberg described in the following way: he said that to analyze a system is to

...identify the complex, its components (people, machines, rules, and procedures), and their interrelationships to determine objectives, requirements, priorities, and the extent to which they all have been satisfied [52:10].

Weinberg then provides two definitions of systems analysis. The definition that relates best to our research is the following:

...the examination of problems, objectives, requirements, priorities, and constraints in an environment, plus identification of cost estimates, benefits, and time requirements for tentative solutions [52:13].

Figure 1-4 is a graphical presentation of this definition.

The definition of structured analysis follows from the definition of systems analysis. SA is "a disciplined

approach to structuring the systems analyst's job [52:33]."  
In addition, it is "defined as a philosophical, top-down  
approach to all phases of the systems life cycle [52:33]."

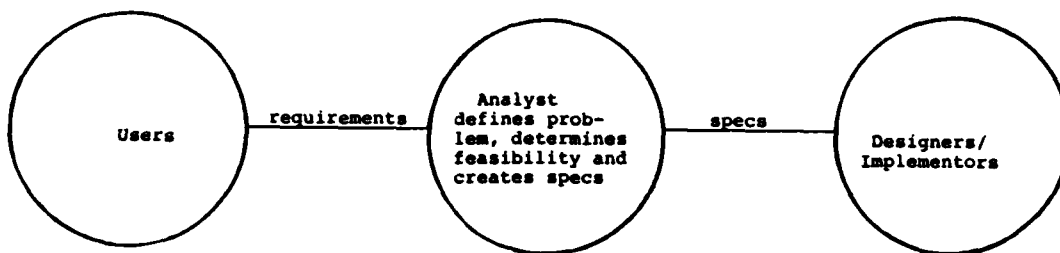


Figure 1-4. Systems Analysis Diagram (52:Figure 1-3).

From the definition of SA, Weinberg details "important guidelines" for implementation of SA:

1. Get the users to participate in the development and evaluation of systems.
2. Consider the technical level of expertise and the bottom-line objectives of the users when producing documents for user review.
3. Use graphic tools to minimize potential communication problems.
4. Build a logical systems model before concentrating on detailed physical requirements.
5. Take a disciplined top-down approach to the analysis and design of systems. Break down major functions into manageable small, component functions.

6. Take a disciplined top-down approach to the implementation of systems. Address the implementation of major functions and the resolution of major potential problems before considering the more predictable detailed systems' functions.

7. Show the users output that they can understand before final systems acceptance. Break large, complex systems into smaller, more manageable projects so that users can see results early and can better evaluate the progress and value of systems.

8. Evaluate systems not only in terms of costs of development and operation, but also in terms of overall lifetime costs and benefits [52:32-33].

After laying a conceptual base for SA, Weinberg then identifies "tools" used in SA. The Weinberg tool used in our research was the Data Flow Diagram (DFD). "A graphic tool that represents data flow and transforms in a process [52:313]." For example, the DFD representation of updating a master file with individual transaction information would look like:

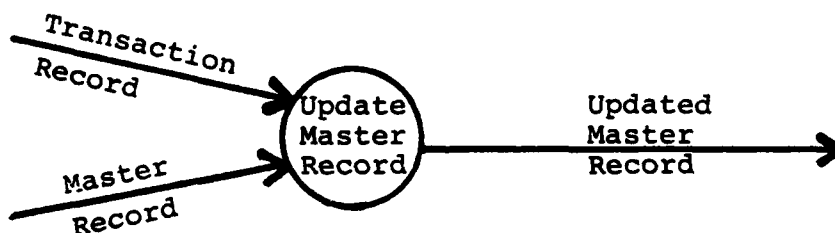


Figure 1-5. Data Flow Diagram Example.

## AIRCREW TRAINING DEVICE (ATD) ACQUISITION

### Definitions.

1. Aircrew Training Device. AFR 50-11 defines an aircrew training device as a synthetic training device that is used to support aircrew training programs. This thesis deals with six of ten types of ATD delineated in AFR 50-11: Part Task Trainers (PTTs), Cockpit Familiarization Trainers (CFTs), Cockpit Procedures Trainers (CPTs), Mission Trainers (MTs), Operational Flight Trainers (OFTs), and Weapon System Trainers (WSTs) (46:1).

2. System-managed ATD. A device used to support a training program for a specific, developing weapon system is called system-managed (46:3) and its acquisition is the responsibility of the weapon system's program manager (PM) (46:5).

3. Nonsystem-managed ATD. ATD that is procured to support training for either more than one system program or for an existing weapon system, or ATD that is procured by an agency separate from a weapon System Program Office (SPO) is considered a nonsystem-managed ATD (46:3).

ATD Acquisition Process. There are many ways that needs for new training devices may evolve. For instance, training organizations are constantly reviewing programs to insure that their graduates are meeting Air Force needs.

These reviews are performed at the task level using the ISD process. Sometimes inputs to these reviews come in the form of individual supervisors' reviews of graduates as well as periodic meetings between training organizations and field representatives. An output of this process is the identification of training deficiencies -- training skills that the graduate should have but does not. Further analysis by the ISD process could reveal that an optimum training media mix should include a new training device.

Essentially, this same process occurs during the early stages of a major weapon system acquisition in that the user ISD personnel and human factors engineers analyze the W/S and target population, identify deficiencies, and subsequently develop training programs with alternative training media packages (43:3). Other ways that needs are developed include obsolescence of existing equipments, cost reduction opportunities, and training technology advances (26:9).

For nonsystem-managed ATD, the need is documented in a Statement of Operational Need (SON) (46:3). This SON should define alternative system concepts "in terms of tasks or events that can be trained in each device [46:3]," and the need should have been developed using ISD procedures (46:3; 43:3; 48:11). After a Major Command (MAJCOM) review, the SON is sent to HQ USAF for validation; and, subsequent to validation by the appropriate authority,

HQ USAF will issue a Program Management Directive (PMD) assigning acquisition authority and additional program direction (47:5). The SPO will usually be ASD's Deputy for Simulators (SIMSPO).

For a system-managed device, the process is similar; however, after the ATD's SON is validated, instead of USAF issuing a PMD for the ATD, the developing weapon system's PMD and other program documents will be amended to reflect the ATD requirement and the weapon system PM becomes responsible for its acquisition (46:5). Then, either the human factors engineers perform additional task analysis using ISD procedures or the task analysis effort is contracted (4; 43:3). Alternative ATD system designs begin to evolve that weigh user prioritized training objectives against cost (4).

At this point, the system-managed and nonsystem-managed ATD are both undergoing similar activities based on and justified by ISD developed training objectives. The nonsystem-managed equipment will progress through the normal 800-series regulations' acquisition process under SIMSPO direction. The system-managed device will undergo a similar process; however, after formal direction to proceed into the demonstration and validation phase, the PM may elect to manage the development or to transfer the management of the ATD development effort to the SIMSPO (1:2).

If the program is transferred to the SIMSPO, the

weapon system PM and SIMSPO will document their respective organizational roles, responsibilities, and procedures in a Memorandum of Agreement (MOA) (1:2). Essentially, the SIMSPO assumes all the management aspects associated with the ATD and will tailor its acquisition program to coincide with the major weapon system's since the ATD must develop dependent on such data as the evolving performance and physical characteristics of the major weapon system as well as its maintenance and operational concepts. In the MOA, the PM will, therefore, define the transfer of data from the major weapon system contractors, users, and SPO, to the ATD's contractors and SIMSPO (1:2).

ATD acquisition programs follow the typical acquisition process. The weapon system acquisition process layers over the ATD process although the weapon system's acquisition is initiated before and ends after the ATD's. Figure 1-6 depicts the time-line for a typical ATD development by SIMSPO, and Figure 1-7 depicts the major data inputs/outputs and processes involved in a typical system-managed ATD acquisition program.

The constraints on the current training system development and ATD acquisition process are:

1. ISD task analysis is not compatible with the current ATD acquisition process.
2. The current process is not designed to encourage iterations of the training analysis to improve the training

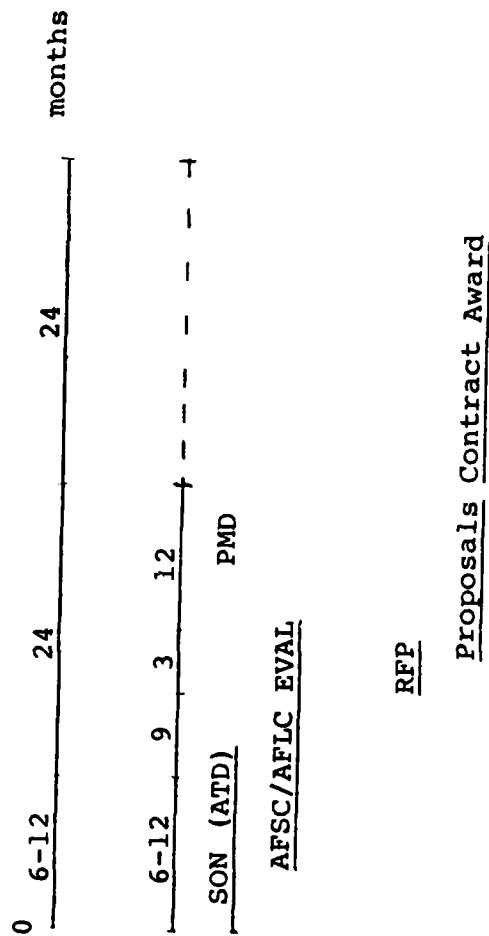


Figure 1-6. ATD Time-line (10).

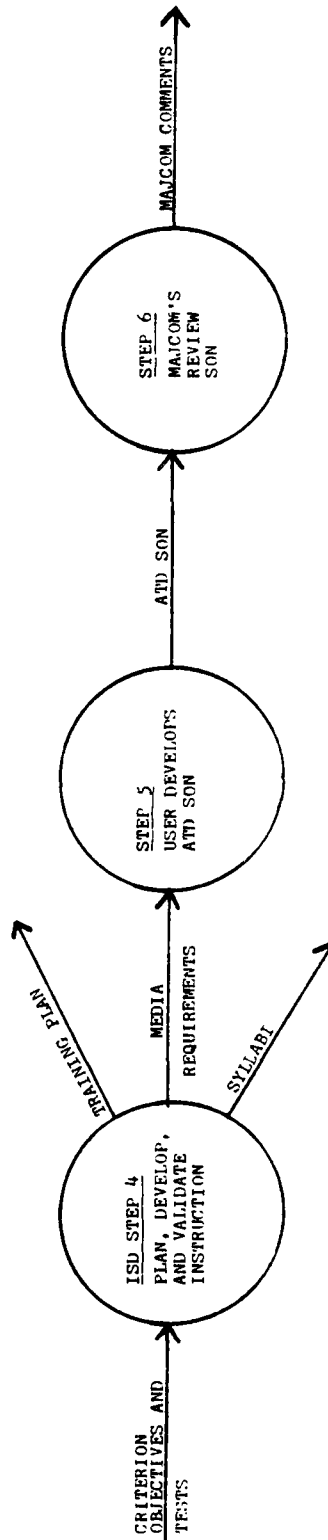
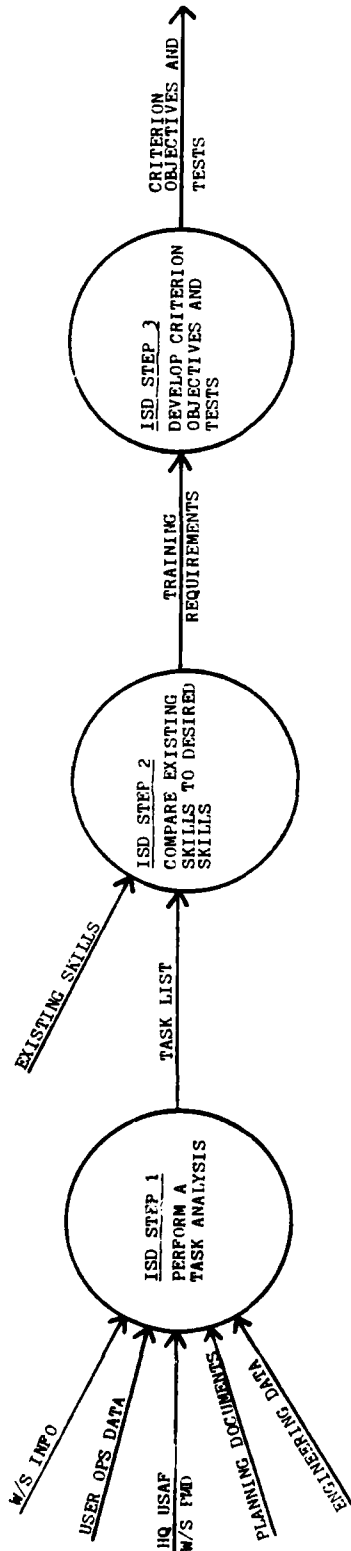


Figure 1-7.  
DFD for ATD Acquisition (Ideal Flow) (1 of 2).

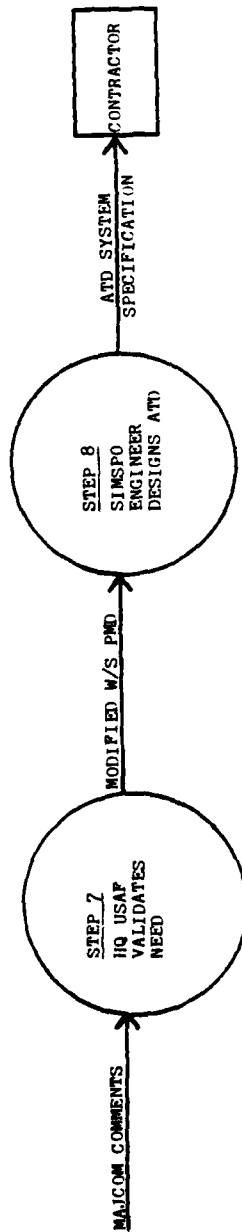


Figure 1-7 (Continued)  
(2 of 2).

system and ATD definition.

3. The current system does not prevent "goldplating" of ATDs with unnecessary capabilities.

4. The current system does not encourage the decision maker to search for optimum training system and ATD configurations.

5. The current system does not deliver ATDs to the user at IOC.

6. The ISD process is not amenable to the time constraints imposed by the weapon system schedule. .

#### RESEARCH QUESTION

What type of structured programming model can be developed that will both enable accurate assessments of ATD requirements early in the acquisition of a major weapon system and be useful for communicating these ATD requirements to the acquisition specification writer and decision maker?

#### SCOPE

This thesis will address the acquisition of Aircrew Training Devices (ATDs), as defined in this chapter. The acquisition of training devices for maintenance has some differences not found with ATD and will not be analyzed as part of this thesis. Further, we will study the acquisition cycle for ATD from the requirements determination process through development of a product specification.

## CHAPTER 2

### METHODOLOGY

We will analyze the current training system and ATD development process, and develop a proposed system model via our modification of Victor Weinberg's structured methodology (52:Ch.4). The modifications enable us to use this processing design methodology for this research. Our methodology consists of eight phases:

1. Problem definition,
2. Description of current system,
3. Criterion definition,
4. Preliminary approaches to problem,
5. Solution overview,
6. Detailed design,
7. Validation walkthrough,
8. Post-evaluation.

This chapter's two sections detail each phase in the methodology and then explain how we will present them in this research project.

#### SECTION 1: CONCEPTUAL FRAMEWORK

In this section, we define each of our methodology's eight phases by reporting the following for each phase: the phase's purpose, major parts, and inputs/outputs (if identified).

PHASE ONE--PROBLEM DEFINITION. Weinberg identified phase one's object and key output as "to identify an existing or anticipated problem [52:291]." In this phase the following subjects are discussed to identify a problem and to lay an information base for the other seven phases:

1. Background data on related topics,
2. Indications of a problem,
3. Problem statement,
4. Constraints associated with the problem.

Inputs for this section come from several sources. The primary source of background information and constraints is Air Force Regulations and publications. Information about indications of a problem comes from interviews, studies, meeting minutes, and regulations. Once we understand background data and the indications of the problem, we focus our attention on describing the current system.

PHASE TWO--DESCRIPTION OF CURRENT SYSTEM. The purpose of phase two is to show how the process should and does operate. It answers the question of how the Air Force identifies and acquires ATDs. A review of ideal and actual (from phase one) processes will identify limitations which prevent the acquisition process from working as it should.

The following areas will be reviewed to describe the current ATD process:

1. Description of ATD acquisition process,
2. Ideal flow of the process information,
3. Comparison with indications of problem (from phase one),
4. Statement of current system limitations.

The limitations on the current system provide the key input to the next phase.

PHASE THREE--CRITERION DEFINITION. The purpose of phase three is to identify the "yardstick"--the criteria--against which to judge alternative, preliminary approaches to the problem solution and our proposed solution. Our definition process starts with the premise that ATDs must be acquired which use design inputs from an ISD-type process very similar to and compatible with Air Force ISD. Our next premise is that the airframe acquisition effort, because of its relative size and resources, is not subject to major changes to accommodate the training and ATD efforts--the tail cannot wag the dog. Next, we assume that if the identified limitations can be eliminated, a new system would equate to an ideal training and acquisition process. Since a perfect solution is improbable, our goal is to ameliorate the identified limitations. Therefore, as Weinberg suggests, we develop criteria that correspond to identified limitations.

Once we establish the criteria, we validate and revise them by using the following procedure. We select

a small group of experts available at Wright-Patterson AFB OH which represent the following areas:

1. ISD analysis/research,
2. ATD acquisition management,
3. ATD acquisition engineering.

In structured interviews we first explain our research topic and problem statement. Next, we present them with the criteria and ask for their comments in the following areas:

1. Are the criteria clear and understandable?
2. Are any major problem areas/limitations missing from the criteria?
3. Are there other comments?

After the interviews, we revise the criteria to reflect these experts' comments.

PHASE FOUR--PRELIMINARY APPROACHES TO PROBLEM. The purpose of phase four is to determine if solutions or ideas which meet our criteria exist in current sources. In this phase we:

1. Identify sources familiar with the problem and/or potential solutions,
2. Report a review of sources,
3. Compare methods reviewed against criteria,
4. Determine if solutions are possible using only existing methods.

The output of this phase would serve one of two

functions. First, if a reviewed method satisfies all criteria it could conceivably solve the problem statement. The second and more probable event is that no method satisfies all criteria, and the method serves as an input to a system model developed by the authors.

PHASE FIVE--SOLUTION OVERVIEW. The purpose of phase five is to begin the system model development and reporting phase. Output is the features of the proposed solution developed by the authors. While the reader must wait until phase six to see the detailed step-by-step model, phase five presents and explains the features that the system contains and how the system model satisfies the criteria.

There are four inputs to phase five. The first input is the criteria developed in phase three. The second input is the methods reviewed in phase four. The third input is phase four's comparison of criteria with reviewed methods. And the fourth input is the knowledge and ideas of the authors.

Using the inputs, the authors develop their proposed system model via the following steps. First, the phase four methods of no use (helped solve no limitation/criterion) are eliminated. Second, a set of method families are established which combine like methods from various articles and sources. Third, method families are identified with training system and ATD development phases,

if possible. Fourth, mutually exclusive and complementary method families are identified. The model building then enters phase six--detailed design. In the thesis' text we place the comparison of criteria and proposed solution after phase six.

PHASE SIX--DETAILED DESIGN. The purpose of phase six is to complete the model development and reporting sequence begun in phase five. The unique aspect of phase six is that the features are represented in DFD form. The inputs come from phase five, and the output is a three-level DFD. The first (summary) level DFD shows the major processes and their inputs/outputs. The next two levels show each process in increasing detail. As suggested by Weinberg, we stop the DFD process when identifiable functions which could be easily assigned to organization units are reached. Following the DFDs and explanation, the model is compared with the criteria.

PHASE SEVEN--VALIDATION WALKTHROUGH. The purpose of phase seven is to subject our system model to the training and ATD development community. We validate our system model with a sample of experts from four functional areas:

1. ISD development/research,
2. MAJCOM liaison,
3. ATD development management,
4. ATD development engineering.

We are able to limit our validation to Wright-Patterson AFB OH because it is the center of aircraft and ATD acquisition, as indicated by the fact that over 50% of AFSC's annual budget is spent by Wright-Patterson's Aeronautical Systems Division. ASD is not only the Air Force's manager of aircraft research and development; but the SIMSPO, an ASD directorate, is charged with Air Force ATD development and acquisition. In addition, MAJCOM liaison offices located at ASD provide the user prospective. Because of the concentration of acquisition activity at Wright-Patterson AFB, it offers an excellent location for the validation walkthrough. We insure a degree of interviewee expertise by defining an expert as a person who meets at least one of the following standards:

1. A published author in the fields of training or ATD development,
2. An incumbent in a training or ATD development job for at least one year,
3. A masters degree or higher in fields related to training or ATD development.

We decided that a structured interview best met our needs and developed the following procedure. After introducing ourselves and our research topic, we ask the interviewee to rate the current Air Force training and ATD development system using a set of prepared statements and Likert five-point scales. Next, we review our proposed

system (draft of Chapter Four) with the interviewee and ask him to rate the system using the same set of statements and Likert scales. Finally, we ask the interviewee for general comments about the system and criteria.

The statements are written and validated in the following manner. At least one statement per criterion is composed with a Likert scale following each question (39:325-326). The statements are validated by the expert opinion of members of the Air Force Institute of Technology (AFIT) faculty.

The prime objective of our validation walkthrough is to record opinions of experts representative of the Air Force training and ATD communities. We will ask Mr. Robert E. Coward, Special Assistant, Deputy for Simulators, to recommend a list of experts that, in his opinion, meet our standards. We feel that Mr. Coward is objective in his recommendations because (1) his unique position as Special Assistant, he is outside the management chain; (2) he is organizationally independent of the other areas in which we will seek recommendations. We select Mr. Coward as our expert in the area of ATD management based on his credentials, and only ask him for experts in the other three areas, and because of his extensive experience in ATD acquisition and participation in training and ATD seminars, Mr. Coward is acquainted with a large portion of the experts in the field.

After the interviews, we test the following hypothesis for each statement/criterion:

$H_0$ : The training and ATD development system proposed by the authors shows no improvement over the current Air Force training and ATD development system.

$H_a$ : The training and ATD development system proposed by the authors is a significant improvement over the current training and ATD development system. Stated mathematically:

$$H_0: U_x - U_y \leq 0$$

$$H_a: U_x - U_y > 0$$

where:  $U_x$  = mean score for the proposed system

$U_y$  = mean score for the current Air Force system

(28; 53:450-452).

The hypothesis is tested with a Paired Sample T-Test. The paired scores for the interviewees are used to develop a t-statistic using the following equation:

$$t = [\bar{D} (n^{\frac{1}{2}})]/s_D$$

where:  $\bar{D} = \frac{\sum_{i=1}^n (X_i - Y_i)}{n}$

= the mean of the differences between the paired scores.

$X_i$  = i th score for the proposed system

$Y_i$  = i th score for the current Air Force system

$n$  = the sample size

$s_D$  = the standard deviation of the difference between the paired values using the  $n-1$  method.

The Texas Instruments, Applied Statistics Solid State Software module, program number 13 (t-Statistic Evaluation) is used for the t-statistic computation (38:4-12 to 4-15). The null hypothesis rejection region is set at the 90% confidence level with  $n-1$  degrees of freedom (53:450-452).

PHASE EIGHT--POST-EVALUATION. The goal of phase eight is to successfully conclude the research effort. The chapter's objectives are to draw final conclusions about our system model and to make recommendations. Our first objective is to make final conclusions and recommendations. Our second objective is to discuss, in general terms, implementation based on our perceptions of the current Air Force and training environments. Our third goal is to identify areas needing continued research.

## SECTION 2: INTEGRATION OF PHASES INTO CHAPTERS

Our research project is our exercise of the eight-phase methodology. The chapter and phase arrangement, and rationale are discussed. There are six chapters:

1. Chapter One--Introduction. We include phases one (Problem Definition) and two (Description of Current System) in this chapter. Our objectives for the chapter is for the reader to understand:

- A. That a problem exists,
- B. The current environment (or background) which includes ISD, W/S, and ATD acquisition,
- C. That Structured Analysis is an orderly method to solve complex problems,
- D. That the current, actual ISD/ATD development faces limitations which cause problem indications.

2. Chapter Two--Methodology. No phases are in this chapter, but the chapter is vital to the research. Our objective for the chapter is for the reader to understand:

- A. Each phase of the structured methodology,
- B. How the chapters and phases are arranged.

3. Chapter Three--Initial Research and Findings. We include phases three (Criterion Definition) and four (Preliminary Approaches to Problem) in this chapter. Our objective for the chapter is for the reader to understand:

- A. The criteria--how they are developed, what they are, and how they are used/graded;
- B. The current knowledge in the area--its sources, contents, and comparison with the criterion.

4. Chapter Four--Model Building. We include phases five (Solution Overview) and six (Detailed Design) in this chapter. Our objective is to present our model and compare it with the criteria.

5. Chapter Five--Validation Walkthrough. We

include phase seven (Validation Walkthrough) in this chapter. Our objective is to determine the validity of our model based on expert opinion.

6. Chapter Six--Conclusions and Recommendations. We include phase eight (Post-Evaluation) in this chapter. Our objectives are to draw final conclusions and to recommend an implementation plan and further research.

### SECTION 3: RESEARCH OUTPUTS

In this section, we summarize the research products. There are three outputs of this research:

SYSTEM MODEL. We present a proposed system model for training and ATD development for emerging W/Ss. First, we present the features which are imbedded in the system model. Second, we present the logical processes needed to develop training and ATD systems.

VALIDATION WALKTHROUGH. We then present the validation results for our system model. The result will indicate if training and ATD development experts feel our system model is or is not an improvement over the current Air Force system.

CONCLUSIONS AND RECOMMENDATIONS. We then present our final conclusions on the training and ATD development system, make general implementation recommendations, and suggest areas needing additional research.

## CHAPTER 3

### INITIAL FINDINGS AND CONCLUSIONS

Having completed phases one and two in Chapter 1 and having developed our methodology in Chapter 2, we continue through the structured methodology in Chapter 3 by, first, defining our research criterion -- phase three. Second, we report on preliminary approaches to problem solution -- phase four. Third, we make some initial conclusions about the preliminary approaches.

#### SECTION 1: PHASE THREE--CRITERION DEFINITION

As described in Chapter 2, Weinberg recommends that criteria be developed using the following sequential process:

1. Identify and gain an understanding of the problems with the current system.
2. Transform the problems into system limitations. This is not a one-to-one process since a system limitation may represent more than one problem and vice versa.
3. Finally, because these limitations are causing systemic problems, the prime objective of the system design effort is to eliminate these limitations (see Research Objectives in Chapter 1). Therefore, define criteria that, when met, eliminate or ameliorate the limitations. The same is true about criteria and limitations that is true about limitations and problems: the transformation

from limitation to criterion is not one-to-one but represents a mental process that enhances the conceptual understanding of the system.

The following are the six criteria based on the problems and limitations identified in Chapter 1. We will use these criteria to evaluate both the potential solutions in Section 2 of this chapter and our own system model in Chapter 4:

1. Criterion: The system output must produce ATD requirements for an emerging weapon system based on the information available at the time the analysis is required. Explanation: This means that the system must identify ATD functional needs based on the data available in the conceptual and validation phases and early in the FSD phase of the W/S development program. If uncertainties exist with the W/S data, then the ATD need must address these uncertainties. The main point here is that the ATD need identification cannot and should not be delayed until the FSD phase of the W/S is completed and the W/S data is firm.

2. Criterion: After the initial iteration of ATD requirements, the system must revise/improve the ATD requirements as new information becomes available. Explanation: If an ATD is functionally defined prior to the W/S data being frozen, then we run the risk of delivering an ATD that does not replicate the fielded W/S. Therefore, as the data changes, the ATD definition must change in those

areas that would limit the training effectiveness of the device.

3. Criterion: The system must produce ATDs with only those capabilities essential to training identified tasks (i.e., prevent "goldplating"). Explanation: We define "goldplating" as knowingly designing an ATD which has excess capabilities and is excessively expensive. It is a hedge against the uncertainty of ill-defined requirements and must be eliminated.

4. Criterion: The system must aid ATD acquisition decision makers (for example: user, W/S SPO, and SIMSPO) with cost/capability/tasks-trainable tradeoffs. Explanation: The current system does not encourage the search for the optimum mixture of ATD cost/capability/tasks-trainable. A system must encourage the decision makers to evaluate numerous ATD mixtures and to select the optimum ATD.

5. Criterion: The system must improve the probability of ATD delivery at IOC or earlier than the current system. Explanation: Assuming that to meet the W/S IOC with training devices is desirable and recognizing the fact that it is mandated by regulation, the training ATD acquisition system must enable the delivery of training effective ATDs prior to the IOC of the W/S.

6. Criterion: The system must shorten the time between the start of W/S analysis and completion of final ATD requirements. Explanation: Training experts claim that

the time to complete the ISD process is relatively fixed, but if the ISD process can be streamlined, it will better fit the current W/S acquisition process.

## SECTION 2: PHASE FOUR--PRELIMINARY APPROACHES TO PROBLEM

The following are potential sources of data and serve as major subsections:

1. Military services' ATD communities,
2. Military study offices/labs,
3. Reports/studies contracted by the services,
4. Other articles/papers.

MILITARY SERVICES' ATD COMMUNITIES. Both the Army and Navy have ATD acquisition functions. TDY visits to the Naval Training Equipment Center (NTEC) and the Army Aviation Center were undertaken and are reported here. While Naval ATD acquisition is centralized at NTEC and one TDY provides a complete view of their process, Army ATD acquisition is decentralized (both in location and command function) and one TDY plus three articles are necessary to give a complete view of the Army process.

Army Aviation Center. The current Army ATD development program is smaller and less developed than the Air Force's ATD development program. This is not surprising, nor necessarily bad, since aviation is only one of many functions assigned to the Army (examples of other functions being infantry, armor, airborne, etc.). In addition, while Air Force aircraft are "center stage" in our operations,

Army aviation units are subservient to their proponent commands. For example, the UH-60A helicopter's mission is to support the infantry.

The current Army "Life Cycle System Management Model" does include training and ATD development as part of W/S development, but actual practice faces three problem areas. First, there is no unifying force behind ATD development. That responsibility is spread over three commands (Training and Doctrine, Army Material Development and Readiness, and the field commands) and various agencies (34:7; 14). Second, in some cases a systematic training development effort is not adequate due to time/money/management constraints (34:8; 14; 18:3-4). Third, the training subsystem is lumped in with other logistics activities while some interviewees felt that training should be separate (14).

A brief review of the Army ATD procurement system reveals that:

1. ISD principles are directed to be used,
2. Desired and actual activities are not possible because of time/money/management constraints,
3. There is a three to five year gap between IOC and simulator delivery (for example, the UH-60A's IOC was May 1979 and ATD operational tests are not scheduled for completion until mid-1982) (16; 27:496-499; 34:7-9),
4. Additional study is needed/desired (18:4).

Naval Training Equipment Center (NTEC). The Navy training device acquisition process, like the Air Force's, begins with a training deficiency, training problem, or need for devices to support an emerging weapon system (51:2). NTEC then performs a Training Situation Analysis (TSA). The TSA can take three forms (17):

1. ISD analysis: This formal process is used to identify training media when no predetermination has been made what media are actually needed to support the instructional program.

2. Training Situation Analysis with Prerequisites: This formal process is used to identify the training media when the segment of training to be addressed is firmly identified. It differs from an ISD analysis because this approach does not require a task analysis.

3. Front End Analysis (FEA): This is not a formal approach but requires "inventiveness and initiative by the analyst [50:2]." The user has either identified the need for a specific type of medium or has identified a specific segment of training that needs to be addressed. The three processes recognize that different situations require varying degrees of analysis and expenditure of resources and time.

The output of a TSA is a functional description of the device/media needed. The functional description is then refined by the project team (training specialist, design

engineer, Integrated Logistics Support manager) through further analysis. Four documents conclude the steps of this process (50):

1. Functional Statement (FS): This is a brief, concise statement of a device requirement that documents the desired behavioral objectives and device physical and functional characteristics. This document receives user/NTEC review.

2. Functional Description (FD): This document builds on the FS by providing additional specificity and performance parameters. This document must receive user/NTEC approval before proceeding.

3. Mini-Military Characteristics (Mini-MC): This document builds on the FD by providing for more detailed functional requirements and addressing ILS. The Mini-MC becomes the source document for the Mini-design effort. User/NTEC approval concludes this step.

4. Detail Military Characteristics (Detail MC): This document adds additional detail to the device functional and physical specifications. It becomes the source document for the design of the device and receives user/ISD review.

The Navy process has two noteworthy strengths. First, the review of each document by users and ISD personnel is conducted to reduce the probability of a disjoint between the item that is finally delivered and the device

that the training program needs. Second, this review is facilitated by the collocation of ISD personnel and project engineers on the same base.

MILITARY STUDY OFFICES/LABS. This subsection reviews the military supported study offices and laboratories. The services' study offices/labs are:

1. U.S. Air Force Human Resources Laboratory (AFHRL), Brooks AFB TX.

2. U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Field Unit, Fort Rucker AL.

We limit our review in this subsection to papers written by office/laboratory members.

Cream, Eggemeier, and Klein. The Cream, et al, article discusses several issues related to ATD design. The issues of most interest to us were defining training requirements and determining ATD capabilities based on training requirements.

This article proposes "an integrated system development process involving users, training psychologists, and simulation engineers [6:146]." This is accomplished by the coordinated efforts of the three groups with the training psychologist coordinating group activities. The group's activities are:

1. Initiate task analysis with a complete stimulus--response (S/R) listing for each control and display.

2. Determine ATD capabilities to support the trained tasks.

3. Rate each task by three dimensions: criticality, frequency, and difficulty of performance (C/F/D). Then delete uniformly low ranked tasks and keep uniformly high ranked tasks.

4. Review remaining tasks which received mixed C/F/D ratings. The relative importance of each factor is weighted.

The authors briefly mention emerging weapon systems. They identify lack of weapon system knowledge as a problem and suggest basing data on existing equipment and tasks. However, they do not present a specific methodology for the emerging W/S (6:146-148).

Finally, the authors discuss the impact that training requirements have on ATD capabilities including: fidelity decisions, performance measures, instructional capability, and crew coordination.

Army Research Institute. The ARI Field Unit, Fort Rucker AL, provides the Army Aviation Center with studies and research related to aviation training. When asked to study training requirements for new helicopters, ARI awarded/supervised a contract to analyze operator's task and training requirements. The contract Statement of Work (SOW) for the mission analysis identifies a five step process to develop training requirements based upon the pro-

jected use of the aircraft and preliminary equipment lists.

The ARI process is to:

1. Develop mission profiles showing how each major equipment system is employed throughout the missions and mission segments.

2. Identify and characterize, for each mission segment, equipment use in terms of operator-equipment functional interactions.

3. Allocate equipment operation functions between and among crewmembers to achieve optimum workload and performance outcomes.

4. Conduct detailed analyses of all tasks and task performance elements for each crewmember in each system.

5. Analyze training requirements for each crewmember in each system.

The end result of the analysis is a set of training objectives based on information available early in the weapon system acquisition. Essentially, this procedure is ISD with a synthetic task analysis. The final report of this project is due in January 1983 (41). The basis of this type of process is also found in a NATO study, discussed later.

REPORTS/STUDIES CONTRACTED BY THE SERVICES. Numerous studies have been contracted to private firms by the services to study/report on aspects of ATD acquisition and training. We review those reports which are germane to our

research.

Wallace W. Prophet. In 1966, Wallace W. Prophet, Director of Research of George Washington University's Human Resources Research Office (HumRRO), Division No. 6 (Aviation) presented a paper on the importance of training requirements in the design of ATDs. We note that HumRRO was a major source of information for Army aviation training in the 1960s and 1970s. Mr. Prophet's thesis is that the full potential of ATDs is not being realized because of poor design procedures (31:1).

The author contends that better ATDs are possible if:

1. Training devices should be built only after careful analysis of the training requirements.
2. Analysis of training requirements should be primarily psychological, rather than engineering in nature.
3. Determination of device characteristics should be oriented toward providing task fidelity, with physical fidelity being provided only as necessary to task fidelity.
4. Synthetic training programs should receive as careful consideration in their development as do the trainers themselves.
5. Devices and synthetic training programs should be tested for training effectiveness just as aircraft are tested.
6. Training devices and simulators can provide an effective means of reinforcing infrequently occurring behaviors [31:8].

We include Mr. Prophet's paper because:

1. it confirms that the ATD problem has been known

for many years.

2. the answers to the ATD acquisition problem proposed by Prophet are echoed in recent studies.

3. it appears that implementation of solutions is the most difficult aspect of the problem.

STREDS Report. The Simulator Training Requirements and Engineering Design Study (STREDS) written by Technology Incorporated is an example of current research in training and ATD acquisition.

The purpose of this study was to develop improved methods for Front End Analysis of training requirements and environmental cues in a data system format which could be translated into engineering performance specifications [40:ii].

In two additional reports, Technology Incorporated will take the STREDS technique from the theory of this first report to an experimental application with an emerging W/S.

STREDS presents a revised ATD acquisition process which will output ATD requirements in time to meet IOC via three phases (Figure 3-1).

The Initial Requirements Format (IRF) provides general policies, training requirements/objectives, and goals. The User Requirements Format (URF) is "a detailed statement of the trainer configuration which MAJCOM desires to meet." An Engineering Design Format (EDF) is the specification given to the vendor (40:2). Of particular interest is the iterative process used to involve the user and SIMSPO in

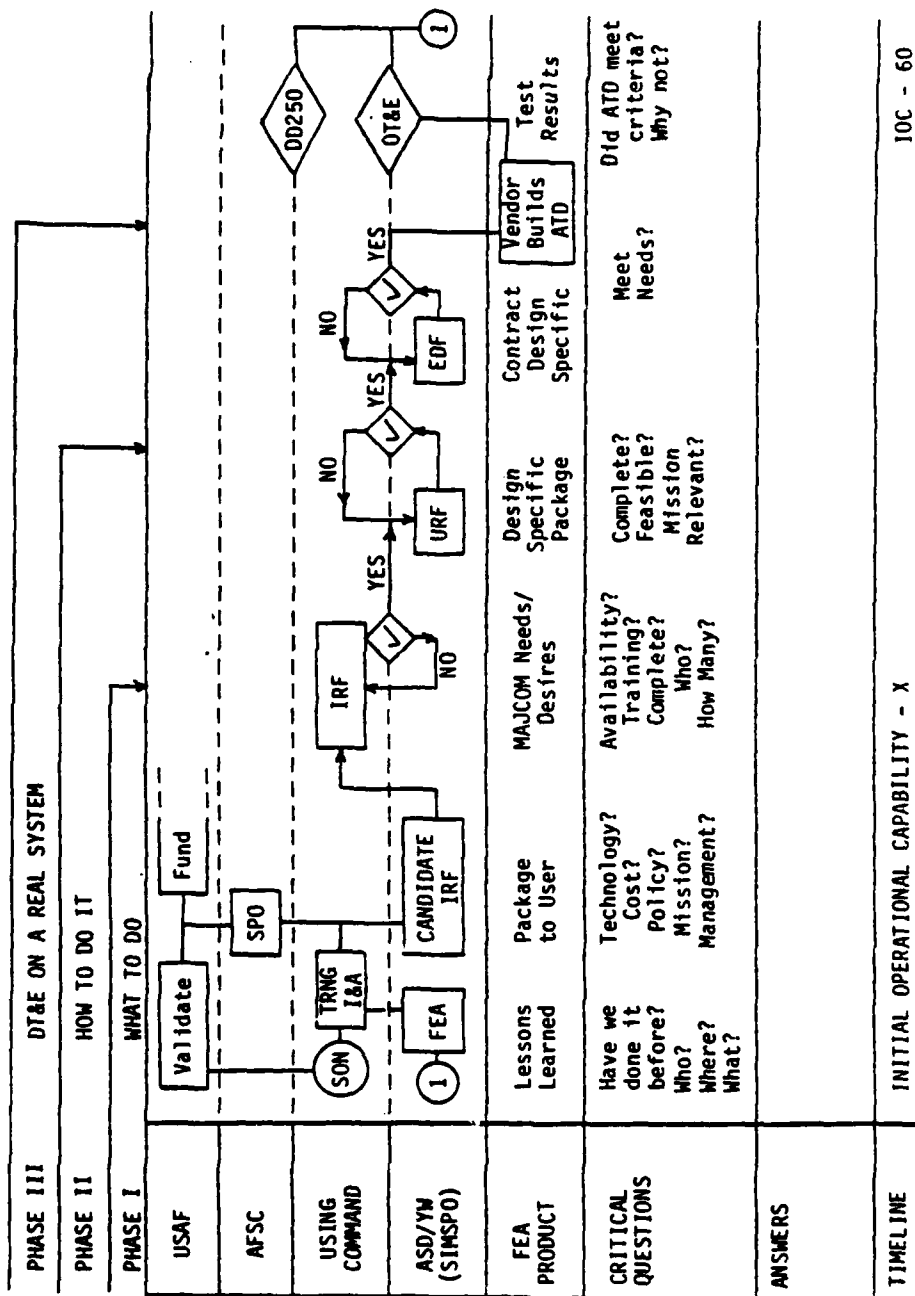


Figure 3-1.  
STREDS' ATD  
Acquisition Process (40).

each phase of specification development.

LOGICON Letter. The LOGICON letter to the B-1B SPO is a discussion of this company's training system development concepts. Points of interest are:

1. Given current ISD procedures and regulations, it is "a practical impossibility" to have a training system on-line before IOC (7:5).

2. Current training equipment design frequently precedes training material development which causes the training program to conform to equipment capabilities.

3. Pieces of training equipment are defined in isolation from other parts of the training program "instead of as an integrated subsystem [7:4]."

4. Training programs should be designed as an "Integrated Training System" (TS) where all parts of the system are developed concurrently (7:2).

5. The TS consists of the Training Management System (TMS) and the Training Plant (TP). The TMS function:

... is to govern the workings of the training plant such that the actual student output ... meets the desired student output ... and that the actual resources consumed ... is equal to or less than the desired resource consumption [7:3].

The TP consists of the components shown in Figure 3-2.

Its function is to conduct and support the training process.

6. "... the basic conceptual sequence of ISD as shown in ... [Figure 3-3] must be preserved and followed [7:5]."

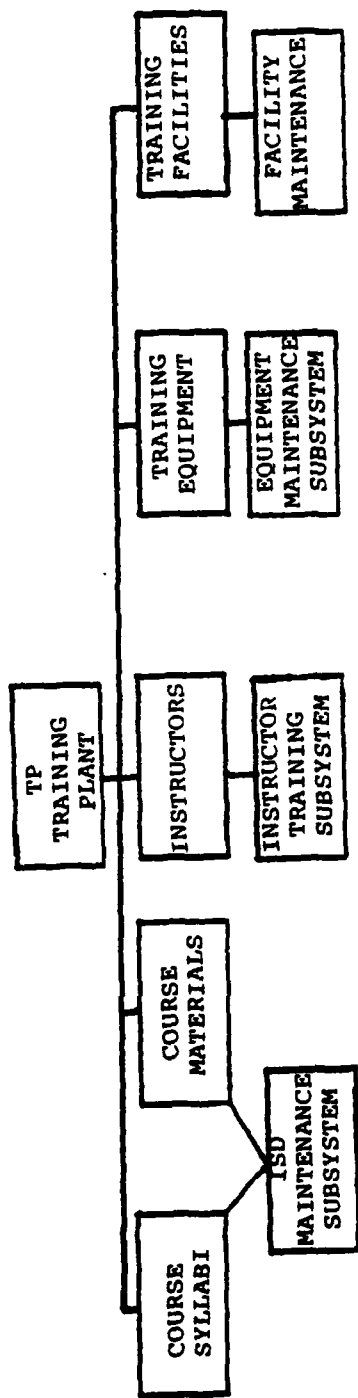


Figure 3-2. Components of the Training Plant (7:Fig.2).

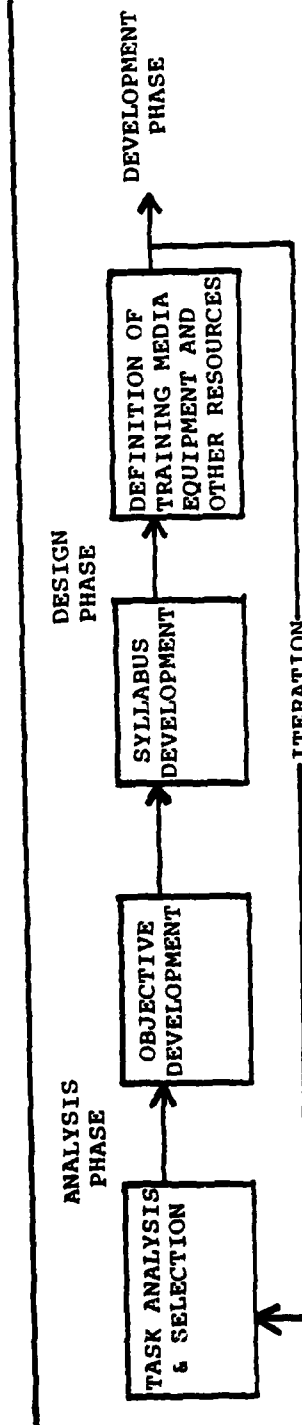


Figure 3-3. Condensed, Partial Representation of the ISD Process (7:Fig.5).

7. The iteration aspect of ISD is commonly overlooked (7:6).

8. LOGICON summarizes:

The point is, that it is possible to preserve the conceptual integrity of the ISD process and to adapt it to the time constraints imposed by the weapon system procurement schedule, if (and only if) a top-down design approach is used which proceeds in iterative steps from a MACRO to a MICRO level of definition. The result that can be expected from such a method is an efficient and integrated TS [integrated training system] design and early implementation [7:7].

9. For a given training requirement, there are "always numerous feasible solutions" (i.e., different versions of training systems and ATDs),... "the optimal solution for a given set of training program constraints can fairly easily be selected from these alternatives, once they are made explicit [7:7]." They continue:

Unfortunately however, current ISD procedures do not emphasize the generation of multiple feasible training system or training system component configurations. The remedy is simply a matter of requiring multiple configurations and a subsequent cost-benefit analysis. Contrary to intuition, this requires very little extra effort, since training system system design should, according to 3.2, proceed in stages from MACRO to MICRO. At the MACRO level it is fairly easy to generate alternative solutions since one is not forced to deal with huge amounts of detail information. As decisions are made in subsequent stages the number of alternatives gets constrained very rapidly, but always with the reassurance that all feasible possibilities have been investigated and that alternatives were not eliminated prematurely [7:8].

10. Improve the probability of a successful training system by using only "genuine professional expertise," since ISD cannot be reduced for the "non-expert [7:8]."

Hritz and Purifoy Study. The Hritz and Purifoy study on Air Force maintenance simulator design and acquisition includes items germane to our research. They present three possible methods to compress the ISD process. They introduce their solutions with:

Throughout the project several problem areas continually emerged ... Thus, in this section of the report these problem areas are addressed along with recommendations and areas for future research [20:68].

The report's first solution states:

It is perhaps reasonable on the surface to suggest that more manpower be made available to perform the ISD analysis ... It is intuitively appealing ... However, it should be recognized that the ISD analysis is dependent upon the availability of the data base [20:68-69].

Therefore, extra people are not useful, unless weapon system information is available. Thus, improved information availability is a possible solution.

The second solution suggests slipping the simulator delivery date. Their discussion is based on maintenance training, but the concept may be applicable to other training situations such as aircrew training:

It has been suggested that one way to increase the time available to perform the ISD analysis is to use actual equipment during the conversion training rather than the maintenance trainer. Using actual equipment during the conversion training would give the ISD analyst more time to design the maintenance trainer [20:69].

This solution is based on three assumptions. First, the study reports that seven-level personnel, the skilled

technicians, are the first workers to receive training in new weapon systems. These skilled technicians are familiar with similar systems and would not need the simulator. Second, actual, equipment would be available for training. Third, three-level, apprentice maintenance technicians are the only trainees who require the simulator. This suggestion gains about a year for completing the ISD analysis. The report suggests further study to determine if seven-level technicians could, indeed, be trained on actual equipment (20:69-70).

The third solution reports two methods to compress the ISD process. The first method would modify the ISD process by relying on more detailed behavioral analysis of the target population, rather than skill and knowledge levels. The second method would reduce the documentation effort via word or data processing (20:70).

OTHER ARTICLES/PAPERS. The last source of data is articles and papers from various publications.

Douglas Aircraft. In an article written by members of Douglas Aircraft Company's Human Factors Engineering function, an argument is advanced to allow the prime airframe contractor to conduct all ISD activity. The main argument for this method is early and easy information availability:

He [the contractor] has immediate access to all the prerequisite technical data and documentation. ISD can be integrated with system engineering and delivery schedules for the air vehicle. His subject matter experts (SMEs) will be system engineers and test pilots with detailed knowledge of system components and operations. He has access to SMEs from the outset, hence facilitating his ability to complete early analysis of system requirements. These capabilities, combined with the requirements for a total systems approach, logically argues that the system and all its constituent elements should be derived from a common source -- the prime contractor [37:208].

The article concludes that ISD/ATD development by the prime contractor is the best method based on the current weapon system acquisition environment (37:207).

NATO Report. NATO established the Advisory Group for Aerospace Research and Development (AGARD) "to bring together the leading personalities of the NATO nations in the field of science and technology [30:ii]." Working Group Ten's objectives were:

1. To review the scope and effectiveness of current simulators.
2. To review technologies and human behavior important to flight simulation.
3. To identify areas needing increased research (30:iii).

AGARD Report number 159 focuses attention on a "framework for the logical selection of training simulator facilities with guidance for making the various tradeoffs" and "address[es] the question of how much fidelity is required to train a given flight phase in isolation [30:2]."

The report suggests a method to develop the requirements for ATDs (Figure 3-4). The method assumes that the missions of an aircraft can be identified. Further, each mission can be split into flight phases (FPs). Once you identify the flight phase, the vital question becomes what ATD capabilities are needed to support each FP (30:2).

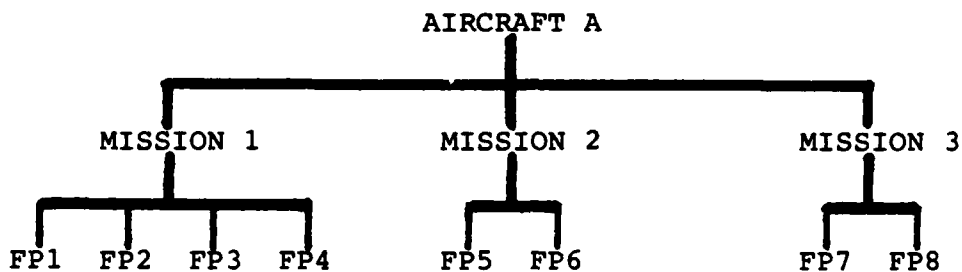


Figure 3-4. Breakdown of W/S use into Missions and Phases.

The report suggests that for each FP, the ATD capability depends "on at least pilot experience/background and the instruction technique used [30:2]." The report continues that there is difficulty in defining the ATD capability that is tied to each FP because of insufficient knowledge of human physiology and the fidelity levels needed to meet task cue requirements. To compensate for these shortcomings, the current procedure is to simply specify the maximum or best

ATD capability available (30:2-3). The authors saw the lack of research in required fidelity as a major roadblock to the ATD requirements process.

Among the recommendations/conclusions presented are:

1. Training objectives should drive ATD design requirements (i.e., the tasks or FPs the ATD is intended to train).

2. Fidelity requirements are also dependent on the training objectives.

3. Cue requirements for specific training objectives require additional research.

4. Additional research is needed in several areas including the procedure to bridge the gap between converting training objectives into ATD capabilities (30:11-12).

Carlucci Pre-Planned Product Improvement (P<sup>3</sup>I) Letter.

This change to the acquisition process set forth by Frank C. Carlucci, The Deputy Secretary of Defense is reviewed because it:

1. represents the future environment in which ATD acquisition would take place. P<sup>3</sup>I references are added to DOD Directive 5000.1, Major System Acquisition (49:2).

2. presents an alternative ATD acquisition strategy for consideration.

In his July 6, 1981 letter entitled Improved the Acquisition Process Through Pre-Planned Product Improvements,

Deputy Secretary Carlucci "directed an evolutionary and lower technological risk concept of ... P<sup>3</sup>I be implemented as a means of reducing unit costs and decreasing acquisition time [3:1]." We briefly review the P<sup>3</sup>I process here.

P<sup>3</sup>I is a modification to current acquisition strategy. Where current acquisition strategy tries to have a full-capability system designed for production, P<sup>3</sup>I uses "the orderly, time phased introduction of incremental system capability to accommodate projected changes in threat or to reduce risk in initial fielding of the system [3:3]." Specifically, P<sup>3</sup>I has initial units contracted which have only partial capability, but with provisions for future modifications which would increase unit capability as the need and the technology become clarified (3:2).

The objectives of P<sup>3</sup>I are:

- shorten the acquisition and deployment time for a new system or an incremental capability;
- reduce overall acquisition and operating and support costs;
- extend useful life of equipment;
- combat military obsolescence;
- accomplish orderly growth from initial to mature system reliability; and
- reduce logistics and support problems entailed with new material introduction [3:2].

While P<sup>3</sup>I is still in its infancy, the concept may be of use in our research project.

Schilling's Article. An article written by David Schilling presents a planning methodology which may complement P<sup>3</sup>I. He presents a strategic facility planning methodology that enables decision makers to delay decisions on final facility configurations for facility systems which require several years to complete. The decision maker defines alternative facility configurations based on a number of possible future environments. These options are defined in a way that maximizes the number of common facilities between options. The common facilities are built first. Then, as additional information becomes available, the decision maker selects the correct configuration for the most likely future environment. Schilling calls this process strategic scenario planning.

This concept can be useful for the acquisition of ATDs for emerging weapon systems. Instead of alternative facility configurations, the acquisition/training community identified alternative training systems based on foreseeable weapon system configurations and operations, maintenance, and training concepts. The idea is to define ATD capabilities to be incorporated into the initial ATD designs and delay decisions on some subsystems, which are subject to the greatest uncertainty, until more information

becomes/available. If P<sup>3</sup>I becomes a viable alternative for ATD procurement, then the additional ATD subsystems are added as the information becomes more certain (33:1-14).

Generic Data Bases (GDBs). We review generic data bases because:

1. NTEC conducted research over several years and feels GDB has some utility.
2. ASD/SIMSPO expressed interest in GDB use.
3. Current literature states that GDB use provides real advantages during ISD-type analysis in an environment where analysis is so constrained by time or money that a traditional ISD task analysis is not yet possible.

A well-designed GDB can place training system development years ahead of a traditional ISD development approach. Traditional ISD task analysis assumes that every new system is unique; therefore, there is no prior task knowledge; and a complete task analysis is essential. GDB, on the other hand, assumes that if there are similarities or links between existing and future aircraft, and if you identify the links; you can develop a generic task list without a formal task analysis and complete up to 75% of the project's task analysis before the first aircraft is built (36:298). Another estimate, attributed to ASD engineers, claims a GDB task capability of up to 95%; we feel this may be optimistic (4).

Mulligan and Funaro of NTEC envision an inter-

service information system with a computerized GDB which includes information about aircraft, missions, tasks, etc. They suggest three GDB versions. The first includes only a generic task listing; the second adds generic behavioral objectives to each task; and the third adds generic media data to the generic task and behavioral objectives. They argue that as the data base increases in capability, the specificity of the outputs increases to the point where the ATD capabilities are produced relatively quickly (29:23-40).

Smith and Murray also discuss generic training development in their report on Computer Aided System for the Development of Aircrew Training (CASDAT). They feel that their generic and computer approach offers "significant potential" over more traditional approaches--even those which used data or word processing, primarily because of its generic aspect. Their model provides computer and generic aid to each step of ISD-type training system development. Their steps are:

1. Task analysis
2. Behavioral objectives
3. Syllabus and media selection
4. Lesson specification

The building of the task list is of special interest.

Smith and Murray claim that their process can identify about 75% of all operator tasks. They start their process by building a data base of current aircraft

task statements which are reduced to their fundamental parts. Once the data base is developed, "common task structures" for "all types of aircraft" are identified. The authors continue task refinement by using additional aircraft dimensions such as mission and weapons configuration to identify ever more specific task statements (36:297-302).

### SECTION 3: PRELIMINARY CONCLUSIONS

In this section we compare the items of the literature/research review with the criteria stated in Section 1 and make initial conclusions. We summarize the comparison results in Table 3-1 and table notes. Because the subject matter is non-quantitative, we rely on our judgement for the comparisons. Clarifying information/comments are provided in the notes to the table. The key to the table's symbols are:

1. Plus(+): In the authors' judgement, the method clearly exceeds the current Air Force method (ISD) for that criterion.

2. Minus(-): In the authors' judgement, the current Air Force method clearly exceeds that method for that criterion.

3. Zero (0): In the authors' judgement, the article and current Air Force method are comparable for that criterion.

4. Blank( ): The article does not address or does not provide sufficient data for that criterion.

| Criteria (Ch.2, Sec.1)                          |                      |                         |                      |                          |                                |                             |
|-------------------------------------------------|----------------------|-------------------------|----------------------|--------------------------|--------------------------------|-----------------------------|
|                                                 | 1. Info availability | 2. Iteration to improve | 3. Aids in tradeoffs | 4. Meets delivery req's. | 5. Only essential capabilities | 6. Shorten analysis process |
| Article                                         |                      |                         |                      |                          |                                |                             |
| Military Services                               |                      |                         |                      |                          |                                |                             |
| -Army Aviation Center <sup>1</sup>              | 0                    | 0                       |                      | -                        |                                | 0                           |
| -Naval Training Eqp. Center <sup>2</sup>        |                      | +                       | 0                    | 0                        | +                              | 0                           |
| Military Study Offices/Labs                     |                      |                         |                      |                          |                                |                             |
| -Cream, Eggemeier, & Klein <sup>3</sup>         | 0                    | +                       | +                    | 0                        | +                              | 0                           |
| -ARI <sup>4</sup>                               | +                    |                         |                      | +                        | 0                              |                             |
| Contracted Studies                              |                      |                         |                      |                          |                                |                             |
| -Wallace W. Prophet <sup>5</sup>                |                      |                         |                      |                          | 0                              | -                           |
| -STREDS <sup>6</sup>                            | +                    | 0                       | 0                    | +                        |                                |                             |
| -LOGICON <sup>7</sup>                           | +                    | +                       | +                    |                          |                                | +                           |
| -Hritz and Purifoy <sup>8</sup>                 |                      |                         |                      | +                        |                                |                             |
| Other Articles/Papers                           |                      |                         |                      |                          |                                |                             |
| -Douglas Aircraft <sup>9</sup>                  | +                    | +                       |                      |                          |                                |                             |
| -NATO Report <sup>10</sup>                      | +                    |                         |                      |                          | 0                              |                             |
| -Carlucci P <sup>3</sup> I Letter <sup>11</sup> | +                    | +                       |                      | +                        |                                | -                           |
| -Schilling's Article <sup>12</sup>              |                      |                         |                      | +                        | +                              |                             |
| -Generic Data Base <sup>13</sup>                | +                    | +                       |                      |                          |                                | +                           |

NOTE: Explanatory notes follow.

Table 3-1.  
Summary of Comparison with Criteria.

<sup>1</sup>While Army Aviation does have a rational and methodical ATD selection process based on ISD, "real world" considerations (for example, see Hofer) reduce its effectiveness to no better than current Air Force acquisition. The major negative factor is late ATD delivery dates.

<sup>2</sup>The Navy's process has two strengths worth noting. First, the iterative review of the developing functional/physical item description by ISD and user personnel reduces the probability of a disjoint between the item that is finally delivered and the device the training program needs. Second, the review process is facilitated by the collocation of ISD personnel and project engineers.

<sup>3</sup>The Cream, Eggemeier and Klein article provides numerous, excellent ideas which, if operationalized, could be better than current ISD procedures. Our only negative comments are the scant attention given to emerging weapon systems and what appears to be the long time to accomplish the analysis.

<sup>4</sup>The advantages of the ARI SOW are that it presents a rational method for building an initial task analysis very early in the weapon systems' development and it could improve the probability of an ATD delivery by IOC. This process is essentially ISD with an artificial task analysis. The result of ARI's efforts will not be known until early

1983, but the effort is noteworthy.

<sup>5</sup>The Prophet article is included not as a possible solution source, but because it cogently states ATD acquisition problems as of 1966 which have yet to be solved.

<sup>6</sup>We note that STREDS is only the first of three reports and, as such, many of its assertions are not supported. The most positive aspect of the report is their proposed use of a generic data base. If successfully implemented, the ATD generic data base could greatly streamline the information gathering process early in a weapon system's development, and, if correctly constructed, aid in the ATD capability identification process. Our initial concern that the MAJCOM was to have "operational control" of the acquisition process was alleviated after consultation with the ASD Technical Consultant for this report contract. The correct interpretation is that the MAJCOM would be responsible for requirements determination with SIMSPO assistance (4). To some extent, we doubt the MAJCOM's ability to lead this effort because they:

1. would require detailed directions from SIMSPO to carry out their duties (40:36).
2. do not have the necessary ISD and ATD acquisition experience (40:11).
3. have not been able to satisfactorily specify ATD configurations in the past (40:61).

We realize; however, that the MAJCOM must be part of the acquisition team because they are the user and a vital source of operational experience.

<sup>7</sup>Based on the assumption that their concepts can be operationalized, LOGICON's suggestions surpass current procedures for several of our criteria.

<sup>8</sup>Hritz and Purifoy's comments provide specific recommendations that addressed only two of our six criteria. Their recommendations are intuitive, but the authors do not provide empirical support for the ideas because they are researching another topic, and the recommendations are just a byproduct.

<sup>9</sup>We doubt the Douglas article's contention that the entire ISD effort should be contracted to the prime airframe builder as biased; however, it will be beneficial to have the easy access to the data that is described in the article. We feel this can be accomplished via contract with the prime contractor.

<sup>10</sup>The most useful aspect of the NATO report is the identification of a methodology that enables task breakdown early in the weapon system's acquisition program. The report quickly reaches the brick wall of identifying fidelity requirements. The authors acknowledge the problem, but failed to attack the issue.

<sup>11</sup>The P<sup>3</sup>I concept has several positive attributes. By delaying decisions on certain ATD capabilities, the designer/developer gains time to acquire information. Second, the use of successive versions of the ATD allow you to iterate the ATD's capabilities from low to high capability/fidelity. Similarly, initial IOC delivery can be met with an initial version of the ATD. Later ATD modifications can reflect improved and clarified information about the weapon system, technology, and ATD.

<sup>12</sup>Schilling's strategic planning concepts, in light of the P<sup>3</sup>I concept, could lead to a system that would deliver a useful training device by IOC. A methodology still needs to be developed that would take these ideas from theory to application.

<sup>13</sup>GDB has the potential of being a powerful tool in training system development. The only major question is the quality of the data base. Our concern is that if current aircrafts' task lists and data are not correct, those errors will be perpetuated in the GDB. Our two assumptions are:

1. Mature weapon systems have correct task lists.
2. Generic behavioral objectives and media data are reviewed, standardized, and improved as part of the GDB building process.

After this review, we concluded that none of the methods met all of our criteria but that many good ideas exist. Many of these concepts, if implemented, would alleviate the problem; however, no documented attempt has been made to infuse many of these ideas into the Air Force ATD acquisition process. We proceed to formulate a model/process of what would be a better, more realistic process that synthesizes many of the ideas presented in the literature and some new ideas (based on experience, and systems and management concepts). This model is developed and presented in the next chapter.

## CHAPTER 4

### MODEL DEVELOPMENT

Chapter 4 covers phases five (Solution Overview) and six (Detailed Design) of our modified Weinberg methodology. Section 1 (Phase Five--Solution Overview) is a general discussion of our model features and their impact, while Section 2 (Phase Six--Detailed Design) is a detailed Data Flow Diagram (DFD) and narrative of our Training System/ATD Development Model. Many of the ideas in these sections are taken from the literature reviewed in Chapter 3 (Figure 4-1).

#### SECTION 1: PHASE FIVE--SOLUTION OVERVIEW

As shown in Chapter 1, the current Air Force ATD acquisition process is inadequate for emerging W/S training developments and none of the systems reviewed in Chapter 3 met our criteria. However, a careful mixture of several ideas will lead to what the authors believe is an improved ATD acquisition process. We group the features of our improved process into four areas:

1. Management and personnel,
2. Information availability,
3. Contracting and delivery strategies,
4. Training System/ATD Development Model.

MANAGEMENT AND PERSONNEL. There are four management and personnel features:

| <u>FEATURE</u>                                | <u>SOURCE</u>                                                                  |
|-----------------------------------------------|--------------------------------------------------------------------------------|
| Generic Data Base                             | STREDS (40)<br>Mulligan and Funaro (29)<br>Coward (4)<br>Smith and Murray (36) |
| Access to Prime Contractor Data               | Douglas Aircraft (37)                                                          |
| Mission Analysis                              | AGARD NATO (30)<br>ARI (41)<br>NTEC (51)                                       |
| MACRO to MICRO analysis via iterative process | NTEC (50)<br>LOGICON (7)                                                       |
| Collocated/designated ATD design team         | NTEC (50)<br>Cream (6)<br>LOGICON (7)<br>STREDS (40)                           |
| Cost-Benefit Analysis                         | Mulligan and Funaro (29)<br>DOD Econ Handbook (9)<br>Cream (6)                 |
| ISD process modifications                     | Hritz and Purifoy (20)                                                         |
| Scenario planning/P <sup>3</sup> I            | Carlucci (3)<br>DOD Directive 5000.1 (49)<br>Schilling (33)                    |
| Specifications                                | Authors<br>Gainer (14)<br>Coward (4 and 5)<br>AGARD NATO (30)                  |
| ASD SIMSPO role                               | STREDS (40)                                                                    |

Figure 4-1. Features and Source(s).

1. Centralize process control/direction,
2. Improve quality and training of personnel,
3. Use team concept,
4. Use collocation or improve access between team members.

Centralize the control and direction of early W/S training and ATD development. While a Navy plan to centralize all DOD ATD acquisition at one location may be politically unacceptable, the Air Force must organize a centralized staff function--a Training SPO (TSPO)--responsible for aiding the MAJCOMs in initial training system development and conducting ATD acquisition. The SIMSPO would become the nucleus of the new TSPO. Additional instructional development, engineering, operations, and research expertise would be added. After organizing, the unit would prepare materials and procedures specifically designed for emerging W/S training systems and ATDs (such as a GDB). When a new W/S SPO came into being, the TSPO, under the command of a single manager, would be prepared to direct the training system and ATD development for the MAJCOMs and W/S PM.

Man the highly technical engineering and instructional development positions with Government Service (GS) personnel. Using GS workers allows for more long-term and stable assignments, justifies the expenditures for long-term training or education for workers, allows recruitment

of highly trained professionals, and retains corporate knowledge. The role of military members should be in the areas of command, support, Subject Matter Experts (SMEs), and program management.

Use the team concept for training system and ATD development. Organize a program team consisting of the following:

1. Program managers (TSPO and user command),
2. Early training system developers (TSPO) and ISD specialists (TSPO, user command, and prime airframe contractor),
3. Design and human factors engineers (TSPO),
4. ILS managers (TSPO),
5. SMEs (W/S user command and prime airframe contractor),
6. W/S SPO,
7. ATD contractor.

The amount of time a team member devoted to the project would vary depending on the stage of the program and his function. For example, the W/S SPO members would probably only work part-time during the entire development and the ATD contractor could not participate at all until the ATD production contract was awarded.

There are four advantages to the team concept. First, it insures that the multiple perspectives, desires, and needs of the various parties are represented. Second,

it aids in the coordination and integration of all activities occurring in the dynamic environment of major W/S, training, and ATD development projects. Third, it minimizes organizationally induced adversarial relationships. Fourth, it encourages the free flow of information between team members.

Collocate the members of the development team for three reasons. First, it encourages the day-to-day interaction necessary to implement the macro-to-micro and iterative aspects of this system. The development of each version of the training system (iteration) involves daily interaction with team members; and, each time a version is complete, the team members and management perform a review. These activities and others require that the team be collocated.

Second, the ATD must evolve concurrently with other training elements. The ATD is only one part of the larger training system and if it does not develop in consonance with the whole, the delivered ATD could have very little in common with the other subsystems and be virtually useless. To prevent this disjoint, daily interaction with the other subsystems is needed, and this can only be accomplished through collocated activities.

Third, collocated functions foster an atmosphere that will lead to a free exchange of ideas not only on the training/ATD program, but also on such things as ISD and

GDB improvements and developing training technology and its applications. This cadre will also maintain a standardized training development process to be used for emerging W/Ss.

If collocation is not possible, then a real-time, interactive computer system is needed to provide the access between team members required to accomplish the first two activities. In this way, the team members can have access to the developing project data base and the GDB. Team members will be able to communicate changes and new information to each other despite being located in different geographical areas.

INFORMATION AVAILABILITY. There are two ways to provide better, more timely information:

1. More accessibility to prime contractor information earlier,
2. Generic Data Base and Mission Analysis.

Improve access to the prime contractor's W/S information via W/S contract data items. As a member of the development team, the prime contractor's representatives would act as purveyors of current W/S information to the team. In addition, the team would have consultation rights to the prime's development contracts with accompanying cost increases. The amount of prime provided information would be most important early in the W/S's development and decrease in importance later as more detailed information becomes available via Air Force sources. Two other ways to

provide early information are Mission Analysis and GDBs.

Develop and use Mission Analysis and an inter-service Generic Data Base for early training system and ATD development. Mission Analysis and GDB enable the training developer to quickly generate much of the information needed to support early training and ATD decisions. The Mission Analysis, as discussed in Chapter 3 as part of the ARI and NATO studies, along with the prime contractor's estimate of emergency and operator maintenance-type tasks yields an initial operator tasks list (TL). At the same time interrogations of the GDB yield the common TL; behavioral objectives (BOs); criticality, frequency and difficulty of performance (C/F/D) scores; and media data (MD). A comparison of Mission Analysis and GDB TLs identifies unique and new tasks. The efforts by the training developers are then directed toward developing estimates of BOs, C/F/D scores, and MDs for the unique tasks.

The features and structure of the GDB determine its utility. The features of Mulligan and Funaro's most complex GDB should be used for the inter-service data base. That data base includes TL, BO, and MD data. This structure allows the training developer to quickly develop relatively fine "specificity of instructional regimens [46:Fig.15]."

While the utility and general operation of GDBs are documented in the training literature, we found little detailed information about the GDB's structure. However, we

feel that each data base entry should be an identified task from a past W/S which includes five fields of information (Figure 4-2). The first entry is key words which describe the task, aircraft, and equipment in sufficient detail to allow searches and commonality sorts of the data like that discussed by Smith and Murray. The second entry is the task name. The third entry is the behavioral objective used to measure the trainee's progress (i.e., When the trainee performs the behavioral objective, we are satisfied that he knows how to perform the task). The fourth entry is the tasks' criticality, frequency, and difficulty of performance (C/F/D) ratings; these are subjective ratings developed by the SMEs and training developers. The fifth area, MD, consists of a media mix code (what media are most appropriate) and capability scale (used to define the more complex media, i.e., ATDs). MD is the most complex and uncertain area; but it has the potential of becoming a powerful tool in ATD acquisition.

Since there is little agreement or useable information on MD, we have established our own propositions. First, we propose that MD's purpose is to help select the correct media mix to train a particular task and to communicate to the engineer the capabilities needed to support that task's training. Second, while there are ISD decision rules to help in media mix selection, we propose that the inter-service GDB developers must undertake the effort to develop

| TASK LIST                            |   |   |   |   |     | X-AXIS |
|--------------------------------------|---|---|---|---|-----|--------|
|                                      | A | B | C | D | ... | X      |
| KEY WORDS                            |   |   |   |   |     |        |
| Word 1                               |   |   |   |   |     |        |
| Word 2                               |   |   |   |   |     |        |
| .                                    |   |   |   |   |     |        |
| .                                    |   |   |   |   |     |        |
| Word X                               |   |   |   |   |     |        |
| TASK NAME/<br>STATEMENT              |   |   |   |   |     |        |
| BEHAVIORAL<br>OBJECTIVE<br>STATEMENT |   |   |   |   |     |        |
| C/F/D<br>RATINGS                     |   |   |   |   |     |        |
| MEDIA DATA                           |   |   |   |   |     |        |
| MEDIA MIX CODE                       |   |   |   |   |     |        |
| CAPABILITY                           |   |   |   |   |     |        |
| Cue 1                                |   |   |   |   |     |        |
| Degree A                             |   |   |   |   |     |        |
| Degree B                             |   |   |   |   |     |        |
| Degree C                             |   |   |   |   |     |        |
| Degree D                             |   |   |   |   |     |        |
| .                                    |   |   |   |   |     |        |
| .                                    |   |   |   |   |     |        |
| .                                    |   |   |   |   |     |        |
| Cue X                                |   |   |   |   |     |        |
| Degree A                             |   |   |   |   |     |        |
| Degree B                             |   |   |   |   |     |        |
| Degree C                             |   |   |   |   |     |        |
| Degree D                             |   |   |   |   |     |        |
| PRODUCT SPEC<br>DATA                 |   |   |   |   |     |        |

Figure 4-2. Generic Data Base Format.

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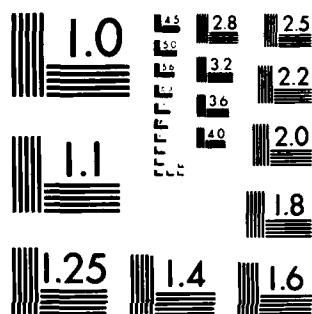
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the capability scales and to conduct a task-by-task MD analysis. Third, we propose that the capability scales will probably go through several versions of increasing complexity and utility.

While the detailed development of the MD capability scales is not of interest to this research effort, we will discuss the topic on a macro level. The initial capability scale will be an enumeration of those cues that the student must receive in the ATD. The NATO AGARD study suggests four categories of cues:

1. Cockpit display systems,
2. External visual scene,
3. Cockpit motion system,
4. Verbal and nonverbal audio environment

(30 :Fig.4).

The capability scale, then, consists of the cues necessary to provide those categories. For each cue, a Yes-No or degree (fidelity) scale is developed. For example, a cue in the cockpit motion category would be degrees of freedom (i.e., how many axis of motion are needed). The degrees for that cue would range from zero (no motion) to three (motion on all three axes).

The ultimate capability scale builds on the earlier scales. In this version, the cue data is tied to product specification(s) needed to have an ATD developed which provides the needed cues. Again, using degrees of freedom as

an example, zero degrees of freedom might call up a specification for a stationary cockpit platform, while the three degrees of freedom might call up specifications related to hydraulic pumps, related equipment, and pump service contracts. The use of the MD is relatively simple, but the results would be powerful.

Regardless of the version of MD developed, the use is the same in the ATD requirements process. After using the media mix codes to identify a group of tasks normally trained in some type of ATD, the job of identifying the ATD's capability begins. As the list of tasks to be trained in an ATD configuration is compiled, a large matrix is formed. The X-axis of the matrix is the list of tasks to be trained in that ATD configuration. The Y-axis of the matrix in the MD portion of the data base is a list of ATD cues and the required fidelity. Each column, then, represents the cues and their fidelity necessary to train a specific task. A summation along the X-axis indicates the ATD cue and fidelity needed to train the list of tasks. With this data, the engineer would develop the product specifications based on the MD data plus his ability. However, if we are using the ultimate capability scale, the product specifications would be keyed to the cue and fidelity responses. So a summation on the Y-axis indicates the specifications needed to support each task in isolation, while a summation on the X-axis indicates the specifications needed to support the

entire list of tasks. The engineer's job becomes one of reviewing and correcting the product specification output.

The power of this process comes from our ability (with the aid of a computer) to quickly mix and match various combinations of tasks. By adding and deleting tasks, we change the needed capability, use, and cost of the ATD configuration. When teamed with an iterative cost-benefit analysis, we can easily generate numerous cost/capability/tasks-trainable combinations for consideration.

There are eight steps in the GDB effort. As noted by Smith and Murray, the first step is to gather the task data from all of the services' aircrew training programs and to normalize (remove writer peculiarities and put in common formats) the task titles/statements. This makes the tasks compatible. Second, the word keys are developed which allow additional dimensions of each task to be accessed (36:297-298). Third, the C/F/D ratings are established by SMEs and training developers. Fourth, the tasks' BO are reviewed and normalized for GDB use. Fifth, the MD is developed. Sixth, data base management and user programs are written. Seventh, all data is entered into the computer. Eighth, the process is tested and validated.

We close the GDB discussion with a caveat to the reader, the areas of MD and cue requirements are ill-defined and in need of additional theoretical and applied research.

CONTRACTING AND DELIVERY STRATEGIES. While the thrust of our research has been in training and ATD development, three contracting and delivery strategies give the developers more time to accomplish their actions. The features are:

1. Scenario development,
2.  $P^3I$ ,
3. Use actual equipment or reduced fidelity ATDs for early operator training.

Use strategic scenario planning in the development of ATDs and their production contracts. Strategic scenario planning is an important input into the design of alternate ATD configurations. The idea is to include tasks with low risk MRs and ATD technology in early ATD configurations and omit high risk tasks. As the omitted tasks' MRs and technological risk decreases, add these capabilities. The result of this process is a set of ATD configurations which are low risk, within current technology, but are initially limited in their use (i.e., some tasks requiring ATD support are not covered by the ATD due to excessive risk). Additional capability comes in later iterations through the Training System/ATD Development Model either before or after basic ATD design freeze. The new capabilities result in increased instructional capability. This incremental design process requires incremental contracting and delivery.

P<sup>3</sup>I provides this incremental contracting and delivery. It is unlikely that a training system, the ATD design, and ATD technology will ever develop fast enough to provide a fully capable ATD at W/S delivery. P<sup>3</sup>I accommodates this problem by allowing for several increasingly capable versions of the ATD. The initial production ATD would be a basic model (ATD-Version A or ATD-A) with only low risk capabilities. The ATD-A would be designed with the idea that modifications or modules will be added later to incorporate additional capabilities. The reader is reminded that iterative passes through the Training System/ATD Development Model would be necessary to insure the instructional system adapts to the changing ATD capability and use.

Use actual equipment or ATD-As for early training. This feature takes into account that having a completely capable ATD at IOC may be impossible and offers two alternatives. First, the Hritz and Purifoy suggestion that actual equipment be used for initial training deserves study. If it is proven that initial trainees in new W/Ss are the more experienced crewmembers transitioning from other aircraft, then the trainee may be able to overcome the disadvantage of having no ATD while less experienced crewmembers may have more need for the ATD. If the initial cadre to be trained is predominantly crewmembers of little experience, then the second suggestion is to use ATD-As for training. While

using the ATD-A provides a degraded training program, the training program may still be superior to using actual equipment. The result of both features is the same--the initial cadre receives degraded training with the promise of an improved ATD and training program later.

TRAINING SYSTEM/ATD DEVELOPMENT MODEL. All of the foregoing features operate within a revised Training System/ATD Development Model. That model is presented via Data Flow Diagrams (DFDs) in the next section, but inherent limitations of DFDs require two model features be presented here;

1. Macro to micro development
2. Iterative development

As presented by LOGICON, the macro to micro and iterative development processes offer a method to "preserve the conceptual integrity of the ISD process and to adapt it to the time constraints imposed by the weapon system procurement schedule [7:7]." The macro to micro process assumes that the amount of information increases and the quality improves during the W/S development. Similarly, the accuracy and quality of decisions based on that information improves. This is fortunate because initial, general decisions in training and ATD development can be made based on macro, early data, while the final specific decisions require micro, later data.

When macro to micro data is teamed with the iterative process, a workable methodology appears. With repeated iter-

ations of an ISD-based process, the clarity of needs and capabilities increases as the W/S develops. The use of the GDB, Mission Analysis, and conventional ISD task analysis fits into this methodology. During the macro stage of development, the Training System/ATD Development Model uses and depends upon generic, simulated, and estimated data. Therefore, the model's outputs allow the decision maker to make initial, general decisions--the best possible decisions based on current information. And, as more detailed W/S information becomes available, the project GDB and Mission Analysis is compared and updated with improved, more micro information. Using the improved project GDB, the model enables the decision maker to make better, more accurate decisions as the W/S development proceeds. Over time all tasks in the project GDB are replaced with conventionally obtained ISD task analysis, and the resulting actual data base can be used with the conventional ISD model; however, this would not be possible until late in the W/S's development or after IOC.

## SECTION 2: PHASE SIX--DETAILED DESIGN

The purpose of this section is to explain our proposed system in greater detail via Data Flow Diagrams (DFDs) and a narrative. The features introduced in section one are imbedded in our proposed system. The DFD is three levels deep:

1. Level 1 is what Weinberg calls an overview of the entire system and is shown on Figure 4-4 (Figures 4-4 through 4-11 are grouped at the end of this chapter for easier reference).

2. Level 2 is a more detailed view of the two processes shown in Figure 4-4. Process 1.0 is expanded and shown on Figure 4-5, and process 2.0 is expanded and shown on Figure 4-9.

3. Level 3 is an even more detailed view of each process of level 2.

Figure 4-3 shows the relationship of each process and figure.

OVERVIEW DFD. Figure 4-4 shows the two major processes in our proposed model--Develop Training System (1.0) and Design ATD Element (2.0)--along with major inputs and outputs. In this section, our definition of Training System (TS) is that suggested by LOGICON and reported in Chapter 3 of our research.

1.0 DEVELOP THE TRAINING SYSTEM. Figure 4-5 shows the three logical processes that are performed in order to develop the TS. They are:

1. Identify the Training Requirements (TRs). TRs are those tasks which must be trained by the TS.

2. Develop alternate training systems (1.2).

3. Select training system (1.3).

Process 1.0 is iterative. The first pass through

| Figure | A<br>Decomposition<br>of | Processes                                                    | Level |
|--------|--------------------------|--------------------------------------------------------------|-------|
| 4-4    | -----                    | 1.0, 2.0                                                     | 1     |
| 4-5    | 1.0                      | 1.1, 1.2, 1.3                                                | 2     |
| 4-6    | 1.1                      | 1.1.1, 1.1.2<br>1.1.3, 1.1.4<br>1.1.5, 1.1.6<br>1.1.7, 1.1.8 | 3     |
| 4-7    | 1.2                      | 1.2.1, 1.2.2<br>1.2.3                                        | 3     |
| 4-8    | 1.2                      | 1.3.1, 1.3.2,<br>1.3.3, 1.3.4,<br>1.3.5, 1.3.6               | 3     |
| 4-9    | 2.0                      | 2.1, 2.2                                                     | 2     |
| 4-10   | 2.1                      | 2.1.1, 2.1.2,<br>2.1.3, 2.1.4                                | 3     |
| 4-11   | 2.2                      | 2.2.1, 2.2.2                                                 | 3     |

Figure 4-3. DFD Directory.

1.0 occurs early in the W/S development and results in initial decisions about the TS and provides initial input to the ATD acquisition team. As more detailed W/S information becomes available, subsequent passes refine and improve the TS. The TS evolves from macro definition of the elements to more micro definitions. The pliability of the TS is constrained over time as more and more TS elements become fixed. For example, if a TS decision caused the Air Force to enter into a contract with Control Data for PLATO computer-based training, future TS versions must treat the PLATO decision as fixed, unless there is strong evidence to justify cancelling the contract. This iterative process continues throughout the training development effort until the TS responsibility is transferred from the TSPO team to the user for TS maintenance.

Of special interest to our research is the ATD's element of the TS. This element can change with the TS until that time that design freeze occurs in order to meet IOC delivery of the particular ATD. The freeze time is determined by the particular ATD and its acquisition process. Relatively simple ATDs like part task trainers would have late freeze dates while the complex weapon system trainers (WSTs) have early freeze dates. Our primary concern is with the more complex ATDs.

Two key outputs of 1.0 related to ATDs are the Validated SON and the ATD Program Plan. The SON is the pre-

ferred method to identify ATD needs, because it allows for alternative solutions to the need. The W/S PMD, modified to recognize an ATD requirement, is the second method to document ATD needs. The ATD Program Plan represents the planning process that insures successful completion of the successive processes of this model. Two parts of the plan are the acquisition plan and the Integrated Logistics Support (ILS) plan. These will guide the activities and team members toward a timely completion of all the activities in the program.

1.1 IDENTIFY TRAINING REQUIREMENTS. Figure 4-6 shows the eight logical processes that occur in order to identify Training Requirements (TRs). This phase equates with the first two steps of the current ISD process: analyze system requirements (i.e., task analysis) and define education/training requirements.

1.1.1 COLLECT W/S INFORMATION AND PARAMETERS. The first activity is to collect W/S information and parameters. This activity continues throughout the acquisition process of the ATD. It must begin here to provide the information necessary for processes 1.1.2 and 1.1.3. The W/S information is grouped into three areas. First, the missions that the new W/S will perform. Second, the functions that the W/S must perform to complete those missions. Third, the performance parameters (speed, for example) that will enable mission accomplishment. The missions, functions,

and performance parameters are used to perform the commonality analysis (1.1.2) and a mission analysis (1.1.3).

1.1.2 PERFORM A COMMONALITY ANALYSIS. A software program is used to perform a commonality analysis with the GDB using the key word tabs. The TSPO loads the W/S information and parameters. Then, using this input, TSPO asks for a task listing of tasks common to the new W/S and deployed W/Ss. Then, upon request, the GDB will provide other data in the tasks' file.

1.1.3 PERFORM A MISSION ANALYSIS. This process is described in Chapter 3. The objective of mission analysis is to use the W/S's missions, functions, and performance parameters to generate an artificial task list. This list includes all of the tasks that are performed in the W/S. This list, the control TL, is different from that in 1.1.2 since it may include system unique tasks not found in the GDB.

1.1.4 IDENTIFY THE UNIQUE TASKS. Now, compare the control TL and the generic TL. As a result of this comparison, the TSPO identifies the task list that is unique to the W/S.

1.1.5 DEVELOP ESTIMATE OF BO, C/F/D AND MD. For the unique tasks, it is now necessary to make educated guesses about associated BO, C/F/D, and MD. The guesses are made using the latest W/S information available and are updated or replaced as better information becomes available.

#### 1.1.6 UPDATE GDB FOR UNIQUE TL, BO, C/F/D, AND MD.

After the unique TL, BO, C/F/D, and MD have been identified, add these to the GDB. This is necessary for two reasons. First, it maintains and updates the current system baseline. Second, after this data is validated with this W/S, it can be used for subsequent W/S developments.

1.1.7 BUILD PROJECT BASELINE. The synthesis of the generic and unique TLs, BOs, C/F/Ds, and MDs is a dedicated, project data base. We define baseline as the information in this data base at any given time.

1.1.8 DETERMINE TRAINING REQUIREMENTS. This process determines which of the tasks in the project baseline need to be trained. By comparing what the student population knows before they enter the TS with the project baseline (what they must know to operate the W/S), we identify the tasks which need to be taught. For example, if we determine that all students entering an advanced pilot training program know how to file a flight plan, we delete that activity from the advanced training program; however, if the student population does not know how to perform a particular task, we would establish a TR for that task.

1.2 DEVELOP ALTERNATE TRAINING SYSTEMS. Figure 4-7 shows three logical processes that occur in order to convert the TRs of 1.1 into a set of alternative TSs.

#### 1.2.1 ENUMERATE ALTERNATE TRAINING STRATEGIES.

During this process the training development team is given

the latitude to enumerate as many alternate training strategies as possible. Since there are no imposed constraints, conventional and unconventional, standard and nonstandard strategies are all given equal weight and consideration.

Among the strategic variables considered are:

1. Intensity and sophistication of ATDs,
2. Degree of training centralization (i.e., one large training facility to many small base level facilities),
3. Degree of computer aided instruction used,
4. Self-paced instruction vs. standard, group classroom presentations.

1.2.2 DEVELOP ALTERNATE TRAINING SYSTEMS. In this process, training systems are developed to carry out the various strategies enumerated in 1.2.1. The elements of the TP and TMS are considered and documented. In early iterations, develop the TSs at a MACRO level. In later iterations; however, as more information is available and fewer TSs are still in consideration, the TSs can be more detailed.

1.2.3 CONSTRAIN ALTERNATE TRAINING SYSTEMS. In this process, the strategies and TSs of 1.2.1 and 1.2.2 are constrained by known constraints. The types of constraints considered may include:

1. Funding levels,
2. MAJCOM desires and needs,
3. W/S development schedule,

4. Degree of W/S technical sophistication,
5. Student population estimates,
6. Instructor force ability,
7. Existing facilities,
8. ATD state-of-the-art.

The output of 1.2.3 is a set of feasible TSs which are candidates for selection.

1.3 SELECT THE TRAINING SYSTEM. Figure 4-8 illustrates the six processes that lead to the selection of a TS, validation of an ATD need, and development of a plan to deliver an ATD in a timely manner. In essence, to select a TS, perform a cost-benefit analysis (Appendix C) and make recommendations to TSPO and user management.

1.3.1 REVIEW TRAINING SYSTEM ASSUMPTIONS AND PARAMETERS. In the last phase, we developed alternative TSs which were based on assumptions. If more information is now available, then refine these assumptions and perform subsequent reconfiguration of the alternatives. This is necessary since, if assumptions change, the alternatives based on those assumptions, must also change.

1.3.2 DETERMINE TRAINING SYSTEM COSTS. As each alternative is developed, the analyst/engineer makes cost estimates based on the information available on the W/S and the TS. Now, re-evaluate the cost estimates to ensure that they reflect the latest information and the latest alternative configuration. In actuality, this process of

alternative refinement and cost estimating is continuous and is included here to illustrate its logical place in the model. Also, it is natural to perform this function as the alternatives are defined, since alternatives with cost estimates beyond the funding profiles must be eliminated at 1.2.3.

1.3.3 DETERMINE TRAINING SYSTEM BENEFITS. Evaluate the benefits of the competing systems. Theoretically, the way to assess benefit is to measure the training effectiveness for each alternative TS before-the-fact. However, there is no universally accepted method to do this. A method to do this vague, but important, function is to use expert opinion. Ask some experts to rate the different alternatives using a series of statements and Likert scales. For example, the following scale could be used:

|                      |   |   |   |                   |
|----------------------|---|---|---|-------------------|
| 1                    | 2 | 3 | 4 | 5                 |
| STRONGLY<br>DISAGREE |   |   |   | STRONGLY<br>AGREE |

Sum these ratings to develop a measure of training effectiveness for each alternate TS. Other methods may also be used; the important point is that it is critical that the benefit of each TS be evaluated, documented, and compared.

1.3.4 SELECT TRAINING SYSTEM. Based on costs, benefits, and other considerations, management decides which TS is "best." This must be a coordinated decision between the TSPO and the user MAJCOM. When the decision

is made, all the components of the TS are somewhat defined. Management should make this decision as late as possible to enable the system to loop between processes 1.2 and 1.3 with more than one iteration. The latest time this decision can be made is the training system development scheduled date. A need for media now is identified and consists of alternative ways to support the baseline with technical orders, films, pictures, ATDs, etc. For each alternative, the ATD will support different tasks and will reflect different configurations and/or fidelity requirements. This development of alternative media needs, was performed in 1.2 to the greatest extent possible. Now, refine these before preparing a SON for validation of the need.

1.3.5 VALIDATE THE NEED. Prepare a SON and follow the necessary review IAW AFR 57-1 and AFR 50-11. After approval, the W/S PMD is modified to show this new W/S program component.

1.3.6 DEVELOP CONTRACTING STRATEGY. TSPO must submit a document to management that reflects the appropriate contracting strategy for the acquisition program. For example, if it is likely that the ATD will not meet IOC, the W/S and ATD users must decide if a late delivery is acceptable. If not, then consider P<sup>3</sup>I or actual equipment use for training. The contracting strategy decision

is critical and is included in this model for emphasis.

2.0 DESIGN ATD ELEMENT. Figure 4-9 depicts the two logical processes of this phase--Select ATD Element (2.1) and Develop Product Specifications (2.2). While other elements of the TS's TP are developed by other parts of the TSPO and user MAJCOM, this phase continues with the ATD element of the TP. However, continued coordination with other TP element developers is needed to prevent TS disjoints.

Two additional points need be made. First, as stated earlier, parts of this process are accomplished concurrently with TS selection. The ATD element is an important part of TS development and selection, so when the SON is validated, a set of ATD systems for the selected TS are already defined on a functional level. The second point is that the ATD cost-benefit analysis is iterative. The designers and training developers try numerous ATD configurations (i.e., different types, capability, and mixes of ATDs).

2.1 SELECT ATD ELEMENT. The alternative ATD solutions identified in the SON are further developed into more detailed functional specifications and a decision made on which element to develop further. The functional specifications should be in enough detail to permit cost and benefit determinations. Figure 4-10 shows the four processes involved in 2.1.

#### 2.1.1 DEVELOP ALTERNATIVE ATD CONFIGURATIONS

(WHICH MEET SON REQUIREMENTS). The TSPO engineer now has alternative media approaches and a project baseline to guide the functional development of the ATD element. We define functional requirements as things which the ATD is able to do or general cues it is expected to simulate. The different media approaches, funding constraints, technological constraints, and user desires suggest alternative ATD needs and configurations. Contracted studies are also useful in developing alternatives.

2.1.2 DETERMINE COSTS. For each ATD system, develop a cost estimate.

2.1.3 DETERMINE BENEFITS. A priori, measure the benefits of each ATD system. A gross measure at this point of the ATD development is a summation of the C/F/D ratings for the group of tasks each ATD system supports. Further, look at the training effectiveness of each system in the same manner of module 1.3.3. Now, rank the alternatives in terms of benefits.

2.1.4 SELECT ATD ELEMENT. The TSPO and the user must look at the costs and benefits associated with each ATD element (set of ATDs) and decide which alternative gives the most benefit for cost. Of course, as in any management decision process, other considerations play a part in the decision. The output of 2.1.4 is a functional specification for the selected ATD element.

2.2 DEVELOP PRODUCT SPECIFICATION. In this phase, Figure 4-11, the functional specification becomes a detailed product specification for each ATD. The engineer, using the GDB's MD, transforms the functional specification into the detail necessary for a production specification.

2.2.1 DEVELOP PRODUCT SPECIFICATION. The functional specifications used today are transformed into engineering oriented product specifications needed for the production contract. The difficulty and accuracy of this process depends a great deal on the media data of the GDB. Early MD versions require more engineering interaction and increase the chance of error, while the ultimate MD version has less engineering interaction and less chance of error.

2.2.2 IMPLEMENT CONTRACTING STRATEGY. The ATD system specification must be in line with the contracting strategy in the ATD Program Plan. For instance, if  $P^3I$  is the approach that was adopted, then the engineer must add functions to the ATD only as the portion of the baseline associated with that function is frozen/finalized by the TSPO and users. The engineers must identify the features of the ATD element that may need modification later to meet these other requirements.

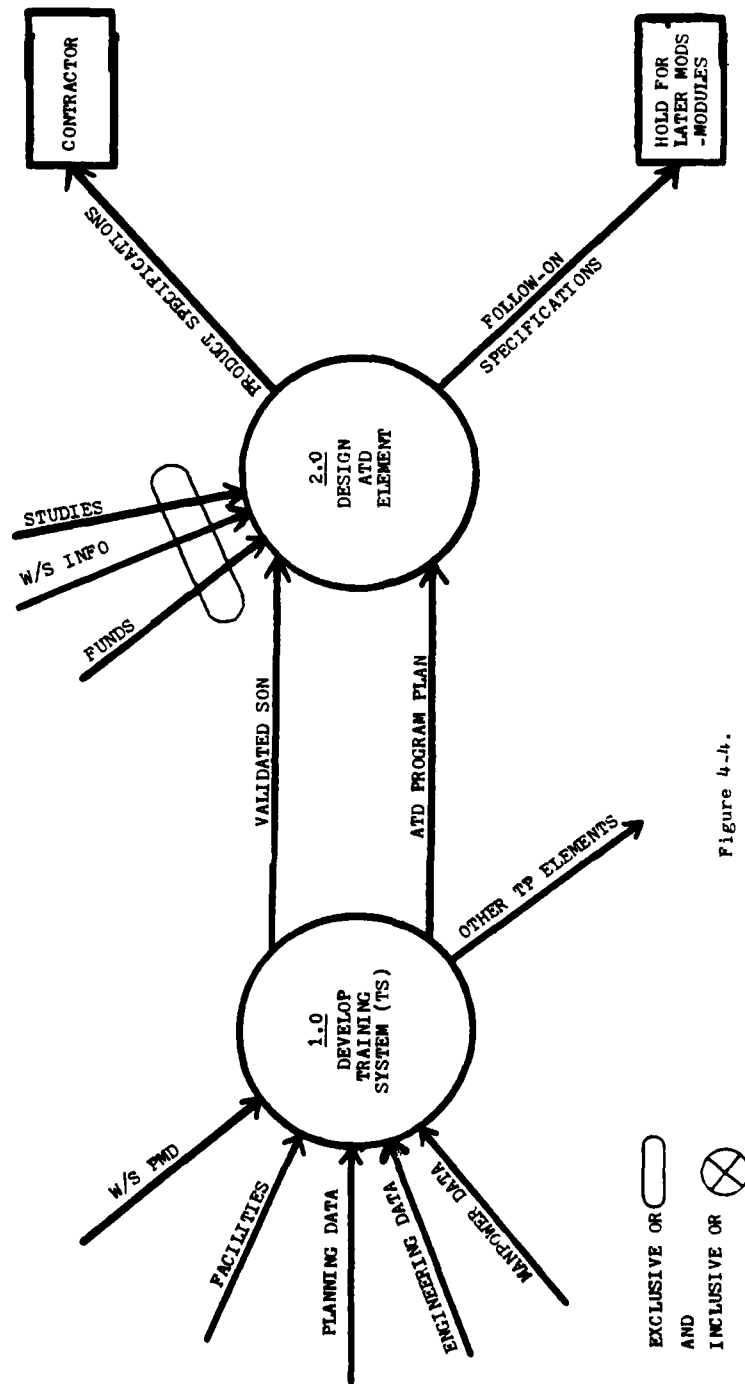


Figure 4-4.  
DFD Level 1--Overview DFD.

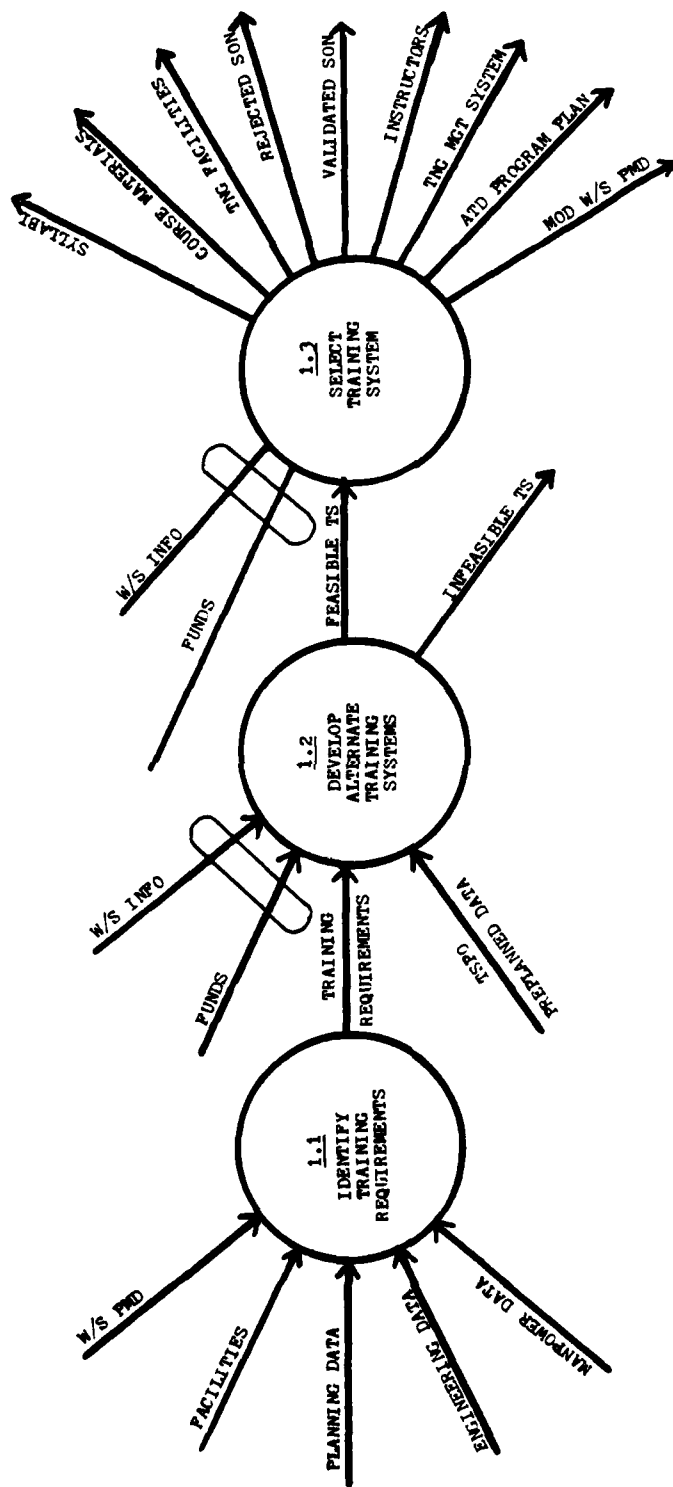


Figure 4-5.  
DFD Level 2--  
Develop Training System (1.0).

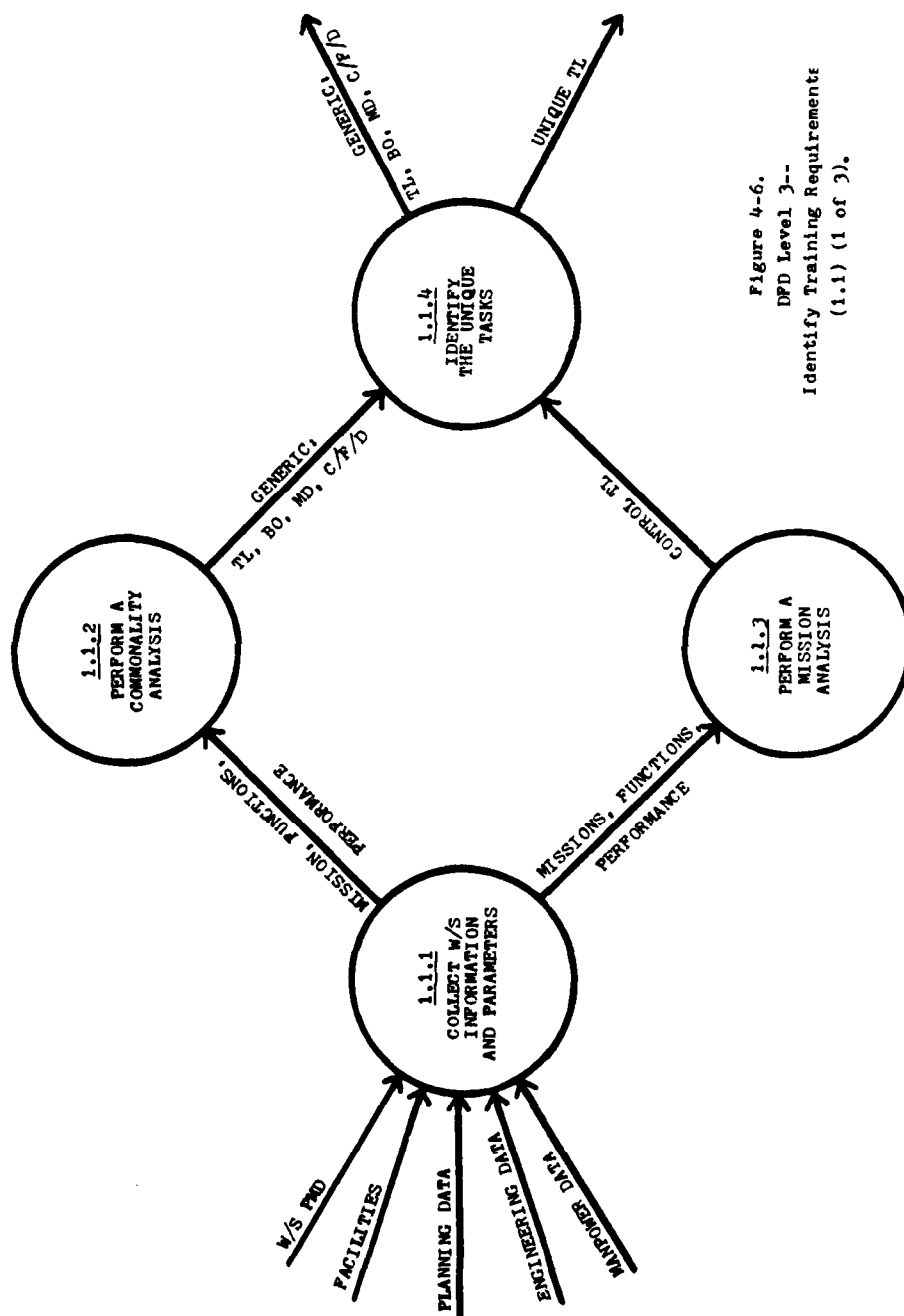


Figure 4-6.  
DPD Level 3--  
Identify Training Requirements  
(1.1) (1 of 3).

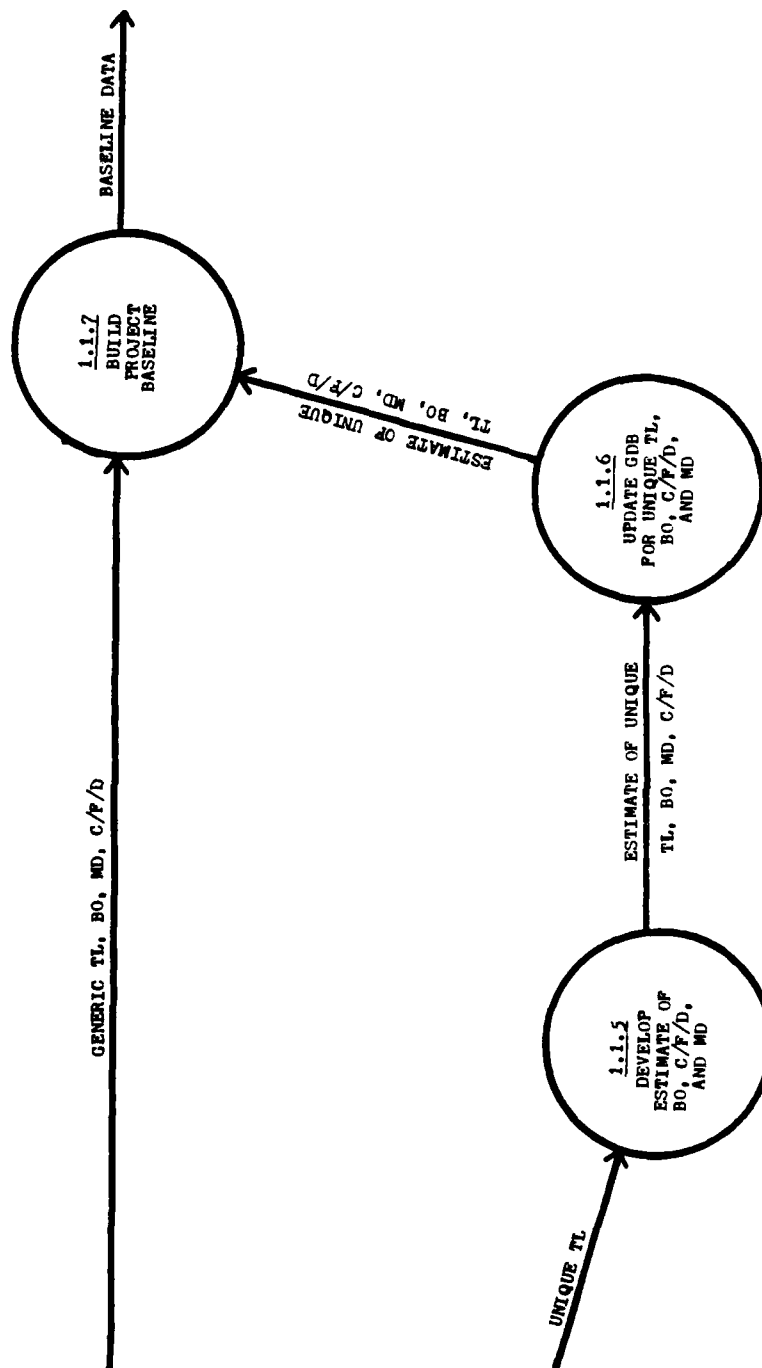


Figure 4-6 (Continued).  
(2 of 3).

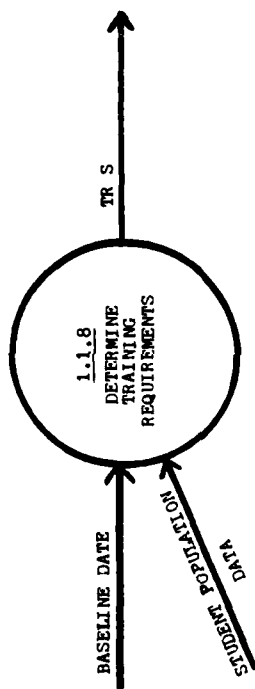


Figure 4-6 (Continued)  
(3 of 3).

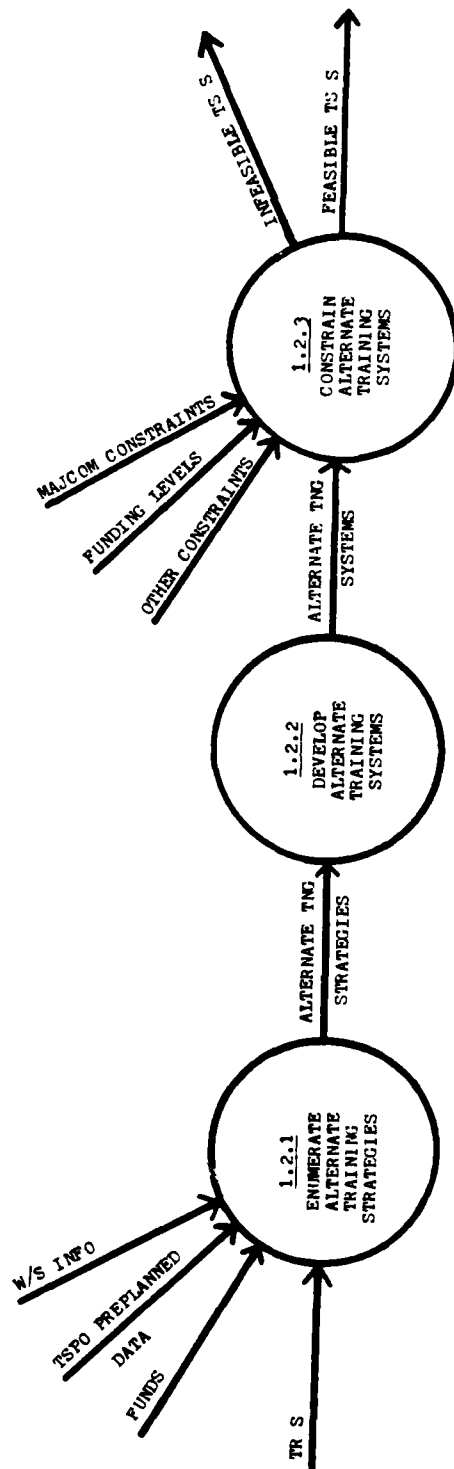


Figure 4-7.  
DFD Level 3--  
Develop Alternate Training  
Systems (1.2).

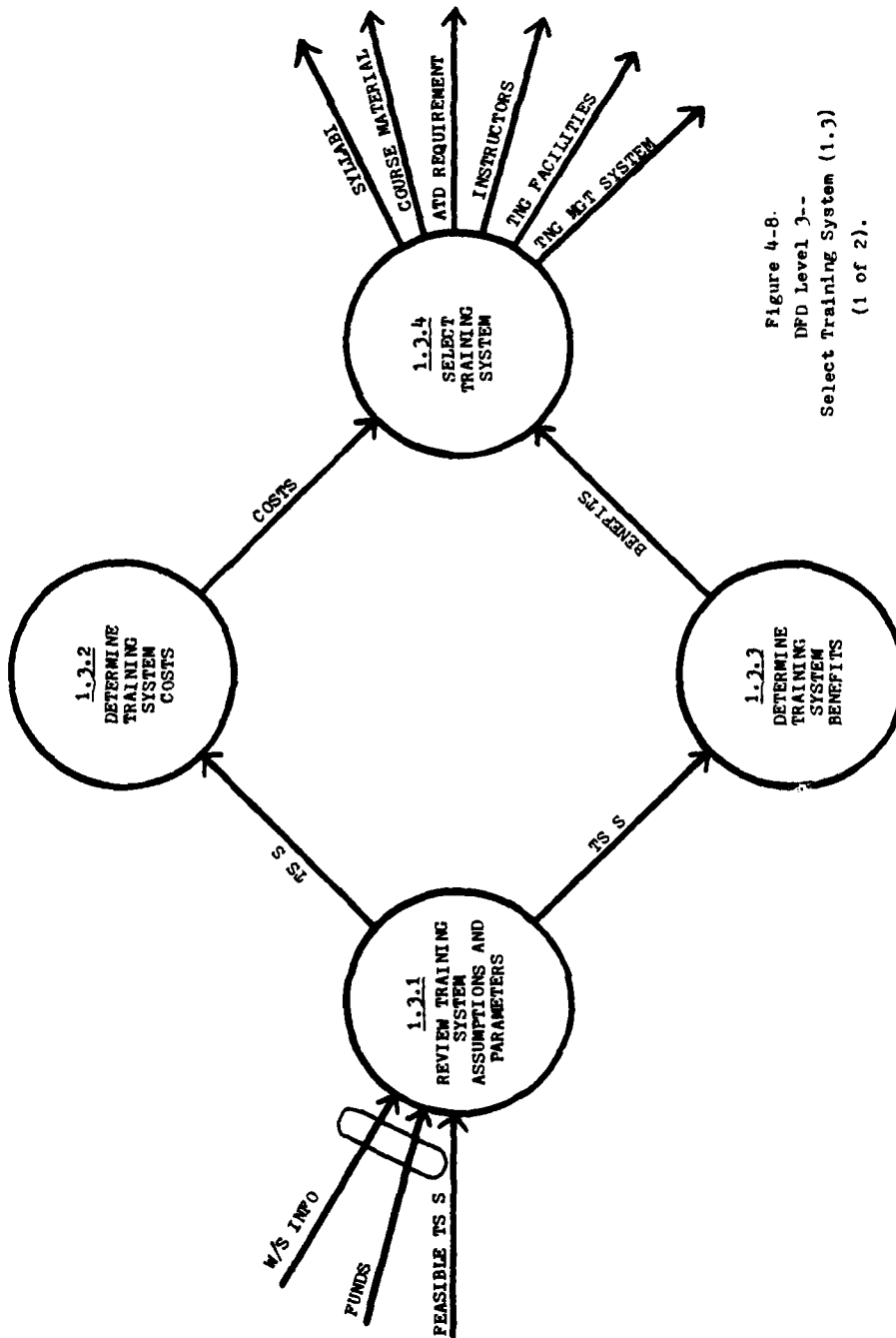


Figure 4-8.  
DFD Level 3--  
Select Training System (1.3)  
(1 of 2).

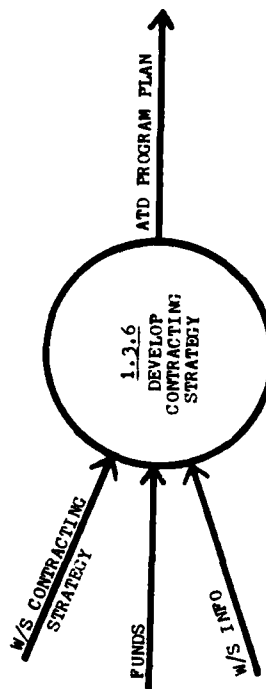
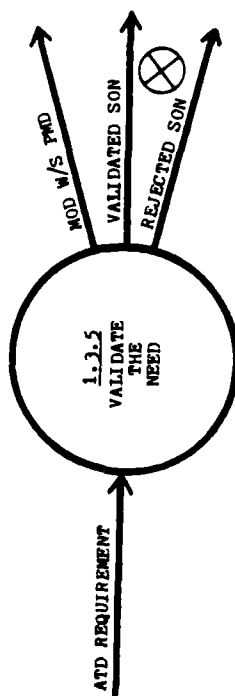


Figure 4-8 (Continued)  
(2 of 2).

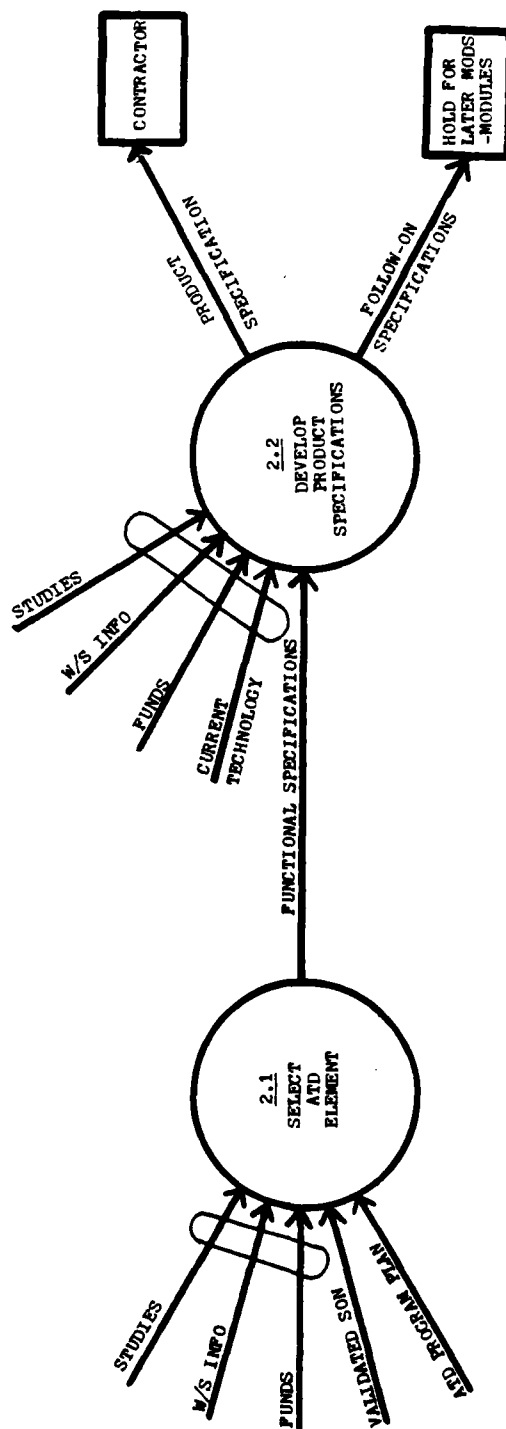


Figure 4-9.  
DFD Level 2--  
Design ATD Element (2.0).

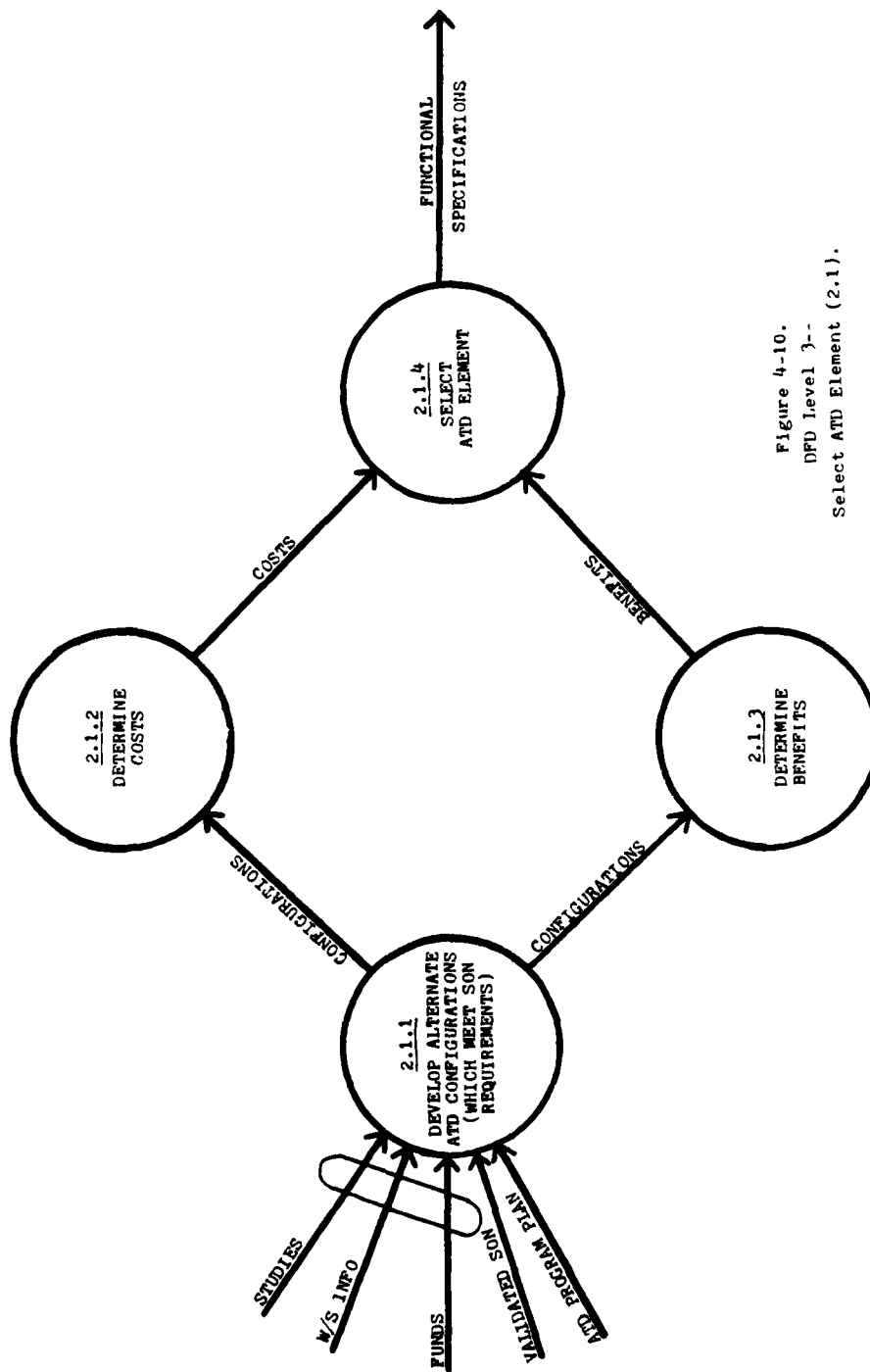


Figure 4-10.  
DPD level 3--  
Select ATD Element (2.1).

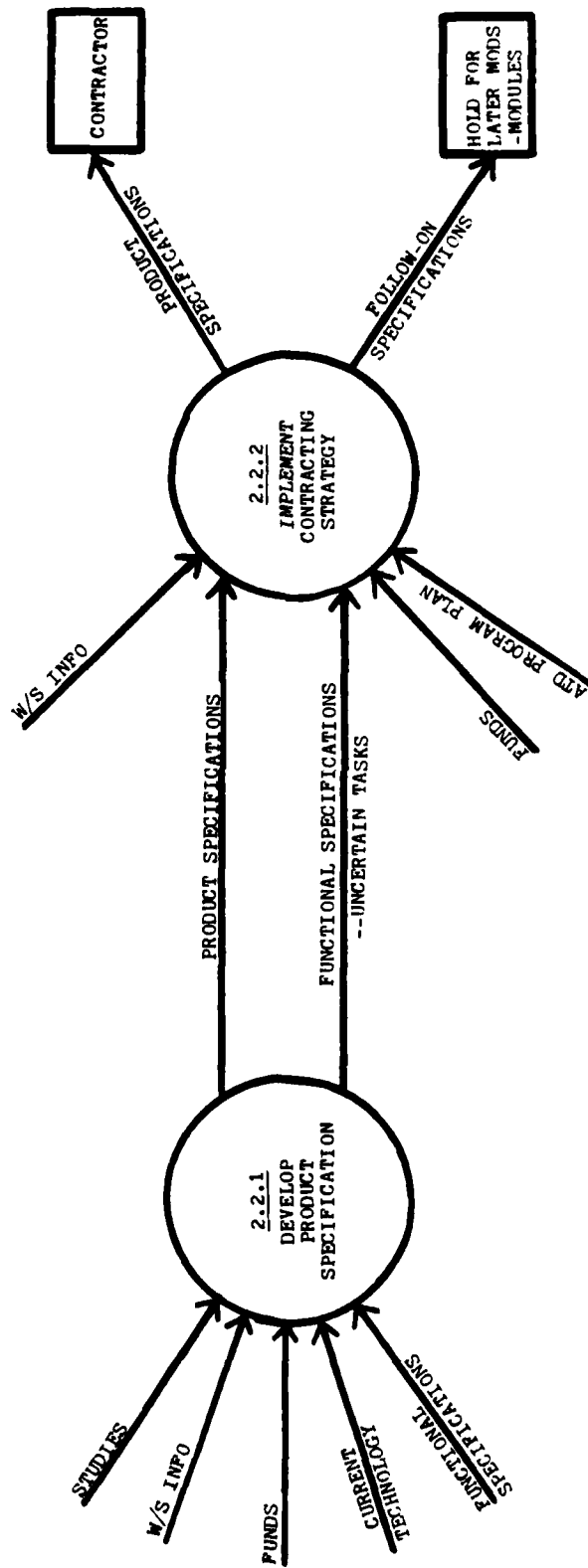


Figure 4-11.  
DFD Level 3--  
Develop Product  
Specification (2.2).

## CHAPTER 5

### VALIDATION WALKTHROUGH

Chapter 5 covers phase seven (Validation Walkthrough) of our modified Weinberg methodology. The purpose of phase seven was to subject the system model to experts in the training and ATD development community. The output of phase seven is the result of experts' evaluations/comparisons between the current and proposed training and ATD development systems. The comparisons are based on the criteria stated in Chapter 3, and the reader is reminded that the criteria are based on limitations found in the current system. Section 1 reports the preparation for validation, and Section 2 reports the results of the validation.

#### SECTION 1: VALIDATION PREPARATION

Preparation for the validation involves three areas:

1. interviewee selection,
2. statement preparation,
3. initial mathematics.

INTERVIEWEE SELECTION. Mr. Robert E. Coward selected the interviewees with one exception. Being unable to contact one of the selected interviewees, we asked Captain Terrance Seman of the AFIT faculty to act as a substitute. Captain Seman was an ATC training developer for the F-4 fighter before being assigned to AFIT and satisfied our expertise standard. The six interviewees are:

1. Captain Terrance R. Seman, AFIT Instructor of Logistics Management, formerly F-4 System Program Manager, 3785th Field Training Group (ATC), Sheppard AFB TX (35).
2. Mr. Robert E. Coward, GS-13, Special Assistant, Deputy for Simulators, ASD/YW (4).
3. Mr. Thomas B. Kelly, GS-13, Deputy Branch Chief, Flight Simulation Branch, ASD/ENETS (22).
4. Lt Col Ronald C. Decker, Operations System Manager, Detachment 4, MACSO (MAC) (8).
5. Mr. Thomas W. Hoog, GS-13, Electronics Engineer, ASD/ENETV (19).
6. Captain Lee D. Puckett, Liaison Research Engineer, AFHRL (32).

STATEMENT PREPARATION. Our goal was to compare the current and our proposed training and ATD development systems against each other using the six criteria presented in Chapter 3, Section 1 as the yardstick. The statements and associated criteria are presented in Section 2 and were initially screened by Dr. Robert Steele, AFIT faculty, for general correctness.

INITIAL MATHEMATICS. Initial mathematics involves determining the statement rejection region. As noted in Chapter 2, we are using a t-statistic to measure the statistical significance of each statement. We set our confidence level at 90% with five (n-1) degrees of freedom. Using Table II in Winkler and Hays, we selected the null

hypothesis rejection region at 1.476 or greater (53:xv). Statements with t-statistics equal to or greater than 1.476 indicate that our proposed system received scores higher than the current system with 90% confidence that the difference is not due to chance.

## SECTION 2: VALIDATION RESULTS

For each criterion we present the criterion, the statement used to measure that criterion, the Likert scores, the t-statistic, and a statement concerning statistical significance.

### CRITERION ONE.

Criterion. The system output must produce ATD requirements for an emerging weapon system based on the information available at the time the analysis is required.

Measurement statement. Sufficient information is available in the weapon system program's conceptual and validation phases to develop ATD requirements.

Likert scores. Scores are presented in Table 5-1.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 2       | 4        |
| Coward  | 2       | 4        |
| Kelly   | 2       | 4        |
| Decker  | 2       | 4        |
| Hoog    | 1       | 2        |
| Puckett | 2       | 3        |

Table 5-1. Criterion One Interview Results.

T-statistic. The t-statistic for criterion one is 7.905.

Statistical significance. The t-statistic score of 7.905 is greater than 1.476; therefore, we reject the null hypothesis.

CRITERION TWO.

Criterion. After the initial iteration of ATD requirements, the system must revise/improve the ATD requirements as new information becomes available.

Measurement statement. Periodically, new weapon system information is considered, and appropriate adjustments to the ATD definition are made.

Likert scores. Scores are presented in Table 5-2.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 4       | 5        |
| Coward  | 4       | 5        |
| Kelly   | 3       | 4        |
| Decker  | 2       | 4        |
| Hoog    | 4       | 4        |
| Puckett | 4       | 4        |

Table 5-2. Criterion Two Interview Results.

T-statistic. The t-statistic for criterion two is 2.71.

Statistical significance. The t-statistic score of 2.71 is greater than 1.476; therefore, we reject the null hypothesis.

CRITERION THREE.

Criterion. The system must produce ATDs with only those capabilities essential to training identified tasks (i.e., prevent "goldplating").

Measurement statement. ATD configurations represent the minimum capability needed to satisfy the training requirements.

Likert scores. Scores are presented in Table 5-3.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 4       | 4        |
| Coward  | 2       | 4        |
| Kelly   | 2       | 4        |
| Decker  | 3       | 4        |
| Hoog    | 4       | 2        |
| Puckett | 2       | 4        |

Table 5-3. Criterion Three Interview Results.

T-statistic. The t-statistic for criterion three is 1.274.

Statistical significance. The t-statistic score of 1.274 is less than 1.476; therefore, we fail to reject the null hypothesis.

CRITERION FOUR.

Criterion. The system must aid ATD acquisition decision makers (for example; user, W/S SPO, and SIMSPO) with cost/capability/tasks-trainable trade-offs.

Measurement statement. Two measurement statements

are used for this criterion:

1. The users and engineers can quickly assess the effect of funding changes on the proposed training program.
2. The users and engineers can develop ATD configuration alternatives that represent comparable levels of training effectiveness.

Likert scores. The summation of the two scores are presented in Table 5-4.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 4       | 8        |
| Coward  | 5       | 9        |
| Kelly   | 4       | 6        |
| Decker  | 6       | 6        |
| Hoog    | 3       | 6        |
| Puckett | 5       | 7        |

Table 5-4. Criterion Four Interview Results.

T-statistic. The t-statistic for criterion four is 4.037.

Statistical significance. The t-statistic score of 4.037 is greater than 1.476; therefore, we reject the null hypothesis.

#### CRITERION FIVE.

Criterion. The system must improve the probability of ATD delivery at IOC or earlier than the current system.

Measurement statement. Training effective ATD can be developed and delivered by weapon system IOC.

Likert scores. Scores are presented in Table 5-5.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 4       | 3        |
| Coward  | 2       | 4        |
| Kelly   | 2       | 4        |
| Decker  | 4       | 4        |
| Hoog    | 2       | 4        |
| Puckett | 1       | 3        |

Table 5-5. Criterion Five Interview Results.

T-statistic. The t-statistic for criterion five is 2.150.

Statistical significance. The t-statistic score of 2.150 is greater than 1.476; therefore, we reject the null hypothesis.

CRITERION SIX.

Criterion. The system must shorten the time between the start of W/S analysis and completion of final ATD requirements.

Measurement statement. The amount of time it takes to identify ATD needs for new weapon systems is about right.

Likert scores. Scores are presented in Table 5-6.

T-statistic. The t-statistic for criterion six is 1.860.

Statistical significance. The t-statistic score of 1.860 is greater than 1.476; therefore, we reject the null hypothesis.

| SUBJECT | SYSTEM  |          |
|---------|---------|----------|
|         | CURRENT | PROPOSED |
| Seman   | 2       | 4        |
| Coward  | 1       | 5        |
| Kelly   | 2       | 3        |
| Decker  | 4       | 2        |
| Hoog    | 2       | 4        |
| Puckett | 2       | 4        |

Table 5-6. Criterion Six Interview Results.

SUMMARY OF RESULTS. A summary of the results for the six criteria is presented in Table 5-7.

| CRITERION | T-STATISTIC | REJECT/FAIL TO REJECT NULL |
|-----------|-------------|----------------------------|
| One       | 7.905       | Reject                     |
| Two       | 2.71        | Reject                     |
| Three     | 1.274       | Fail to reject             |
| Four      | 4.037       | Reject                     |
| Five      | 2.150       | Reject                     |
| Six       | 1.860       | Reject                     |

Table 5-7. Summary of Interview Results.

## Chapter 6

### CONCLUSIONS AND RECOMMENDATIONS

Chapter 6 covers phase eight (Post-Evaluation) of our modified Weinberg methodology by presenting conclusions (Section 1) and recommendations (Section 2).

#### SECTION 1: CONCLUSIONS.

Our research objective was to use a structured analysis methodology to improve the process to identify and to communicate ATD requirements. To this end, we developed our system model (Chapter 4); and, using expert opinion, we completed a validation of our system model (Chapter 5).

For five of the six criteria, we rejected the null hypothesis that our system was not an improvement, with statistical significance at the ninety per cent confidence level. Even the criterion with which we failed to reject the null hypothesis had a mean score higher for our system model than the current system. Based on our validation results, we conclude that there is a strong indication that our system model is an improvement over the current system.

#### SECTION 2: RECOMMENDATIONS.

SYSTEM MODEL. We recommend that the model we have developed be implemented by the United States Air Force. We recognize that our proposed system is a significant departure from the current way of "doing business." However, it incorporates the solution to many of the existing

problems with ATD acquisition as well as the development of training systems, in general.

Some aspects of the model can be used right away with little expenditure of resources:

1. Delivery strategies/scenario planning,
2. Alternative development,
3. Cost/benefit analysis,
4. Team concept.

This is because these are really only changes in philosophy. Of course, to implant these ideas firmly in the training system acquisition community will take time and constant attention by management.

Other model characteristics will be more difficult to implement because of resource expenditures and behavioral considerations:

1. GDB technology,
2. Mission analysis,
3. Centralization/collocation.

These will take more time, and resource expenditure may be high. However, the benefits to be derived will be far-reaching starting with initial improvements; and, through technical interchanges between team members, leading to synergistic improvements in the future.

AREAS FOR ADDITIONAL RESEARCH. Some aspects of our system model were based on ongoing research and require more work:

1. Additional research is needed in two areas of cuing. Several researchers identified lack of cuing data as the cause of "goldplating" ATDs. Before we can truly attempt to design ATDs with only essential capabilities, cuing must be better understood. First, the minimum cue fidelity needed to train tasks needs development; and second, a method to identify, select, and standardize the cues needed to train specific tasks needs to be developed.

2. Although current GDB research indicates that GDBs can be developed, many questions still need to be answered. First, since many of the existing ATD systems were developed using procedures inadequate for developing weapon systems (ISD task analysis), will the use of this data diminish GDB's usefulness? Second, a method must be developed to enable the GDB development personnel to identify "common tasks." This is because the existing data give different names to like tasks; and, therefore, it will be inappropriate to merely input raw, task data into the GDB. It must first be translated or normalized into a standardized terminology.

3. Our concept of media data is that it must indicate that the task in question (1) can be trained with various types of media; (2) can provide a relative ranking of which medium is best for the task; and, (3) include a cost factor with each media alternative that will indicate,

for example, that although a task can be most effectively trained in a Weapon System Trainer (WST), inclusion might lead to an unacceptable increase in WST cost. Research in these areas would test these concepts and determine the best way to incorporate media data into the GDB.

4. We feel that our system model is also applicable to maintenance training devices for new weapon systems. This is because, despite the differences between operations and maintenance activities, the ATD acquisition environment presented in Chapter 1 is also the environment in which maintenance devices are developed. They must work under the same regulatory guidance, with the same acquisition offices, and with the same time frames. Further, many of the problems we identified with ATD acquisitions were revealed to us by simulator development personnel who participate in both maintenance and operator training device programs. Therefore, further research needs to be completed to determine if our system model can be extended to maintenance training devices.

APPENDIX A  
ACRONYMS AND ABBREVIATIONS

AAF: Army Air Force

AFHRL: Air Force Human Resources Laboratory

AFIT: Air Force Institute of Technology

AFM: Air Force Manual

AFP: Air Force Pamphlet

AFR: Air Force Regulation

AFSC: Air Force Systems Command

AGARD: Advisory Group for Aerospace Research and Development

ARI: United States Army Research Institute for the Behavioral  
and Social Sciences

ASD: Aeronautical Systems Division

ATC: Air Training Command

ATD: Aircrew Training Device

ATD-A: Aircrew Training Device - Version A

BO: Behavioral Objectives

CASDAT: Computer Aided System for the Development of Aircrew  
Training

C/F/D: Criticality, Frequency, and Difficulty of Performance

CFT: Cockpit Procedures Trainer

CRI: Criterion-Referenced Instructions

DFD: Data Flow Diagram

DOD: Department of Defense

EDF: Engineering Design Format

FD: Functional Description

FEA: Front End Analysis

FP: Flight Phase

FS: Functional Statement

FSD: Full Scale Development

GDB: Generic Data Base

GS: Government Service

HQ: Headquarters

HumRRO: Human Resources Research Office

ILS: Integrated Logistics Support

INFO: Information

IOC: Initial Operational Capability

IRF: Initial Requirements Format

ISD: Instructional Systems Development

MAJCOM: Major Command

MC: Military Characteristic

MD: Media Data

MGT: Management

MOA: Memorandum of Agreement

MT: Mission Trainer

NATO: North Atlantic Treaty Organization

NTEC: Naval Training Equipment Center

OFT: Operational Flight Trainer

OT&E: Operational Test and Evaluation

P<sup>3</sup>I: Pre-Planned Product Improvement

PM: Program Manager

PMD: Program Management Directive

PTT: Part Task Trainers

RFP: Request For Proposals

SA: Structured Analysis

SIMSPO: Simulator System Program Office

SME: Subject Matter Expert

SON: Statement of Operational Need

SOW: Statement of Work

SPO: System Program Office

S/R: Stimulus -- Response

STREDS: Simulator Training Requirements and Engineering  
Design Study

TL: Task List

TMS: Training Management System

TNG: Training

TP: Training Plant

TR: Training Requirements

TS: Integrated Training System

TSA: Training Situation Analysis

TSPO: Training System Program Office

URF: User Requirements Format

USAF: United States Air Force

W/S: Weapon System

WST: Weapon System Trainer

APPENDIX B  
HOW TO DEVELOP ALTERNATIVES

Mulligan and Funaro say that alternative development is a creative activity with "no known proceduralization . . . (of the activities). . . involved in generating alternative action plans [29:17]." They suggest that the analyst begin by defining an ideal alternative with no constraints considered. Then, the analyst should introduce constraints into his analysis in order to define additional alternatives, in such a way, as to account for all possible trade-offs.

The DOD Economic Analysis Handbook reiterates the idea that the development of alternatives is an acquired skill (9:3). Like Mulligan and Funaro, this handbook, prepared by the Defense Economic Analysis Council, says that it is the analyst's job to "study all feasible alternatives and to present to the decision maker those alternatives most cost effective [9:3]." The handbook says that the analyst must select alternatives with constraints in mind. This helps to identify alternatives that are, in fact, different and to eliminate those that are infeasible. Finally, the handbook mentions that the analyst must also test the alternatives under uncertainty. The insights gained from the uncertainty testing can lead to a new alternative that will "provide a reasonably good hedge against a range of the more significant uncertainties [9:9]."

David Schilling, in discussing his scenario planning

concept, says that alternatives should be based on alternative "futures or scenarios [33:2]." Schilling believes the following:

A set of alternative futures can be developed simply by combining best-case and worst-case scenarios with the most probable future or by identifying events within the planning horizon that will alter historical trends [33:2].

The differences between alternatives should be developed in light of those future events that could change the course of the training system development. The DOD Economic Analysis Handbook calls these future occurrences, assumptions (9:5). However, while the handbook talks about developing one set of assumptions, Schilling's theory suggests that a set of different assumptions should be developed based on different "futures." Finally, Schilling recommends that the alternatives should be developed with a maximum of common characteristics. This way development can proceed on the common aspects first and as additional information makes the "futures" more certain, development can continue.

Figure B-1 depicts the basic model for developing alternatives. The analyst, first, develops constraints, assumptions, and identifies common characteristics. Then, the analyst should work with decision makers and the training system development team to develop a collection of alternatives that are reasonable. With a GDB, all the alternatives could begin with a common core of characteristics and building onto this core will lead to alternatives. As

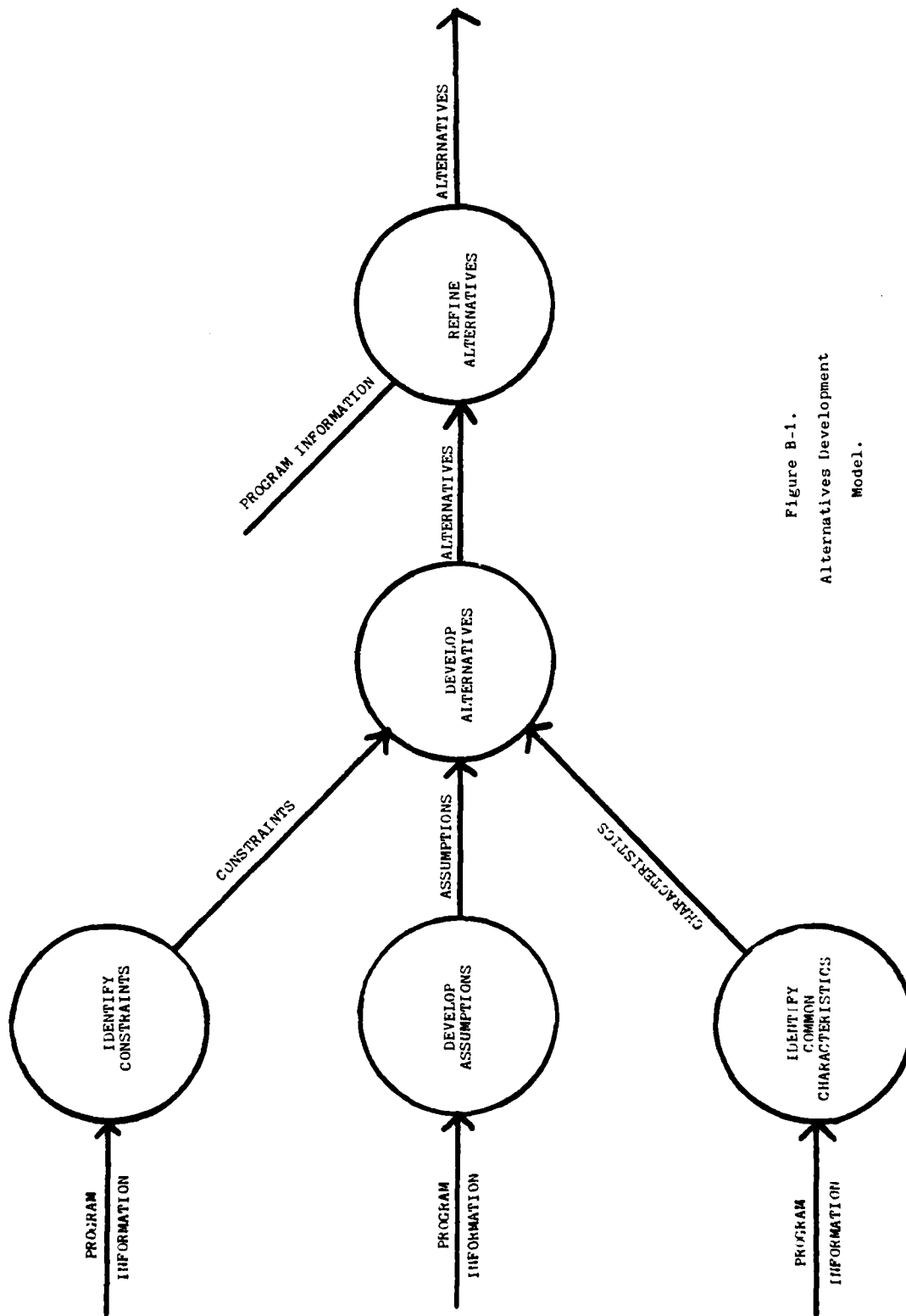


Figure B-1.  
Alternatives Development  
Model.

additional weapon system program information becomes available, some of these alternatives will become less likely, and some more likely and more detailed.

APPENDIX C  
HOW TO CHOOSE BETWEEN ALTERNATIVES

Mulligan and Funaro say that after alternatives have been formulated, the next step is to estimate effectiveness, cost, and risk for each alternative (29:17). Then, develop selection criteria:

. . . a list of statements, preferably quantitative, that delineate in detail the maximum acceptable limits permitted by constraints and resources, and the minimum acceptable limits afforded by system objectives, standards, and specifications [29:20].

To estimate effectiveness, measure or judge each alternative's performance against "some yardstick against which performance may be evaluated [29:18]." Each system alternative should be judged in terms of productivity, reliability, maintainability, validity, safety, accuracy, acceptability, availability, security, and quality.

Next, determine the cost of each alternative using any of the methods discussed in the DOD Economic Analysis Handbook (9). The handbook discusses the parametric method, engineering method, and analogous system method. Determine effectiveness and cost for each alternative in a consistent manner in order to allow a meaningful comparison.

Mulligan and Funaro recommend the use of a cost-effectiveness index. Record the index, absolute cost, and absolute effectiveness for each alternative. Thus, if two alternatives have equivalent index values, then look at the cost and effectiveness values to enable a meaningful comparison.

Then, rank each alternative according to risk. The analyst makes a subjective judgement based on the uncertainties he knows exist with each alternative, the tentativeness of the assumptions, and the possibility of actually achieving each alternative. The analyst develops a rating scale and assigns a risk factor to each alternative.

The selection criteria defines a feasible region for the evaluation of each alternative. Due to the analyst's development of the alternatives in light of constraints and other limiting factors, it is likely that the alternatives will already be within the feasible region.

The DOD Economic Analysis Handbook has a more direct, equally subjective, approach. First, estimate cost for each alternative using one of the three approaches already mentioned. Again, the same costing procedure must be applied to each alternative to enable a meaningful comparison. Then quantify the benefits of each alternative (the handbook explains how to complete this difficult step). Finally, the analyst must rank each alternative according to one of three criteria:

1. Least cost for a given level of effectiveness.
2. Most effectiveness for a given cost constraint.
3. Largest ratio of effectiveness to cost (9:8).

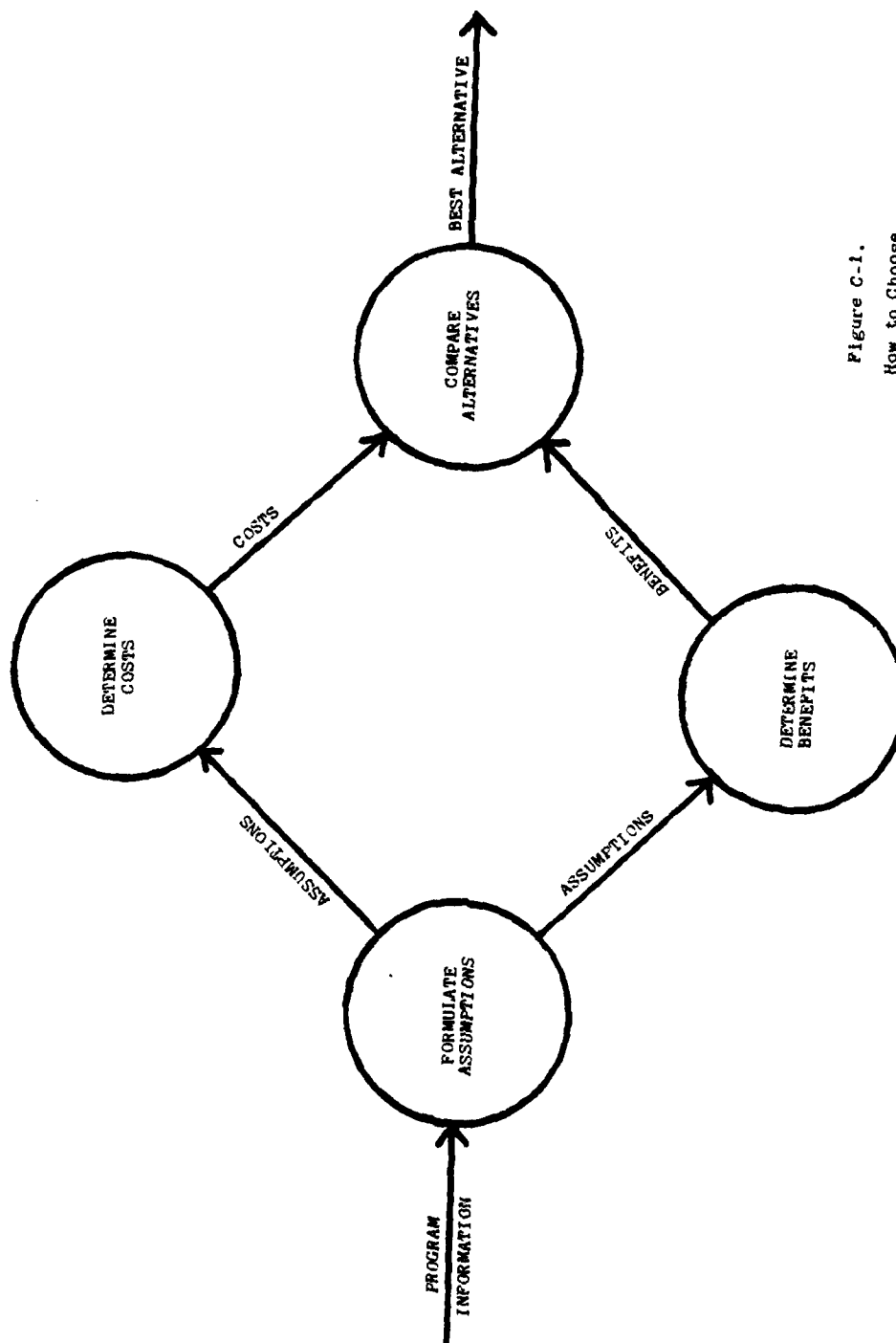


Figure C-1.  
How to Choose  
Between Alternatives.

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