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AIR FORCE AIRCREW TRAINING DEVICES MASTER PLAN

FINAL REPORT

MARCH 1978

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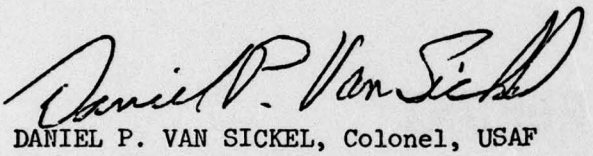
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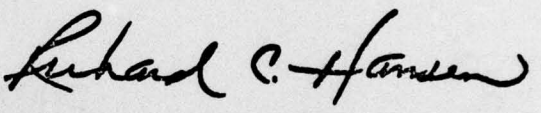
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This technical report has been reviewed and is approved for publication.



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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Aircrew training in the United Stated Air Force is addressed from the viewpoint of devices and technologies that are essential to aircrew proficiency, effectiveness and operational readiness. Major operating commands provided current and projected requirements for aircrew training devices for incorporation into formal training programs together with estimates of their impact on flight training. The impact of the instructional systems development (ISD) process on each major operating command's training program

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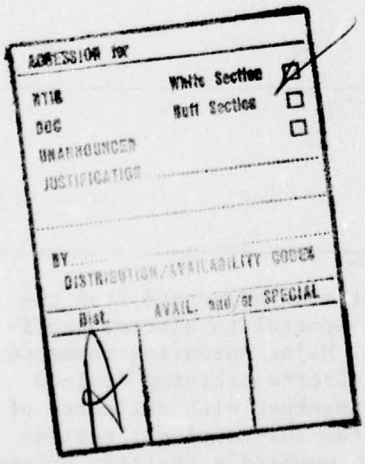
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is discussed. Issues surrounding the use of platform motion systems are addressed together with the Air Force's initiatives to resolve these issues.

Air Force organizational responsibilities are presented and institutional and management problems are delineated. Air Force R&D and acquisition programs and schedules are shown, and an initial attempt is made at diagrammatically depicting the interactions of these programs.



FOREWORD

On 8 October 1973, a Headquarters USAF/CSAF message directed that an Air Force Master Plan for Simulators for Aircrew Training be developed. The Air Force Systems Command/Aeronautical Systems Division, Deputy for Development Planning was subsequently assigned as the Office of Primary Responsibility. The message directed that the Plan should address but not be limited to the following:

- "Identification of the most immediate and effective action for increased simulator use;
- "Identification of reduction of flying hours made possible by increased simulator use;
- "Increased research and development of simulation technology;
- "Development and procurement of additional simulators; and
- "Recommended budget to support decisions."

The Plan is intended to be useful in achieving the Secretary of Defense Management Objective Number 6, which states that each Service should increase its use of flight simulators consistent with effectiveness of training, costs, and operation.

As a result of the initial direction, and in keeping with the above objective, two previous editions of the Master Plan (June 1974 and December 1975) were published. This edition documents US Air Force planning efforts toward satisfying operational requirements for flight simulator systems. It provides an overview of USAF flight simulation requirements envisioned through post-FY 87, current and required technology, research and development efforts, and acquisition management.

Past editions have been found extremely valuable as a primer for staff officers and supervisors who are new to the flight simulation business. The Plan also fostered intercommand and interservice communications, and has been reported as a valuable source of information to industry and to Congress.

This edition of the Plan has been structured not only to satisfy its continuing need as a primer, but most important, to put into perspective the relationship of research and development, engineering development, and acquisition programs. The latter should be of vital use to decision makers.

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While this document has been titled 'Master Plan', it should be recognized that there is no single organization responsible for simulator planning. There exists no simulator Czar. Planning for aircrew training devices is accomplished by many diverse organizations including the Air Staff, MAJCOMs, Air Force Systems Command, and Air Force Logistics Command. Therefore, this 'Master Plan' essentially reports on the plans of these organizations and attempts to point out those aspects of these plans that are in consonance and those that appear to diverge. It is also the single source document for Air Force research and development, engineering development, and acquisition program plans.

In accordance with the Deputy Secretary of Defense Program Budget decision of 9 December 1974, and by direction of the Commander of the Air Force Systems Command, this document updates and replaces the previous edition of the Air Force Master Plan, Simulators for Aircrew Training, dated December 1975.

ACKNOWLEDGMENTS

This document represents the collective efforts of many people representing several Air Force organizations. Sincere appreciation is expressed to representatives of the Major Operating Commands for their cooperation and considerable effort to provide relevant data. Similarly, appreciation is expressed to the simulator OPRs of Hq USAF, Hq AFLC and Hq AFSC for their assistance in clarifying the roles and responsibilities of organizations engaged in the simulator decision-making process. The Air Force Human Resources Laboratory; the Simulator Division, Directorate of Equipment Engineering (ASD/ENET); and, the Simulator System Program Office (ASD/SD24) provided material covering technology and acquisition programs.

Participation by and contributions from all organizations named above constitute a substantial and essential part of the total effort and are gratefully acknowledged. Special appreciation is expressed to Mrs. Mary J. Layman for the prodigious task of typing and preparing the manuscript for publication.

LIST OF CONTENTS

SECTION		PAGE
I	INTRODUCTION	I-1
	A. PURPOSE AND OBJECTIVES	I-1
	B. BACKGROUND	I-1
	C. CONCEPT AND APPROACH	I-5
II	PROGRAM MANAGEMENT	II-1
	A. INTRODUCTION	II-1
	B. PROGRAM APPROVAL	II-1
	1. Requirements	II-1
	2. Hq USAF OPR	II-1
	3. Requirements Review Group (RRG)	II-2
	C. BUDGET APPROVAL	II-3
	1. The Air Force Board Structure	II-3
	2. Chief of Staff	II-4
	3. Secretary of the Air Force	II-4
	4. Office of the Secretary of Defense (OSD) and Office of Management and Budget (OMB) .	II-4
	5. The President	II-4
	6. Congress	II-5
	D. PROGRAM IMPLEMENTATION	II-6
	1. Hq USAF	II-6
	2. AFSC Organization	II-7
	3. Field Commands - Overview	II-9
	4. AFSC Simulator Management	II-9
	5. AFLC Organization	II-12
	6. AFLC Management	II-12
	7. Operating and Participating Commands	II-13

SECTION		PAGE
	E. ACQUISITION MANAGEMENT INITIATIVES	II-14
	1. USAF Organizational Initiatives	II-14
	2. Mission Area Planning	II-14
	3. Congressional Hearing	II-15
	4. DoD Reports	II-15
	5. Congressional Guidance	II-16
	6. Streamlining Flight Simulator Acquisition	II-16
	7. Interservice Liaison	II-19
	F. MANAGEMENT AND PLANNING ISSUES	II-19
III	OVERVIEW OF SIMULATOR TECHNOLOGY	III-1
	A. THE EVOLUTION OF FLIGHT SIMULATION IN TRAINING	III-1
	B. MODIFICATION POTENTIAL OF EXISTING SIMULATORS .	III-4
	C. SIMULATOR TECHNOLOGY STATUS	III-5
	1. Visual Systems	III-5
	2. Motion and Force Cues	III-16
	3. Sensor Simulation	III-18
	4. Electronic Warfare Simulation	III-20
	5. Instructor/Operator Technology	III-23
	6. Modeling and Computation	III-24
	7. Adaptive Training	III-28
	D. DEVELOPMENT PROGRAMS	III-30
	1. Development Responsibilities	III-30
	2. Development Funding	III-32
	3. Development Program Descriptions	III-32
	4. Major Command Support	III-75

SECTION		PAGE
IV	ACQUISITION AND TECHNOLOGY PROGRAM INTEGRATION . . .	IV-1
	A. INTRODUCTION	IV-1
	1. Acquisition	IV-1
	2. Technology	IV-2
	C. SCHEDULES	IV-3
	1. Acquisition	IV-4
	2. Technology	IV-13
	3. Program Interactions	IV-13
	INTRODUCTION TO COMMAND SECTIONS	C-1
V	AIR TRAINING COMMAND (TAC)	V-1
	A. GENERAL	V-1
	B. TRAINING DEVICE STATUS AND REQUIREMENTS	V-5
	1. Future Reductions	V-7
	C. IMPACT OF NEW TRAINING CAPABILITIES ON TRAINING PROGRAMS	V-8
	D. COMMAND PRIORITIZATION	V-9
VI	TACTICAL AIR FORCES (TAF)	VI-1
	A. GENERAL	VI-1
	B. TRAINING DEVICE STATUS AND REQUIREMENTS	VI-4
	1. F-4C/D/E	VI-5
	2. RF-4C	VI-5
	3. F-111A/D/E/F	VI-6
	4. A-7D	VI-7
	5. F-15	VI-7
	6. A-10	VI-7
	7. F-16 Combat Fighter (ACF)	VI-7
	8. E-3A	VI-9
	9. F-4GWW	VI-11
	10. EF-111A	VI-11

SECTION		PAGE
	C. PROGRAM DATA	VI-11
	D. IMPACT OF NEW CAPABILITIES ON TRAINING PROGRAMS	VI-11
	E. PRIORITIZATION OF NEW CAPABILITIES	VI-11
	F. ADVANCED SYSTEMS	VI-13
	G. TAF MAINTENANCE CONCEPT FOR AIRCREW TRAINING DEVICES	VI-13
	1. Objective	VI-13
	2. Training	VI-14
	3. Technical Data	VI-14
	4. Supportability	VI-14
	5. Inspection Requirements	VI-15
	6. Operational Flight Program Update Capability	VI-16
	7. Stabilized Power Requirement	VI-16
VII.	MILITARY AIRLIFT COMMAND (MAC)	VII-1
	A. GENERAL	VII-1
	1. Command Philosophy	VII-1
	2. Planning Considerations	VII-1
	3. Key Issues	VII-2
	B. TRAINING DEVICE STATUS AND REQUIREMENTS	VII-7
	1. Airlift Aircraft	VII-7
	2. Rescue Aircraft	VII-11
	3. Commercial Contract Simulators	VII-12
	C. PROGRAM DATA	VII-12
	D. IMPACT OF NEW CAPABILITIES ON TRAINING PROGRAMS	VII-14
	E. COMMAND PRIORITIZATION OF NEW CAPABILITIES	VII-16
	1. Near Term Delivery of Validated and Identified ROCs	VII-16
	2. Equipment Required to Provide Increased Training Capabilities	VII-16

SECTION		PAGE
VIII	STRATEGIC AIR COMMAND (SAC)	VIII-1
	A. GENERAL	VIII-1
	1. Command Philosophy of Training	VIII-1
	2. ISD Activities	VIII-2
	3. Simulator Certification	VIII-3
	4. Impact of High Fidelity Simulation	VIII-4
	B. TRAINING DEVICE STATUS AND REQUIREMENTS	VIII-5
	C. PROGRAM DATA	VIII-13
	D. AIR RESERVE FORCES (ARF)	VIII-15
IX	AEROSPACE DEFENSE COMMAND (ADCOM)	IX-1
	A. GENERAL	IX-1
	B. TRAINING DEVICE STATUS AND REQUIREMENTS	IX-1
	1. F-106 Trainer	IX-1
	2. Follow-On Interceptor Trainers	IX-2
	3. F-106 Radar/IR Part Task Trainer (PTT) . . .	IX-3
	4. F-106 Aerial Gunnery Part Task Trainer (AGPTT) . . .	IX-3
	5. Contractual Training	IX-3
	C. PART TASK TRAINER PROCUREMENT	IX-4
	D. FLYING HOUR AVOIDANCES	IX-4
	E. SIMULATOR RELATED ISD EFFORTS	IX-5
	F. ADCOM SIMCERT	IX-6
REFERENCES	. . . . .	R-1
GLOSSARY	. . . . .	G-1

LIST OF ILLUSTRATIONS

FIGURE		PAGE
II-1	Responsible Air Force Aircrew Training Device Organization	II-2
II-2	Hq AFSC Organizational Structure for Simulators	II-8
II-3	AFLC Primary Organizational Structure for Simulators	II-12
III-1	Flight Simulator Development	III-5
III-2	Visual Simulation System Architecture	III-6
III-3	Elements of ECM/ESM Simulation	III-21
III-4	AFHRL Support of Operational Test and Evaluation Programs	III-76
IV-1	Acquisition Programs - Directed	IV-5
IV-2	Acquisition Programs - Awaiting Direction	IV-7
IV-3	Acquisition Programs - Proposed	IV-9
IV-4	Acquisition Programs - Potential/Conceptual	IV-11
IV-5	Schedules of Planned Simulator Technology Development Program	IV-14
IV-6	Model and Computation Technology Interaction and Application	IV-25
VI-1	Schedule Summary - Future TAF Simulators	VI-12
VII-1	MAC Planning Schedule	VII-13
VIII-1	SAC Planning Schedule	VIII-13

LIST OF TABLES

TABLE		PAGE
III-1	COMPUTATION SYSTEMS COMPENDIUM	III-25
III-2	SUMMARY OF PLANNED SIMULATOR TECHNOLOGY	III-33
III-3	AFHRL Support of Operational Test and EVALUATION PROGRAMS	III-76
V-1	PROGRAM ENTRIES	V-2
V-2	ATC TRAINING EQUIPMENT AND GLOSSARY OF TERMS	V-2
V-3	FLYING HOURS/STUDENT (CURRENT PROGRAMS)	V-4
V-4	SIMULATOR UTILIZATION SUMMARY (HOURS/STUDENT)	V-5
V-5A	FLYING HOURS/STUDENT	V-5
V-5B	UNT FLYING AND SIMULATOR HOURS/STUDENT	V-6
V-6	UPT/PIT FLYING HOURS/STUDENT	V-6
V-7	TRAINING PROGRAM SUMMARY	V-8
VI-1	TAF FORMAL AIRCREW TRAINING PROGRAMS	VI-1
VI-2	IMPACT OF ISD APPROACH ON TAC CCTS/RTU AIRCREW TRAINING	VI-2
VI-3	TAC TRAINING PROGRAM SUMMARY	VI-3
VII-1	MAC FORMAL TRANSITION AIRCREW TRAINING	VII-4
VII-2	IMPACT OF ISD INITIAL TRAINING	VII-5
VII-3	MAC NONREVENUE TRAINING SUMMARY	VII-14
VII-4	ESTIMATED FLIGHT TIME REDUCTIONS DUE TO SIMULATORS	VII-15
VII-5	SUMMARY - MAC ROC ACTIVITY	VII-15
VIII-1	SAC TRAINING PROGRAM SUMMARY	VIII-6
VIII-2	REQUIRED SIMULATION DEVICES DEPLOYMENT	VIII-14
IX-1	PROGRAM STATUS OF ADCOM WEAPONS SYSTEMS TRAINING	IX-5

AIR FORCE
AIRCREW TRAINING DEVICES
MASTER PLAN

I. INTRODUCTION

A. PURPOSE AND OBJECTIVES

The Secretary of Defense Management Objective Number 6 states that each Service should increase its use of flight simulators consistent with effectiveness of training, costs and operation. This Plan is intended to be useful in achieving the objective which requires:

- Review of current status of flight simulators;
- Definition of programs for increased use of simulators in Undergraduate Pilot Training, Aircrew Operational Readiness Training and Operational Crew Training;
- Development and acquisition of simulators; and
- Increased utilization of simulators be considered carefully so as to have the least risk to operational capability.

In keeping with these objectives, a concerted effort was undertaken in late 1973 by the Air Force Major Commands to assess their training programs and to identify their needs relative to increased use of simulators for aircrew training. Since that time, personnel from Major Commands have worked with representatives of the Air Force Human Resources Laboratory, Air Force Logistics Command, and elements of the Aeronautical Systems Division to translate these needs into programs and associated fiscal support requirements. These efforts resulted in the publication of the initial Master Plan in June 1974, and a subsequent revision in December 1975.

It is intended that this updated Plan identify those simulator programs defined and prioritized by the Major Commands, and conceptualized by the development planners. Additional prime objectives of the Plan are to indicate the interrelationships and interdependencies of technology programs, and to propose viable research and development efforts which are essential to support ongoing, near-term, and far-term simulator acquisition programs.

B. BACKGROUND

1. In January 1969, a "Special Report of the USAF Scientific Advisory Board, Human Resources Panel, Visit with the Airline Industry" discussed

the procedures being utilized in training and upgrading airline pilots. The panel concluded that the Air Force would be rewarded by studying the airline's experience and recommended that the Air Force initiate studies to determine ways of improving present pilot training methodology as a result of the work done by civilian airlines. The conclusion and recommendations were considered valid even though the panel recognized both the differences in duties, requirements, and responsibilities of the Air Force and airline pilots and that certain areas of training are not directly comparable.

2. In early 1969, a report was published based on a USAF Ad Hoc Review of Airline Pilot Training. Two very cogent recommendations emerged:

"a. The USAF should apply the latest developments in educational design to its flying training programs. This includes the systems approach, which combines the latest in learning and communication theories with multimedia devices to accelerate and individualize training, and

b. R&D efforts directed toward instructional systems application should be continued and expanded."

3. The Air Force Chief of Staff, General McConnell in a letter, dated 16 June 1969, transmitted the Ad Hoc Review to all major Air Force organizations. The Chief of Staff expressed his increasing concern with "the rising costs of pilot training" and stated that "the recommendations stated in this document deserve careful and decisive evaluation by all commanders and their staff managers who conduct or maintain pilot training programs."

4. Air Force Chief of Staff, General Ryan, in a letter dated 2 February 1970 to the five major operating commands, referred to General McConnell's letter and listed five "principles that I would like to see incorporated into our flying programs:

"a. Ensure that each course is structured to contain precisely the training required;

b. Give only training appropriate to the individual;

c. Measure training on proficiency, not course length;

d. Make maximum use of least cost training before progressing to more costly training; and

e. When a skill is particularly difficult, seek ways to alter the task to make it easier."

5. In January 1974, the Air Force Energy R&D Steering Group was formed to review the future of the Air Force and to suggest R&D programs which would help alleviate future energy problems. A set of findings was

published in November 1974, some of which were pertinent to the role simulators are expected to play in the Air Force future.

A pertinent recommendation of the Steering Group's report was that the Air Force should establish goals for the reduction of flying hours through the use of simulators.

The report also concluded that there is a "problem" period of 10 to 15 years during which we have to rely on existing fuels and propulsion systems. During this period, the only available techniques for coping with the problem, are conservation and some modification of existing systems to improve their efficiency. The theme of conservation has become increasingly more prevalent as evidenced by a statement made by President Jimmy Carter on 10 February 1977:

> *"Saving energy must be a major national priority. It is one of America's greatest challenges . . . Conservation energy is the energy derived by replacing habits and technologies with more efficient ones . . . Conservation energy will be the centerpiece of our national energy policy."*

6. Four additional studies completed by the Assistant Chief of Staff, Studies and Analysis (July 1972), USAF Scientific Advisory Board (January 1973), Office of Management and Budget (July 1973), and General Accounting Office (August 1973) concluded that the Air Force has not fully exploited the potentialities of simulators for aircrew training to achieve reductions in actual flight time requirements. The reasons cited for lack of Air Force progress toward full utilization of simulators were generally not technological, but rather were ascribed to management constraints, budget limitations and negative attitudes on the part of aircrew members and commanders. On the other hand, the studies generally agreed there is a lack of quantitative data which can be used to compare simulator training with aircraft training.

7. In addition to the aforementioned study findings, the energy crisis, the escalating costs of aircraft procurement and operation, and the need to extend the life of operational aircraft have necessitated near-term major capital investments to accelerate improved simulator capabilities and subsequent expanded utilization. Upon these bases, and with a positive attitude towards alleviating past deficiencies, the Air Force has undertaken major initiatives from early 1969 through mid 1977:

a. During this time period, the Air Force Major Commands (TAC SAC, MAC, ADCOM and ATC) have initiated Instructional Systems Development (ISD) programs for their major weapon systems. Instructional Systems Development as defined in AFM 50-2 and AFP 50-58 "is a deliberate and orderly process for planning and developing instructional

programs which ensure that personnel are taught the knowledge, skills, and attitudes essential for successful job performance. The process depends on a description and analysis of the tasks necessary for performing the job, criteria, objectives and tests clearly stated before instruction begins, evaluation procedures to determine whether or not the objectives have been reached, and methods for revising the process based on empirical data."

b. In May 1973 the AFSC, Aeronautical Systems Division, established a Simulator System Program Office to manage the development and acquisition of simulators.

c. In October 1973 USAF/CSAF directed that an Air Force Master Plan for Simulators for Aircrew Training be developed and designated AFSC as the lead Command.

d. A General Officer within the Deputy Chief of Staff for Operations, Hq USAF has been designated as Special Assistant for Aircrew Flight Simulator matters. This has provided much needed visibility of simulators at the Chief of Staff and Secretary of the Air Force levels.

e. A single focal point for simulator matters was established within Hq AFSC under the Deputy Chief of Staff for Systems. Also within AFSC, a Simulator Advisory Board has been chartered. This Board has the prioritization of simulator technology programs as one of its key responsibilities.

f. The Air Force Human Resources Laboratory was designated as focal point laboratory for the development of training simulator technology. The Air Force Avionics Laboratory and the Air Force Flight Dynamics Laboratory were designated as participating laboratories.

g. A Simulator Advisory Group (SAG) was established by direction of the Commander, AFSC and a charter was approved by the ASD Vice Commander in May 1975. Membership of the SAG includes representatives from Air Force Systems Command, Air Force Logistics Command, and the Major Operating Commands. The Group is chaired by the Deputy for Systems.

h. An exchange of liaison officers was effected between the Naval Training Equipment Center (NTEC) and the Simulator SPO. This exchange provides resident liaison officers to assist the flow of information between the Navy and the Air Force at the research and development/acquisition level.

i. A Simulator Panel has been established at Hq USAF and is responsible for reporting to the Air Staff Board.

j. There have been a multitude of additional actions taken to enhance the acceptance and usage of aircrew training devices. While the utility of these actions is intuitively high, only time will justify their implementation. A few of the more noteworthy actions are:

- The development of a cost data base and cost estimating relationships have been undertaken by the Simulator SPO. Hq USAF/ACM initiated an effort in 1975 to assess the operating and maintenance cost for simulators. These data are published as a part of AFR 173-10 (Reference 4);

- A Data Item Description (DID) UT 3920A-ASD "Simulator Design Data Requirements" was completed in early 1977. The DID is being used by the Simulator SPO to acquire the necessary simulator data from airframe manufacturers;

- At the operating level, the simulator maintenance function has been transferred from operations to logistics;

- A revised AFR 60-1 "Flight Management Policies" is in draft form for coordination. This revised Regulation could allow certain tasks trained on simulators to be credited for comparable tasks trained in the aircraft; and

- A new Regulation AFR 50-11 "Management and Utilization of Training Devices" has been published. A portion of this Regulation addresses simulator certification (SIMCERT) which is a process of validating simulator capability to effectively train aircrew members. Guidelines for implementing the SIMCERT program are being developed by the Major Operating Commands.

The delineation of Air Force initiatives toward simulators could have appropriately been discussed in a subsequent section. However, it is believed that their inclusion here serves to emphasize the positive steps the Air Force has taken to minimize the aforementioned deficiencies. Indeed, the Air Force efforts in recent years are evidence of its recognition of the value of aircrew training devices on their own merits and not principally as a surrogate of the aircraft. There also exists an awareness of the potential of aircrew training devices to significantly enhance flying safety and discipline through practice of difficult flying tasks, infrequently encountered weather or operational hazards, equipment malfunctions/degradation and emergency procedures. In addition, future aircrew training devices will have the capability to simulate combat situations without the need for war or actual enemy engagement. These enhancements of flying safety will reduce the cost to the Air Force, during flight, of catastrophic loss of valuable capital investments in personnel and equipment resources.

C. CONCEPT AND APPROACH

Previous editions of the Master Plan have placed primary emphasis on identifying and defining programs which would result in greater

simulator use and a concommitant reduction in aircraft flying hours required for equivalent training of aircrew members. Since the publication of the most recent edition of the Plan (Reference 5), two areas of constructive criticism have been prevalent: (1) the document is not a plan in that it does not provide the objectives, goals, and stepwise efforts needed for their accomplishment; and (2) the document is not used by decision makers in determining research and development and acquisition prioritizations and funding levels. While retaining the emphasis of the previous Plan, this document also attempts to address the previously stated objectives; namely, to indicate the interrelationships and interdependence of technology programs; and to prepare viable research and development efforts which are essential to support ongoing, near-term, and far-term simulator acquisition programs. It is believed that this approach will receive greater acceptance and provide the budget authority with the necessary technology and acquisition program data to make prioritization and funding decisions.

The term "Master Plan" is viewed by many as being synonymous with "Road Map" - the latter often accompanied by a detailed "Trip Tick." A Road Map implies distinctive but restrictive paths (alternatives) for proceeding from an existing state (situation) to an ultimate state (goal). However, it is clear that a Simulator Master Plan must provide much more flexibility due to numerous uncontrollable variables such as changes within programs and priorities, funding constraints, technological breakthroughs, program deletions/additions, shifts in operational emphasis, and variations in procurement strategies. Therefore, it is important to recognize that planning is a continuing function and a plan is today's view of how to proceed. Acceptance of this fact would dictate that we temper our desires for immediate, precise and immutable solution to long standing problems. Since the Plan itself is temporal, it is important that the Master Plan provide a means for its own continuity and updating. To this end, the subsequent sections were structured.

Section II presents the management and planning processes which currently exist for establishing simulator requirements, technology base developments, acquisition programs and logistics support. The organizational responsibilities are defined from the Presidential and Congressional levels down through and including the product divisions and operational levels. The information presented in this section is intended to provide interested parties with an appreciation for, and an understanding of, the decision making process within the Air Force which encompasses simulator R&D, acquisition and modification programs.

An overview of technology as it applies to simulators is presented in Section III. The evolution of major technological areas are briefly discussed. Specific ongoing and planned exploratory, advanced and engineering development programs are described in terms of objectives and scope.

Section IV provides the interrelationships and interdependencies of the technology programs discussed in Section III. In addition, the overall relationship of research and development, engineering development, and acquisition programs are depicted graphically.

Sections V through IX presents the Major Commands' training device status and requirements. Included within the MAJCOM requirements are those of the Air Reserve Forces where applicable. These sections translate the MAJCOMs' needs into programs, fiscal support requirements and provides estimated benefits in terms of projected flying hour avoidances.

II. PROGRAM MANAGEMENT

A. INTRODUCTION

Past editions of the Master Plan have been found extremely valuable as a primer for staff officers and supervisors who are new to the flight simulation business, as an information source for Congress and industry, and have promoted intercommand and interservice harmony. With this in mind, this section has been tailored to provide an overview of USAF flight simulator acquisition/modification program management organization and process. For detailed guidance, an excellent information source is Air Force Systems Command Pamphlet 800-3, "A Guide for Program Management." Figure II-1 shows the principle Air Force organizations responsible for aircrew training devices requirements/approval, R&D, acquisition and support.

B. PROGRAM APPROVAL

1. Requirements.

Hq USAF relies primarily on the operating commands to analyze their mission capabilities and identify operational requirements. Most flight simulator programs evolve to satisfy requirements for:

a. A training capability to support a new weapon system;

b. New training devices to replace existing devices that are obsolescent;

c. Modifications to training devices to improve their capability, such as installing visual systems; and

d. Modifications to training devices to reflect an associated modification to the weapon system.

An operating command documents and submits operational requirements to Hq USAF in accordance with AFR 57-1. Copies are simultaneously provided to Air Force Systems Command (AFSC) and Air Force Logistics Command (AFLC). AFSC develops alternative proposed system acquisition programs, including cost estimates and schedules, to satisfy the requirement. Likewise, AFLC develops proposed modification programs which are envisioned as alternatives to satisfy the operating command's requirement. These program proposals are submitted to Hq USAF.

2. Hq USAF OPR.

When the operational requirement document is received by Hq USAF from the operating command, the Requirements Management Office selects an Office of Primary Responsibility (OPR) to provide the program officer

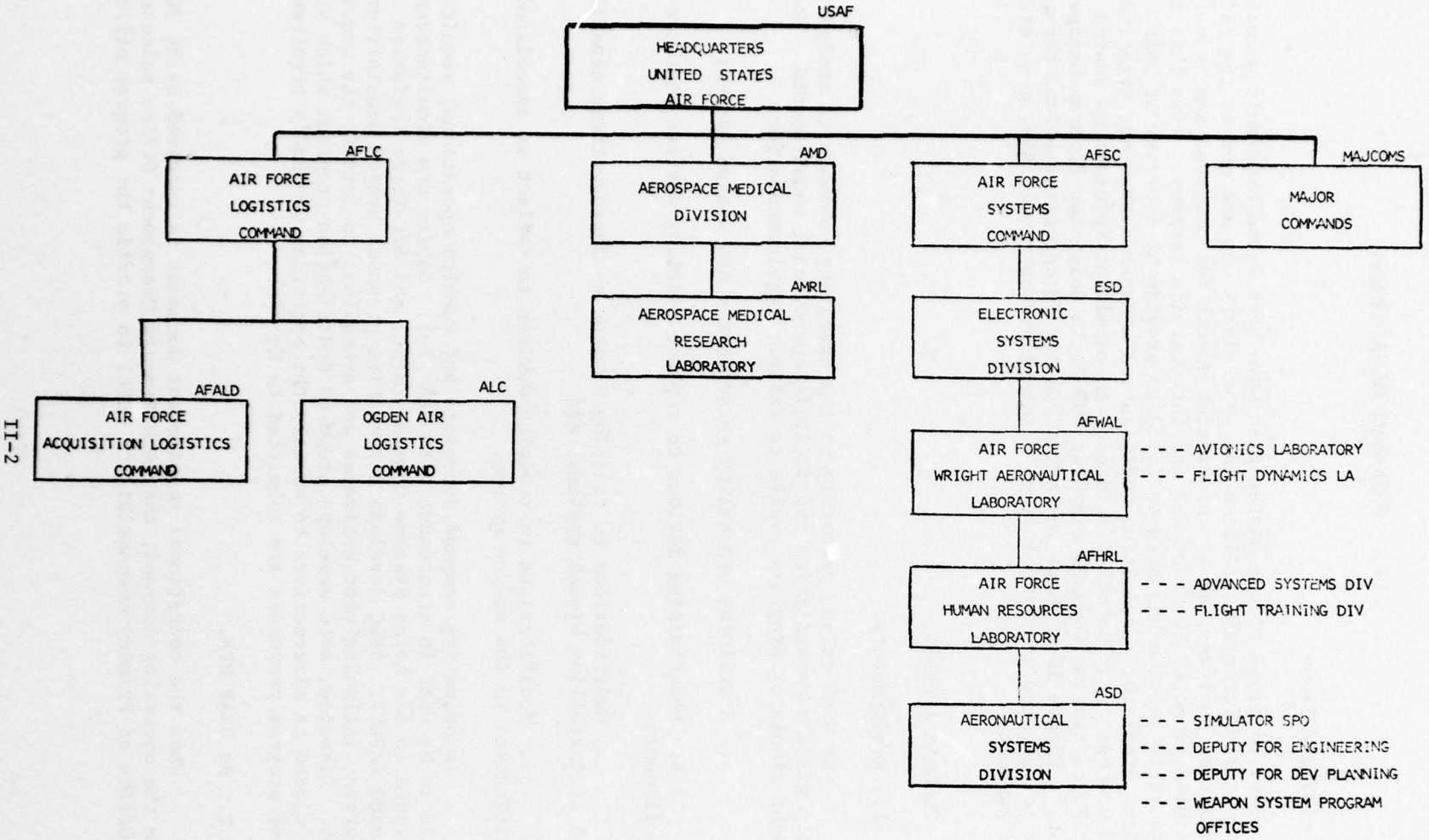


FIGURE II-1. Responsible Air Force Aircrew Training Devices Organizations

responsible for advocacy of program approval through the Chief of Staff, Secretary of the Air Force, Secretary of Defense, the President, and Congress. Normally, the OPR for a new flight simulator requirement is within the Directorate of Operational Requirements. The program officer obtains comments from the Air Staff, Major Commands, other Departments/Services/Agencies and conducts a thorough evaluation of the stated requirement and the AFSC/AFLC program alternatives. He develops a proposed course of action and submits the requirement and recommendations to the Requirements Review Group.

3. Requirements Review Group (RRG).

This Group is chaired by the Director of Operational Requirements and the members are the Director of Programs (AF/PRP), Director of Maintenance, Engineering and Supply (AF/LGY), Director of Logistics Plans and Programs (AF/LGX), Director of Development and Acquisition (AF/RDP), Director of Operations and Readiness (AF/XOO), Director of Plans (AF/XOX), and the Director of Reconnaissance and Electronic Warfare (AF/RDR). The RRG provides an early corporate review of an operational requirement prior to commitment of significant resources. If the RRG validates the requirement, the proposed program will receive further review as it progresses through the approval process and the planning/programming/budgeting system.

Department of Defense Directives 5000.1 and 5000.2 outline policies and procedures for the management of "major" system acquisitions. These Directives are implemented in the Air Force by AFR 800-2, "Program Management." The Secretary of Defense designates acquisitions as "major programs" using as a criterion an anticipated cost of $75 million in research, development, test and evaluation or $300 million in production. These programs proceed through a sequence of specified phases of program activity and division events. The Air Force System Acquisition Review Council and the Defense System Acquisition Review Council act as advisory bodies to the Secretary of the Air Force and the Secretary of Defense in making their decisions to initiate, increase, decrease, produce, or terminate a major system. Secretary of Defense milestone decisions do not authorize the commitment of funds; that is, the program must proceed through the planning/programming/budgeting system for budget approval and funding.

Generally, flight simulator programs are not of the magnitude to be designated as "major systems;" however, the process follows the same general approach and philosophy as that for major systems. The main difference lies in the levels of review and approval for the program. The program may skip part or all of a phase, or combine phases. Secretary of the Air Force and Secretary of Defense level control may consist only of fiscal approval through the annual budget approval process.

C. BUDGET APPROVAL

1. The Air Force Board Structure.

The Board Structure increases management's effectiveness by applying the collective judgment and experience of Air Force senior officials to programs, objectives, and problems. Findings and recommendations of Board Structure elements are forwarded to the Chief of Staff and appropriate staff officers. These recommendations are not directive and do not supersede the decision authority or responsibility of functional staff officials.

The Air Staff Board (ASB) assists the Air Staff through recommendations to the appropriate functional official at director level, or expedites director-level coordination on major, urgent, and complex issues. The ASB may refer matters to any of the functional staff at director level, or to the Air Force Council for further consideration. The ASB may also refer any matter to one or more of its subelements for review. The ASB consists of permanent committees, permanent panels, and ad hoc select groups as required to carry out its responsibilities. The ASB Chairman is responsible to the Vice Chief of Staff.

- The permanent panels are established as subelements of the ASB primarily for conducting the initial review and making recommendations on subjects proposed for presentation through the Board structure. The Simulator Panel is chaired by the Deputy Director of Operations.

- The Security Assistance Committee evaluates issues and recommends proposals related to successful implementation of the security assistance responsibilities of the USAF, and advises on the release of first-line, or otherwise significant Air Force equipment, technology, training, and capabilities to foreign governments under the security assistance program.

- The Force Structure Committee (FSC) reviews proposals and makes recommendations relevant to projections of enemy military strengths and to the composition of forces required to meet the threat.

- The Air Force Council (AFC) makes recommendations to the Chief of Staff, or provides expedited Deputy Chief of Staff (DCS) level coordination on major, urgent, and complex issues. The AFC may refer matters to the functional staff at DCS level for study, review or action, or to the ASB for review and recommendations. The AFC reviews and evaluates Air Force objectives, policies, plans, problems and studies.

2. Chief of Staff.

The Chief of Staff makes the final approval or adjustment action at Hq USAF. A designated General Officer Special Assistant to the Chief of Staff for flight simulation has been established. The special assistant is the Deputy Director of Operations and Readiness, who serves in an advisory capacity to the Chief. Upon approval by the Chief of Staff, the programs are submitted for departmental approval to the Secretary of the Air Force.

3. Secretary of the Air Force.

The Secretary of the Air Force takes the last official action on the programs and their budget estimates in the Department of the Air Force. He is assisted in this evaluation by the Under Secretary and Assistant Secretaries, particularly by the Assistant Secretary for Financial Management.

4. Office of the Secretary of Defense (OSD) and Office of Management and Budget (OMB).

After final approval by the Department of the Air Force, the budget estimate is transmitted to OSD. The estimates are reviewed jointly by OSD and OMB, a staff arm of the President. This review culminates in a series of alternatives presented to the Secretary of Defense for decision. OSD decisions are transmitted to the Air Force for review and/or reclama. Final OSD decisions follow reclama and the resulting estimates submitted to the OMB. The OMB takes another look and has the authority to amend accounts in its final independent review just before the budget estimates are submitted to the President.

5. The President.

The President, under the Constitution and laws enacted pursuant thereto, has final and conclusive authority over the budget estimates within the Executive Branch of our government. His consideration of the estimates includes the weighing, not only of the factors which the Air Force considered in determining the amounts requested, but also other factors such as the needs of the government as a whole - both defense and nondefense; the necessity or possibility of balancing the budget; and how large a Federal budget the national economy will permit or may require. The President's determinations are then made known to the departments in Letters of Allowance from the OMB. The departments must then revise all of their various budget schedules and statements to conform to such allowances for printing in the President' budget.

Reclamas to both the markups received from the Department of Defense and the allowances announced by the OMB are allowed if time and other considerations permit. These appeals may request complete or

partial restoration of deductions and must include the strongest possible justification for action sought. Once the reclamas are entertained by either the Department of Defense or the OMB - or both - their resultant decisions are binding.

The preparation of the Federal budget is accomplished after final Presidential determinations have been made and all agencies have revised their estimates and submitted their material to the OMB for printing in the document which goes to Congress. To the estimates of the many Executive Departments and agencies are added the estimates of the Legislative and Judiciary Branches of the government, analyses of revenues, and other numerous special analyses of various kinds. The President's Budget Message is normally included as a preface to the Federal budget. The OMB has this data printed and bound into the tremendous document called The Budget of the US Government, usually by the end of December.

6. Congress

In accordance with long-standing custom, the House takes first action on appropriation bills, although this is not required by law. In the House, the Budget is referred to the Committee on Appropriations, a very important standing committee of the House. The Appropriations Committee then refers the estimates for the Air Force to the Department of Defense Subcommittee for detailed consideration.

The Department of Defense Subcommittee holds hearings on the broader aspects of policies, programs, and objectives for the Department of Defense as a whole. The Secretary of Defense, Assistant Secretaries of Defense, and the civilian and military heads of each of the military departments usually appear before the DoD Subcommittee. Following this, more extensive and detailed hearings on the estimates of the individual Services are held by the Subcommittee. This is a very detailed, searching, and useful type of review. The presentations by the Air Force extend over a period of months.

Upon completion of its hearings, the Department of Defense Subcommittee drafts an Appropriation Bill for consideration of the full Committee on Appropriations. Finally, the Bill as approved by the full Committee is brought to the floor of the House of Representatives for debate by the whole House.

This is accompanied by a report which explains decisions by the Department of Defense Subcommittee which effected the Bill. It is a "Readers Digest" version of the hearings. In it may be deletions from or additions to the estimates submitted by the Services, or it could specify certain limitations which the Appropriations Committee considers necessary. The Bill might be amended on the floor of the House before it is passed.

The Senate receives the Appropriations Bill passed by the House and takes similar actions to those taken by the House of Representatives.

It processes the Bill through its Committee on Appropriations and to the Department of Defense Subcommittee. The Senate actions are somewhat less time consuming and detailed because it has available to it not only the House-passed Bill, but also the transcript of the Hearings held by the House Committee and Subcommittee and the report of the DoD Subcommittee. Senate action is consummated by passage of a Senate Appropriation Bill which usually and understandably differs in varying degrees from the Bill passed by the House. Then the Senate version or amendments to the Appropriation Bill are referred back to the House. The House receives and reviews the amendments as made by the Senate. If the House disagrees with any of the Senate's amendments, this difference is reconciled by means of Conference Action.

Conference Action is the process in which the Senate and House appoint several members to a Committee of Conference whose function is to reconcile the two versions of the Bill so that a single Bill can be recommended which will gain the approval of both Houses of Congress. The proceedings of this Committee of Conference culminate in a Conference Report which is referred to both the House of Representatives and the Senate. Adoption of the Conference Report by both Houses results in passage of the Appropriation Bill.

Apportionment is the distribution of the monies appropriated by the Congress in the Appropriation Act which has been signed into law by the President. The Air Force submits an apportionment request to OSD with supporting background similar to that utilized in the submission of budget estimates. Adjusted requests are transmitted to the OMB by the Comptroller, OSD. Approved apportionments come back to the Air Force through OSD. Apportionments may be for 12 months or any lesser period specified and they limit the authority of the Air Force to obligate funds by appropriation or activity for the time period specified.

D. PROGRAM IMPLEMENTATION

1. Hq USAF.

The Hq USAF OPR is responsible for the overall management and monitoring of approved USAF programs and for providing program management direction and guidance to the implementing command and the commands and agencies having supporting, participating, and operating responsibilities. For programs requiring funding over several fiscal years, the Hq USAF OPR must carry approved programs through the planning/programming/budgeting system in succeeding years to gain appropriation of the required funds.

Each program has its own peculiarities and follows a somewhat different course. If a validated program is to be satisfied by an acquisition program, the program officer normally begins developing program guidance and direction when he judges that program funding is likely. A Program Management Directive (PMD) is prepared and coordinated

directing initial efforts. Normally, this PMD will be published prior to the actual budget approval so that the implementing command will be in a position to obligate program funds during the fiscal year they are budgeted. Depending on program requirements, the PMD may direct efforts associated with demonstration and validation, full-scale engineering development, or for a low risk program, the PMD may even direct the initiation of a production program. The PMD may include program funding information for planning purposes; however, a PMD does not provide authority to negotiate a contract or obligate or expend funds, except as authorized in the appropriate PA/BA. Once a production effort is directed, the Hq USAF OPR will normally transfer from AF/RDQ to AF/RDP. This transfer will be designated in the PMD, and the new OPR assumes responsibilities for monitoring the program to completion.

If a validated requirement is to be satisfied by a Class V Modification to existing equipment, the program officer develops guidance and direction to accomplish the effort. When he judges that funding is likely, he prepares and coordinates a PMD to direct the initial efforts. The PMD may direct efforts associated with demonstration and validation or full-scale engineering development. Once a PMD is published to implement the modification program, the Hq USAF OPR normally will transfer from AF/RDQ to AF/LGY. This transfer will be designated by the PMD, and the new OPR assumes responsibilities for monitoring the program to completion.

Hq USAF functional offices work with the OPR in attaining program goals. Primary Hq USAF functional offices actively engaged in the management of flight simulator programs are the Directorates of Operations and Readiness (AF/XOO), Plans (AF/XOX), Programs and Resources (AF/PRP), Manpower and Organization (AF/PRM), Engineering and Services (AF/PRE), Personnel Programs (AF/DPP), Budget (AF/ACB), Management Analysis (AF/ACM), and Planning, Programming and Analysis (AF/RDX). AF/RDQ and AF/LGY also have functional responsibilities when not an OPR.

2. AFSC Organization.

Hq AFSC is located at Andrews AFB, MD. Simulator responsibility rests primarily within the headquarters' organizational structure depicted in Figure II-2. The Director of Operational Support Systems (SDA) provides the AFSC simulator focal point for the management of all flight simulator matters.

The focal point receives functional support from DCS/Development Plans (XR), DCS/Test and Evaluation (TE), and the Director of Science and Technology (DL). Representatives of these offices form an advisory board chaired by SDA. DCS/Development Plans is responsible for identifying and reviewing future simulator requirements, identifying the planning factors for simulator activities, and assists the Advisory Board in developing program priorities. DCS/Test and Evaluation develops/provides simulator test policies and guidance and arranges for simulator

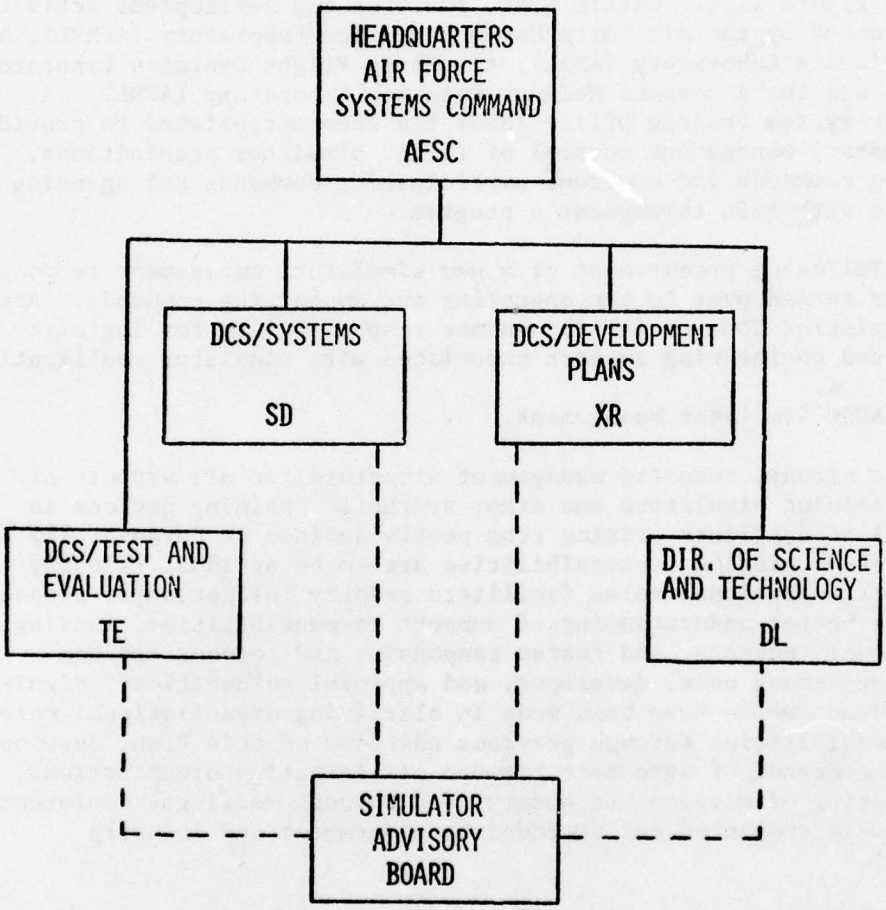


Figure II-2. Hq AFSC Organizational Structure for Simulators

test support resources. The Director of Science and Technology provides current data and recommendations for laboratory programs. Operating commands' liaison officers assigned to the Office of Operational Liaison (SDO) and other staff representatives provide inputs to the Advisory Board as needed.

3. Field Commands - Overview.

Management responsibility for development and procurement of new flight simulators is normally assigned to the AFSC field commands shown in Figure II-1. Within AFSC, research and development activities are conducted by the Air Force Human Resources Laboratory (AFHRL), Air Force Avionics Laboratory (AFAL), Air Force Flight Dynamics Laboratory (AFFDL), and the Aerospace Medical Research Laboratory (AFML). A simulator System Program Office (SPO) has been established to provide the necessary management control of flight simulator acquisitions. The operating commands and numerous participating commands and agencies interface with AFSC throughout a program.

Following procurement of a new simulator, management responsibility is turned over to the operating and supporting commands. Air Force Logistics Command (AFLC) assumes responsibility for logistic support and engineering support associated with simulator modifications.

4. AFSC Simulator Management.

A strong, cohesive management structure for all aspects of flight training simulators and other synthetic training devices is essential if conflicts arising from poorly defined or purposefully misunderstood mission responsibilities are to be avoided. Clearly defined organizational roles facilitate orderly initiation of projects, provide a better understanding of support responsibilities, funding and manpower requests, and foster responsive and responsible communications among user, developer, and approval authorities. Significant advancements have been made in clarifying organizational roles and responsibilities through previous editions of this Plan, development of memoranda of agreement between participating organizations, restructuring of mission statements, and through meetings, conferences, and symposia sponsored and attended by government and industry personnel.

The management concept for simulators within the Air Force, although formally structured by directives and regulations, is justifiably in a constant state of refinement. However, the management responsibilities for R&D and acquisition programs are well defined. A Program Management Directive is the vehicle by which general program direction and identified resources are transmitted from Hq USAF to Hq AFSC. AFSC selects the appropriate field command to manage the program and provides direction and guidance. With but few exceptions, simulator programs are managed by two organizations in

key roles, with support from several others in their particular areas of expertise. These organizations and their roles are: AFHRL, headquartered at Brooks Air Force Base, Texas, provides the technology foundation for training devices, in both equipment and human terms; and the Simulator SPO (ASD/SD24) located at Wright-Patterson Air Force Base, Ohio manages engineering development projects and acquisition programs during validation, full-scale development, and production phases. The Ogden Air Logistics Center of AFLC is responsible for simulator configuration, modification, and logistics support, but will be discussed in a subsequent section. Each of the above organizations are also responsible for operating as a central point with its indicated area of activity for continuing liaison with other government agencies (e.g., Navy, Army, NASA, FAA, etc.), airlines, industry, and the ultimate users within the operating commands of the Air Force.

As the key organization in the technology efforts on training devices, AFHRL is the action organization for the 6.2 and designated 6.3 programs described and listed in Section III. An important ingredient in performance of those programs is the level of participation and assistance rendered by AFFDL, AFAL, and AMRL. Provisions are made for informal but regular and systematic review by those organizations of plans and progress on the AFHRL simulator programs as a means to exploit their unique position as developers of complementary technology and users of simulators in their own right. The designation of AFAL and AFFDL as participants in support of AFHRL was done in full recognition of the distinction existing in the association these laboratories have vis-a-vis simulators. Their involvements are primarily in the role of users of simulators to support engineering design and evaluation of weapon systems and related technologies. The resulting expertise, however, does represent a resource that is profitably applied to the design evaluation, and operation of simulators for training purposes. The Aerospace Medical Research Laboratory (AMRL) is also a valuable resource for assistance to AFHRL in developing and conducting an effective R&D program.

The Simulator SPO (ASD/SD24) functions as a central program management organization for engineering development, production, test, and deployment of simulators and other instructional devices for all operational Air Force aeronautical weapon systems and functions as the simulator acquisition management agency for new weapon system developments when assigned that role by the ASD Commander. In addition to management of the acquisition of synthetic training devices in direct support of new weapon systems, other activities involved include: management of prototype technology integration programs; maintaining awareness of operational command experience with equipment; providing guidance to technology programs; assisting operational commands in development of requirements that realistically account for the state-of-the-art in simulation; and carrying-on active interface with other agencies using and/or developing simulators.

The Simulators Division (ASD/ENET) has historically functioned in the role of engineering support for the engineering development and production activities on simulators through collocated personnel in the various weapon system program offices. It is the point where all engineering aspects of simulator technology are integrated for comprehensive support of all Engineering Development and Production programs carried on by ASD/SD24. Fulfillment of that role has required gradual withdrawal of ASD/ENET personnel collocated with weapon system SPOs as simulator projects have been completed or transferred to SD24. Ultimate total dedication of the aircrew training simulator personnel of ENET to support of SD24 activities is rapidly becoming a realization with the recent physical move of the majority of ENET to the Simulator SPO.

A further major area of support for the Simulator SPO is that of advance planning, the assigned mission of the Deputy for Development Planning (ASD/XR). ASD/XR is actively engaged in advance planning for training simulators as a part of a continuing, overall examination of the training equipment needs for advanced aeronautical weapon systems. As advanced systems concepts move from the Conceptual Phase toward full-scale development and a SPO Cadre is formed within ASD/XR, the requirements for and funding of training devices are a matter of specific attention and should include participation by personnel from ASD/SD24 and ENET. This arrangement provides for the incorporation of ASD/XR's planning into the definitive planning/programming of the SPO Cadre and early involvement of the organizations (SD24 and ENET) that will subsequently carry-on the development/production of the training equipment involved.

The management concept discussed above and expressed in terms of roles and responsibilities for organizations involved in the conception and realization of simulation and training devices has required minimal restructuring of existing organizational functional statements, but does call for examination of the skills and human resources available within the organizations involved and the nature of activities in which they are or should be engaged.

Successful program management of simulator acquisition programs requires well coordinated contributions of operating, supporting, and participating commands. AFSC Pamphlet 800-3 should be consulted for detailed USAF acquisition management information.

Within AFSC, Aeronautical Systems Division and various laboratories conduct research and development and acquisition programs as directed by Hq AFSC. A simulator advisory group has been established at ASD to periodically review Air Force simulator programs for effectiveness and efficiency and to promote timely definition and integration of research, technology, engineering, acquisition, and logistic support. The ASD Deputy for Systems (ASD/SD) chairs the group and membership includes representatives from AFSC, AFLC, USAFA and the operating commands (TAC, SAC, MAC, ADCOM and ATC).

5. AFLC Organization.

Hq AFLC is located at Wright-Patterson AFB, Ohio. The Director, Equipment, Munitions and Electronics provides the AFLC simulator focal point for the management of all flight simulator matters. Figure II-3 shows the primary organizations responsible for simulator configuration updates, modifications and logistic support.

Various staff functional offices participate with the focal point in accomplishing the Hq AFLC mission in logistics support and modifications. Within AFLC, the Air Force Acquisition Logistics Division (AFALD) interfaces with the AFSC product divisions and laboratories in the planning and development of new systems and equipments. The AFALD has AFLC operational authority for the management of Integrated Logistics Support Office (ILSO), ASD/SD24L, located in the Simulator SPO. Ogden ALC is the responsible simulator ALC and assures that simulators are supportable for post-production and subsequent life of the system.

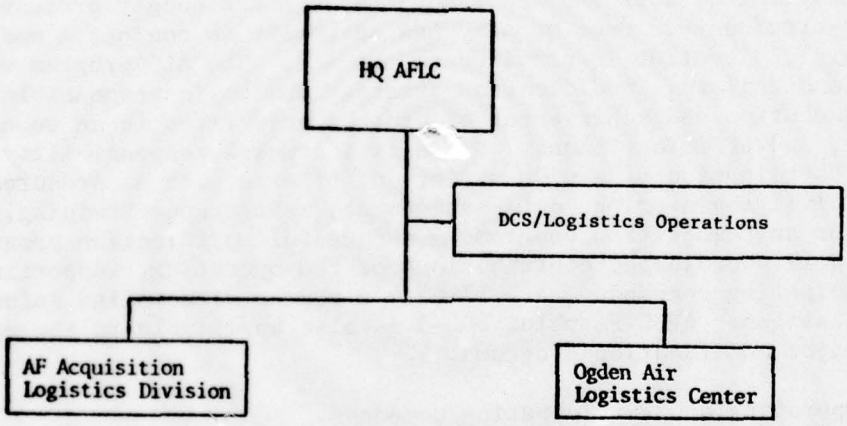


Figure II-3. AFLC Primary Organizational Structure for Simulators

6. AFLC Management.

AFALD is responsible for the introduction of logistics planning early in the development cycle and for ensuring that design to support/maintain receive equal priority with design to performance. AFALD participates with AFSC in reliability assessment, life cycle cost analysis and tradeoffs and is responsible for the feedback of field experience (lessons learned) on simulators to the AFSC simulator community. AFALD works with the SPO in business strategies such as incentive warrants

and is responsible with the AFLC simulator systems manager for the monitoring of such contractual items. The AFALD, through the chief of the Integrated Logistics Support Office in the Simulator SPO, assures that the preproduction responsibilities are carried-out effectively in support of simulator programs.

After a simulator is delivered to the operating command and program management responsibility has been transferred from AFSC to AFLC, the Ogden ALC system manager maintains overall system responsibility including configuration control, modifications and update planning. The main responsibility of keeping the simulators operational through spares support rests with the Ogden ALC Item Managers. Each manager manages a large number of items and is responsible for planning, budgeting, ordering, and distribution to using bases. This is done for the Air Force, Air Reserve Forces, and other Services under interservice agreements, and foreign countries under the many foreign sales and military assistance programs. There are numerous types of equipment modifications for which AFLC is responsible. The modification process is detailed by AFR 57-4. Modification requirements are generally originated by the operating command. Approval authority for a proposed modification is dependent on the type and magnitude of the program. A major modification is originated, approved and funded through the budget process described previously. Once Hq AFLC has authority to conduct a modification program, direction is provided to the ALC. The ALC program manager develops and tailors a modification strategy and he is responsible for program execution and achievement of program objectives in an economical, effective, and efficient manner. This is a complex responsibility that involves coordination of a wide variety of efforts such as procurement, testing, civil engineering, data management, maintenance training, etc. Just as for an acquisition program, a successful modification program requires well coordinated contributions of the operating, supporting and participating commands. AFR 57-4 is a source of detailed information on modifications. AFSC Pamphlet 800-3 is also applicable to the management of major modification programs.

7. Operating and Participating Commands.

There are several USAF organizations whose participation with AFSC and AFLC is essential for a successful acquisition or modification program. Primarily, these organizations are the major operating commands, the Air Training Command (ATC), and the Air Force Test and Evaluation Center (AFTEC).

The operating command must plan, program and provide such resources as civil engineering, operators, and maintenance personnel. Participation of the operating command throughout the program ensures that the operational system is responsive to user needs and prepares the command to test, operate and maintain the new system.

ATC, besides being an operating command supports nearly every acquisition or modification program. ATC makes program inputs

concerning human factors and is responsible for providing training programs for implementing, supporting and operating commands so that trained personnel will be available to test, operate and maintain new systems.

Air Force Test and Evaluation Center (AFTEC) is responsible for Operational Test and Evaluation (OT&E) program management. OT&E is conducted during a program to estimate the military utility, operational effectiveness and operational suitability of the new system, and test results are used in making program decisions. AFTEC conducts OT&E on major systems and on those non-major systems designated by Hq USAF. On other systems, the operating command conducts the OT&E and AFTEC monitors the testing.

E. ACQUISITION MANAGEMENT INITIATIVES

1. USAF Organizational Initiatives.

Increased emphasis has been placed on Air Force flight simulation beginning primarily in the late 1960s. This emphasis evolved as simulation technology made dramatic advances, as aircraft operating costs increased significantly, and as the nation was faced with an energy crisis. During this period, several organizational changes were initiated to facilitate effective management of simulator development and procurement.

Within Hq USAF, a General Officer Special Assistant to the Chief of Staff was designated for flight simulation matters, and a Simulator Panel was created as part of the Air Force Board Structure.

Within AFSC, a single focal point for flight simulation matters was established at AFSC Headquarters. Also at Hq AFSC, a Simulator Advisory Board was created. AFHRL was designated the focal point laboratory for the development of simulator technology. The Simulator System Program Office was created at ASD to consolidate activities associated with simulator acquisition. A Simulator Advisory Group was also established at ASD.

2. Mission Area Planning.

Department of Defense Directives 5000.1 and 5000.2 were published in January 1977 and affect the USAF requirements and system acquisition processes. Air Force Regulations are being revised to implement the directives. One provision of the directives calls for the Services to conduct continuing analyses of mission areas to identify mission needs and to define, develop, produce and deploy systems to satisfy those needs.

Currently underway at Hq USAF in DCS/R&D is a process called "Mission Area Planning" for budget estimate development. The process consists of three sequential, iterative activities: mission area analysis, development planning, and zero-based budgeting.

Mission area analysis involves dividing the Air Force mission into mission areas, dividing each mission area into smaller functional tasks, defining conditions under which the mission functions must be performed, and assigning relative importance weights to the functional tasks and conditions. For functional tasks, the weights indicate the relative importance of each task to accomplishing the mission, and for conditions the weights indicate the degree to which each condition would influence the overall planning to achieve mission area objectives. Individual functional task/condition deficiencies are identified by comparing capability versus threat for each functional task under each condition, and a need value is determined to indicate how individual deficiencies rank over the whole mission area.

Development planning is then conducted to define alternative solutions for the deficiencies. Alternatives for each program address various funding levels. The contribution of each program element (at its alternative levels) toward satisfying deficiencies is assessed and weighed, and unconstrained budget alternatives are formulated.

In zero-based budgeting "decision packages" comprised of selected program element alternatives are combined, considering importance value and cost, into an integrated mission area investment strategy which optimizes deficiency satisfication over time at each of three fiscal constraints; current, minimum, and enhanced levels. The results are integrated with the ongoing total Air Force budget preparation process.

3. Congressional Hearing.

On 13 May 1976 the Subcommittee on Research and Development, Senate Armed Services Committee, conducted a hearing of the Department of Defense on flight simulators. This hearing was somewhat unique in that it was the first Congressional Hearing directed exclusively at flight simulators. The hearing consisted of a statement by Dr. John L. Allen, Deputy Director of Defense Research and Engineering (Research and Advanced Technology), Office of the Secretary of Defense. Army, Navy and Air Force witnesses provided statements and testimony concerning R&D and procurement programs, funding requirements, and management.

The hearing was a valuable exchange of information and a record was printed for use by the entire Armed Services Committee.

4. DoD Reports.

Since FY 1974 the Senate Armed Services Committee has asked DoD to provide a report on flight simulators with the annual budget submission. The FY 1978 report included a summary of the FY 1978 and 1979 procurement requests, anticipated FY 1978 flying hour savings, amortization data, a discussion of simulation benefits and savings which are not readily quantifiable, and DoD flying hour reduction goals. The Committee has found these reports to be very useful and informative.

5. Congressional Guidance.

In reviewing the FY 1978 budget request, the Senate Armed Services Committee stated, "The Committee believes the flight simulator programs are proceeding well, but cautions the Services to make sure each system is properly defined before production contracts are let. The Committee will not normally look with favor on subsequent requests for additional funds to change or modify systems in production or just procured. The Committee compliments the Department of Defense on the FY 1978 flight simulator report, which greatly facilitates review of the various program requests. Consequently, the Committee requests a similar report be submitted with the FY 1979 budget to include the following:

- Summary of the FY 1979 flight training device procurement requested;

- Summary of the proposed FY 1980 flight simulator procurement program;

- Anticipated FY 1979 flying hour savings by aircraft (in dollars and fuel) along with the actual savings achieved in the FY 1977 as compared to the anticipated savings;

- An update of the amortization data in the FY 1978 report;

- A summary by Service of the FY 1979 research and development programs bearing on flight simulators; and

- Other data the Department believes should be brought to the attention of the Committee.

6. Streamlining Flight Simulator Acquisition.

USAF experience on programs managed by the Simulator System Program Office (SPO) indicates that over five years have been required on the average from submittal of a draft Required Operational Capability (ROC) to Ready for Training (RFT) date of the initial unit. The average times grouped as:

	ACTIVITY	OPERATIONAL FLIGHT TRAINER (OFT) Average Time *
a.	Draft ROC to Program Management Directive (PMD)	16 Months
b.	PMD to Contract Award (CA)	16 Months
c.	CA to First Unit RFT	30 Months
		62 Months

* These average times may change as General Operational Requirements (GORs) replace ROCs.

In regard to activity a., there has been a continual improvement in communications over the past three years between the ROC initiator and the Simulator SPO. However, the activity from draft/published ROC submittals through completion of the ASD draft/published ROC evaluations generally accounts for anywhere from three to six months. The bulk of the remaining time has been required for the Air Force review and approval cycle and culminated in issuance of a PMD. The review and approval cycle has included one or more reexamination(s) of the stated training needs, proposed alternative solutions, training benefits, selection of preferred solution, and identification of available funds.

In regard to activity b., the following steps have been or are being employed to improve the quality of the procurement, minimize the length of activity b., and minimize the life cycle costs:

- Final detailed review of user training needs to ensure that the system specification, statement of work, and contract data requirements do not contain unnecessary requirements;

- Use of a system performance specification, in lieu of a detailed design specification, to permit the proposed contractors maximum flexibility in trading-off technical approach, cost, risk, and schedule to arrive at an optimum solution;

- Strong emphasis in the Request for Proposal (RFP), and during source selection on Life Cycle Cost implications, rather than just lowest acquisition cost;

- Release of a draft RFP to prospective bidders for review and comments on attainability prior to finalization and issuance of the RFP; and

- The B-52/KC-135 Weapon System Trainer program was selected to test a proposed "Four-Step" source selection procedure being evaluated within the DoD. (Four other AFSC programs were also named as test programs; five programs, including the C-130 WST were identified as controls.) Detailed in DoD Directive 4105.62 "Selection of Contractual Sources for Major Defense Systems," 6 January 1976, the Four-Step Procedure was designed to improve the effectiveness of competitive procurements. The four steps outlined in DoDD 4105.62 are:

  - Technical proposals are solicited and evaluated;
  - Cost/Price proposals and technical revisions are matched to a competitive range;
  - A common cutoff is set for receipt of final revisions and selection of a winner; and
  - A contract is negotiated with the winner.

By establishing these steps as sequential phases of a source selection, it is possible to eliminate offerors who are not technically competent at the outset; thereby, terminating any additional effort which might be spent in additional preparation or evaluation of proposals. Leading government contractors reportedly favor a procedure which permits proposal teams to be disbanded as soon as it can be determined that the proposal is noncompetitive.

Upon completion of all of the source selection activities associated with the test and control programs, a detailed analysis of this procedure will be completed. If the evaluation is favorable, the Four-Step procedure could become directive in nature for all future competitive procurements for major defense systems.

- Combining two separate program procurements into a single procurement for the B-52/KC-135 WSTs due to the commonality of many training needs and the physical location of B-52 and KC-135 WSTs at the same bases. The Strategic Air Command had previously combined the military construction programs for the same reason.

- When warranted, using a pilot production or prototype phase to permit design, development, and test of the trainer prior to a production commitment. The pilot production phase has been used on the C-130 IFS program and is being employed on the B-52/KC-135 WST and C-130 visual system programs. The prototype phase is being employed to develop the first full visual system (engineering development Project 2360, Fighter/Attack Simulator Visual System), and lower cost electronic warfare (EW) simulation for fighter/attack aircraft, Program Element 64229F.

- Using competitive pilot production (B-52/KC-135 WST program) or prototype (Project 2360 and fighter EW simulation) phase to obtain significantly lower life cycle costs.

- Incorporating Firm Fixed Price contractor maintenance options (up to three or four annual options) in the C-130 IFS contract and C-130 visual system RFP to emphasize lower life cycle cost. By requiring the contractor to maintain the system for a reasonable period of time, the Air Force is attempting to motivate the contractor to maximize reliability and maintainability in the initial phase of system design.

- Separating the original C-130 IFS (with visual system) program into separate OFT and visual system procurements to permit additional time for development by Industry of visual systems capable of meeting most, if not all, of the user's training needs.

In regard to activity c., approximately 24 months are required for a cockpit procedure trainer and about 36 months for a weapon system trainer. These times are required for design, development, fabrication, and test of the first unit.

7. Interservice Liaison.

A principal service interface is between the Air Force Simulator System Program Office (SPO) at Wright-Patterson AFB, Ohio and the Naval Training Equipment Center (NTEC) at Orlando, Florida. Liaison officers are permanently stationed at the SPO (Navy representative) and at NTEC (Air Force representative). The Air Force Liaison Officer also interfaces with the Army Training Device Center (ATDC) at Orlando. A similar information exchange occurs between the Office of the Chief of Naval Education and Training at Pensacola, Florida and the Flying Training Division of AFHRL at Williams AFB, Arizona, The Navy has an officer on permanent assignment at Williams AFB to act as an Air Force/Navy interface on all flying training research. AFHRL tracks the activities of the Navy, the Army, and NASA as well as industry to help minimize any duplication of effort. Presently, AFHRL and the Army are funding a joint effort to develop a laser scanned visual system. The Army is responsible for the development of the model board and laser scanned probe, while the Air Force is responsible for the laser scanned visual display system and adapting this display technique to computer generated imagery.

Other interagency exchanges take place in the form of regularly scheduled meetings. The Naval Training Equipment Center hosts an NTEC/ Industry Conference annually at Orlando. This three-day conference covers many topics of interest and opens many avenues of communications.

A semiannual meeting takes place in the form of the DoD/NASA Simulation Technology Coordination Group. For each session, one main topic of interest (e.g., simulator certification, simulator motion requirements, etc.) is chosen, and all agencies brief their organization's programs in this area.

The Office of the Director of Defense Research and Engineering chairs an annual Topical Review for aircrew training simulation. The Air Force Simulator SPO, Air Force Human Resources Laboratory, the Army and the Navy all participate and exchange data on their current acquisition, research and development programs. As a result of these scheduled meetings, the various agencies within DoD and NASA keep up-to-date on the activities of the other agencies.

F. MANAGEMENT AND PLANNING ISSUES

The Office of Management and Budget in a 26 July 1973 report very succinctly put forth three critical issues in regard to the use of simulators in the Services: How much simulation is technically feasible? How much is militarily acceptable? and, How much is economically mandatory?

Section III of this report deals largely with the first of these questions. There is little doubt, if any, that technology can produce

simulators to accomplish any given training task given enough time and money. The questions of how much will it cost, when can it be made available and which things should be done first, belong to the realm of programs which are dealt with in Section IV and subsequent sections for each major Air Force Command on a weapon system basis. The questions of military acceptability and economic drives and constraints are far more difficult to deal with because they are issues which require data not in evidence to feel confident about the answers. As discussed earlier in this section, there have been several institutional changes made in an attempt to resolve the latter issues. However, these changes are of such recent vintage that their impact will not be fully known for several years. They are however, positive management actions which are indicative of the type of planning required as the training medium of simulators becomes more and more prominent, and as simulator complexity and costs increase.

Since the publication of the initial edition of the Master Plan in June 1974, the Air Force has come to grips with significant management and planning issues which could have adversely affected simulator technology development and acquisition programs. There are however, several additional issues which must receive commensurate high level commitments in order to add coherence to future programs.

1. Several institutionalized attutudes have had deleterious effects upon the retention and career progression of highly qualified training officers and airmen. The problem results from a lack of recognition of the importance of providing positive career incentives for those working in the training field. The concept of the development of a cadre of highly skilled, motivated and properly rewarded officers and airmen is a current necessity with the decision to emphasize synthetic training devices. As the training programs become progressively more important in terms of overall Command proficiency and as the training media become more complex, there should be a commensurate upgrading of personnel rewards.

2. The present undergraduate pilot training (UPT) program is so thoroughly planned that the student rarely faces a new situation. Students are almost never forced to rely on their own decisions for mission accomplishment. The opportunity to develop judgment and make decisions could be provided in the simulator or perhaps a simulator/learning center combination. Research into training for autonomous behavior should be considered at the earliest opportunity. Emphasis should be directed at the cues used by pilots in performance of flying tasks, performance assessment, maneuver performance frequency to maintain required proficiency levels, and optimization of training features. Training in judgment and provisions for greater opportunities for individual decision making is vital to UPT student development.

3. One of the most significant planning uncertainties continues to be the degree to which simulator training can be substituted for

aircraft flying time. This uncertainty influences not only predictions regarding reduced training loads on aircraft, but also on the number of simulators required to accommodate the training needs which have resulted from the planned flight reductions.

Confidence in substituting simulator training for aircraft training is impacted by things such as simulator fidelity, instructional strategy, student ability, training tasks and aircraft type. A considerable body of evidence exists which indicates that high fidelity instrument simulators can substitute for a large part of instrument practice. This is especially true with experienced pilots. There is likewise considerable knowledge that to support simulator training in straight-in approaches, front window visual systems are sufficient.

However at this time, flying tasks that are more demanding of pilot skill (i.e., circling approaches, air-to-air combat, air-to-surface weapon delivery) as well as simulator capabilities, have only sketchy data concerning what can be trained, what equipment is required for the training, and how this simulator training should be integrated with aircraft training.

To obtain the needed data on transfer of training, studies in the operational crew training environment must be carried out. To be conclusive, the research must be accomplished with rigorous control that will impact regular training operations; for example, changes to the training syllabus or substitution of simulator for aircraft sorties may be required. These changes place a burden on the training squadrons involved because students in a study may receive different instruction or use different equipment and thus, may not graduate with standardized training. If this occurs, the training/research team must provide supplemental flying practice to assure that all research participants attain an acceptable performance level before being graduated and that nothing is done that will adversely affect their Air Force career. In the near term, this will be costly in aircraft sorties and training time but the information gained will permit appropriate syllabus modifications to improve future training.

4. A valid concern exists for proper consideration of maintaining the skill level and motivation of personnel engaged in support and interface functions. As simulator time replaces actual aircraft flying time, the functions of aircraft maintenance, ground environment communications and control, emergency crew operation, etc., could stagnate and deteriorate for lack of exercise. Means will have to be sought to protect surge capability by continuation training for these interface functions. While this problem could be slow to materialize, and may in fact never develop, it is nonetheless, a valid concern as significant reductions in air time are achieved.

5. A major problem with modification acquisition is in obtaining training for maintenance personnel in sufficient time to have a blue-suit capability for acceptance test participation and to meet equipment Ready for Training (RFT) dates. ATC should be involved in the early stages of modification definition to assess training requirements.

Contracts must include provisions for training maintenance personnel in support of modifications, and technical data must be adequate and available for training purposes prior to modification kit delivery. To properly assess the training requirements for simulators, the maintenance and support concepts must be considered and identified where possible during the ISD process.

6. Instructional System Development (ISD), adopted by the Air Force in the early seventies, is the process for developing and managing all training requirements and responds to changes in those requirements throughout the life cycle of each system. The ISD process, as previously defined, begins in the conceptual stage of weapon system development -- during or shortly after the development of the General Operational Requirement (GOR). In the past, ISD has not always been applied in the initial stages of weapon system development. While it is clear that useful data can be derived from ISD initiated late in the development cycle, the Air Force must ensure the process begins at the proper time for future systems. This requires MAJCOM identification and Air Staff support of manpower/funding requirements for early ISD implementation. Properly used -- beginning very early in the weapon system development cycle -- full benefits from ISD can be achieved.

7. An important issue which impacts acquisition and support responsibilities is the development of cockpit familiarization trainers (CFTs) and egress procedrues trainers (EPTs). In the past, some weapon system SPOs (e.g., F-15 and A-10) have had contractors design and build the initial CFT and EPT units. These SPOs have subsequently contracted with Air Training Command (ATC) to build the remaining units. ATC is currently fabricating all such devices for the F-16 SPO. However, the key issue is, who will support these ATC designed and built trainers after program management responsibility has been transferred from AFSC to AFLC? If the Ogden Air Logistics Center (ALC) is expected to manage and support the CFTs and EPTs, the devices will have to be procured in a manner that will produce adequate engineering drawings, provisioning data, manuals, etc. Support responsibility must be clearly defined and coordinated prior to initiating procurement. The simulator SPO (ASD/SD24) should procure the devices and the required support data in the most cost effective manner.

In keeping with the above issue, the Major Commands have expressed concern regarding the procedures for obtaining part task trainers (PTTs). They have found the present Required Operational Capability (ROC) procedures to be unresponsive due to the long lead time required to obtain equipment. ATC, in conjunction with training equipment personnel from ADCOM, TAC, SAC, and ASD has proposed an alterante method of obtaining using command funded training equipment using primarily in-house capability to fabricate and maintain such equipment. The proposal was studied by the Simulator Advisory Group (SAG) which determined that there is only one PTT awaiting funding/

development. In the future, PTTs will either: (1) be developed in-house by the MAJCOM; (2) be developed by the Air Training Command; or (3) be part of a larger aircrew training devices package which will be procured by either the Weapon System Program Office or the Simulator SPO. As a result, there appears to be no requirement to modify the ROC (or GOR) process to expedite procurement of PTT devices.

8. Development planning for simulators must receive the high level attention within planning organizations that is currently enjoyed by other major systems. The Deputy for Development Planning, Aeronautical Systems Division (ASD/XR) is the prime organization responsible for long-range planning for simulators. Key issues associated with successful development planning activities are the definition of roles and responsibilities and the availability of personnel resources to undertake the defined tasks. ASD/XR must provide guidance to Air Force Laboratories, the Simulator SPO, and ASD Engineering on matters related to conceptual aeronautical systems. This guidance will ensure that appropriate research is undertaken in technology areas, in a timely manner, to support the Air Force mission for aircrew training and will provide an awareness of potential acquisition programs. The Deputy must be cognizant of future system requirements in the tactical, strategic and airlift mission areas and assess their impact on future R&D and acquisition programs. In addition, it must be responsible for identifying and reviewing future simulator requirements, conducting relevant simulator studies, and assisting in reviewing development planning priorities.

9. Planning and programming for facilities to house simulators must be coordinated with the technical development. It normally requires approximately three or more years to program, develop criteria, design, and construct a facility. Therefore, it is imperative that the responsible civil engineers be knowledgeable and participate in the entire planning effort.

10. There is a need for greater efficiencies throughout the Air Force. This can be brought about if organizations would document lessons learned so that there can be a cross-feed of these lessons to others. Lessons learned once should be used and not forgotten, only to be learned again in the future. An organization should be established for receipt of lessons learned and the maintenance of a corporate memory. This organization needs a broad base from which it can draw upon in order to take the maximum advantage possible of the variety of experiences with aircrew training devices. This base should be composed of, but not limited to, the major commands, AFSC Product Divisions, Air Force Test Centers, AFALD, the Ogden ALC, and industry.

11. The Aeronautical Systems Division and the Air Force Acquisition Logistics Division are working closely to ensure maximum logistic support for aircrew training devices. However, additional attention must be given to the area of commonality among ATD subsystems. Commonality would allow AFLC to support subsystems such as embedded computers

and power supplies with a common set of technical data, support equipment, spares and software programs. Such efforts would result in major reductions in life cycle costs. In addition to commonality, adaptability of simulators should be emphasized to minimize complexity and costs of future modifications.

12. An extremely important issue which has surfaced very recently is concerned with the planning for and acquisition of maintenance trainers. Heretofore, the planning for maintenance trainers has been accomplished by one or more of the following: Air Training Command; Weapon System Program Office; Air Logistics Center(s); major operating command; and, simulator contractor. Likewise, the acquisition of these trainers have had no central focus. The expenditures for maintenance trainers represent large capital investments by the Air Force and accordingly, the prime management, planning and acquisition responsibilities for these devices should be centered in one organization. The leading and possibly most logical condidate organization is the Simulator SPO. However, the additional responsibilities for maintenance trainers within the Simulator SPO would require an expansion of the SPO's functional charter and a substantial increase in manpower resources.

The issue of responsibility for maintenance trainers also suggests that responsibility for other aircrew related training devices (radar, ECM, DRLMS, etc.) should also be centered in one organization. Again, the Simulator SPO is an apparent candidate.

Given that the appropriate management resources were made available, a Specialized Trainer Division with the Simulator SPO is one viable alternative to resolving the issues associated with responsibility for maintenance trainers and other aircrew related training devices.

III. OVERVIEW OF SIMULATOR TECHNOLOGY

A. THE EVOLUTION OF FLIGHT SIMULATION IN TRAINING

The history of the development of the technology for flight simulation in training, as we know it today, originated in the "Link Trainer" of World War II, and significant advances in the technology have occurred progressively in programs that can be categorized in steps of approximately ten years duration.

The original Link Trainer design was based upon the utilization of instrumentation systems that were largely mechanical in nature. In the late 1940s, techniques were developed to replace these mechanical systems with electrical and electronic designs.

At approximately the turn of the decade (1950s), the analog flight simulator was developed for training. This simulator employed special purpose, fixed wired computer systems that solved certain special purpose, and simplified equations for the forces and motion of the aircraft simulated under very limited conditions. These original analog techniques, which were used until the latter part of the 1950s, employed an a.c. carrier design that added to the special purpose nature of the simulation. The d.c. analog computer systems were introduced in this period and provided a more scientific and general purpose approach to simulator design. It was also during this period that several unsuccessful attempts were made to develop visual simulation devices. Sensor simulators which simulated the operation of airborne radar systems were also under development. These early simulations utilized a technique that employed ultrasonic waves which were transmitted through water to a 3-D model of the area represented. Although the approach was very crude, limited in operation, and difficult to modify, many trainers employing this design were used in aircrew training. This period saw the introduction of the photo-transparency approach for radar landmass simulation. The first systems encoded the data in shades of gray, using one transparency for radar reflectivity and another for elevation information. Later systems used a single transparent map and had both elevation and cultural information stored by using three colors (red and blue for elevation, green for culture). The technique utilized a flying spot scanner tube to scan the map and then process the resultant amount of light such that a realistic presentation of radar information was displayed on the operator's indicator. This photographic approach, with some recent improvements, is still the system installed in most of the present day Air Force simulators. During this period, simulation of electronic warfare equipment was introduced. These systems used analog techniques for the simulation of the emitters and countermeasures. Although quite cumbersome to operate and maintain, these systems provided an effective training capability for electronic warfare officers. Motion systems were also beginning to evolve through several stages, utilizing a variety of mechanisms ranging from pneumatic actuators and gear driven mechanical systems to hydraulic systems which became predominant toward the end of the decade.

Early in the 1960s, the development of a real time, medium sized digital computer was completed and demonstrated to be suitable for training simulation. It was also during this period that the development of a model board and TV approach to visual simulation was initiated. Like many other "concurrent" (simultaneous technology development and hardware acquisition) programs, this visual simulation effort resulted in failure. Later in the 1960 decade, three additional attempts were made at concurrent visual simulation development, however, none of these were successful either. From these first attempts to develop visual systems, the Services and industry learned many things which were later applied in the formulation of an exploratory development interim visual simulation program and in the development of a successful technique, which was originally applied by the commerical airlines. Conceptual studies were conducted for the development of techniques for generating radar simulation using digital techniques; however, due to the limited resources, no hardware was developed.

In the 1970s, the band pass of video systems was increased and successful work was done in both narrow and wide field of view optical probes. These techniques demonstrated that wide angle, high resolution, infinite depth of focus visual image generation, based upon probe and TV, was now feasible, although specific systems usually required additional development. The first successful Air Force development of a visual simulation system in an operational organization was completed on the C-5/C-141 system. Two significant large and complex advanced development programs in the simulation area were initiated early in the 1970s. One was the Advanced Simulator for Undergraduate Pilot Training (ASUPT) and was originally intended for research programs in the UPT area. It is now being used as a research tool to investigate other areas of Air Force flying training. As a result, the name of the system has been changed to Advanced Simulation in Pilot Training (ASPT). The other was the Simulator for Air-to-Air Combat (SAAC) and was intended to demonstrate the utility of simulation for training and research in air-to-air combat. In addition to providing large and complex simulation systems for training and research, the ASPT and SAAC now provide a means for the development and demonstration of advanced simulation technology. The ASPT development program has advanced technology in computer image generation (CIG), large CRT displays, "g" seat and advanced instructional capabilities. The SAAC demonstrated advances in one-on-one aerial combat tactics, segmented virtual image displays and high resolution double raster image assembly techniques. A program has been completed for adding visual simulation to an advanced F-4E fighter simulator (F-4E #18). This was based upon the application of the wide angle probe and image intensifier combined with a high resolution color TV system. This program followed a development course similar to some of the earlier "concurrent" efforts, without the benefit of strong technical management from the Laboratory or Engineering community such as was applied to the ASPT and SAAC development programs. As a result, the F-4E #18 simulator met with the same results of past "concurrent" programs and was found to be of little value for training.

A radar simulation system for the F-111 simulator has been developed based upon the application of digital techniques. This system has been installed on an F-111A simulator and is being tested to determine the increase in training effectiveness of this approach vice analog. Project 1183, Digital Radar Landmass Simulator (DRLMS) was also designed to develop standard techniques that could be applied to other radar simulator programs (B-52/KC-135, C-130, F-16, etc.). The Defense Mapping Agency developed a high resolution digital data base (gaming areas), while concurrently a contracted effort was employed to develop high speed digital storage and processing hardware/software. While Project 1183 DRLMS system was found to be unacceptable for low-level automatic terrain-following radar training, the program was considered a success. The display, realism and accuracy were significantly increased over the analog system, and allows valuable navigation and targeting missions to be accomplished. The digital concept has been slightly modified and will be used by all DRLMS systems developed after March 1977.

A significant advanced development program on Training Simulation Technology Integration commenced during 1975. This program is intended for the design, development, and fabrication of advanced training simulation systems for test and demonstration of their performance capabilities. Included are the development of a holographic version of the pancake window successfully employed on the ASPT and SAAC visual simulators, the development of an advanced, low-cost g-seat for motion simulation and advanced electrooptical sensor simulation developments. The holographic pancake window offers potential for significant cost and weight savings compared to the conventional all-glass pancake window, and also offers potential for providing a full color visual simulation. The g-seat offers potential for significant cost savings as a viable method for motion simulation. The sensor simulation developments provide a mechansim for developing and evaluating advanced algorithms and the determination of key parameters and cues necessary to simulate EO weapons for aircrew training.

With the advent of increased activity in electronic warfare and the limited airspace available for airborne training, digital techniques were applied in the development of the Simulator for Electronic Warfare Training (SEWT). With the introduction of SEWT in January of 1974, the Electronic Warfare Officer Training Course at ATC became a no-fly program.

A program has been initiated to develop techniques for simulation of infrared and low light-level television systems, based upon the application of digital image generation techniques. Mathematical and programming techniques are being developed to automate some of the functions of the simulator instructor. Results have indicated a considerable amount of success in techniques for objective performance measurement, automated task selection and variable task difficulty. These techniques open up great promise for completely individualized performance based simulation.

Early in the 1970s the concepts of System Approach to Training (or Instructional System Development) were accepted by the Operating Commands and have since been seriously applied in developing training requirements. It is clear that in the future, simulation requirements will be determined during a total Instructional System Development Program and will be applied in a continuum of training programs and equipment that range from the academic to the flying environment.

B. MODIFICATION POTENTIAL OF EXISTING SIMULATORS

Since the present USAF inventory of simulators is the result of acquisitions made at various points in the evolutionary process, it is useful to categorize them as follows:

1. Very old devices using alternating current analog computers and no motion systems (mid-1950s) (B-52/KC-135);

2. First generation direct current analog computers, no motion (late 1950s) (F-106);

3. Second generation d.c. analog machines with early motion systems (early 1960s) (C-130, F-4);

4. First generation digital computer simulator, updated motion devices (mid 1960s) (F-111A, F-4E); and

5. Modern general purpose digital computer simulators with good motion but not latest state-of-the-art (late 1960s and early 1970s) (C-5, A-7, FB-111).

Figure III-1 is a pictorial showing these classes arranged along the horizontal axis of a three-dimensional axis system. Computational sophistication, especially as represented by the advent of the digital computer, has been the key to growth into the other dimensions of motion and visual representation.

The very old devices are extremely difficult to augment. The computers utilize hardwired mathematical models which are totally inadequate to drive either motion systems or visual devices. The cockpits and instructor areas are large, heavy and not stressed to withstand a motion system. Augmenting these trainers (e.g., B-52), therefore, requires a new development effort with schedules consistent with such programs. It is possible to update for aircraft changes or to change the program use. The same considerations apply to early d.c. analog devices.

It is possible to add state-of-the-art visual devices to second generation d.c. analog simulators by adding small digital computers to correct deficiencies in flight characteristics. In some cases, the existing motion systems do not have the weight capacity.

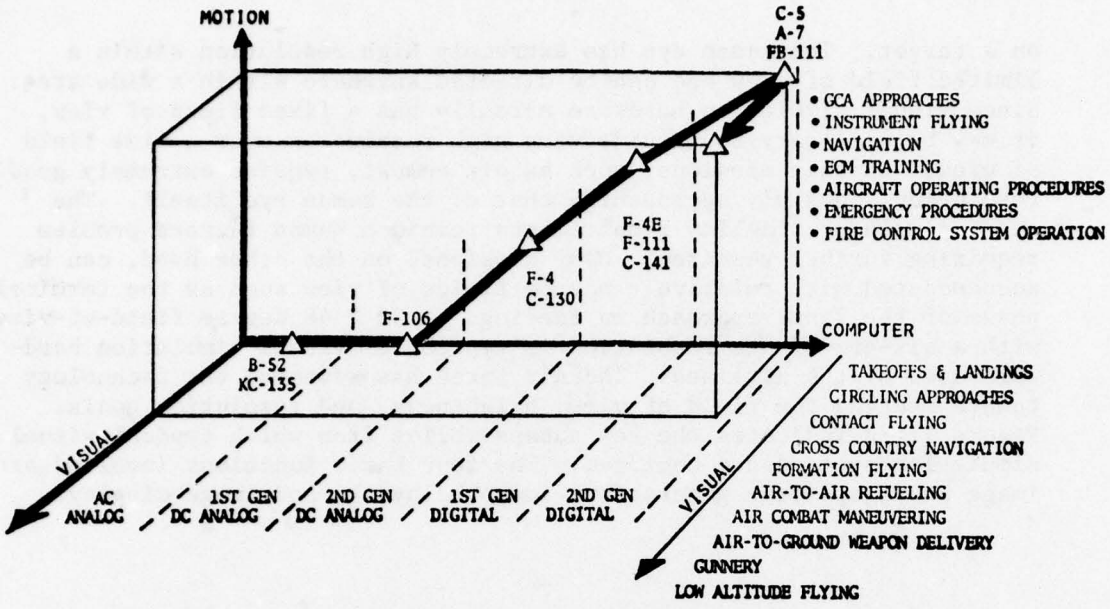


FIGURE III-1. Flight Simulator Development

All of the digitally driven simulators can be modified to add visual devices and more modern motion systems if needed. In addition to the motion systems, other somatic cue devices such as g-seats and g-suits can be added. In general, visual systems should not be added to simulators without g-cueing systems. Starting with Class 4 simulators, computational flexibility is sufficient to consider the merits of modification to open the way to a vast new training task domain offered by visual simulation. Figure III-1 lists the additional training tasks made possible for simulation by the incorporation of adequate visual systems. Each system must be examined carefully however, to assure that other factors do not mitigate against modification as a superior choice to replacement in a cost-effectiveness sense.

C. SIMULATOR TECHNOLOGY STATUS

1. Visual Systems.

As noted previously, a key element in increasing the use of simulators in aircrew training is the development of adequate visual systems to extend their use into mission segments formerly reserved for aircraft. Visual simulation in the Air Force has been deficient in meeting some Command requirements due to the nature of the military mission and the inherently incompatible combination of wide field of view and high resolution required in the visual scene. Air-to-ground weapon delivery, for example, requires the pilot to be able to look throughout his entire visible field-of-view during a circling attack

on a target. The human eye has extremely high resolution within a limited field of view and can be directed anywhere within a wide area. Since visual simulation hardware normally has a fixed field of view, it may be necessary to provide very high resolution over a wide field of view. Certain missions, such as air combat, require extremely good resolution, possibly approaching that of the human eye itself. The exact simulator fidelity requirements remain a human factors problem requiring further research. Many missions, on the other hand, can be accommodated with relatively narrow fields of view such as the terminal phase of the final approach in landing. A 35 X 48 degree field-of-view with a six-arc-minute resolution is typical of visual simulation hardware used by the airlines. The Air Force has advanced the technology toward meeting the field of view, brightness, and resolution goals. Figure III-2 indicates the key subassemblies from which typical visual simulation systems are composed. The four basic functions involved are image storage, image generation, image relaying, and image display.

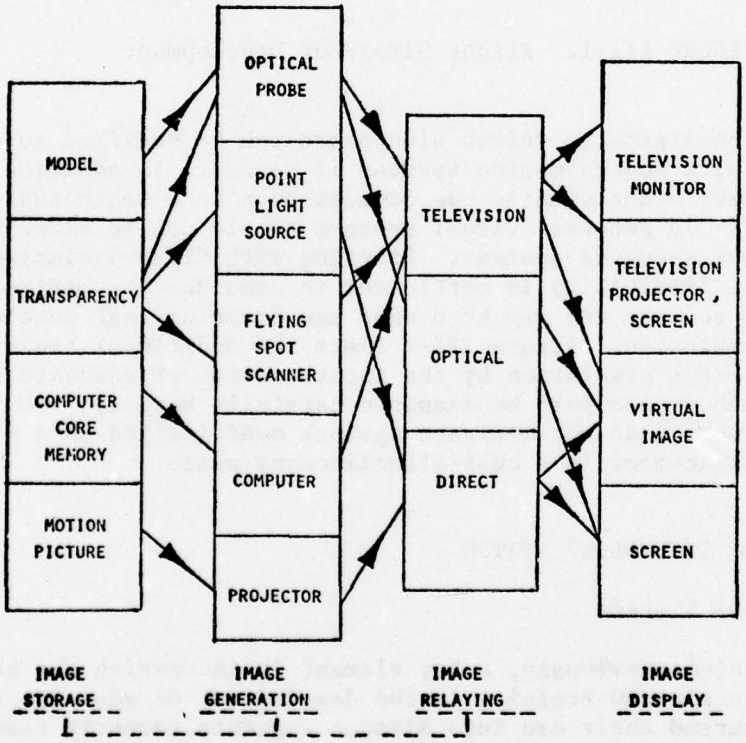


FIGURE III-2. Visual Simulation System Architecture

Two basic classes of image display are available for visual simulation. These are (1) the virtual image type in which the pilot sees the terrain and/or targets at optical infinity, and (2) the real image type in which the displayed imagery is viewed on a screen or cathode ray tube (CRT).

a. Virtual Image Display Systems

(1) In-Line, On-Axis Virtual Reflective Display

The system, normally referred to as the Farrand pancake window, consists of a spherical beam splitting mirror, a flat beam splitter, two linear polarizers, and two quarter wave plates. The image is formed on either a rear projection screen or a direct view cathode ray tube directly behind the optical elements. It passes through the spherical beam splitter and is reflected off the flat beam splitter back to the surface of the spherical beam splitter. Optically, this is the same as if the image were input at the focal plane of the spherical beam splitter, at a distance of half its radius. The viewer positions his eye at the origin of the radius and views the image at infinity. He is prevented from looking directly through the beam splitting optics to the input by the polarization of the imagery. This type of display has several significant advantages The most important is that it allows a wide field of view and can readily be mosaicked for even wider fields of view. Farrand has proposed a display in the form of a dodecahedron or a twelve-sided figure made up of equal sized pentagons. Activation of eight sides or facets of the dodecahedron provides a display with little loss of normal fighter type cockpit viewing as on the SAAC.

The limitations of this type of display are low light transmission and unwanted reflections or "ghosts" which are not completely extinguished by the polarizers. The low transmission requires high brightness input CRTs to achieve six-foot lamberts highlight brightness on the SAAC and ASPT systems. The unwanted reflections typically fall within the range of 0.5 to 5.0 percent of the wanted image. Comments from pilots indicate that these reflections are unnoticeable when flying the simulator except in a high contrast night scene.

The choice of image generator with these multichannel mosaicked displays is important. The image generator must be capable of providing several channels of video from the same viewpoint with overlapping images. These images must be stable in order to minimize discontinuities between the image on adjacent channels. The ASPT simulator employs digitally computed visual imagery and the SAAC employs an analog computed visual imagery to meet these requirements.

Holographic versions of the pancake window are under development. These offer potential significant savings in cost and weight compared to the conventional or all-glass pancake windows such as are employed in the ASPT and SAAC systems. This is due to the fact that the heavy, expensive glass spherical mirror/beamsplitter is

replaced by a two-dimensional holographic analog of the mirror. In addition, a trichromatic holographic pancake window is also under development. If successful, this window, with its associated developmental liquid crystal color projector, will provide a full color visual simulation.

(2) Folded, On-Axis Reflective Display

This type of collimated display consists of a diffuse screen located at the focal surface of a spherical mirror with the viewing position located at the center of curvature of the spherical mirror. A beam splitter is inserted in the optical path to allow the input screen to be folded out of the viewing path. The image can be inserted into the display by means of a television projector and rear projection screen or by means of a cathode ray tube (CRT) whose diffuse phosphor screen is located physically at the focal surface of the spherical mirror. The more commonly used image input device is the cathode ray tube, which may be either a minochrome or color type tube. This type of display, because of geometrical interrelations between the spherical mirror and the beam splitter, has a limited vertical field-of-view, usually on the order of 30-36 degrees. The typical field-of-view produced by this type of display is 36 degrees vertical by 48 degrees horizontal. This type of display is frequently used on commercial airline simulators due to its compact size, low cost, and its ability to be utilized in front of both the pilot and copilot viewing positions. The commercial multichannel version of this type display produced by the Singer Company is known as the Wide Angle Collimated (WAC) window. Other simulator manufacturers have comparable displays sold under their individual trade name; for example, the Redifon "Monoview." An increased field-of-view capability can be achieved by stacking multiple displays.

(3) Off-Axis Reflective Display

This type of system is approximately the same as the folded on-axis reflective display. The beam splitter, however, is eliminated and the image source and the viewer are located somewhat off the major optical axis of the collimating mirror, thus introducing a limited amount of optical distortion. The "Duo-View" display built by Redifon is the primary type of off-axis infinity image display currently in use. With a 50 - 60 degree diagonal FOV and a large exit pupil[1] achieved by the use of very large mirrors, side-by-side viewing is possible. However, unlike the flat screen/projector system, perspective is very nearly correct for more than one crew position. The Duo-View is currently utilized by various airlines and the Air Force.

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[1] "Exit pupil" refers to that area in which the viewer can get an intelligible view of the displayed information.

Air Force installations of the Duo-View include the C-5/C-141 simulators at Altus AFB, the AWACS simulator, and the AFFDL engineering simulators at Wright-Patterson AFB.

(4) Refractive Image Display

These displays utilize large refractive lenses (usually plastic) to collimate the input imagery. Both monochrome and color image input devices can be used with this type display. Lenses required with this type of display can become very large in size and quite heavy, and for these reasons the lenses employed are generally simple lenses. The use of simple lenses generally results in color fringes being visible in the display which can distract and detract from realism in the simulation. The requirement for large lenses also means that the individual channel field-of-view is narrow, usually on the order of 36 degrees vertical by 48 degrees horizontal. The field-of-view can be increased by stacking multiple displays, but is difficult to accomplish in an acceptable manner. The basic display is relatively inexpensive, but because of the characteristic color fringing, this type of display is not widely utilized in simulation applications.

b. Real Image Systems

(1) Flat Screen Projector

This TV projector/flat screen type display system utilizes either a front or rear projection screen to display an image at a finite distance in front of the simulator flight crew (usually 6 - 12 feet). It usually provides a nominal 50 degrees to 60 degrees diagonal FOV. Although this type of display does not offer the fidelity and realism of infinity viewing devices such as the pancake window or mirror/beam splitter display, the matrixing of screens for wide FOV and side-by-side viewing is possible. Proper viewing perspective can only be offered for one crew position but an otherwise intelligible view of the display is available anywhere within the cockpit. Although these displays are used on the Navy 2F90 ADM training device and device 2B35, none are currently in use by the Air Force. The major objection to their use in Air Force simulators is the lack of realism caused by the real image (noninfinity) presentation and perspective errors which occur if more than one viewer or large head motions are involved in the simulation.

(2) Spherical Screen

The visual display system on the LAMARS (Large Amplitude Multimode Aerospace Research Simulator) is an example of the spherical screen display. This display consists of a 20-feet diameter sphere mounted on a motion system with the pilot's eye at the center of the sphere. A monochrome television projector is located close to the pilot's head to project a target aircraft or terrain information on the spherical screen. A point-light source transparency projector,

as described elsewhere, is located well behind and above the pilot to provide sky/horizon images and fills a larger portion of the sphere with more imagery than is possible with the TV projector. The television image is considerably brighter and is clearly visible when projected over the terrain sky image. The total field-of-view is ±138 degrees horizontally and +108 degrees, -4 degrees (or as limited by the cockpit) vertically. The projected television image is typically 60 degrees on the diagonal. Smaller fields-of-view with higher resolution are possible by changing projection lenses.

c. Image Generators

The image generator (IG) generates and provides electrical or light signals to the display subsystems. These signals are then transformed by the display into a visual scene similar to that encountered in flight. This scene is continuously updated to represent changing aircraft position and attitudes.

The IG receives flight parameters from the simulator describing the simulated aircraft position and attitude. Using these data, the appropriate imagery is extracted from the image storage (see Figure III-2). This imagery is processed, special effects such as visibility and fading are added, and the results relayed to the display. The image storage may consist of a three-dimensional relief model, film transparency, numbers in computer core or motion picture film, as illustrated in Figure III-2. The image extracted from storage is that portion which the pilot can see at one time while the stored image can be orders of magnitude larger. The following sections describe the IG technology which is currently available.

(1) Full Raster Scanned Computer Image Generation

The Computer Image Generation (CIG) technique takes advantage of the memory or storage features of the computer to store visual scene content in the form of numbers. The scene consists of surface patterns or objects formed by planes of different brightness levels which are in turn bounded by straight lines called "edges." The number of edges in a scene is a relative measure of image content and CIG system performance. The raster scanned display is produced from video signals generated from the computer output and, while stylized in character, is similar to the real world scene. The total stored environmental data base utilizing conventional computer storage techniques such as magnetic discs, tape, etc., may be much larger than the working storage.

The principal advantages of the CIG approach are exact perspective, moving object generation, quick change of the scene content, unlimited altitude, attitude and rates, large area of flight coverage, and ease of multichannel image generation. The system also requires less space and building height than the terrain model-board

appraoch. Disadvantages include limited scene content due to limitations in the working storage and processing capability and the resulting stylized appearance of the scene. Velocity limitation is another disadvantage of CIG displays. The scene seems to "jump." The perceptability of the effect is directly proportional to the rate of change of the display. Likewise, rapid changes in line of motion (spectral bandwidth) is also affected. The ASPT system which employs this technique will be used by AFHRL to gain insight into the ability of this system to train students in undergraduate pilot training. The training tasks will include:

- Taxiing;
- Takeoff and climb out;
- Overhead approach pattern and landing;
- Airwork and aerobatics;
- Formation flight; and
- Night flight.

The Boeing Commercial Airplane Division is currently using two 1000-edge presentations, 4000-edge data base, three-channel CIG systems for training. These two image generators are scheduled-shared between four cockpits. These visual systems have been certified for training by the FAA. The Navy has procured two 1000-edge presentations, 10,000-edge data base, three-channel CIG systems (Device 2B35) for use on the 2F90 OFT. With this visual system, the Navy has been able to reduce the number of aircraft training flights with simulator time and is currently investigating their curriculum for additional reduction in flight time. Other CIG systems which have been developed and delivered are: (1) Computer-aided operation research facility (CAORF) to the maritime administration, (2) Electronic Scene Generator to NASA-Johnson Space Center, (3) Day/night CIG to Lufthansa, and (4) the multiple role combat aircraft simulator for Federal Republic of Germany.

(2) Calligraphic/Night Only Systems

This concept in visual image generation, a variation of computer generated imagery, has evolved over the past several years into a highly acceptable means to generate a realistic night representation of an airfield area. Scene detail includes horizon glow, runway markings and airfield light-points (including VASI and approach strobes). The calligraphic generation technique is totally different from the raster scan method utilized in full day/night CIG systems. With the calligraphic technique, the electron beam is moved directly from one computed light position to another and is turned on only at those positions. In lieu of the usual shadow mask color CRT, beam penetration type CRTs are utilized. Color is controlled by the intensity of the electron beam. Color rendition is limited to red and

green and the spectrum between. Several display channels can be utilized to give a wide horizontal field-of-view. Advantages of these systems are: relatively low acquisition cost; high MTBF and low MTTR; no additional facilities requirement; and the capability to readily change from one airfield area to another. One disadvantage is that in order to maintain resolution, reliability, and simplicity, only beam penetration CRTs can be utilized. This currently rules out utilization of video projectors and limits the display to the folded, on-axis reflective type. Night-only systems are currently in use by several airlines.

(3) Calligraphic/Day-Night Computer Image Generation

This image generation capability is an extension of the calligraphic night only technology. This type of generation includes all the scene content of the night-only image generation with additional "surface" capability. The "state-of-the-art" system capacity is 6000 light points for night simulation or 500 surfaces for day simulation. The day simulation capability includes scanning the entire CRT face calligraphically with sky and terrain features.

Another improved feature beyond the night-only simulation is the addition of occulting electronics which allows solid object simulation within the scene. The day simulation capability of this technology is approaching the capacity of a 1000-edge full raster scanning computer image generator, but does not have features, such as edge smoothing, curved surface shading and full color simulation.

This technology is limited to CRT displays, folded on-axis reflective optics, and lower display brightness due to the calligraphic beam penetration scanning versus the raster scanning computer image display brightness.

(4) Analog

Analog systems provide low detail ground plane and horizon information to the pilot. A current example of analog system is the Synthetic Terrain Generator (STG) on the SAAC. This system fills the entire FOV with a matrix of one-half nautical mile squares, similar to a checkerboard, that represent the ground plane, a horizon, and the sky. The squares are displayed in four shades of gray with a haze generator that reduces the contrast of the squares as range increases. Unique symbols in the ground plane provide geographically fixed reference points. The STG system provides the pilot with cues to his attitude, altitude, heading, velocity, and position with no maneuver restrictions. This type of system may be used by itself or may be used to augment an area of interest system.

(5) Area of Interest

State-of-the-art image generation systems cannot fill the full field-of-view (FOV) of a very wide angle visual display with detailed imagery. To best utilize the smaller FOV with detailed imagery, the area of interest (AOI) approach was developed. This approach moves the small FOV detailed image in azimuth and elevation throughout the wide FOV display. The AOI may be mechanized to follow either the line-of-sight from the pilot's eye point to some preselected geographic location or, utilize some suitable head position sensing system to follow the direction in which the pilot is looking. Either approach allows the pilot the freedom to maneuver the simulator about the AOI (i.e., a ground target or airfield) with very few restrictions. AOI systems using a preselected geographic location or pilot head sensing have been demosntrated.

(6) Model-Board Television

One basic technique which has been developed to a high level of sophistication is the terrain (model) board for image storage, the optical probe and television camera for image generation, and a variety of display techniques. The optical probe and television camera "look" at the scale terrain model according to aircraft position and attitude, with the video information thus generated representing the real world visual environment. This information is then displayed to the pilot in the simulator.

Visual simulation systems employing optical probes and scale terrain relief models are currently being manufactured by several firms, including Redifon, The Singer Company, and CAE. These devices possess narrow field-of-view capabilities, usually on the order of 60 degrees on the diagonal, and exhibit depth-of-field limitations at low altitudes. The commercial airlines are using these visual simulation devices due to the relatively simple nature of the visual portion of their training programs and the similarity of aircraft involved. The Air Force, however, is faced with the situation where visual simulation is required for training in complex and diversified missions involving a wide variety of dissimilar aircraft. The capabilities provided by narrow field-of-view visual simulation devices cannot fulfill total Air Force requirements for training, since in many cases a wide field of view is essential.

A development program demonstrated that an essentially infinite depth of field could be achieved from an optical probe. Subsequent improvements in video techniques coupled with the optical probe improvements have resulted in highly acceptable narrow angle (49 degrees horizontal x 36 degrees vertical) visual systems. Another development program was conducted and an engineering feasibility probe exhibiting a 140 degrees field-of-view, excellent resolution and infinite depth of

field was produced for monochrome systems. This probe requires sohpisticated computer controlled manipulation of servo-driven optical elements. Further work in this area is required before the full capability of these probes will be realized.

Recent improvements in modeling techniques have greatly enhanced the realism of camera/model systems. Additional new modeling techniques, pioneered by Redifon Flight Simulation, Ltd., now make it possible to realistically create takeoff and landing model boards at a scale of 4000:1; thus, greatly reducing facility size and lighting power requirements.

A technique of simulating another aircraft in the visual field-of-view utilizing a gimbal mounted aircraft model and high resolution monochrome television camera was perfected in the SAAC program.

Virtual image display systems such as the Redifon Duo-View and the mirror/beam splitter (WAC window) are the types most widely used today with camera/model terrain image generators. The more economical flat screen/projector type displays are also used but do not offer the infinity viewing and correct perspective as do the virtual image type. All of the above systems are basically limited to a maximum field-of-view of approximately 36 degrees vertical by 48 degrees horizontal. In order to facilitate the display of the wide field-of-view information offered by some probes, matrixing of several basic display units is required. Redifon is presently pursuing an internal development effort in order to matrix multiple Duo-View displays. Several Air Force in-house development programs will continue investigating methods of displaying wide fields-of-view for multiple crew, wide-body aircraft cockpits.

(7) The LAMARS at AFFDL is the most recent example of this technology. The transparency consists of two small transparent hemispheres which have images of a featureless brown earth, a clear blue sky with occasional clouds, and a well defined horizon. Inside these hemispheres, two point-light sources are positioned in accordance with the x, y, and z coordinates of the simulator so that the projected horizon is always correctly located without distortion. The entire assembly is then rotated about the three axes to provide roll, pitch, and yaw. The image on the transparencies is displayed to the pilot on the inner wall of a spherical screen. This approach provides the pilot with attitude and heading cues, but very limited altitude and no linear velocity cues.

d. Air Force State-of-the-Art Visual Systems

(1) Simulator for Air-to-Air Combat (SAAC)

The SAAC Advanced Development Program grew out of a 1965 TAC requirement to develop a one-on-one air-to-air combat simulator. In 1971, a three-window breadboard visual system was demonstrated at ASD and a contract was let for the full two-cockpit SAAC system in early 1972.

The SAAC system consists of a two-cockpit simulator complex, each cockpit and its visual display mounted on a six degree-of-freedom motion base. The simulators represent nonslatted F-4E aircraft and allow one-on-one air-to-air combat with AIM-7E radar and AIM-9E infrared missiles, and 20mm cannon. Software changes are complete and hardware installation is underway to configure one cockpit as an F-4E (slatted wing). The SAAC can then be used by TAC for training crews in both aircraft configurations. At the operator's console, an Air Combat Engagement Display provides a 2-D representation of the 3-D air-to-air engagement on a CRT for monitoring and evaluation. Scoring print and record/playback systems provide documentation of training missions for later debriefing and evaluation. A record/playback system allows selected systems to be played back for later evaluation.

The SAAC visual display system is an eight channel mosaic of pentagonal "pancake windows" to provide a field-of-view of ±148 degrees horizontally and +150 degrees, -30 degrees vertically. The input for the display is a dual raster, monochrome TV system using one raster for the background terrain/sky and one raster for the opposing aircraft. The background terrain/sky is a contact analog checkerboard terrain providing attitude, heading, altitude, and velocity cues and, with symbols in the terrain, geographic location. The target aircraft image generator is a gimballed model aircraft viewed by a TV camera. The SAAC is located at Luke AFB, Arizona.

(2) Advanced Simulator for Pilot Training (ASPT)

The ASPT visual simulation system consists of a Computer Image Generation (CIG) system and a seven channel in-line, on-axis optical display with a FOV of approximately 300 degrees horizontal and 150 degrees vertical. The FOV can also be quickly modified by the operator to any desired FOV less than maximum in one degree increments both vertically and horizontally. This defined FOV can also be utilized as an Area of Interest (AOI) using helmet mounted sensors. Also available is a video inset capability for vector and alpha numeric information generation in the forward channel to allow instructional feedback techniques to be researched. (Image generation features of this simulator have been described previously.) The system has a moving aircraft model feature which permits training in formation flight. This moving model represents a T-37 aircraft which moves in accordance with outputs from the simulator. The display system completely surrounds the student and instructor pilots. This system required development of large optics and the world's largest CRT (36 inch). The ASPT system is located at AFHRL/FT, Williams AFB, Arizona.

(3) Large Amplitude Multimode Aerospace Research Simulator (LAMARS)

The visual simulation system on the LAMARS consists of a sky-earth projector, television camera/model, television projector

and spherical screen. The simulator pilot's viewing position is in the center of the spherical screen to avoid distortion of his view of the projected images. The sky-earth projector consists of two hemispherical transparencies with two point-light sources located inside the transparencies. This projector is located at a considerable distance from the center of the screen. To provide the pilot with the proper perspective and undistorted image, the point-light sources move within the transparencies. The television projector is also located off-center of the screen. The projector provides either a 60 degrees diagonal or 15 degrees diagonal field-of-view image on the screen by means of lens changes. The input video to this projector is generated either by a conventional model board/probe/television camera system or an air-to-air target image generator. The air-to-air target aircraft model is encapsulated in a clear plastic ball. This ball is then viewed by the television and is rotated to generate the pilot's line-of-sight attitude between the two aircraft. This system is installed at the Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio.

2. Motion and Force Cues

The six-post synergistic six-degree-of-freedom platform motion system had gained wide spread utilization during the late sixties, primarily due to the favorable acceptance and usage by the airlines. By the early 1970s most government procurements of flight simulators specified the use of these six-post systems based on their intuitive appeal as a cost effective and low risk method of providing motion cues. This was done despite the fact that little investigation of the true cost effectiveness of motion bases had been conducted. Because all six-degrees-of-freedom were inherent in the system, it was considered not necessary to analyze and specify particular degrees-of-freedom for each training device. In addition, the six-post configuration offered commonality in hardware, and thus, was thought to increase maintainability and lower life cycle cost.

Recently however, the use of the six-post synergistic system as a cost effective platform motion system for fight/attack simulators has been the subject of considerable controversy. This controversy has been due primarily to research efforts which cast serious doubts about the contribution to training effectiveness of the six-post systems. Transfer of training studies have illuminated the system's inability to replicate the rapid rotational velocities and accelerations of fighter/attack aircraft. Recent improvements to the system have improved its bandpass and frequency response, thus reducing its inherent lags. In addition, considerable effort has been expended in reducing the "turn around bump" (a false cue which results when any of the hydraulic actuators reverse direction) so as to make these systems more acceptable.

Currently, the six-post synergistic six-degree-of-freedom system appears to be an acceptable solution to provide the motion cues

needed for wide-bodied aircraft (bomber, tanker and cargo aircraft). These systems are also employed with the new trainer simulators (UPT-IFS) for Air Training Command. They are not however, currently considered acceptable for fighter/attack simulators. A special ad hoc committee of the US Air Force Scientific Advisory Board has been studying the problem of motion systems for simulators, and motion systems for fighter/attack simulators in particular. A final report from this Scientific Advisory Board is expected to be released in March 1978. This report will include suggested research efforts aimed at resolving the question of what kind of motion cueing devices, if any, are required for fighter/attack simulators.

Since the early 1970s, progress had been made in developing viable alternate or augmenting methods for providing motion cues. These include simulator g-suit and g-seat systems. The Air Force currently has six pneumatic g-seats which are being evaluated for training effectiveness. Three of these seats are used in combination with g-suits. The g-suit simulation system provides the mechanization and drive control necessary to properly control the pressure in the crew member's anti-g-suit system. Activation of the system provides the crew member with familiar body sensory cues of the instantaneous and sustained "g" forces acting on the simulated aircraft. The g-seat system is comprised of compartmentalized seat pan and backrest cushions with an active lap belt subsystem. The drive concept for the g-suit system is relatively straight forward; suit inflation is proportional to the specific acceleration (g) acting upon the simulated aircraft. The drive concept for the g-seat system, however, is little better than exploratory. The g-seat imparts cues by contouring the seat to vary the pressure distribution on the pilot while displacing him vertically and/or logitudinal and by tilting the seat pan and/or backrest planes. The lap belt force drive must be coordinated with the seat and backrest drive. The possible combinations of g-seat subsystem drives are virtually limitless and further confounded by the requirement of coordinating the g-seat drives with motion system and visual system drives. Reliable models of how the human somatic sensors operate independently and in conjunction with the vestibular and visual senses would be invaluable in this regard, but do not exist. Additional research is warranted. A human motion and force sensory mechanism modeling effort, described under Section III.D is well underway and is providing some answers in this area.

Another type of motion cueing system is the Vibration/Buffet System. These are typically small displacement, high frequency motion systems which are utilized to provide the higher frequency vibration and buffet cues either in the absence of or as a complement to the larger scale motion systems. These are desirable where the visual system design precludes the incorporation of a larger scale motion system (such as NASA Langley Research Center's Differential Maneuvering Simulator (DMS)), or where it is undesirable to buffet the total cockpit/visual system complex (such as SAAC). These systems are typically capable of providing acceleration cue levels up to ±1 g vertically at frequencies up to 20 H_z, but with a total displacement

on the order of two inches. The general drive philosophy is to subject the simulated cockpit seats and controls to the same vibration environment as would be encountered on the aircraft being simulated in the same flight condition. Given the necessary aircraft data, this drive concept can be readily implemented.

An advanced low-cost g-cueing system (ALCOGS) is being developed under PE 63227F (Project 1958). This research device includes an advanced hydraulic g-seat, pneumatic g-suit, and a hydraulic seat shaker system. The ALCOGS represents the second generation of somatic cueing systems with respect to performance and application. The responsive hydraulic seat will be used to investigate the effect of onset as well as sustained cueing with a g-seat/suit/shaker system in the absence of a motion platform. The ALCOGS application is towards the fighter/attack aircraft simulation problem. The seat is an A-10/F-15 type with the capability of being tilted into the F-16 configuration. The ALCOGS test and evaluation should result in a more exact specification for the future g-cueing simulation systems in the Air Force. The program has already impacted the A-10 simulator g-seat design.

3. Sensor Simulation

The following basic sensor system types are relevant to current Air Force simulation for aircrew training: radar, infrared (IR), and low light level television (LLLTV).

a. Radar Simulation

The only area of sensor simulation in which the Air Force has made significant progress is radar simulation. The majority of such equipments (A-7D, C-5A, F-111, F-4, B-52, B-58) utilized the light optic (transparency) technique. Basic source data from air target charts are encoded by a photographic process producing a transparency which permits light to pass in proportion to the reflectivity and elevation values of the elements of the scene. A basic limitation with this approach is that the detail of information content in the data base is not sufficient to provide simulation of a high resolution radar system, and the analog processing circuitry introduces errors and lacks the necessary growth capability to go with the required additional data base capability. There are significant difficulties associated with improving the data base: curtural data are encoded with only the basic outline shown as area return at approximately 500 feet resolution and terrain contour spacings vary from 100 feet at the lower elevations to 600 feet at higher elevations. The transparency technique cannot be rapidly updated. These problems have caused the Air Force to develop a digital technique which encodes all the cultural and terrain information in digital format. Programs which have incorporated the digital technique are the Undergraduate Navigation Training System (UNTS), the

Navy 1D23 and A6E, and the German Air Force F-4F Simulator (a foreign military sale). The problem of improved resolution still remained with these systems since the basic source data did not have sufficient cultural information. Two significant activities are currently underway to improve radar simulation capability: the Defense Mapping Agency (DMA) has developed a new digital data base with cultural and terrain information encoded at various levels of resolution. To date, they have encoded approximately 1,500,000 sq. NM of cultural information and 1,600,000 sq. NM of terrain information in DMA standard format. The Air Force's engineering development program under PE 64708F (Project 1183) in conjunction with DMA's program has produced a high resolution digital radar landmass (DRLMS) processing hardware/software. Current programs such as the B-52/KC-135, C-130, and the F-16 will incorporate DRLMS, and are utilizing the initial results of Project 1183. The DMA has revised its digital data base production specification and is embarking on a production program that encompasses most of the northern hemisphere.

b. Infrared and Low Light Level Television Simulation

Current Air Force simulation capability for these sensors is extremely limited with respect to providing adequate crew training. The B-57G Rear Seat Operational Trainer was the Air Force's first operational device and it provided a very limited simulation of electrooptical (EO) sensors. It used an optically scanned film strip and the resultant video was displayed on a CRT. The film was made from a recording taken from an actual B-57G flight. Some targets were added artificially. The simulated flight path was limited to that of the aircraft and sensor position and control settings. The Functional Integrated System Trainer (FIST) was developed as a part task trainer for three of the AC-130 Gunship system operators. This included EO simulation consisting of a film plate taken from an aircraft flight which was optically scanned and the video displayed.

Primary emphasis is now placed upon the use of computer image generation as the technology most suitable for satisfying requirements for simulation profiles over large gaming areas. It is also considered that this technology is most applicable for providing perspective scenarios representative of the culture and topography encountered in the real world as well as presenting anomalies characteristic of EO sensor systems. The utility of the above technology was established through multiphase exploratory programs and IR&D activities which demonstrated that typical cultural features together with sensor parameters such that transfer function and noise could be represented to a fidelity that would permit accurate correlation to scenes as generated by operational sensors. Further efforts conducted under advanced and engineering development programs established the utility of the DMA topographic data for use with computer image generation methods for sensor simulation. This would be predicated upon the use of a transformation program which "compressed" the DMA data while preserving the essential character of the topography. Static

scenarios generated utilizing actual DMA sensor data and the above transformation program tentatively validated the applicability of CIG technology to provide requisite simulation where low altitude mission profiles are concerned.

While the above programs established that digital technology was available for application to the sensor simulation problem, deficiencies were noted with regard to providing the scene fidelity necessary for low level flight maneuvers while enabling accurate representation of target identification and anomalies associated with these sensor systems. An effort has recently been completed which surveyed a variety of target areas under varying seasonal and weather conditions. A large amount of imagery and associated meterological data was collected. This will be utilized for algorithm development directed toward representation of seasonal and time of day variations in simulated scenarios. Further efforts of this type have also been conducted utilizing the DMA cultural data for the high resolution portion (1 sq. mi.) at Las Vegas. A measurement program was conducted and curves were generated for representing diurnal cycles that could be correlated to infrared imagery of the same variety. Current thrusts are now concerned with providing texturing methods that will permit representation of foliage relief, small man-made features, and random patterns for generalized representation of ground texture. It is expected that these efforts will greatly enhance the utility of digital methods for low altitude simulation and detail target identification.

4. Electronic Warfare Simulation

Electronic Warfare is divided into three distinct areas: Electronic Countermeasures (ECM), Electronic Counter Countermeasures (ECCM), and Electronic Warfare Support Measures (ESM). Many aircrew simulators being procured by the Air Force provide some form of electronic warfare simulation. This simulation is primarily in the area of ECM and in special cases, ESM. The typical elements of ECM/ESM simulation is illustrated in Figure III-3. ECCM simulation is similar; however, it is more oriented to an internal equipment counteraction instead of an operator's reaction. A firm requirement for ECCM simulation has yet to be developed by the Major Operating Commands.

The data base contains the information with respect to threat location and parameters (frequency, pulse width, pulse repetition frequency, etc.) pertinent to the problem. The data is then modified by the environment and receiver simulation characteristics (distance and bearing from threat, antenna pattern, etc.). The received power, bearing and signal characteristics are then processed and displayed on the student's display. As the student observes the information presented, he then becomes a part of the loop. In the case of ESM, the student will manipulate his individual controls, record or note the various characteristics observed and pass the

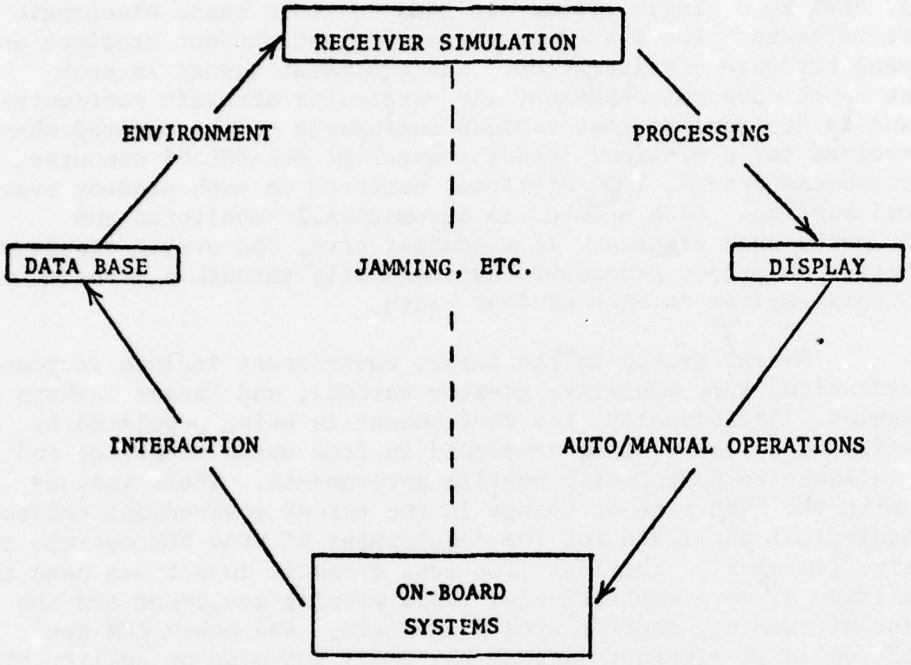


Figure III-3. Elements of ECM/ESM Simulation

information to an external source. For this type of simulation the process stops. In the case of ECM, the student provides an input to the process based on the information displayed. He may use his onboard systems, activating jammers, chaff, flares, etc. This may then cause a reaction of the data base; i.e., change in frequency. At this point the loop would then be reprocessed.

Various forms of electronic warfare simulation can be found on mission simulators such as the F-111, F-4, and A-7. This simulation, however, is limited to air and ground targets, jamming, and chaff drops as would be seen on a tactical radar scope. Its primary concern is with making the operator familiar with what ECM is and how it appears on the radar indicator. For the B-52 and other systems which incorporate a defensive position, a much more elaborate simulation capability is provided. Present EW officers in SAC are trained on analog systems such as the AN/ALQ-T-4 simulator. These simulators provide a signal environment which allows the student to activate all onboard systems. These devices provide full aural and visual indications of the various emitters. These simulators, however, are 1960 vintage and will eventually be replaced by digital

simulators, such as the simulator for Electronic Warfare Training (SEWT). SEWT is a single system designed to train basic electronic warfare officers. The system consists of eight student stations and a general hardware configuration. The equipment layout in each student booth does not represent any particular aircraft configuration and is designed so that various equipments can be covered when not required for a mission. Under control of the SEL 86 computer, the system can provide 1000 different emitters to each student over a normal mission. Each student is automatically monitored and scored during each mission. If a student errs, the system displays instruction on proper procedures automatically through a cathode ray tube display system in each student booth.

Recent trends in the threat environment include increased sophistication, more mobility, greater variety, and larger numbers of deployables. Additionally, the environment is being populated by sophisticated threat systems developed in free world countries and made available to potentially hostile governments. These factors along with the high rate of change in the threat environment creates a technological challenge for the development of USAF ECM systems and defensive (survival) tactics. The most dramatic impact has been the installation of more sophisticated radar warning equipment and the addition of jamming, chaff/flares dispensers, and other ECM gear, not only on large aircraft such as the B-52, but also on smaller aircraft such as the A-10 and F-16. Rapid adaptability to the changing threat environment is being accomplished via digital reprogramming techniques and expedited use of intelligence data in support of the onboard system.

The impact of recent trends in the threat environment on simulators is the need for added complexity and adaptability with respect to ECM equipment and threat simulations. Inherently this also creates the need for sensitive intelligence data and information on defensive tactics in the process of design. Simulators now being procured for use in the 1980s are being designed to permit training in war gaming tactics and will include features for Air Force organic reprogramming in the area of threat characteristics and onboard equipment processing ECM simulation. The design approach generally used for threat simulation is the use of the GP computer for threat modeling and onboard equipment simulation. Simulation of onboard computers used in signal processing also creates a special challenge due to the complex signal environment, processing, routines, displays, and, in some cases, extensive crew interaction with the equipment. However, as with other types of onboard computers, the simulation approach is normally either a stimulation of the onboard processor or a functional model in the simulator's GP computer. Choice of approach requires a careful trade-off involving many factors.

The scope of ECM simulation required for single-cockpit aircraft simulators in the 1980s is not well established. Several

comparative approaches will be taken and evaluated for cost effectiveness and relative training value. This is being implemented by separate approaches for the A-10 and F-16 ECM requirements.

5. Instructor/Operator Technology

Originally, instructor/operator stations (IOS) for flight simulators were comprised largely of repeater instruments with a limited number of controls for inserting malfunctions, and varying a few parameters such as rough air, wind direction and speed. Over the years, particularly since digital computers have become commonplace in simulation, the trend has been toward the use of cathode ray tube (CRT) displays and an alphanumeric keyboard to provide the instructor/operator with the needed control and display capability. This trend has increased the reliability of station components, increased display flexibility, allowed for one-on-many instructor-to-student ratios, and provided a capability for advanced training features such as preprogrammed missions and automatic monitoring of procedural tasks. At the same time, the trend toward the use of CRT displays has resulted in unresolved problems which demand answers through the development and pursuit of an appropriate research program.

Despite considerable progress in IOS design, there are still no answers to fundamental questions such as, "What is the best station configuration and how many displays should it contain?", "What should be displayed?", and "How should differing types of information be related to the instructor/operator?" Currently, it is necessary to rely on writers of procurement proposals and contractors to make sometimes arbitrary decisions with respect to these questions. This has resulted in a variety of IOSs which have differing shortcomings and advantages, but no standards and few guidelines exist for specifying or evaluating alternative designs. In short, requirements in the IOS area have led the necessary supportive exploratory development work by several years. Accelerated efforts in this area are needed to provide information to use in developing sound specifications and evaluating proposals.

AFHRL's experience during the ASPT Operational Utilization Test (OUT) suggested that instructor pilots (IPs) could be more effective if the information received about student performance was integrated into one or two displays, or if the pertinent sources of information were all gathered together. An objection of the IPs during the OUT was that the IOS provided inadequate information about the students' visual environment (for some maneuvers). Perhaps something like an Area of Interest (AOI) display could be usefully implemented; i.e., the IP could control the contents of the display on one or two CRTs at his console. In two research studies, the automated flight training system (AFTS) has been shown to have potential for improving the IP/student ratio. The results suggest that instructional personnel who are not qualified pilots or weapon systems officers (WSOs) could learn the task and the equipment well

enough to manage as many as three students simultaneously. Research experiences with AFTS also indicate that the instructor WSOs are not interested in the adaptive training feature for students, but are primarily concerned with satisfying syllabus requirements. Operational crews have found the AFTS useful for continuation training.

IOS research is required in the areas of (1) man-machine interface and display technology, and (2) performance modeling and data compression for characterizing performance succinctly for the instructor/operator. Research in the first area should deal with such issues as display formats, required number of CRT displays, advanced display methods (e.g., 3-D) that maximize the information content of a definite display area, and improved methods of controlling training from a remote IOS which are less reliant on use of a keyboard. Research in the second area should deal with determining what needs to be displayed, designing methods of modeling relevant aspects of trainee performance, and using model variables to succinctly characterize performance at the IOS, and new methods of data compression and representation which minimize information processing workload of the instructor/operator.

6. Modeling and Computation

The design process for simulators begins with derivation and development of mathematical models for all primary systems and selection of the computational hardware for implementation of these models. The quality and fidelity of the simulator is directly related to the quality of the driving model. The crew inputs from and system outputs to the simulator are controlled through the model as implemented in the computer system.

Mathematical models are mathematical representations of the real world system to be simulated. For the aircraft performance, the mathematical models are derived from approved design criteria, which consist of information defining weapon system performance and characteristics. This information is available in various documents and reports which are identified and compiled in a list called the approved criteria list. The total set of approved criteria defines the system including the environment to be simulated; e.g., electronic, tactical and other stimuli necessary to provide a realistic training situation. The flight performance data package is usually developed from wind tunnel testing although new flight testing techniques promise to provide improvement in stability and control data. Historically, models for simulators have been derived from the following data sources: aerodynamics - wind tunnel data; engine - ground testing with predictions for installation losses; control loading - ground tests of hardware and engineering design data; and systems - engineering design data. Aerodynamic, engine, and control loading data derived in these time honored methods have been historically in error, producing simulators which do not precisely reproduce flying qualities of the aircraft. Recent advances in flight test technology, specifically the parameter identification technique developed by NASA, and Edwards AFB may provide a method of deriving flight related aerodynamic data.

A Data Item Description, "Data Requirements for Simulator Design" (UT-3920-ASD) has been prepared which provides a listing of the data that is required in the design and construction of Aircraft Flight Training Devices. In addition, the Naval Air Test Center at Patuxent River Air Station has developed a simulator test method which relies upon flight test techniques to verify the simulator.

Mathematical models must be derived in a manner to accurately depict the simulated system relative to training requirements. As the model requirements increase in complexity, the cost of the total system increases proportionately or in some cases, geometrically. As training requirements increase in terms of both high fidelity performance and more comprehensive environmental and instructional features, modeling requirements likewise increase in complexity with a net increase in system complexity and cost. Mathematical modeling techniques have not changed significantly from the time of early analog computer devices. With the advent of digital computing techniques, system performance tolerances were tightened since analog computation restrictions were eliminated. Tolerances were tightened as a direct function of computational technology availability, rather than as a function of simulator performance derived from training requirements. Considering this evolution of tolerances based on technology rather than training requirements, a restructuring and redefinition of completed parameters and associated tolerances offers a potential of improved training simulator realism together with a reduction in acquisition costs through identifying and eliminating over-simulation.

The rapid evolution of computer technology from analog to high capacity digital technology has facilitated higher fidelity and more comprehensive training simulator systems. General purpose digital computers have been incorporared on all recent simulators for aircrew training. Table III-1 identifies the computers used on several major training simulators.

TABLE III-1. COMPUTATION SYSTEMS COMPENDIUM

TRAINING DEVICE	MANUFACTURER	COMPUTER	COMPUTERS/ SIMULATOR	LENGTH OF THE OPERATIONAL COMPUTER PROG SYS (WORDS OF CORE)
C-135B	SINGER	MARK I	1	NOT AVAILABLE
C-141A	CURTISS WRIGHT	CDC 924	2	38K
C-141A	SINGER (LINK)	SEL 840A	1	34K
F-4E	SINGER	GP4B (SINGER)	1	92K
C-5A	MDEC (CONDUCTRON)	SEL 840A/840MP	2	63K
F-111A	SINGER	GP4	1	92K
FB-111A BOMB/NAV	SINGER	SIGMA 5	2	88K
FB-111A	SINGER	SIGMA 5	3	180K
A-7D	MDEC	DC 6024/1	1	40K
HH-53C	REFLECTONE/ SECOR	DC 6024/3	1	30K
CH-3	REFLECTONE/ SECOR	DC 6024/3	1	30K
F-111D	SINGER	GP4B	2	194K
F-111F	SINGER	GP4B	2	175K
F-15	GOODYEAR	DC 6024/4	2	103K

TABLE III-1. COMPUTATION SYSTEMS COMPENDIUM (Continued)

TRAINING DEVICE	MANUFACTURER	COMPUTER	COMPUTERS/ SIMULATOR	LENGTH OF THE OPERATIONAL COMPUTER PROG SYS (WORDS OF CORE)
T-37	SINGER	DC 6024/4	3/4	42K
T-38	SINGER	DC 6024/4	3/4	49K
B-52 (MOD)	SECOR	DC 6024/5	1	30K
SEWT (SIMULATOR FOR ELECTRONIC WARFARE)	AAI	SEL 86	1	50K
ASUPT (ADVANCED SIMULATOR FOR UNDERGRADUATE PILOT TRAINING)	SINGER	SEL 86	3	FLIGHT 83K VISUAL 32K (FORTRAN)
SAAC (SIMULATOR FOR AIR-TO-AIR COMBAT)	SINGER	SIGMA 5	4	80 - 100K (FORTRAN)
UNTS (UNDERGRADUATE NAVIGATION TRAINING SIMULATOR)	HONEYWELL MARINE SYSTEMS	HONEYWELL H 716	41/52	COMPLEX 51K 13 EA RADAR CONTROL 9K (1 TIME)

The computer system performs the real time information processing functions which activate the simulator. Computed functions include flight, aerodynamics, engines, ballistics, and avionics to simulate performance of the weapon system. Additionally, instructional provisions are implemented by the computer to provide instructor control of the training situation. The expanded processing and storage capacities of modern general purpose computers have facilitated digital generation and processing of visual and sensor environmental stimuli simulation. Student performance recording and automated flight demonstrations have been made possible and implemented with faster, higher capacity magnetic storage devices. The computer system is also configured and developed with appropriate software facilities to support the maintenance and changing mission requirements of the training simulator. Computer system technology incorporates both computer equipment and computer program systems (software). The integral relationship between hardware and software requirements is critical to the cost-effective application of computer technology in training systems development. Computer equipment capabilities are directly related to the level and efficiency of computer programming capabilities and thus have a major impact on life cycle cost and supportability.

A new "megamini" computer technology is evolving which will have a major impact on the real time computational technology. The megamini computer adds a new dimension in real time computation by combining the powerful instruction set and performance capacity of the 32-bit computers with the low cost of 16-bit minicomputers. These computers typically feature high rate internal processing, including fast floating-point, which facilitates real time compiler level (high order language) programming.

The specific impact of the megamini computer on training simulators is the cost-effective application of FORTRAN language to the real time computer program requirements. This computer technology applications "breakthrough" will permit an improvement in life cycle costs and the cost-effective utilization of training simulators. In particular, software supportability will be simplified with changes to the computer program system being simpler to accomplish and, therefore, less costly.

A preliminary Technical Memorandum, ASD/ENCT-75-2, "Considerations in High Order Language Compiler versus Assembler for Programming Real Time Training Simulators," was prepared as part of an AFSC study to establish applicability, commonality and standardization of programming language(s) across all AFSC acquired systems. The Air Force policy on computer programming language use is prescribed by AFR 300-10 which states, in part, that high order languages (HOL) are required for all activities using or planning to use computer programming languages. In addition, an AFSC Supplement to Volume I of AFR 800-14 implements the Air Force HOL policy.

Associated with the increased speeds and total processing capacity of digital computers has been the application of digital processing technology across a wider spectrum of the simulator information processing requirements. For example, out-the-window visual and sensor information is being stored and processed with digital technology including large capacity random access magnetic storage devices, real time retrieval and processing computers and high speed digital pipeline processors. The impact of these approaches is the distribution of several general purpose computers throughout one simulator system. Visual subsystems and sensor subsystems; e.g., radar landmass systems, can be developed as add-on subsystems contracted separately from the simulator. Certain digitally based visual systems have been developed and are competitively available commercially as a developed standard product, including the computer subsystems equipment and programs. Thus, computer equipment commonality and standardization may be achieved either within a weapon system simulator, or across weapon system simulators within subsystem application areas. These alternatives are being reviewed to assess the practicalities of acquisition and minimal development risk with the objectives of commonality and standardization.

Another consideration in computation technology is the advent and application of microprocessors. Microprocessors can be developed for very low costs as dedicated functional processors. These microelectronic digital processors can be designed to perform specific dedicated functions such as trignometric, transcendental, matrix manipulation, linear function interpolation, and other functions which have a low probability of variance over the life of the simulator. These "hardwired" processors may be designed and developed as more cost-effective approaches to the implementation of simulator computational requirements. Microprocessors also offer the potential advantage of being standard electronic components if the functions implemented are properly identified and defined.

Computer program system (software) definition, acquisition and life-cycle support have been the subjects of high-level concern and attention across all Air Force activities. Project Pacer Flash was initiated in response to AFR 20-1 which established a requirement to assess methods of providing support for weapon systems software. Pacer Flash Final Report, Volume IV, Appendix C, addresses Aircrew Trainers and contains a recommended concept involving a combination of AFSC, AFLC and using command activities to achieve software supportability in simulators. Following the Pacer Flash Study, a new Air Force Regulation, AFR 800-14, was written addressing acquisition management of computer resources. An ASD weapon systems software workshop was conducted at which the concepts and challenges associated with the acquisition of simulator software were discussed including the specific challenge of simulating onboard avionics computer software in the training environment. The relative merits of three approaches to simulating onboard operational flight programs were presented in a paper entitled, "Alternative Consideration for Onboard Computer Performance Simulation in Crew Trainers."

A program for continued technological development is outlined in Section D including a number of engineering developments required to exploit the products of advanced developments for the general improvements of Air Force computer resources.

7. Adaptive Training

Presently, the Air Force has no real capability to train students adaptively using an aircraft simulator. An F-4 training simulator at Luke AFB has what is referred to as an Adaptive Flight Training System (AFTS). The system has been well received by the user and has demonstrated the capability of providing effective training to the student pilots. However, the AFTS is not an adaptive system in the strict sense of the word. Though "adaptive" is used in the system title, there is evidence that the manufacturer/user definition of adaptive differs from the conventional one. Adaptive is usually understood to mean that the training task is modified automatically as a function of student performance. The modification is designed to enhance the student's learning and help him if he is having difficulty. The definition of adaptive that can be inferred from the AFTS at Luke AFB is limited to providing an automatic scoring feature when performing a ground controlled approach (GCA). The AFTS does provide training of the GCA, but it is not an adaptive trainer in the sense of optimizing future training events on the basis of these scores.

For a training system to be adaptive, the computational system must, as mentioned above, modify the task being trained to enhance learning. This implies the solution of two critical problems in developing the adaptive trainer. First, for every procedure or maneuver that is to be trained, a scoring algorithm must be developed. This entails the gathering, weighing, combining and

mathematical operation on predetermined system output variables such that an indication of student performance can be obtained. The resultant score must permit the objective ordering of task performance on the maneuver in question. Secondly, having determined the maneuver score, it is necessary to determine and construct the adaptive logic that will allow task modification to meet student skill level on a given trial. If a maneuver is to be trained in an adaptive manner, many "micro" decisions must be made by the user. For instance, if a loop is to be trained, the user may want to begin the sequence by damping some of the dynamic characteristics of the aircraft. Then, as the student improves, the amount of damping is lessened until the real aircraft is being flown. An alternative to this approach would be to dissect the maneuver into smaller submaneuver segments and have the student train to some criteria on these smaller segments. Whatever method is employed, it is imperative that the user participate actively in the development of this logic for each task (maneuver) that is to be trained. From the brief discussion above, it is apparent that, for each maneuver to be trained. a separate scoring algorithm must be obtained and an adaptive logic developed.

Should a user contemplate the use of an adaptive device, there are several important factors that must be considered:

a. The amount of adaptive training required directly and significantly impacts the amount of computer core and the size of the associated software package. For example, ideal maneuver profiles must be stored as well as student performance history on each maneuver. This performance history is in the form of scores obtained from the scoring algorithm which is also part of the computational system.

b. The using command must play an active role in the development of the adaptive logic. This requires the use of extensive manpower resources and in most cases will require the establishment of an organic unit with expertise in learning theory and advanced training techniques. The alternative is contractual arrangements on a continuing basis.

c. The particular tasks or maneuvers that are to be trained using adaptive techniques must be selected with extreme care. The literature is fairly conclusive that tasks, which can be easily broken into discrete steps, can be trained in an adaptive manner. This is not the case when dealing with dynamic control tasks which may constitute a significant portion of the total training program. Whether or not it is possible to break up some of the dynamic control tasks (maneuvers) into smaller subtasks, has not been demonstrated conclusively.

In summary, the computer aided instruction or adaptive training area, particularly when dealing with dynamic control tasks, is

considered to be an extension of our present state-of-the-art. There are, therefore, correspondingly high risks in terms of dollar and manpower resources required to develop the logic and algorithms needed to effectively apply adaptive training features in sophisticated simulators. For the present, effort should be limited to those tasks that are easily defined and quantified; i.e., ILS and TACAN approaches. Prior to making commitments to full-scale development of an AFTS for integration with a mission simulator, a prototype AFTS should be funded.

D. DEVELOPMENT PROGRAMS

1. Development Responsibilities

The Air Force Human Resources Laboratory (AFHRL) as assigned by AFSC Regulation 23-1 is responsible for the conduct of Exploratory Development under PE 62205F, "Training and Simulation Technology" and Advanced Development under PE 63227F, "Advanced Simulator Technology." The Exploratory Development projects under PE 62205F which are directed towards the development of training simulation technology are: Project 6114, Simulation Techniques for Air Force Training; Project 1710, Training for Advanced Air Force Systems; and, Project 1123, USAF Flying Training Development. Project 6114 is for the development of training simulation techniques and devices, and Projects 1710 and 1123 are for the development of the human factors aspects of training simulation. The Advanced Development projects under PE 63227F, directed towards the development of training simulation technology are: Project 1958, Training Simulation Technology Integration; and, Project 2363, Advanced Tactical Visual System. Project 1958 is for the design, development and fabrication of integrated simulation systems or major subsystems for test and demonstration of their performance capabilities. Project 2363 is a development oriented to low cost, high performance visual technology for the fighter/attack type of aircraft simulator, and Project 2364 is oriented to the development of advanced CIG system technology capable of providing both sensor and visual simulation imagery from a common data base and generating system.

Three other Laboratory organizations, the Aerospace Medical Research Laboratory (Aerospace Medical Division), the Avionics Laboratory, and Flight Dynamics Laboratory (the latter two are now a part of the recently formed Wright Aeronautical Laboratory) are involved in simulation. Although training simulation is a very specialized field of technology with its own set of problems, methods, data bases, and criteria, it can profit from advances made in engineering simulation. There are both commonalities and dissimilarities in simulators designed for different purposes. These must be carefully considered when making decisions about the applicability of techniques from one area to another. The commonality is the "equipment;" the differences are in how the equipment or tools are used and for what purpose.

The basic difference in mission responsibilities between AFHRL and the other Laboratories involved in simulation is that of developer versus user. AFHRL has the responsibility for developing training simulation technology; whereas, the other Laboratories are users of simulation for medical or engineering analysis or design. Recognition of the fact that the field of training simulation can profit from the "spin-off" of simulation efforts of the other Laboratories led to AFHRL, in January 1975, being assigned the responsibility of Focal Point Laboratory for training simulation technology. This responsibility includes: (1) maintaining an awareness of all significant R&D being conducted by the other AF Laboratories, other DoD organizations, NASA, and industry's IR&D; (2) making recommendations concerning work assignments, the elimination of redundancy, changes in emphasis, and required resources; and, (3) preparation of an overview covering all Air Force training and training related simulation technology on an annual basis.

The Deputy for Development Planning, Aeronautical Systems Division, is responsible for development planning activities related to future aeronautical systems, major system modification and other aeronautical related equipment. The Support and Subsystems Planning Directorate of this Deputy is responsible for providing guidance to the Air Force Laboratories, Simulator SPO, and ASD Engineering on matters related to conceptual aeronautical systems. This guidance is provided to ensure that appropriate research is undertaken in technology areas in a timely manner, to support the Air Force mission for aircrew training and to provide an awareness of potential acquisition programs. The Directorate will be cognizant of future systems requirements, in the tactical, strategic and airlift mission areas and assess their impact on future R&D and acquisition programs. The Directorate is also responsible for identifying and reviewing future simulator requirements conceived by other Planning Directorates, identifying and conducting relevant simulator studies which are clearly not the responsibility of other organizations involved in simulator activity, and assist in reviewing development planning priorities.

The Simulator SPO, with engineering assistance from the Simulator Division, Deputy for Engineering, is responsible for engineering development projects to adapt existing technology to training simulator applications. Current and planned development programs are: PE 64227F, Project 2360, Fighter/Attack Simulator Visual System; PE 64708F, Other Operational Equipment; Project 1183, Digital Radar Landmass; PE 64227F, Flight Simulator Development, which is wholly dedicated to simulator engineering development; and, the B-52 Instructional System Sensor RDT&E. Management, engineering and financial responsibility has been requested for specific simulator computer system projects proposed under PE 64740F, Applications for Information Processing Technology.

2. Development Funding

The exploratory development budget for training simulation technology development within the Air Force had steadily declined since 1960 to a zero funding level in FY 75. The advanced development budget has been at a reasonable level since 1971; however, it was solely devoted to one project, the ASPT system development. Project 1958, Training Simulation Technology Integration, was initiated in FY 72, but was zero funded for three years until near the end of FY 75. This situation of limited resources available to the laboratory responsible for simulation technology development has resulted in: (1) the technology development programs falling far behind the technology requirements for simulator acquisition programs; (2) the conduct of exploratory and advanced development on hardware development programs; and, (3) the conduct of advanced development efforts by other organizations with available resources.

The funding situation for exploratory and advanced development in FY 76 was improved; however, the advanced development budget was still at about one-half the required level. Since many of the advanced and exploratory development efforts are still lagging behind, many have been catch-up efforts which require initial funding levels greater than those required for a continuing program that has kept pace with the technology needs. Also, the milestone dates for the described programs are based on the available funding and not technology need dates for the acquisition programs. Funding in FY 76, FY 7T, and FY 77 was ten to thirty percent below requested levels. Because of the lower than required funding levels in the past, it has not been possible to start some development programs and others are artificially stretched to match the approved funding. The exploratory development funding for FY 78 is projected to be at a satisfactory level. However, the advanced development funding in FY 78 is about twenty percent below the requested level, and again programs will have to be artificially stretched to match the approved funding.

Reduction in engineering development funding in PE 64227F has resulted in schedule slippages and will delay obtaining some capabilities on production simulators.

3. Development Program Descriptions

Development programs are planned and in process in two allied areas: training simulation technology development; and supporting research. The former is focused on the development of improved methods of simulation while the latter is aimed at improving our fundamental understanding of the training process as influenced by simulator capability and instructional strategies.

Table III-2 summarizes planned development tasks and projects by technical area and includes 6.1 Basic Research, 6.2 Exploratory Development, 6.3 Advanced Development, and 6.4 Engineering Development.

TABLE III-2

SUMMARY OF PLANNED SIMULATOR TECHNOLOGY DEVELOPMENT PROGRAMS

TECHNICAL AREA/TITLE	B.P.	P.E.	PROJECT	TASK	OPR
a. VISUAL					
1. Improved CIG Edge Utilization Study	6.2	62205F	6114	05	AFHRL/AS
2. Helmet Mounted Display Prototype Development	6.2	62205F	6114	05	AFHRL/AS
3. Scanned Laser Visual Display System Development	6.2	62205F	6114	05	AFHRL/AS
4. Psychophysiological Design Criteria	6.2	62205F	6114	05	AFHRL/AS
5. Three-Dimensional Imaging Study	6.2	62205F	6114	05	AFHRL/AS
6. Advanced CIG Design Methods	6.2	62205F	6114	05	AFHRL/AS
7. Wide Angle, Low Cost Infinity Optics Visual System	6.3	63227F	1958	01	AFHRL/AS
8. Wide Angle, Color, Infinity Optics	6.3	63227F	1958	01	AFHRL/AS
9. High Resolution/High Brightness Color Projector Development	6.3	63227F	1958	01	AFHRL/AS
10. Wide Angle Multiviewer Display Development	6.3	63227F	1958	01	AFHRL/AS
11. Diamond Turned Pancake Window	6.3	63227F	1958	01	AFHRL/AS
12. Advanced Tactical Air Combat Simulation (ATACS)	6.3	63227F	2363	--	AFHRL/AS
13. F-16 Independent Assessment Simulation	6.4	64229F	2185	05	AFAL/AA
14. Expand Manned Simulation Air-to-Air and Air-to-Ground Display Capability	6.2	62201F	2403	01	AFFDL/FG
15. B-52 Aerial Refueling Part Task Trainer	6.4	64227F	2201	--	ASD/SD24
16. KC-135 Boom Operator Part Task Trainer	6.4	64227F	2201	--	ASD/SD24
17. Fighter/Attack Simulator Visual System	6.4	64227F	2360	--	ASD/SD24
18. Visually Coupled Airborne System	6.2	62202F	7184	--	AMRL/HEA

TABLE III-2 (Continued)

SUMMARY OF PLANNED SIMULATOR TECHNOLOGY DEVELOPMENT PROGRAMS

TECHNICAL AREA/TITLE	B.P.	P.E.	PROJECT	TASK	OPR
b. MOTION AND FORCE					
1. Sensory Mechanism Modeling Study	6.2	62205F	6114	19	AFHRL/AS
2. ASPT G-Seat Configuration Simulation	6.2	62205F	6114	19	AFHRL/AS
3. Determination of G-Cue Environments	6.2	62205F	6114	19	AFHRL/AS
4. High G-Augmentation Device	6.2	62205F	6114	19	AFHRL/AS
5. Bionic Visual Control	6.2	62205F	6114	19	AFHRL/AS
6. Motion and G-Seat Algorithms	6.2	62205F	6114	19	AFHRL/AS
7. Advanced Motion and Force Design Methods	6.2	62205F	6114	19	AFHRL/AS
8. Advanced Low Cost G-Cueing System	6.3	63227F	1958	02	AFHRL/AS
9. Manned Flight Simulation Verification	6.2	62201F	1986	01	AFFDL/FG
10. High G-Model of Pilot Tracking Performance	6.2	62202F	6893	02	AMRL/EMT
11. Human Operator Models for Simulation	6.2	62202F	6893	06	AMRL/EMT
12. Fighter Motion Cue REquirements Study	6.2	62205F	6114	19	AFHRL/AS
13. Platform Disturbance Motion	6.2	62205F	1123	12	AFHRL/FT
14. Improved "G" Onset Cueing	6.2	62205F	1123	--	AFHRL/FT
c. SENSOR					
1. Sensor Data Characterization	6.2	62205F	6114	14	AFHRL/AS
2. Data Base Descriptors	6.2	62205F	6114	14	AFHRL/AS
3. Nonlinear Terrain Simulation	6.2	62205F	6114	14	AFHRL/AS
4. Surface Texturing Study	6.2	62205F	6114	14	AFHRL/AS
5. CIG Texturing Study	6.2	62205F	6114	14	AFHRL/AS
6. Advanced Electrooptical Sensor Simulation	6.3	63227F	1958	03	AFHRL/AS
7. Common CIG Visual/Sensor System	6.3	63227F	2364	--	AFHRL/AS
8. Digital Radar Landmass Simulation (DRLMS)	6.4	64708F	1183	--	ASD/SD24
9. Fighter/Attack EW Simulator	6.4	64229F	2185	--	ASD/SD24
10. B-52 Electrooptical Viewing System	6.4	64227F	2269	--	ASD/SD24

TABLE III-2 (Continued)

SUMMARY OF PLANNED SIMULATOR TECHNOLOGY DEVELOPMENT PROGRAMS

TECHNICAL AREA/TITLE	B.P.	P.E.	PROJECT	TASK	OPR
d. MODELING AND COMPUTATION					
1. Higher Order Languages	6.2	62205F	6114	07	AFHRL/AS
2. Advanced Computer Configurations	6.2	62205F	6114	07	AFHRL/AS
3. Software Partioning Methods	6.2	62205F	6114	07	AFHRL/AS
4. Simulation of Onboard Avionics Software					
5. Central vs Distributed Computers					
6. Hardware Implementation of Specific Functions					
7. Computer Programming Techniques					
8. Computer Selection and Sizing Model	6.4	64227F	2325	06	ASD/SD24
9. ASD Reg for Simulation Computer System Application					
10. Software Acquisition Engineering Guidebook	6.4		In-House	--	ASD/SD24E
11. Hybrid Computer Errors in Engineering Flight Simulation	6.1	61102F	2307	03	AFFDL/FG
e. INSTRUCTIONAL FEATURES/TRAINING TECHNIQUE					
1. Survey of Instructor/Operator Station (IOS) Hardware	6.2	62205F	6114	20	AFHRL/AS
2. Pilot Models for Performance Measurement	6.2	62205F	6114	20	AFHRL/AS
3. Advanced Instructor/Operator Display Evaluation Techniques	6.2	62205F	6114	20	AFHRL/AS
4. Advanced IOS Control Methods	6.2	62205F	6114	20	AFHRL/AS
5. Tactical Performance Characterization	6.2	62205F	6114	20	AFHRL/AS
6. Multi-Dimensional Displays	6.2	62205F	6114	20	AFHRL/AS
7. Aircrew Performance Measurement Development	6.2	62205F	1123	01	AFHRL/FT
8. Pilot Performance Measurement System	6.3	63751F	2359	--	AFHRL/FT
9. Advanced Training Features Evaluation	6.2	62205F	1123	03	AFHRL/FT
10. Instructor/Operator Display Design Guide	6.2	62205F	6114	07	AFHRL/AS
11. Skills Maintenance and Reacquisition Training	6.2	62205F	1123	--	AFHRL/FT
12. Training Methods and Media for Flying Skills	6.2	62205F	1123	--	AFHRL/FT

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TABLE III-2 (Continued)

SUMMARY OF PLANNED SIMULATOR TECHNOLOGY DEVELOPMENT PROGRAMS

TECHNICAL AREA/TITLE	B.P.	P.E.	PROJECT	TASK	OPR
e. INSTRUCTIONAL FEATURES/TRAINING TECHNIQUE (Continued)					
13. Advanced Instructional Features Evaluation	6.2	62205F	1123	--	AFHRL/FT
14. Workload and Pilot Cognitive Functions/ Physiological Indices	6.2	62205F	1123	--	AFHRL/FT
15. Workload and Pilot Cognitive Functions/ Behavioral Indices	6.2	62205F	1123	--	AFHRL/FT
16. Tactical Decision Making	6.2	62205F	1123	--	AFHRL/FT
17. Effectiveness of ACM Training Programs	6.2	62205F	1123	--	AFHRL/FT
18. Validation of Candidate Performance Measurement Systems	6.2	62205F	1123	--	AFHRL/FT
19. Maneuverable Airborne Target System	6.2	62205F	1123	--	AFHRL/FT
20. Instructor/Operator System Development	6.4	64227F	2325	03	ASD/SD24
f. SIMULATOR APPLICATION AND EVALUATION					
1. Maintenance of Flying Skills	6.2	62205F	1123	02	AFHRL/FT
2. KC-135 Visual System Evaluations	6.2	62205F	1123	03	AFHRL/FT
3. ASPT Utilization	6.3	63751F	1192	PROJ	AFHRL/FT
4. Effectiveness of Platform Motion	6.2	62205F	1123	01	AFHRL/FT
5. ASPT Visual System Evaluation	6.2	62205F	1123	03	AFHRL/FT
6. Effective Simulator Utilization	6.2	62205F	1123	03	AFHRL/FT
7. Area of Interest Evaluation	6.2	62205F	1123	03	AFHRL/FT
8. A-10 Training Research Support	6.2	62205F	1123	11	AFHRL/FT
9. Aerial Refueling Simulation Study	6.2	62205F	1123	10	AFHRL/FT
10. ASPT Distributed Processor	6.2	62205F	1123	10	AFHRL/FT
11. CIG Overload Algorithm	6.2	62205F	1123	10	AFHRL/FT
12. CIG Software Modularization	6.2	62205F	1123	10	AFHRL/FT
13. Advanced CIG Data Base Modeling	6.2	62205F	1123	10	AFHRL/FT
14. G-Seat Optimization	6.2	62205F	1123	10	AFHRL/FT
15. ASPT Distributed Processor Analysis	6.2	62205F	1123	10	AFHRL/FT
16. Advanced Air-to-Ground Displays	6.2	62205F	1123	10	AFHRL/FT
17. Automatic Adaptive Training	6.2	62205F	1123	10	AFHRL/FT
18. ASPT Air-to-Air Combat Simulation	6.2	62205F	1123	10	AFHRL/FT
19. Visual Data Base Standards		C A N C E L L E D			
20. Realism Requirements for Flying Training Simulators	6.2	62205F	1123	03	AFHRL/FT

TABLE III-2 (Continued)

SUMMARY OF PLANNED SIMULATOR TECHNOLOGY DEVELOPMENT PROGRAMS

TECHNICAL AREA/TITLE	B.P.	P.E.	PROJECT	TASK	OPR
f. SIMULATOR APPLICATION AND EVALUATION (Continued)					
21. R&D Applications Support	6.2	62205F	1123	04	AFHRL/FT
22. F-106 Radar/IR PTT Evaluation	6.2	62205F	1710	--	AFHRL/AS
23. Strategic Avionics Crew Station Design	--	11113F	2405	--	AMRL/HED
24. Air Force/Navy Landing Study	6.2	62205F	1123	10	AFHRL/FT
25. Visual Parameter Model	6.2	62205F	1123	10	AFHRL/FT
26. SAAC Utilization	6.2	62205F	1123	12	AFHRL/FT
27. Simulator Task Analysis	6.2	62205F	1123	12	AFHRL/FT
g. SIMULATION REQUIREMENTS VALIDATION AND SPECIFICATIONS					
1. Simulator Development Activities	6.4	64227F	2325	--	ASD/SD24
2. Training Device Design Guide	6.2	62205F	1710	--	AFHRL/AS
3. Simulator Training Requirements Effectiveness Study (STRES)	6.2	62205F	1710	03	AFHRL/AS
4. Prime Specification Development	6.4	64227F	2325	05	ASD/SD24
h. SIMULATOR TESTING/ACCEPTANCE TECHNIQUES					
1. Simulator Operational Test and Evaluation	6.2	62205F	1123	--	AFHRL/FT
2. Flight Test Data Correlation	6.2	62201F	1986	01	AFFDL/FG
3. Dynamic Fidelity Testing	6.2	62205F	6114	07	AFHRL/AS
4. Simulator Instrumentation System	6.4	64227F	2325	03	ASD/SD24
5. Operational Test and Evaluation (OT&E) Handbook	6.2	62205F	1123	--	AFHRL/FT

Summaries of schedules for each planned project or task are included in Section IV.

A brief explanation of each of the tasks and projects follows:

a. Visual

(1) Improved CIG Edge Utilization Study

With wide field-of-view displays, the limited number of edges in the CIG scene is sparsely distributed. Adding edges means added hardware and cost. This effort is to develop methods of providing a highly detailed area of interest by sacrificing detail at the perimeters of the field-of-view.

(2) Helmet-Mounted Display Prototype Development

A helmet-mounted display could potentially provide a wide field, high resolution, collimated (or possibly steroscopic) scene for visual simulation at considerably reduced costs compared to present systems. This effort, being carried out jointly by AMRL and AFHRL, is developing a prototype helmet-mounted display to explore this potential.

(3) Scanned Laser Visual Display System Development

This effort, being funded jointly by the Army and Air Force, is to develop a real image display system using a scanned laser to provide a continuous, high brightness, high resolution visual scene. The work also includes investigation of the feasibility of adapting a conventional computer image generator to the laser display system.

(4) Psychophysiological Design Criteria

Virtual image (infinity) display systems developed up to now have had visual tolerances, when specified at all, based on desired performance of the system rather than on psychophysical characteristics of the human. This effort is to establish physiological design criteria for virtual image displays and, thus, capitalize on human characteristics in an attempt to develop improved, cost-effective visual systems.

(5) Three-Dimensional Imaging Study

This effort will investigate the training tasks which may require a stereoscopic depth cue capability and develop design approaches for providing this capability in visual simulation systems.

The work will take advantage of efforts in progress for the development of stereoscopic visual systems for boom operator training. Training tasks in which stereo cues are assumed to have importance include aerial refueling, formation flight, landing, and air-to-ground target acquisition and weapon delivery. Development and application of a suitable display technique will make realistic assessment of its training value possible.

(6) Advanced CIG Design Methods

A limiting factor of existing approaches to CIG improvement is that they do not address or take advantage of the visual processing capabilities and limitations of the human. This effort will identify characteristics of man's visual perceptual system which have the greatest potential impact on CIG design; and, develop advanced design methods that capitalize on these characteristics.

(7) Wide Angle, Low Cost Infinity Optics Visual System (Holographic Pancake Window)

Develop an in-line, infinity image optical system (pancake window) which utilizes a holographic lens analog of the conventional glass spherical mirror/beam splitter. The holographic pancake window will be monochrome due to the narrow bandwidth of the laser used in exposing the hologram. The holographic pancake window is expected to provide a 75 percent savings in weight and cost over a conventional pancake window.

(8) Wide Angle, Color, Infinity Optics Display (Color Holographic Window)

Develop an in-line, infinity image optical system (pancake window) which utilizes a holographic lens analog of the conventional glass spherical mirror/beamsplitter. One approach to be investigated will be to expose three holograms, each in the frequency range of the three primary colors, and cement them together along with the remaining pancake window devices to transmit the color images. A substantial savings in weight and cost over the conventional window is expected.

(9) High Resolution/High Brightness Color Projector Development

Develop a color projector capable of projecting high resolution, bright imagery for both infinity and real image viewing. Projector will be capable of producing a minimum of 1000 line and 480 feet Lamberts with potential for growth in both parameters.

(10) Wide Angle, Multiviewer Display Development

Develop a wide angle visual display system with a large viewing volume suitable for viewing in the proper perspective and without optical aberrations by multiple crew members of wide body aircraft. This effort will utilize the results of exploratory development tasks in the design of a wide field-of-view display with a volume large enough to allow multiple crew members to see the visual scene in the proper position with the proper perspective.

(11) Diamond Turned Pancake Window

Develop a technique to cut the spherical mirror/beamsplitter of the pancake window from plastic, using a diamond cutting tool to produce an optical surface without further grinding and polishing. If successful, this will provide a backup technique to the trichromatic holographic window for producing color pancake windows at substantially reduced cost and with less weight.

(12) Advanced Tactical Air Combat Simulation (ATACS)

Develop and demonstrate the hardware and software technology necessary to provide advanced visual simulation capabilities for the next generation fighter/attack aircraft simulators. Technology will be developed to provide multiple, high resolution, independently maneuvered targets and a ground plane with enhanced information and including color and texturing.

(13) F-16 Independent Assessment Simulation

This project has resulted in a real time simulator being constructed for the F-16 avionic system with out-the-window scene generation. It is suitable as a part task trainer.

(14) Expand Manned Simulation Air-to-Air and Air-to-Ground Display Capability

Improvements in the visual projections for air-to-air tracking and air-to-ground tracking will be made in manned engineering simulation. Target image generator will be improved for air-to-air combat simulation in the LAMARS cockpit and a HUD will be installed for use in both air-to-air and air-to-ground displays. The air-to-ground weapon delivery envelope will be expanded by removing the pitch limitation which currently exists on the terrain board probe. The capability along with an added capability to measure eye motion, and simulating FLIR, radar, and LLLTV displays will be available for use in all the engineering simulation cockpits.

(15) B-52 Aerial Refueling Part Task Trainer

Effort will develop and demonstrate a production prototype part task trainer designed to provide high fidelity cueing

necessary to train the aerial refueling task. Testing will demonstrate the feasibility and cost effectiveness of ground training for this particular task.

(16) KC-135 Boom Operator Part Task Trainer

Effort consists of in-house development of hardware designed to provide cueing necessary to train KC-135 boom operators in the aerial refueling task. Resultant hardware will be evaluated to demonstrate proof of the training concept.

(17) Fighter/Attack Simulator Visual System

The objective of the Fighter/Attack Simulator Visual System Program (Project 2360) is to obtain for the Air Force full mission capable visual systems for any fighter/attack aircraft simulators. Once the visual system has been demonstrated, a production effort will begin to equip A-10, F-16, and other high performance aircraft simulators to bring them to full mission simulator configuration. The visual system will be integrated with two host Operational Flight Trainers (OFTs) to form a Weapon System Trainer (WST). A visual scene will be provided to either or both trainee stations, depending on whether the trainee stations are operating separately or interactively. The visual system will consist of the following major components:

(a) Image generation subsystem;

(b) Two wide field-of-view visual displays;

(c) Interface hardware and software; and

(d) Instructor/operator station visual system controls.

The system will be designed to provide visual cues for all phases of training to include: all tasks in the transition, instrument, formation, air refueling, basic attack maneuvers, surface attack, surface attack tactical, offensive and defensive combat maneuvering, dissimilar combat maneuvering, dissimilar air combat training, search and rescue, and escort. The role assigned to a particular aircraft's simulator, the appropriate syllabus of instruction, and the user's assessment of the capability as demonstrated during test and evaluation will dictate the applicability of the visual system to provide cues to train any or all of the above tasks in a particular fighter/attack simulator.

(18) Visually Coupled Airborne Systems Simulator

This effort will accomplish engineering design research to examine the feasibility of Line-of-Sight Controlled Wide

Field-of-View Hemispherical Helmet Mounted Display for Ground and Airborne Use. This work is being performed by AMRL under Project 7184 and is supported by AFHRL under Project 6114.

b. Motion and Force

The ASD Technical Need TN-ASD-AFHRL/AMRL-0602-77-66, Establishment of a Data Base for the Definition of Requirements for Flight Simulator Motion and Force Cueing, requests the development of a data base from which motion and force simulation hardware and software can be developed. Another Technical Need, TN-ASD-AFFDL-0508-77-72, Motion System Requirements for Flight Simulation, requires the development of a data base for the optimal blend of platform motion, g-seat, g-suit, and buffet cues using the in-flight, variable stability (NT-33) aircraft. Although work is underway to satisfy these Technical Needs, an extensive effort in motion and force simulation is necessary to meet all requirements. The human motion and force sensory mechanism modeling effort will develop some, but not all, of the data base requested in these two TNs. Motion cue threshold studies on the man-carrying rotation device (at NASA-Ames) will also provide some insight into the development of the motion data base. In-flight simulator studies, such as those requested in TN-72, may also provide some useful information about motion cueing. However, these TNs cannot be fully satisfied with existing technology. Research needs to be initiated in the areas of g-force characterization and analysis of these forces at the pilot's station. Once the g-cue environment has been identified, these data can be provided as inputs to the motion sensory model to identify those sensory mechanisms that are thereby stimulated. New work in the area of evoked potential may lead to a better understanding of how the human uses various motion and force cues. Once some of these efforts have come to fruition, a design specification for motion and force cueing devices can be developed. Until qualitative and quantitative data are available from these efforts, user requirements cannot be fully satisfied. Following are descriptions of several ongoing or anticipated studies that are required:

(1) Sensory Mechanism Modeling Study

Although motion and force simulation systems have been specified for nearly every recent simulator procurement, there is little information concerning the training effectiveness of existing systems or the degree of simulation required for future systems. Motion systems designs are typically based on aircraft performance with little attention given to the human to which the motion systems are intended to impart cues. This effort will concentrate on the human and how he perceives motion through his various sensing mechanisms (vestibular, somatic, visual, etc.) in order to determine what mechanisms are most important for stimulation and new and unique means of stimulation to produce the sensations of motion and force as

experienced in flight. The delivered model will be driven first with a tactical aircraft motion profile and the output of the sensors will be observed. This output will indicate which motion and force sensors appear to be the most important for stimulating. The model will be validated on motion research equipment and compared with existing and new psychophysical data.

(2) ASPT G-Seat Configuration Simulation

This effort is aimed at these goals: (1) improving existing g-seat hardware components, and (2) investigating simpler, more economical approaches to g-seat design. A feedback metal bellows has been developed and investigated which, when driven with compensation circuitry, shows an improved response. This work has resulted in the experimental use of a different electropneumatic control valve for g-seats. An advanced, low cost g-seat was emulated on the ASPT in October 1976 and demonstrated an improved approach to g-cueing. This research is providing the ALCOGS program with valuable drive algorithm information. This effort will continue on the ASPT and the ALCOGS.

(3) Determination of G-Cue Environments

The objective of this effort is to determine the pilot's g-cue environment of various representative aircraft under typical maneuvers. The results will be applicable to the development of future motion and force systems including the advanced low cost g-cueing system. The end product of this work is a data base of representative aircraft g-cue environment profiles.

(4) High-G Augmentation Device

This effort is for the design of prototype high-g augmentation devices to enhance the g-cue environment of future simulators. The devices will load the pilot's limbs, head, and shoulders to augment the simulation of high-g effects. A twelve-month study contract for the design of g-cueing devices will be awarded. Prototype devices (hardware and software) will be designed to apply appropriate forces effectively and safely. The contractor will investigate such techniques and devices as straps, active shoulder harness, active helmet, lower and upper body negative pressure, and a sound system for aural cueing. After these devices have been designed, a separate contract will be awarded to build prototypes of any designs which are promising.

(5) Bionic Visual Control

This effort encompasses the design and development of a software program and associated hardware for the bionic control of acceleration-induced dimming of the simulator pilot's visual display. Current display techniques are not pilot-interactive in

that the pilot has no physical control over the dimming of the visual display. This effort has significant training implications. Two algorithms will be developed to control the display. One will be a dynamic algorithm of the human visual system which will be driven by the simulator pilot's g-environment. The other will be an algorithm to predict the effectiveness of the pilot's M-1 maneuver (straining performed by pilot in actual aircraft to withstand increased g's), which will be driven by electromyographic potentials from selected muscle groups. The outputs from these two algorithms will be integrated to drive a brightness controller for the simulator pilot's visual display. The integrated system will be implemented at the AFHRL STARS facility on the T-38 simulator.

(6) Motion and G-Seat Algorithms

This effort is to develop standardized, composite algorithms for motion and g-cueing devices. This work will be based on the results of modeling and g-force characterization studies and will produce algorithms which drive motion and force systems in an integrated manner for application in future simulators.

(7) Advanced Motion and Force Design Methods

This effort is for the development of advanced design concepts for motion and force systems based on human perception characteristics and cue utilization methods. The work will include the application of techniques for determining motion and force cue utilization or perception characteristics in the environment of perceptual/motor task performance.

(8) Advanced Low Cost G-Cueing System (ALCOGS)

This effort represents the second generation of somatic cueing developments for motion and force simulation. The ALCOGS has three primary components including a g-seat, g-suit, and seat shaker system. The ALCOGS will demonstrate the next generation g-cueing system, as it is an A-10/F-15 type seat with an F-16 tilt-back (30 degrees) capability. Highly responsive, wide bandwidth hydraulic actuators will give response times which will enable onset cueing research. The present g-seats are acceleration sustaining devices and are not responsive enough to be used for onset cueing research with current CIG visual systems. The ALCOGS test and evaluation should result in a better g-cueing specification for the Air Force's tactical aircraft simulators including the A-10 and F-16.

(9) Manned Flight Simulation Verification

The objective is to assess the effects of linear acceleration washout currently implemented on the LAMARS, compare them with other approaches, and update existing software to incorporate changes in the motion drives as required.

(10) High-G Model of Pilot Tracking Performance

This effort is to investigate the g effects upon the tracking phase of air combat performance.

(11) Human Operator Models for Simulation Design Technology

Investigates angular motion effect upon tracking and ties into Project 689302 where linear motion is examined.

(12) Fighter Motion Cue Requirements Plan

The objective of the plan described herein is to determine motion cue requirements for flight simulators to satisfy Air Force training objectives. The initial emphasis will be on the fighter/attack type aircraft simulator. The term "motion cue requirements" is not intended to imply that this plan is directed towards nor limited to determining requirements for platform motion or any other particular type of motion cueing device. The efforts described are intended, through a fundamental approach, to determine first, motion cueing requirements independent of current motion and force cueing devices; and second, to define the most effective device(s) for providing those cues in a flight training simulator. The devices defined could range from wide field-of-view visual systems, to g-seats, to platform systems, to high-g augmentation systems or any combination of these or other new devices.

Based upon recent motion reaearch results, the following tentative conclusions can be drawn:

- Current platform motion systems do not make a measurable contribution to any UPT training tasks as measured by transfer of training (TOT);

- Simulated motion cues do make a difference in training certain tasks in wide-bodied aircraft (e.g., engine-out studies for KC-135 in the Flight Simulator for Advanced Aircraft), but such has not been confirmed with TOT measures in the aircraft;

- There is evidence that pilot performance differs as a function of the presence or absence of motion (e.g., Huddleston and Rolfe, Applied Ergonomics, 1971);

- Wide-angle visual systems provide strong positional motion cues and interact with other motion cueing systems in ways not yet completely understood;

- The next generation of platform motion systems (such as the UPT-IFS T-38) are significantly improved over current systems, and

- The g-seat, although in its infancy in development, has been very well accepted and appears to be a part of the future motion and force simulation equipment. Experiments conducted using the Advanced Simulator for Pilot Training (ASPT) and Simulator for Air-to-Air Combat (SAAC) have shown improved performance when the g-seats were used (Waters and Grunzke, 1976 AIAA Conference; also, Stark, 1976, AIAA Conference).

The proposed plan taps Air Force resources in the AFHRL, AMRL, AFFDL, TAC, and ADCOM. The suggested tasks were developed mutually by AFHRL/AS, ASD, AMRL, and AFFDL.

- PHASE I - Literature Survey and Short-Term Experiments

One objective of this initial Phase is to provide the Simulator SPO with the latest information on motion studies and simulation literature on which to base near-term decisions on procuring platform motion systems or other motion cueing devices for tactical aircraft simulators. Another objective of this Phase is to conduct short-term experiements on the unique AMRL devices in order to add perspective to platform motion system and other studies which have already been completed and reported in the literature. In addition, an effort will be undertaken to characterize the g-force environment of the pilot. All of these efforts can provide helpful information within six months and should provide the Simulator SPO with the best advice available on which to base near-term decisions.

- PHASE II - Development of a Preliminary Motion-Cueing Functional Specification

Two parallel efforts are identified under this Phase; the motion task analysis and sensory modeling development, which lead into the development of a functional specification.

The objective of the task analysis is to develop a synthesis of the cues and activities representative of the pilots behavior in operating high performance, single place aircraft and which are relevant to motion simulation. Attention will be given exclusively to the F-4 and the F-106 because; (a) these aircraft are representative, and (b) the basic information is already available for use in the analysis. From a characterization of the missions each performs, subsidiary mission elements will be identified. Each unique mission element will be defined as to the visual, aural, and motion cues and the actions involved. Those for the F-4 will be cross-compared with those for the F-106 and a single listing prepared. Finally, any elements judged largely procedural or essentially redundant will be dropped. The resulting series of unique task descriptions will be used in conjunction with the results obtained from Phase I and the modeling. They will represent the typical multisensory, cue-response sequences involving aircraft motion in piloting high performance aircraft.

The objective of the modeling task is to complete the development of a model of how the human senses motion and forces, and to use the model to determine which sensory mechanisms are being stimulated and to what extent under various flight conditions.

Based on the results available from Phase I, the sensory model and the task analysis, a functional specification will be developed. This specification will essentially be a functional description of motion cueing equipment performance required for tactical aircraft training simulators. A range for motion cues will result which can be interpreted in terms of possible cueing devices. These devices could range from wide field-of-view visual displays, to improved platform motion systems, to high-g augmentation systems or any combination of these or other devices.

- PHASE III - Development of a Preliminary Motion-Cueing Design Specification

After g-force and hardware requirements have been analyzed, a preliminary design specification will be developed. This effort should take no more than five months and result in a document which would provide the basis and design criteria for motion cueing hardware.

After a preliminary specification has been drafted, a comparative evaluation of current motion simulation devices will be performed. This effort would entail comparing the specification against the measured characteristics of current motion simulation systems. The comparison would include current motion platforms, g-seats, g-suits, seat-shakers, high-g augmentation devices, aural cueing systems, and wide angle visual displays.

- PHASE IV - Device Development/Refinement

After comparing the preliminary specification against current simulation devices, such as platform motion systems, g-seats, etc., the decision can be made whether to build new devices or to refine/modify existing equipment. If present technology is satisfactory with some modifications, then those devices which appear satisfactory with refinements/additions will be modified. Should it be deemed necessary to develop an entirely new hardware system, then a contract will have to be let for the design and development of the device(s). AFHRL experience on various development programs indicates that at least 24 months are required for the development of a totally new device. This includes release of RFP to integration and acceptance of deliverable hardware.

If a motion simulation device need only be refined in order to meet the new specifications, the device development phase can be reduced considerably, depending upon the degree of the refinement. In this case the validation phase can begin much sooner.

- PHASE V - Validation of Developed/Refined Devices

After a device(s) has been refined/developed, it will be installed and integrated with an appropriate fighter/attack simulator and evaluated using transfer of training techniques. A period of six months is estimated for this validation phase. Although not a part of this plan, a parallel technical effort for improving performance measurement techniques in both the simulator and aircraft must be undertaken. Current techniques are inadequate for quantifying some of the subtle differences that motion cues make in training. Improved performance measurement techniques will be essential for the successful conduct of this validation phase. After the motion simulation device(s) has been evaluated/validated, a final design specification can be developed.

- Milestones

With respect to milestones in this plan, there are three major milestones which would provide significant output: (1) five months from the start of the effort, after the completion of the literature survey and short-term experiemnts; (2) eighteen months from the start of the effort, after completion of Phase III, an unvalidated specification would be available; and, (3) thirty-five to fifty-three months from the start of the effort, a validated specification would result.

(13) Platform Disturbance Motion

This effort will examine the value of platform distrubance as a cue in training pilots to deal with extremes in aircraft motion due to flight departures, extreme turbulence, wind shear, etc.

(14) Improved "G" Onset Cueing

This effort intends to demonstrate the training value of improved "G" onset cueing for simulators for high performance aircraft.

c. Sensor

Current user requirements are concerned with simulation of performance characteristics from a wide range of sensor systems. This includes infrared, low light level television, and radar under both active and passive modes of operation. Research is necessary to establish the modeling requirements for representing the anomalies associated with the above systems for different modes of operation.

The requirements for low level flying, target identification and bomb damage assessment within the sensor simulation

system imposes severe requirements upon both the "front" end and "back" end of the simulation system. The attendant costs of providing data base detail that fulfill the above requirements are considered prohibitive. Therefore, it is considered incumbent upon the simulation system to provide the added detail information on a representative basis for use in the simulation program. This requires the development of texturing techniques which will enable the representation of small man-made features and discrimination among natural features such as trees, grass, lakes, etc. The use of edges is considered costly and inefficient in view of the large quantity of data which must be processed. Therefore, methods will be explored which permit compression of the information to be stored, processed, and displayed. The techniques to be explored include use of curved surface mathematics and transformation techniques for reducing the edge processing requirements while preserving the essential character of the topographic and cultural information. The utility of the techniques for performing simulator tasks must then be evaluated in the context of real time applications.

(1) Sensor Data Characterization

This effort will utilize results of the Sensor Data Base Characterization Program, completed in June 1977, for development of algorithms that will permit representation of seasonal and weather effects in the simulation program. It is planned that accumulative data for at least three target complexes will be employed during this development effort. Data collected over all seasons will be analyzed to permit mathematical formulations and algorithm development that correlate with actual conditions. Emphasis is placed upon use of cultural targets but will encompass consideration of foliage representation. Scenarios will be synthesized for validation of results.

(2) Data Base Descriptors

This effort will result in delivery of a system capable of providing dynamic sensor simulation of the performance characteristics of Infrared and Low Light Level (LLLTV) sensor systems. Flexibility, together with rapid scene update capability, are considered prime features of this system. Actual simulation will be performed in nonreal time, and through video recording and playback, a representation of real time simulation can be accomplished. The resulting scenarios will be used to assess the impact of data base fidelity and contribution of simulated sensor parameters for performing low level flying and target identification tasks. Scheduling of this effort is such that results can be provided for use in B-52 EVS simulator acquisition programs. The system is also being configured to permit implementation of alternate algorithms and approaches to sensor simulation.

(3) Nonlinear Terrain Simulation

This effort is to investigate the use of curved surface mathematics for terrain representation for future sensor simulation

systems. The work will include development of necessary algorithms; evaluation of resulting, static imagery; and, pending results, conduction of real time dynamic tests.

(4) Surface Texturing Study

This effort will explore the use of pseudo-random noise codes for providing texture representative of real world scenes. The work will include refinement of algorithms to include generation of noise codes in the data base and transformation of them to the image plane in conjunction with scenario generation.

(5) CIG Texturing Study

This effort will explore representation of foliage relief utilizing real world data. Imagery depicting foliage relief will be digitized and sampling methods will be employed in conjunction with determining required sampling rates for the varying detail associated with different ranges to the target.

(6) Advanced Electrooptical Sensor Simulation

To develop a flexible sensor simulation capability using DMA data to determine and evaluate the critical parameters germane to simulating EO sensor imagery for aircrew training.

(7) Common CIG Visual/Sensor System

This effort will develop a new concept of computer image generation (CIG) which should improve its training effectiveness by providing more detail than is possible with state-of-the-art systems. This will include new techniques for storing the data base. extracting data as required, and constructing the image. A three-phase effort is anticipated, beginning with a multiple study of design concepts. Proposed approaches are expected to range from optimization of current CIG techniques to totally new concepts. Phases 2 and 3 will consist of system development and evaluation followed by hardware construction.

(8) Digital Radar Landmass Simulation (DRLMS)

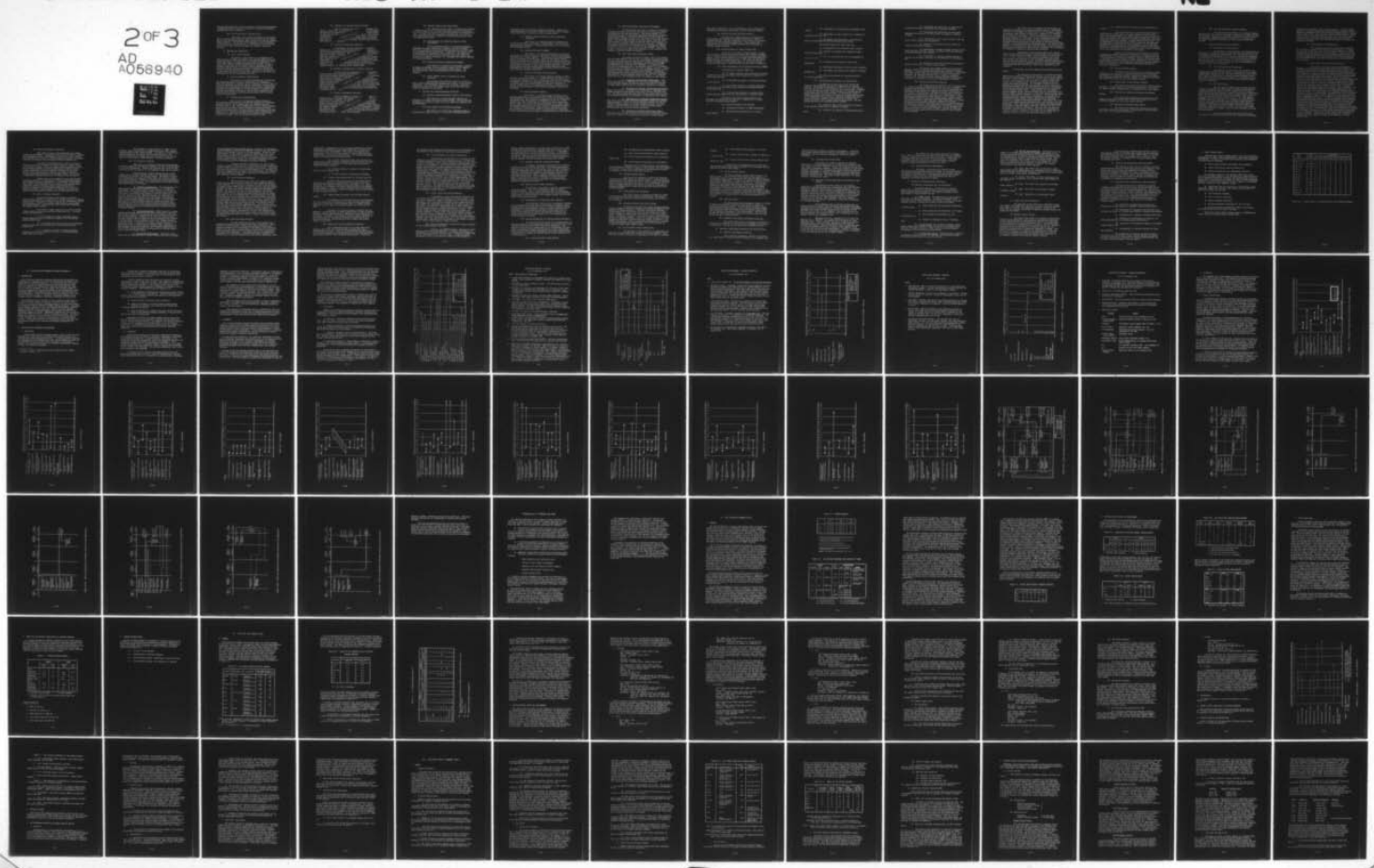
This effort, which is near completion, will demonstrate the technical and operational feasibility of modifying an F-111 simulator with digitally generated radar landmass image capability. Integration of the DRLMS into an operational training simulator has been accomplished. Data is being collected upon which to base follow-on production and simulator modification decisions.

(9) Fighter/Attack Electronic Warfare (EW) Simulator

This effort will demonstrate the feasibility of a simplified, low cost, fighter/attack electronic warfare simulation.

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Hardware developed phases will be evaluated, thus providing management and engineering data to support decisions for follow-on production equipment for future simulators.

(10) B-52 Electrooptical Viewing System

This effort will develop and demonstrate an Electro-optical Viewing System (EVS) for real time simulation of the B-52G/H EVS by using the Defense Mapping Agency digital data base and computer image generation. The EVS will be incorporated in the B-52 Weapon System Trainer pilot production unit. Evaluation of the EVS in this system will provide the data necessary for follow-on production decisions.

d. Modeling and Computation

(1) Higher Order Languages

The purpose of this effort is to investigate the characteristics required in a higher order language (HOL) for use in flight simulation. The approach is to develop a comprehensive benchmark flight simulator problem; determine specifications for an optimal HOL; evaluate several existing HOLs as possible candidates, including identification of required language enhancements; and, identify potential methods and problems in applying a standard HOL in future simulator development efforts. Results will be applied in the DoD common HOL effort to assure that the needs of simulation are represented in any DoD standardization of HOL.

(2) Advanced Computer Configurations

This effort is to develop methodology for designing and evaluating advanced computer configurations for simulation which take advantage of state-of-the-art technology and assure that the resulting simulation system will operate efficiently. This includes provisions for investigating and solving interprocessor communication problems and assigning tasks to various processors to optimize data flow and computational efficiency. Results will be applied in the development of simulator specifications and evaluation of advanced computer configurations.

(3) Software Partitioning Methods

This effort is to develop automated methods of partitioning flight simulation software for execution on a multiple-processor system. The techniques must also optimally allocate processor power to the various computational tasks to assure adequate spare time per processor, satisfy temporal and functional inter-depencencies among tasks, and assure overall computational efficiency. Results will be applied to provide standardization, optimization, and automation of a task which otherwise, would escalate already high software development costs if routinely performed by hand.

(4) Simulation of Onboard Avionics Software

With the expanded use of onboard programmable computers, a need exists to identify information processing requirements and computational approaches to support program driven avionics system performance in the simulator. The question of providing the simulation systems which utilize such processors is critical as it has a great impact on development risk, performance, flexibility for change, and on initial and life cycle costs of the simulator.

(5) Central vs Distributed Computers

A requirement has been identified to initially develop a set of criteria which relate advantages and disadvantages of central versus distributed general purpose computer configurations in real time training simulators. These criteria can be formulated into a model. The model will address a set of simulator system-level requirements including acquisition, development, operation, maintainability, and standardization considerations. The model will evaluate the relative merits of central versus distributed computer configurations for the particular simulator. The results of this effort would be used in the conceptual definition of training system configurations.

(6) Hardware Implementation of Specific Functions

An effort has been initiated to identify candidate functions which may be designed and developed as hardwired or fixed microelectronic digital processors. Functions to be considered will include trignometric, transcendental manipulation, linear function interpolation routines, input/output processing. Within the total simulator complex there are many information processing elements which are common to a given simulator and across several simulators. The objective of this effort is to identify these and define standard hardware modules and potentially achieve standard electronics modules. Application of microprosessor technology will be included in this effort.

(7) Computer Programming Techniques

Air Force emphasis on organic software support requires methods of systematic disciplined computer programming to facilitate rapid, complete, and comprehensive documentation, and to promote ease of modification to computer programs. A requirement exists to analyze and develop software acquisition and programming techniques such as structured programming, threat concepts, and standard computer languages as applied to the development of training simulator software. Develop criteria with which to evaluate individual computer's capability to efficiently process real time programs written in higher order languages.

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(8) Computer Selection and Sizing Model

The objective of this task is to develop and implement a computer model to aid in determining computer system configuration for aircrew training devices and to provide estimates for computational load. The model will allow systematic consideration of all factors that significantly affect information processing and potential growth of computational systems.

(9) ASD Regulation for Simulation Computer System Application

Air Force Regulation 800-14, Acquisition Management - Management of Computer Resources in Systems, has been published. Since this regulation covers all systems acquired under the 800 series, it is somewhat general by necessity. A need exists to prepare an ASD training simulator supplement to this regulation. This supplement will be drafted in-house to define specific acquisition policy and direction for computer resources; i.e., equipment and computer programs in training simulators.

(10) Software Acquisition Engineering Guidebook

This effort is to develop an encyclopedia, organized by topics, of guidance on how to acquire software that is embedded in ground systems related to aeronautical weapon systems. The work includes both crew training simulators and automatic test equipment.

(11) Hybrid Computer Errors in Engineering Flight Simulation

This research will define the source of errors present in hybrid simulation and determine their impact on long duration simulations. This information will be used to design a simulation computation system that will minimize their errors and effect more realistic simulation to the pilots.

e. Instructional Features/Training Techniques

(1) Survey of Instructor/Operator Station (IOS) Hardware

This effort was to survey hardware which may be applicable to advanced instructor station designs. Results have been documented in a technical report for use by simulation engineers and system designers.

(2) Pilot Models for Performance Measurement

This effort is to survey pilot modeling methods to determine which might be useful as a basis for developing sensitive

performance measures for use in simulation research. Results are being documented in a technical report and have been used in designing a study effort to develop a control strategy model.

(3) Advanced Instructor/Operator Display Evaluation Techniques

This effort is to develop objective techniques for evaluating alternative IOS display configurations. Results will be applied to the development of display design guides for use in future IOS development efforts.

(4) Advanced IOS Control Methods

This effort is to identify new methods by which the instructor can exercise control of and provide inputs to the computer and cockpit in a flight simulator. The work will also include development of technology for objectively evaluating alternative control methods by assessing their probable impact on the instructor's ability to perform his job as it involves using advanced training features and retrieving various types of data as the mission progresses. Results will be used to specify new IOS control methods which are human engineered for the task of instructing and which optimize the instructors' ability to perform effectively.

(5) Tactical Performance Characterization

This effort is to develop advanced methods of characterizing tactical performance in a flight simulator for display at the instructor/operator station. Specifically, the work will include development of methods for computing the importance placed by the pilot on various short and long-term objectives and the acquisition of various vantage points in the maneuvering envelope. Results will be applied to the development of new tactical performance displays for IOS design.

(6) Multidimensional Displays

This effort is to develop advanced methods of displaying information to the instructor at a remote station which: (a) take advantage of man's ability to assimilate and use multidimensional information; and, (b) maximize the information content of a finite display area. The overall goal is to reduce the total display area that is required and reduce the workload imposed by the need to scan and integrate many sources of data to acquire a comprehensive picture of training or mission status. Results will be used in the design and procurement of future IOSs which are compatible with human capabilities and limitations and impose a minimum workload on the instructor.

(7) Aircrew Performance Measurement Development

The objective of this area of research is to provide sensitive, accurate, and reliable measurement of aircrew performance in ground-based and airborne devices. The primary emphasis is on development of real time automated measurement systems for assessing simulator performance. Measurement formats will be developed for representative task/skill areas, pilot experience levels, and aircraft types. The measurement systems are oriented toward criterion referenced indices of aircraft system states and pilot control inputs, but also include descriptive indices of pilot performance. Performance measurement systems will be developed for the tasks/skills required in the T-37, T-38, F-4, A-10, and C-5 aircraft systems. The results of these efforts can be used in the evaluation of the training effectiveness of training syllabi and devices.

(8) Pilot Performance Measurement System

The primary objective of Project 2359 is the development and demonstration of the utility of automated measurement systems for use in existing and near term Air Force flight training simulators. Automated objective simulator measurement systems will be designed and implemented for three aircraft simulators - the simulator for the T-38 (a training aircraft), the simulator for the C-5 (a transport aircraft), and the simulator for the F-16 (a fighter aircraft). Following installation in these simulators, the measurement systems will be evaluated for their utility in operational training. From Project 2359, requirements will be generated to provide automated measurement capability for future generation simulation devices. To accomplish these objectives, the following efforts are planned for each system:

(a) Definition of Measurement Requirements - This effort will identify a representative set of training tasks for each of the selected aircraft and specify appropriate measures necessary to assess skills required for the successful completion of training.

(b) Definition of Simulator Capabilities and Requirements - This effort will document the feasibility of implementing an automated objective measurement system using existing simulator hardware. Necessary hardware/software modifications and/or additions will be determined along with cost estimates for implementing such changes.

(c) Implementation of Simulator Measurement Systems - This effort will implement objective measurement systems for selected flight simulators. This will include hardware additions as well as software changes necessary to provide automated scoring. For each simulator, the end result will be one or more automated mission profiles which can be used to assess proficiency.

(d) Evaluation of Simulator Measurement System - This effort will evaluate the objective proficiency assessment systems within the context of the respective operational training programs.

From these evaluations, a set of requirements will be generated for implementing performance measurement in future simulator systems.

(9) Advanced Training Features Evaluation

The objective of these efforts is to evaluate the effectiveness and determine the optimum utilization of advanced training features. The major emphasis is to be placed on the demonstration and record/playback capabilities. Other efforts will address the use of student feedback and objective measurement as advanced training features.

(10) Instructor/Operator Display Design Guide

This effort is intended to apply methods of evaluating alternative instructor/operator station (IOS) display configuration to develop a design guide for use in future simulator development efforts. The evaluation methods are currently under development by Boeing Aircraft on an existing contract. The results of this effort will be utilized in the procurement phase for all future systems during the preparation of specifications and evaluation of proposals.

(11) Skills Maintenance and Reacquisition Training (SMART)

The objectives of Project SMART are:

(a) To develop reliable, valid, quantitative methods of measuring the critical, higher-order flying skills required of a combat-ready aircrew;

(b) To determine the impact of nonflying intervals on such skills;

(c) Obtain data necessary to optimize maintenance of critical skill proficiency given the projected energy shortfall of the 1980s; and

(d) To obtain data necessary to optimize future flying training programs for the reacquisition of critical skills.

This effort will focus on the missions of the Strategic Air Command and the Tactical Air Command and is divided into the following program elements:

(a) Program development and planning;

(b) Preliminary evaluation of SMART methodology;

(c) Identification and definition of critical flying skills;

(d) Development of critical skills measurement techniques;

(e) Measurement of skill retention as a function of nonflying intervals; and

(f) Development and evaluation of cost-effective means for maintaining/reacquiring necessary skill levels.

The expected benefits of this effort are:

(a) Recommendations for improved flying training;

(b) Analysis of training cost tradeoffs in maintaining flying skills;

(c) Test of alternative policies for management of the rated force;

(d) Determination of factors in pilot skill degradation;

(e) Operational definition of pilot mission readiness;

(f) Development and evaluation of innovative training methods; and

(g) Improved procedures for classifying pilots for flying assignments.

(12) Training Methods and Media for Flying Skills

The objective of this effort is to develop and evaluate training methods and media for application in simulator research. The driving consideration is that it is not only what you have, but how you use it that determines the training value. Emphasis is placed on defining optimal using strategies for integrating the various media used in flying programs. A comprehensive study of simulator training requirements and simulator training programs leads to the identification of existing or potential problem areas which can be researched. Emphasis is on exploration of methods for enhancing existing device capabilities and applications. Specific ongoing and soon to be initiated efforts include:

(a) Studies of media device selection in relation to and subtask alternatives for simulator training;

(b) Studies of the advanced training provisions of ASPT;

(c) Development and application of cognitive pre-training strategies as enhancements for simulator training;

(d) Development and application of flying skill taxonomies as analytical and design tools for simulator training programs;

(e) Investigation of the current status of the ISD process within flying training programs;

(f) Studies of the instructor pilot within the simulator training environment;

(g) Exploration of computer managed systems to integrate curricula, programs, methods, and media of UPT with simulator training requirements and programs;

(h) Development of training programs designed to instruct the simulator instructor in the optimal use of the device; and

(i) Evaluation of the task segmentation approach to simulator instruction of lengthy complex tasks.

Cost savings and training benefits will be derived through a variety of improved applications of training technology including: (1) methodologies for optimal media selection - utilization based upon specific task characteristics and least-cost training decisions, (2) empirically derived data to support procurement decisions, and (3) improved flying training programs through better utilization of simulator resources and technologies of training.

(13) Advanced Instructional Features

The flight simulator affords not only the opportunity for training tasks not trainable in the aircraft (e.g., emergency procedures and equipment malfunctions), but also the opportunity for overcoming certain spatial and temporal constraints encountered in conventional flying training. The manner in which these constraints are overcome is contained in large part in the application of the simulator's advanced instructional features. These features include preprogrammed demonstrations, performance replays, problem freeze, rapid reinitialization, automated performance measurement, in-cockpit and operator console graphic displays, malfunction insertion, automated Ground Controlled Approach instruction, variable turbulence and visibility settings, video inserters, and automated task sequencing. At present few if any guidelines exist for the systematic and timely use of these instructional features. Neither are there any accepted measures against which the effectiveness of such features can be evaluated.

This effort will first address the development and comparative evaluation of currently available features. In conjunction with the development of applications for the "standard" features, research will also address the simulator's capability for modifying the feedback characteristics of the tasks themselves (e.g., feedback delay) as well as the format, content, and scheduling of performance feedback presented to the student. Specific applications will be integrated into an A-10 air-to-surface weapons delivery training "package" and further studied for the purpose of developing candidate measures of instructional effectiveness/efficiency. The thrust of this portion of the research will shift from the student to the instructor/operator, and the manner in which effective strategies can be developed for managing the simulator's instructional resources.

Applications of this research effort will significantly improve the cost and training effectiveness of tactical air-to-surface weapons delivery training. Improved methods for utilizing flight simulators beyond the UPT training environment will result. This research will contribute to the development of general guidelines for the utilization of current and future simulator instructional features and will provide candidate measures of instructional effectiveness against which alternative instructional approaches can be evaluated.

(14) Workload and Pilot Cognitive Functions/Physiological Indices

The objective of this effort is to develop and apply physiological indices of attention and workload for use in the optimization of flying training. The first of these efforts follows earlier work which clearly established the presence of stress during Undergraduate Pilot Training in both aircraft and simulator among both student and instructor pilots. The biochemical measures of pilot workload will further describe the occurrence of stress effects and provide new insights into the relationships between the circumstances which accompany varying levels of pilot workload and the associated task performances which result. Understanding the relationships between simulator stress, aircraft stress, and pilot performance will enable training program designers to effectively design programs which minimize stress and its effects on performance. The second line of investigation also follows previous research which established the relationship between evoked cortical potentials and behavioral measures of information processing task load. This effort will focus on the relationship between task difficulty, pilot workload, and task performance. This investigation will help sharpen our understanding of the pilot's task performance strategies and point the way to the development of effective strategies. This work will be conducted principally through contract efforts which will be supplemented by in-house projects. Ultimately, the results of this effort will be integrated with the data on the behavioral indices effort.

(15) Workload and Pilot Cognitive Functions/Behavioral Indices

This effort will focus on the attentional demands of flight and the flight control strategies employed by pilots given various attentional demands. The effort combines in-house and contract work. The contract effort will be concerned primarily with pilot cross-checking strategies and information processing capabilities, and their interaction with pilot workload. In-house efforts will include: (1) an examination of workload during initial acquisition and subsequent reacquisition of flying skills, (2) an examination of the dual-task paradigm for assessing workload and attentional demands during flight, and (3) an investigation of the flexibility of pilot control strategies via a paper and pencil task currently in development.

Studies on crosschecking and information processing strategies are aimed at providing a data base for designing training programs which are effective in teaching students to make optimal use of the information in instrument displays. Workload studies are aimed at developing a sensitive measure of pilot proficiency. Such studies would be very useful in evaluating pilot proficiency during reacquisition of flying skills, when traditional performance measures are relatively insensitive.

(16) Tactical Desision Making

The objective of this effort is to evaluate existing methods TAC uses in tactics training and determine the requirements and methods for integrating specific training in congitive processes. Such training research will provide concepts to be applied in the SAAC and other devices used for air-to-air combat training.

(17) Effectiveness of ACM Training Programs

This effort will evaluate existing air combat maneuvering (ACM) training programs for training effectiveness. The thrust is to compare training accomplishments to performance on the ACM ranges.

(18) Validation of Candidate Performance Measurement Systems

This effort will demonstrate the usefulness of performance measurement systems (such as Good Stick Index) for use in simulators designed for air-to-air combat training.

(19) Maneuverable Airborne Target System

This effort will examine the training utility and performance measurement capability of a maneuverable airborne target when used in an air combat training role.

(20) Instructor/Operator System Development

The objective of this effort is to develop a generic instructor/operator station emphasizing flexibility in display software and hardware. The goal is to provide a capability with which to evaluate multiple hardware/software configurations, in a timely manner, to support engineering development of future instructor/operator systems.

f. Simulator Application and Evaluation

(1) Maintenance of Flying Skills

The objective of these efforts is the development and validation of an Air Force skills maintenance and reacquisition training program. The project will address: (1) training cost trade-offs in maintaining flying skills; (2) alternative policies for management of the rated force; (3) operational definition and objective measurement of individual and unit readiness; (4) improved procedures for classifying pilots for flying assignments; and (5) determination of factors in pilot skill degradation.

(2) KC-135 Visual System Evaluations

The objective of this effort was to evaluate the training effectiveness of three types of visual systems for students transitioning into the KC-135. The three included a TV camera model board system, a day/night color computer generated imagery system, and a night only point light source system. The evaluation was conducted in cooperation with ASD/SD24 and utilized commercial flight simulation facilities.

(3) ASPT Utilization

The ASPT supports AFHRL flying training simulation research by providing the state-of-the-art simulation hardware and software required to conduct critical configuration and training effectiveness simulation research. Research results will dramatically impact the configuration and utilization of multi-million dollar Air Force simulator acquisitions planned through 1985. ASPT research findings are made available to the user (i.e., Air Force MAJCOMs, ASD/SD24, AMRL, Navy, and Army) on a continual, as-completed basis. The ASPT is a unique research device and offers flying training research potential that is not duplicated within DoD, industry or academia. Other agencies possess research simulators which offer fractional capabilities relative to ASPT; e.g., Air Force MAJCOMs, NASA, Navy, Army, and industry. None are fully dedicated to flying training research.

The ASPT is presently used in two major areas: (1) actual A-10 student training in aircraft transition and bombing/

gunnery, and (2) general flying training research. The A-10 student training is providing significant research data as a fallout benefit. Present and planned research studies include Maverick Missile, textural cueing, night visual, A-10 operation station, determination of optimal A-10 simulator instructional design, motion and force cueing, aerial refueling, ASPT reliability and maintainability, aircraft carrier landings (cooperation with USN), expanded performance envelopes, and baseline F-16 studies.

(4) Effectiveness of Platform Motion

The objective of this effort has been to determine the incremental training effectiveness of platform motion. In-house efforts have focused on the use of the Advanced Simulator for Pilot Training and the Simulator for Air-to-Air Combat. Mission areas have included transition, aerobatics, air-to-surface weapons delivery and air combat maneuvering. The contract effort will focus on platform motion requirements for air combat training using a large amplitude motion system.

(5) ASPT Visual System Training Capabilities

This effort includes a series of investigations designed to further develop and evaluate the training capabilities of the ASPT computer-generated visual image display system (CGI). The flexibility of the ASPT CGI system has previously been demonstrated in its ability to support effective training, utilizing various visual models including conventional and tactical bomb delivery environments, simulated point-light source night scenes, as well as modeling a variety of runway environments, terrain features, and weather conditions. A joint project with the Navy will continue to explore the training implications of reducing a "flutter" phenomenon which appears under certain high frequency control inputs. Efforts will be continued in the area of investigating the optimal level of detail required to support various training tasks such as landing, aerial refueling, nap-of-the-earth navigation, aerobatics, air combat maneuvering, and formation flight. The training value of displaying bomb and missile impact points will be investigated. The inclusion of artificial training cues in initial stages of skill acquisition will also be investigated. Considerable effort will be devoted to continuing work in the area of enhancing texture cues. The lack of adequate texturing cues, particularly noticeable during low altitude maneuvers such as landing and nap-of-the-earth flight, has been a criticism of many simulator visual scenes especially those employing a CGI system. The initial emphasis is on determining adequate texture cues required in the touchdown zone and surrounding runway areas by systematically varying the density of cues. The results of these efforts should be to increase the training effectiveness of visual flight simulators and definition of any necessary software and/or hardware modifications required for further capability. Another effort will address the feasibility of improving the ASPT formation display by the addition of visual distance cues.

(6) Effective Simulator Utilization

This effort focuses on the application in an operational test environment of the methods found to be effective in research and development efforts. Development and evaluation of test instructional syllabi for a variety of flying programs and subsets of programs have been the mechanism for determining effective simulator use.

The syllabus development effort takes into account the proper use of the simulator for specific tasks at optimal points in the overall program. Issues of concern include the amount of simulator training required, the proper sequencing of simulator versus aircraft experience, the use of simulator features such as motion cueing, advanced instructional features, the length of simulator sorties, the optimal location of the instructor pilot, and the type of performance feedback required by the student and the instructor.

Another major area of emphasis is the identification of problems which will be encountered in the operational environment when syllabus changes are implemented. Such problems include regulating student flow, scheduling other activities around prerequisites, forecasting aircraft scheduling changes, maintaining student-instructor continuity, and providing alternatives in the event of simulator downtime. The development of a syllabus must take these factors into consideration as well as the training factors per se.

(7) Area of Interest Evaluation

The area of interest (AOI) concept in simulator visual systems provides a concentration of available edges in a computer-generated scene resulting in greater detail in the task relevant portion of the display. The AOI can be either head-slaved or target-slaved. This feature permits a less expensive visual system which maintains the required level of detail.

This effort is being conducted in the ASPT utilizing a helmet-mounted system which provides a head-slaved AOI. The objectives of the effort are:

(a) To determine the minimum acceptable area-of-interest dimensions used in simulator training of the conventional weapons delivery task;

(b) To determine the extent and affect of interaction between AOI size and scene detail level in conventional weapons delivery; and

(c) To determine the effect of adding permanent peripheral visual cues, external to the AOI, in performing various flight tasks in the ASPT.

This research is being conducted in support of the Simulator System Program Office's engineering Project 2360, Fighter/Attack Simulator Visual System (F/ASVS). In addition to providing information necessary for design and procurement decisions, this research should provide insight into the utilization of the AOI concept in a broad range of flight simulator training requirements.

(8) A-10 Transition Training

This effort is a program of research and development activities planned for the Advanced Simulator for Pilot Training (ASPT) in its A-10 configuration. Efforts are projected into the FY 82 time frame and include all aspects of A-10 simulator design and utilization.

Long-range goals, inputs from the Air Force using command (TAC), and other relevant research and development sources, determined the content of the planned program. The specific research to be accomplished is categorized under three major research fields. These major fields are: simulator configuration; training methodology; and operational effectiveness. The research thrust and studies within these three fields is as follows:

(a) Simulator Configuration. The configuration (i.e., major subsystem components) represents the heart of any simulator procurement. Thus, the question of concern becomes: given that we want to train or maintain proficiency for a given task or skill, what is the most cost-effective configuration which will adequately do the job? Research in this field will produce data that will have direct impact upon the definition of A-10 simulator requirements. There are five studies planned within this field: Force Cue Requirements for Air-to-Surface Weapons Delivery Simulation; Visual Cue Requirements for Air-to-Surface Weapons Delivery Simulation; Human Factors Evaluation of the A-10 Instructor/Operator Console; A-10 Low Altitude Textural Visual Cue Considerations; and Terrain Correlated Turbulence Modeling.

(b) Training Methodology. While research on configuration optimization impacts directly on the definition of simulator requirements, studies of training methods and techniques focus on how best to use simulation. Research in this field is directed toward the most efficient uses of simulation in the acquisition and retention of flying skills. The development of effective "training software" is the end product of this field of effort. Four studies are planned within this field: A Taxonomy of A-10 Flying Skills; Cognitive Pretraining in Air-to-Surface Weapons Delivery Tasks; Applications of ASPT Advanced Instructional Features; and Preliminary Application of Project SMART (Skills Maintenance and Reacquisition Training) Methodology to the A-10 Weapons System.

(c) Operational Effectiveness. This field is concerned with the implementation of flight training simulation technology

to an operational flying training program. The goal is to develop an optimal syllabus of simulator training and to specify the most efficient manner of integrating it within a training program. Studies in this field address a broad range of issues that impinge upon the overall effectiveness of ASPT in an operational setting. There are three studies proposed within this field: A-10 Aircrew Transition and Basic Surface Attack Training; Stress and Performance Measurement System for A-10 Training; and A-10 Emergency Procedures Training.

Although systematic investigation in each of these fields is planned, initial choices of studies will be made considering potential impact on near-term A-10 simulator procurements. Using such priorities in conjunction with cost-effectiveness (e.g., defining A-10 force cue configurations in terms of cost differences), it is believed that these studies will make highly significant contributions to the A-10 simulator training program.

(9) Aerial Refueling Simulation

The objective of the effort is to evaluate several visual scene parameters for the design of aerial refueling simulator visual displays. It is desired to increase the utility of the device by having a visual display which can also be used for training landing and take-off tasks. The visual parameters which have been specified include: (a) the field-of-view, (b) the placement of the visual display with respect to the pilot's viewing location, and (c) the level of detail of the computer-generated tanker aircraft and drogue boom models in the air refueling task. The capabilities of the ASPT permit adaptation of the existing visual display to model and present the experimental visual parameters to subject pilots. The evaluation of these parameters will be conducted by having representative expert pilots attempt the aerial refueling, landing, and take-off tasks in the ASPT under various display configurations. The evaluation will make use of both objective and subjective information collected during the performance of the tasks. This effort is being conducted in support of the Simulator System Program Office's requirements and will provide fundamental information to the Air Force regarding the visual parameter requirements of field-of-view, level of model detail, and display placement within the context of aerial refueling, landing, and take-off.

(10) ASPT Distributed Processor

The ASPT computation system is being updated with a distributed processor which utilizes three SEL 32 processors. Specifically, they will provide a functionally separate 30 H_Z aircraft simulation capability for both Cockpit A and Cockpit B with sufficient computer core and time to support motion, visual, g-seat, and performance measurement subsystems. Each simulation will be independently controllable and observable. A software concordance capability for documenting the resulting simulation software will be developed. Each

cockpit will be programmed to fly in separate mathematically modeled environments, allowing the simultaneous simulation of distinct aircraft and aircraft environments. Additionally, the general data input/output control will be moved from its current sequential processing mode to a parallel processing mode. The software development effort is proceeding in three primary areas:

(a) Aircraft Simulation Modules which include the aeronautical equation changes, de-indexing, platform motion and g-seat program modifications required for 30 H_Z operation and functional separation between cockpits;

(b) Software Handlers to support the input/output special purpose routines; and

(c) Software Structure and Executive Processors.

(11) Computer Image Generation (CIG) Overload Algorithm

An ASPT overload algorithm will be developed which will allow a nondistracting degradation of the visual scene when flying the ASPT simulator through a dense environment; i.e., reduce the detail in a systematic and nondistracting fashion in the special purpose computer. Moreover, overload conditions will be anticipated by monitoring key parameters so that the proper routine can be started in time to prevent overload.

(12) Computer Image Generation (CIG) Software Modularization

A refinement of the CIG software will be accomplished to: (a) execute more efficiently; (b) reduce software modification time; and (c) allow for a more efficient means of building software systems to fit the needs of particular projects or studies on the ASPT.

Currently, the on-line software is divided into two programs. Any modification of either program takes 30 minutes minimum. With this software modularization, a modification would take about 7 - 10 minutes. At present, the merging of special features designed for one project with special features designed for another project is very time consuming. Modularization of the software will greatly simplify this process.

(13) Advanced CIG Data Base Modeling Techniques

This technological update of the ASPT system will provide a more timely and efficient means of generating visual environmental data bases. This will be accomplished through computer assisted and automated data base generation in an off-line mode permitting training research to be conducted simultaneously. Therefore,

the valuable system time previously required for the development of data bases will be available for conducting training research.

(14) G-Seat Hardware and Software Optimization

The objective of this effort is to improve the performance and usefulness of the ASPT pneumatic g-seat. A bench test, including compressor, valves, and g-seat bellow with instrumentation, is used to investigate more effective hardware configurations, components, and adjustments. This includes the effect of hose diameters, needle valve settings, operating pressures, conoflow adjustments, booster valve uses, digital to analog/circuit modifications, and applications of feedback. The software optimization consists of: adding explanatory comments; reducing arrays; maximizing linear flow; eliminating unnecessary branching and constants; utilizing more effective and faster techniques; and reorganizing in a more logical fashion. This will result in a more usable, understandable, and efficient program with reduced execution time which will add to the improved response gained by hardware optimization. The results of this work will be useful and applicable to future and existing pneumatic g-seats. The improved performance and software will also make it possible to use ASPT to evaluate new g-cueing system designs and concepts such as was done for the Advanced Low-Cost G-Cueing System (ALCOGS) on ASPT's g-seat.

(15) Central versus Distributed Computers

A requirement has been identified to develop a set of criteria which relate to the advantages or disadvantages of central versus distributed computer configuration for real time flight simulators. ASPT is currently undergoing a major configuration update through the replacement of a single SEL 86 computer with three SEL 32/55s. The functions performed by each of these systems is essentially the same; i.e., flight simulation for two T-37 cockpits with six degree-of-motion platforms and pneumatic g-seats. This system's change provides the opportunity to do an in-depth comparative analysis of central versus distributed computer systems and provides actual data on advantages of one system versus the other. The areas to be examined include CPU utilization, core requirements, software efficiency, system flexibility, cost, and ability to perform required task. This data would be valuable in the design or evaluation of future flight simulator computer systems.

(16) Advanced Development of Instructor Operator Displays for Air-to-Ground Weapon Deliveries

Currently, the AFHRL/FT Advanced Simulator for Pilot Training (ASPT) provides alphanumeric and graphic CRT displays for evaluating strafe and bomb deliveries on a conventional weapons range and for bomb deliveries on tactical targets. Highly successful preliminary results of the ASPT A-10 transition training/air-to-

surface research program have shown that each of the first six ASPT trained novice pilots (direct from UPT) qualified the first time on the range and two of them out-performed their IPs. A requirement has been identified to further develop the displays to provide more information along with new scoring systems for strafe and rocket deliveries. This development will include new scoring programs and new and expanded displays developed from present ASPT systems.

(17) Automatic Adaptive Training Development

At present, the Flying Training Division's Advanced Simulator for Pilot Training (ASPT) has a performance measurement system for many tasks in pilot training. Also, the ASPT preprogramming system has been used to control sequencing on some part task missions. Additional development of the automated system will include setting difficulty levels, automated sequence control, and performance measurement. After completion of the system development, a study will be conducted to validate the ASPT automatic adaptive training system using various basic and advanced flight maneuvers utilizing naive subjects.

(18) ASPT Air-to-Air Combat Simulation

The ASPT will be expanded to include a capability for air-to-air combat. This will significantly expand the ASPT's research potential. Other system refinements will be accomplished as part of this engineering modification, and will include additional moving models, cannon and rocket fire, weapons scoring, and the simulation of sun-glint and glare.

(19) Determination of Visual Data Base Standards

The objective of this work is to determine a standard for visual data bases using ASPT so that visual environments may be readily adapted to existing and future CIG visual simulation systems. Requirements for many behavioral research studies necessitate the generation of an environmental data base for ASPT which has previously been developed for another DoD simulation facility, but cannot be utilized on the ASPT system due to the incompatibility of the structure and format.

(20) Realism Requirements for Flying Training Simulators

The objective of this effort is to systematically outline the aspects of flight simulators whose training value can be substantially enhanced by increased "real world" properties. Past efforts in this area have concentrated on the effectiveness of synergistic six-degrees-of-freedom platform motion on skill acquisition, field-of-view visual display requirements, and visual display system characteristics. Ongoing and planned efforts include evaluating the training value of:

(a) G-seat and g-suit cueing systems;

(b) Collimated versus noncollimated visual displays;

(c) Color versus black-and-white visual displays;

(d) Terrain correlated turbulence for low-altitude flight; and

(e) Visual display system depth cue requirements.

Training value is determined jointly by performance in the simulator, transfer of skills to the aircraft, and pilot opinion. The results of these studies contribute to the information necessary to formulate cost-effective procurement decisions.

(21) R&D Applications Support

Efforts will be continued to utilize the Simulator for Air-to-Air Combat (SAAC) in training research. Exisitng research capabilities and new innovations will be used to further the knowledge about training in the air-to-air arena. As the requirement for F-4 ACES II training diminishes, the SAAC can be used in a multitude of research configurations to answer future questions about air-to-air training problems.

(22) F-106 Radar/IR PTT Evaluation

The F-106 trainer was developed by AFHRL for ADCOM, using behavioral task data to define training device requirements. The training effectiveness evaluation will determine the validity of this technique.

(23) Strategic Avionics Crew Station Design

The Strategic Avionics Crew Station Design Evaluation Facility (SACDEF) consists of modified and instrumented AN/ALQ-T4 and AN/APQ-T10 training simulators. Proposed offensive and defensive system hardware are incorporated into the crew station and a representative sample of combat ready crews execute a SIOP-like mission sortie. Assessments are made of crew station layout, controls/display design, and operator workload. Potential training problems and training device requirements identification are natural by-products of the SACDEF study efforts. This is a continuing program which is intended to enhance knowledge and understanding of crew station design for current and future bomber weapon systems.

(24) Air Force/Navy Flight Landing Study

The objective of this research is to investigate the potential for wide angle visual systems for carrier landings. Specified fixed fields-of-view will be implemented on the ASPT to evaluate:

(a) A wide field-of-view approach to a carrier landing;

(b) A narrow field-of-view, straight in approach to a carrier; and

(c) A narrow field-of-view circling approach with artificial cues.

A carrier will be implemented into the ASPT data base and performance measurements developed to be determined specifications part task trainer designs.

(25) Visual Parameter Monitor

The Visual Parameter Monitor (VPM) feature of the ASPT provides a tool for both trainer researcher and engineer to investigate computer image generation (CIG) system hardware and hardware limiting parameters. The VPM can be applied in several CIG functional areas. Applications include an ability to conduct environmental data base statistical analyses, experimental configuration definition, maintenance trouble-shooting, real time performance monitoring and more accurate specification of future CIG system requirements. Interaction with the CIG parameter processing is via a continuous display on a high-speed, interactive CRT display terminal. Under keyboard control the operator has the option of selecting specific parameters or standard formats of preselected parameters for display.

(26) SAAC Utilization

The SAAC operation and maintenance contract is funded by AFLC to provide daily operation of the system in support of training and training research. The USAF Tactical Fighter Weapons Center processes weekly groups of pilots through Air Combat Engagement Simulators (ACES II), and HRL's Tactical Research Branch (FTO) performs research in support of TAC's requirements. The ISD teams at Luke AFB work hand-in-glove with FTO to provide instructors and pilots for use in research efforts.

(27) Simulator Task Analysis Validation Using SAAC

This effort will focus on developing a procedure for validating task analysis of training events programmed for training in simulators. The SAAC will be used as the validation device.

g. Simulation Requirements Validation and Specifications

(1) Simulator Development Activities

Effort involves conducting a variety of activities on a timely basis to provide improved information for management and

technical decisions relating to simulator development. Activities will include system trade-off analyses, development of acquisition, management, test and evaluation strategies, and mission support activities.

(2) Training Device Design Guide

This effort is a direct outgrowth and expanded application of the methodology used in the Functional Integrated Systems Trainer, F-106 MA-1 Radar/IR Trainer, and the Aerial Gunnery Part Task Trainer development programs. A guide was compiled for operational personnel responsible for collecting and applying behavioral data and training requirements to simulator requirements, and for engineering personnel responsible for converting training requirement data into simulator specifications. The primary program objective is to apply, evaluate, and modify this guide.

(3) Simulator Training Requirements Effectiveness Study (STRES)

The objective of this effort is the systematic gathering of information which has a bearing upon the cost and effectiveness of important characteristics of flight simulators. Such information shall be used to assist in determining the nature of the simulation required to meet each specific behavioral requirement for training, indicating the most effective techniques for using aircrew training devices, and specifying maximally effective instructional features of such devices. This information also will indicate critical gaps in the available technology. Plans will be developed for filling these gaps.

The information will be obtained in many ways, including literature reviews, field interviews and systematic analysis. The study will be actively guided by a multidisciplinary, multicommand management team which includes representatives of Hq USAF and the Army and Navy, as well as, all commands. The information which is obtained through this contracted effort will be finalized in a subsequent effort by the management team.

The products of this program will be of direct and immediate use to ASD/SD24. The products will be used in at least three basic ways. First, they will be used in deciding the precise characteristics of aircraft flight simulators to meet specific training requirements. Second, they will be used in evaluating ROCs for aircrew training systems and in guiding using commands in the preparation and revision of such requirements. Finally, the products of this program will be used in determining which other 6.4 programs on aircrew training devices are of highest urgency.

The products of this program will have two related uses. One is to specify the best ways to use simulators to capitalize on their strength and counteract their limitations. Another will be to estimate the life cycle costs of aircrew trainers. Sufficient information should be produced to achieve the desired trade-off between training effectiveness and life cycle costs.

(4) Prime Specification Development

The object of this task is to develop a prime specification and supporting rationale handbook for training simulators. The prime specification will be used as a guide for preparing specific system Part I Specifications. The supporting handbook will contain the detailed rationale for the prime specification and will be formatted to be easily adaptable to change.

h. Simulator Testing/Acceptance Techniques

(1) Simulator Operational Test and Evaluations

The general objective of this area is to provide methods and procedures for the operational test and evaluation of newly acquired aircrew simulators. The simulator systems on which OT&E support is being provided include:

(a) AWACS - E-3A. The AWACS E-3A test and evaluation deals with two distinct simulators: the Mission Simulator for C^3 functions, and the Flight Simulator for the pilot, copilot, and flight engineer stations. The specific research areas will include:

- Skill acquisition and proficiency maintenance in flying tasks;
- Skill acquisition and maintenance in C^3 tasks;
- Team training and measurement of crew coordination; and
- Transfer of training of the air refueling task.

(b) B-52/KC-135 WST. The B-52/KC-135 Weapons Systems Trainer program will involve a "fly-off" test of two prototype units. Research will address studies of skill acquisition and proficiency maintenance of all crew members of each system.

(c) B-52 Part Task Trainer. Research will be conducted to determine the pilot transfer of training from the Receiver Aerial Refueling Part Task Trainer to the B-52 aircraft.

(d) FB-111A Visual Simulator. The objective of this effort is to estimate and quantify the relative improvement in the initial acquisition training (CCTS) and proficiency maintenance training capabilities of the FB-111A simulator resulting from the addition of the multichannel computer image generation visual display. The resulting information will be used in the determination and refinement of an operational CCT Syllabus and in the formation of a proficiency maintenance syllabus designed to maximize the training effectiveness of the modified flight simulator.

(e) A-10. This effort will use the ASPT to determine optimal syllabus requirements, the configuration of the Instructor Operator Station, a performance measurement system, motion cueing requirements, and visual cueing design configurations.

(f) C-130. This effort is a dual evaluation of an Instrument Flight Trainer and a full field-of-view visual system for the simulator.

(g) F-16. This effort will evaluate an Instrument Flight simulator.

(h) C-5A. This effort will evaluate a cockpit procedures trainer.

(i) F-5E. Evaluation of an instrument flight simulator.

(2) Flight Test Data Correlation

The objective of this effort is to establish a feedback channel from flight test activities to anable data to be obtained from flight to correlate with simulation models to be updated for future use and a greater correlation of simulation program results with flight test activities.

(3) Dynanic Fidelity Testing

This effort will result in a rational, scientifically founded, integrated generic test/evaluation specification applicable to the flying qualities and performance of non-VTOL, non-rotary-wing aircraft powered by gas turbine propulsion units. The specification will be designed for computerization to provide for ease of reference, manipulation, and the production of consistent generic test and evaluation specifications for particular simulators on demand. This master specification is not intended for promulgation as a MIL Spec, but rather is intended to provide a scientific basis for objective testing and evaluation which will also dovetail with other work in the simulator community on perceptual fidelity criteria.

The work will be conducted under contract, with in-house support devoted to evaluation and coordination with simulator test/evaluation activities of ASD, AFWAL, AFTEC, AFFTC, and Hq AFSC. The proposed schedule calls for contract work to begin on 1 April 1978 and be concluded on 1 November 1979. Proposed funding calls for $40,000 in FY 78/3.

(4) Simulator Instrumentation System Development

The objective of this task is to develop a portable instrumentation system and appropriate aircraft instrumentation techniques with which to gather and comparatively analyze simulator and aircraft handling characteristics data. The simulator instrumentation system will be capable of recording and analyzing cue time histories in response to control inputs. Aircraft instrumentation techniques will be refined to acquire flight test data meeting the requirements of simulation system testing.

(5) Operational Test and Evaluation (OT&E) Handbook

A contract effort will be undertaken to develop a handbook containing detailed methodology for the evaluation of the training effectiveness of aircrew training simulators. This effort will address aircrew simulator training capability and transfer, media utilization, human engineering, device reliability and maintainability, operability and life cycle costs. The resulting handbook will contain detailed test procedures and supporting statistical and cost estimation techniques for the test, analysis and evaluation of simulator training effectiveness. This effort will encompass the following tasks:

(a) Definition of measures and techniques for evaluation of various aspects of simulator training effectiveness;

(b) Development of instruments and protocols to investigate the impact of attitudes upon simulator training effectiveness;

(c) Determination of simulator training capabilities;

(d) Definition of relationships of simulator reliability/availability to training program effectiveness;

(e) Application of costs/benefits models to determine economic impact; and

(f) Determination of resources required for tests and evaluation.

The handbook will be used by test and evaluation specialists and the Air Force flight training community to provide critical effectiveness information to training program managers and Air Force system procurement decision makers.

4. Major Command Support

The objective of major command support is to utilize existing knowledge and to apply research methodology to real-world flying training problems. In order to accomplish this objective, three principle activities must be performed:

- Develop basic methods, instruments, and techniques;
- Conduct specialized, applied studies; and
- Provide consultation and technological resources.

The primary customers are the MAJCOMs, AFTEC, and various Air Force procurement agencies. The end products of these activities, such as improving evaluation techniques and optimizing the design and utilization of training devices, impacts Air Force training operations. Examples of research being conducted in direct support of the MAJCOMs and other related Air Force agencies include:

- Operational test and evaluation of the following aircrew simulators: AWACS-3-EA, FB-111A, C-5A, C-141A, C-130, F-5E, F-15, F-16, A-10, KC-135, and the B-52;
- A-10 transition training;
- Area of interest evaluation;
- Aerial refuleing simulation;
- Aircrew performance measurement for the C-5A; and
- Desired Operational Capabilities (DOC) of specialized air-to-ground and air-to-air lead-in training.

Figure III-4 shows AFHRL's planned support for MAJCOM operational test and evaluation programs through 1984.

OT&E EFFORT	AGENCY SUPPORTED	FISCAL YEARS						
		FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84
B-52/KC-135 WST	ASD	X	X	X	X	X	X	X
B-52 REF PTT	ASD/SAC	X	X	X				
KC-135 BUPTT	ASD/SAC	X	X					
F-111B VIS	SAC	X	X					
C-5A CPT	ASD		X					
C-130 CPT	ASD	X	X	X				
C-130 VIS	ASD	X	X	X				
F-15 OT&E	TAC	X	X					
F-5E IFS	AFTEC	X	X					
A-10 OFT	AFTEC	X						
F-16 IFS	TAC	X	X	X				
AWACS - E-3A	TAC	X	X					
PROJ 2360	ASD	X	X					

FIGURE III-4. AFHRL Support of Operational Test and Evaluation Programs

IV. ACQUISITION AND TECHNOLOGY PROGRAM INTEGRATION

A. INTRODUCTION

One of the most significant planning uncertainties associated with satisfying user requirements for aircrew training devices (ATDs) is the availability of training technology. A prime concern among decision makers is the almost conspicuous absence of published material which explicitly depicts the integration of simulator technology with simulator acquisition programs. In this regard, this section attempts to put into prospective the interrelationships and interdependencies among technology programs and indicate their contribution and application to ATD acquisitions. It must be recognized that this approach is far from being a "road map" because of "catch-up" technology programs and the tremendous surge in simulator acquisition activities in recent years.

The complicated fiscal structure of the technology program plan is the result of many factors, but mostly the results of a prior lack of priority to develop and fund a coherent program of research and development within the classic laboratory (AFHRL) funding structure. The danger in the complex structure is one of maintaining technological coherence within a noncoherent fiscal structure. Efforts to assure adequate funding in each of the program elements must succeed in order for the technology program to succeed. Management attention will be required to impact the fiscal structure to assure a continuity of funds. An initial attempt by management to come to grips with this problem has been the Hq AFSC Simulator Advisory Board's prioritization of approved AFHRL projects. Additional visibility of interactions between technology and acquisition programs can be obtained in subsequent paragraphs and figures.

B. ACQUISITION AND TECHNOLOGY OBSERVATIONS

1. Acquisition

Recent flight simulator programs; namely, the F-15 and F-16, have highlighted the difficulty in acquiring aircrew training devices concurrently with first operational aircraft.[1] If early transition training is predicated upon the availability of full mission simulators, there is the likelihood of costly delays and/or last minute "work-arounds" caused by late simulator delivery or by extensive modifications required to assure its adequate performance.

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[1] TIG Brief 2, 1977, "Optimizing the Use of Simulators and Trainer Aircraft - AFISC, p. 21.

Specifically, simulator development lags that of the aircraft due to the need to identify and duplicate the aircraft's demonstrated performance characteristics. These problems can be minimized by integrating devices and trainer aircraft.

Aircraft production should be planned so a majority of early deliveries are trainer (two seat) aircraft. This should not significantly impact program costs, inasmuch as the same total numbers of training and mission aircraft are procured. It will enable early training to be accomplished without forcing simulator development to conform to an unrealistic schedule. Other benefits from this approach are:

- Allows simulator technology base development in areas crucial to satisfying user requirements. These developments can then become a part of the original simulator specification, thus precluding costly modifications/retrofits.

- Faster buildup of instructor pilot experience.

- Reduced requirements for chase aircraft during initial checkouts of students, with resultant fuel savings and increased scheduling flexibility.

- Closer supervision of students with safer initial checkouts. Then, as the simulator becomes available, it can pick up its part of the overall training load.

Management in AFSC and the using commands should realize that both of these resources must be phased to achieve the most effective initial aircrew training possible. An integrated full mission simulator/trainer aircraft program must be planned early - prior to contract definition. A coordinated simulator and training aircraft program can reduce total program risks while enhancing the initial operating capability.

2. Technology

Much has been written up to this point regarding the importance of technology and the criticality of simulator technology in satisfying user training requirements. As defined herein, "Technology is the combination of science, engineering, skills and background applied to the conception, design, manufacture and support of equipment." It is therefore perishable and it dissipates rapidly with time as the concept becomes broadly known and understood. Hence, we should view technology not as a product, but knowledge - and that once understood, then a value can be placed on this knowledge.

In keeping with the concept of minimizing future "catch-up" technology programs and to provide a means for establishing a coherent fiscal structure for R&D, it is necessary to understand how a technology

advantage is gained and protected. Revolutionary gains in technology are related primarily to the synergistic combining of elemental technologies via systems design and is not inherently time dependent. It is need oriented. A technology advantage is maintained most effectively by active, continuous replenishment of existing 'old' technology through research and development. It is not protected by attempting to preserve existing - and therefore obsolescing - technical capabilities.

The remainder of this section will deal primarily with the interrelationships and interdependencies of technologies and the application of these technologies to simulator acquisition programs. These technologies, although appearing very broad, are highly focused. Basic research is conducted to obtain knowledge - but, by definition, there is no end product. Applied research is a little tighter, but still hazy. Advanced development tightens the knowledge element even more but still not at a specific end product.

When the range of effort gets into what is known as engineering development, such things as design development, prototype, schedules, etc., begin to surface. Only in production is technology applied to produce a specific product.

This evolution of definition should be considered by those responsible for structuring the Air Force's technology programs and associated fiscal structure to ensure that technology advances are attained and maintained to meet near-term and future simulation requirements.

C. SCHEDULES

This section summarizes planned acquisition and technology program schedules. Because of the changing priorities dictated by day-to-day system acquisition activities, the schedules and quantities of aircrew training devices require constant review by program managers to ensure minimum impact on user requirements. Acquisition priorities are normally predicated on funding constraints and in rare instances by funding relief, but seldom on technology availability.

Limited resources available to the Laboratory responsible for simulation technology development has resulted in (1) the technology developments falling far behind the technology requirements for simulator acquisition programs, (2) the conduct of exploratory and advanced development on hardware development programs, and (3) the conduct of advanced development efforts by other organizations with available resources.

Because of the past funding situation most of the exploratory and advanced development programs described in Section III are relatively new starts. Those that are continuing efforts were funded by Laboratory Directors, funding or advanced development funding released near the end of FY 75. Since the advanced and exploratory development efforts are

lagging far behind, many catch-up efforts require initial funding levels greater than those required for a continuing program that has kept pace with the technology needs. Also, the milestone dates for the described programs are based on the available funding and not technology need dates for the acquisition programs. Because of the lower than required funding levels it is not possible to start some development programs, and others are artificially stretched to match the approved funding.

The traditional funding situation for development programs has placed the Air Force in the position of procuring weapon systems and simulators concurrently while simultaneously pursuing simulation technology to support training systems requirements. Subsequent schedules will reflect key technology areas that have minimum impact on ongoing and near-term acquisition programs.

The Air Force is taking positive action to minimize this trend in the future through careful review, assessment, and prioritization of technology programs, and by determining their application to near and long-term acquisition programs. It will then be encumbered upon all echelons of the Air Force to clearly and concisely justify those key technology programs to the Secretary of Defense and to the Congress.

1. Acquisition

Figures IV-1 through IV-4 presents acquisition programs that are categorized as directed, awaiting direction, proposed, and potential, respectively. For the purpose of this document, these categorizations are defined as follows:

a. Directed - Acquisition programs have been directed by Hq USAF. They are either on contract or are in the normal procurement cycle (RFP preparation through source selection).

b. Awaiting Direction - Formal GOR evaluation has been completed and Hq USAF is reviewing prior to validating the requirements and directing initiation of the program.

c. Proposed - Program is still in planning phase. Draft GOR has been submitted or Simulator SPO is working with the new weapon system SPO. However, formal GOR evaluation has not been completed and forwarded to Hq AFSC and Hq USAF.

d. Potential/Conceptual - Using command is preparing or plans to prepare a draft GOR for operational weapon system. Or, new weapon system program is in the conceptual planning phase (program schedule is premature).

In the latter three categories the majority of the schedules are tentative and are based on an estimated date of direction and a normal procurement and development cycle. Following each figure are notes which amplify the status of each program listed. These notes are keyed to the superscript following each listed program in the figures. In addition, the source of the requirement is indicated parenthetically for the majority of programs in categories a and b.

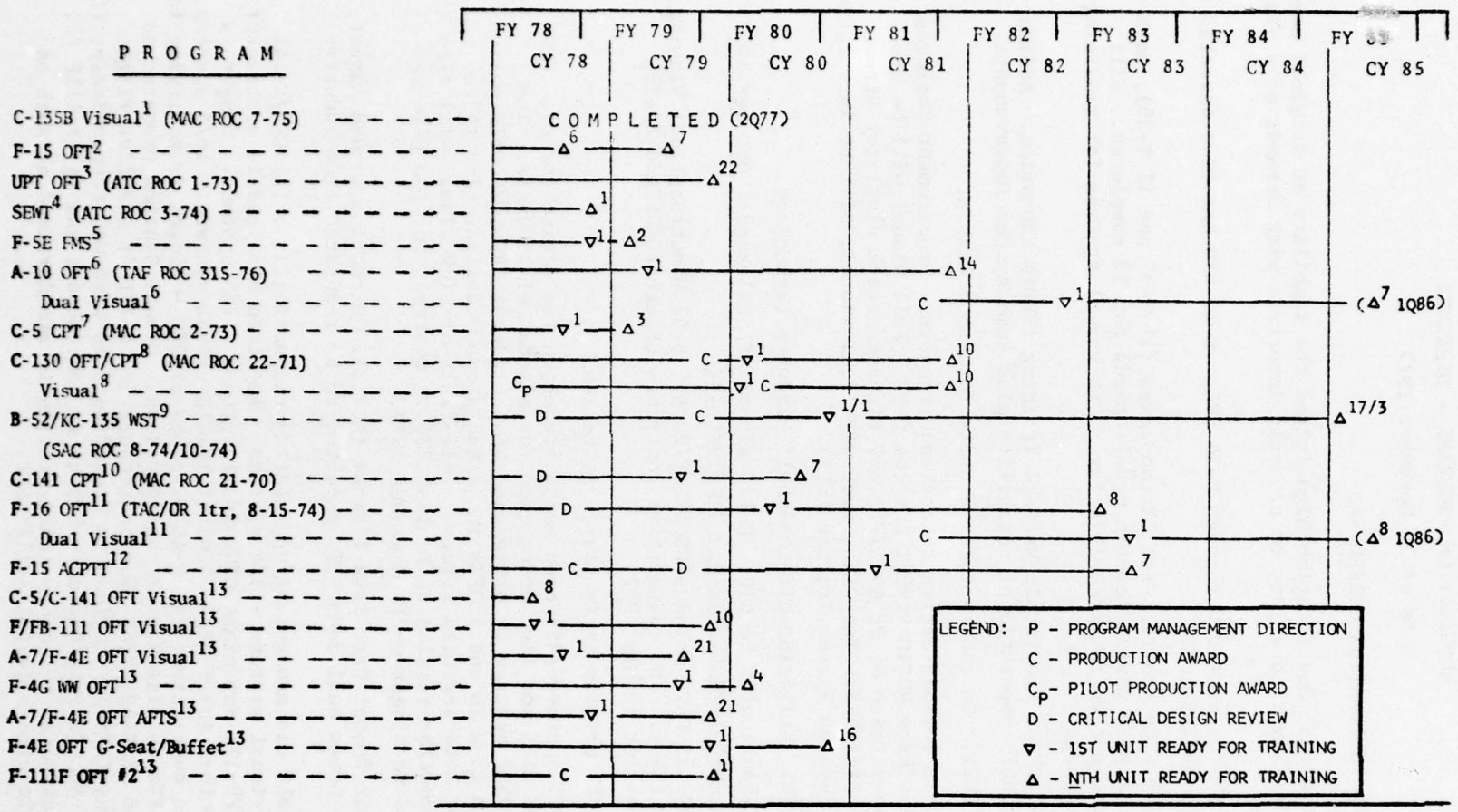


Figure IV-1. Acquisition Programs - Directed

ACQUISITION PROGRAMS - DIRECTED

As of 30 November 1977

NOTES: NEW INFORMATION UNDERLINED

1. C-135B Visual Modification highlighted the inability of original aerodynamic flight equations to properly interface with demands of a visual system.

2. F-15 OFTs on contract through F-15 SPO. F-15 SPO has been directed to buy the seventh OFT.

3. UPT-OFTs. On contract for 22 complexes (11 T-37 and 11 T-38), each 4 cockpits plus camera/terrain model boards for 12 complexes. Will exercise option in March 1978 for NOCIG visual systems for remaining 10 complexes.

4. Simulator for Electronic Warfare Training (SEWT) Expansion. Adding assitional computational capability plus some system improvements.

5. F-5E (FMS). On contract for 2 units for Saudi Arabia.

6. A-10 OFTs include active forces requirements. Procurement includes single window NOCIG visual for two OFTs. Full visual will be production version of PE 64227F/P2360 Fighter/Attack Simulator Visual System (F/ASVS). Two OFTs, each with full visual, will be integrated into a Weapon System Trainer (WST).

7. C-5 CPTs. Utilizing off-the-shelf hardware technology.

8. C-130 Visual will be CIG. C-130 visual RFP released 7 October 1977. Source Selection to begin 5 December 1977.

9. B-52/KC-135 WST includes PE64227F/P2269, B-52 Electrooptical Viewing System (EVS). Two competitive contracts (Singer/LINK and Boeing Wichita) let in May 1977.

10. C-141 CPT program is in source selection.

11. F-16 OFT approved/directed units are shown for active forces. EPG and FMS will add five units each for a total of 26 units. The total USAF program is envisioned to include 31 OFTs, 26 OFTs paired to form 13 WSTs and 5 OFTs in "stand alone" configuration to be used by Reserve/Guard forces. Full-field-of-view visual will also be production version of Project 2360. Contract for the OFTs was awarded to Singer on 11 November 1977.

12. F-15 Air Combat Part Task Trainer (ACPTT). Direction issued August 1977. Seven dual dome PTTs expected to be requested from Industry.

13. Ogden ALC has management/engineering responsibility: (a) C-5/C-141 NOCIG visual systems - 3/5 systems. American Airlines is contractor; (b) F/FB-111 day/night CIG visual systems - 7/3 systems. Singer is contractor; (c) F-4E/A-7D vital IV CIG visual systems - 16/5 systems. MDEC is contractor; (d) F-4G Wild Weasel OFT - Singer is modifying four F-4E OFTs to Wide Weasel configuration. Visual Systems procured as part of 16 F-4E VITAL IV procurement; (e) A-7/F-4E Adaptive Flight Training (AFTS) - Logicon is providing 5/16 systems, respectively; (f) F-4E G-Seat/G-Suit/Buffet - Singer is contractor; and (g) F-111F #2. Ogden directed to ensure configuration is standardized as much as possible with original F-111F OFT.

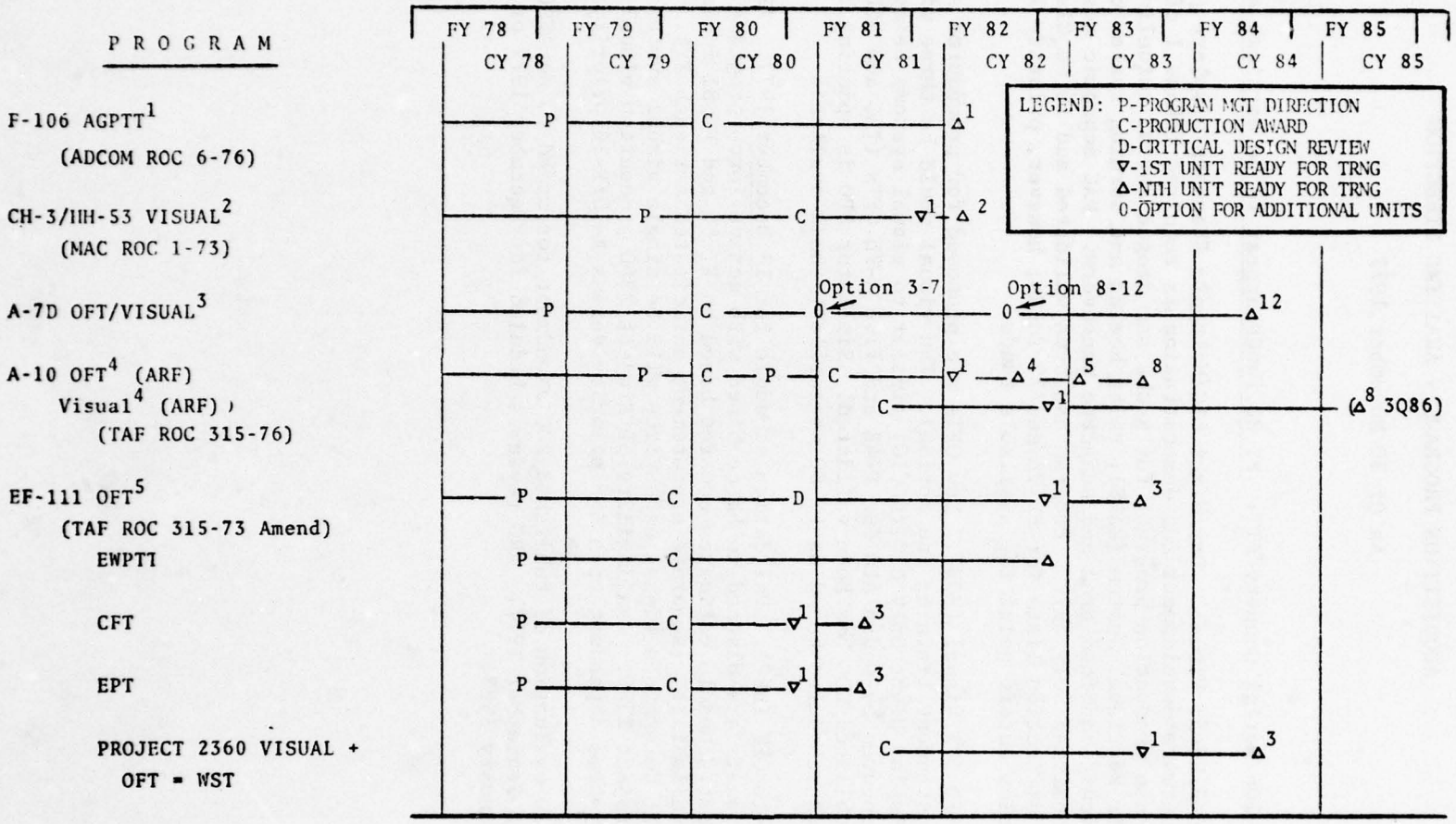


Figure IV-2. Acquisition Programs - Awaiting Direction

ACQUISITION PROGRAMS - AWAITING DIRECTION

As Of 30 November 1977

NOTE:

1. F-106 Aerial Gunnery PTT. FY 80 funds appear to be earliest available.

2. CH-3/HH-53 Visual. Day/Night CIG/Multiple Channels/Displays proposed. Software development and demonstration is required (Phase I of two-phase production program) for probe and drogue aerial refueling, Mid-Air Retrieval System (MARS), radar homing and warning system operations, confined area and seascape maneuvers. MAC economic analysis submitted July 1977. Program has been validated and is on Class V Modification lists for FY 78 and 79 funds; however, priority is well below cutoff point for available funds.

3. A-7D OFT/Visual (NGB). New OFTs are proposed for procedures and instrument training (no motion). The visual would be three window display Night Only CIG (NOCIG) similar to visual systems being procured by Ogden ALC for F-4E and five A-7D OFTs (TAC and NGB). Published ROC has been validated. Simulator SPO is updating costs and schedules based on FY 80 as earliest funds available.

4. A-10 OFT (ARF). Validation schedule for 13 December 1977. ARF OFT/Visuals are planned to be combined with active force programs. OFT cost/schedule estimates updated based on FY 80 and FY 81 funds availability (separate procurement anticipated for each FY). TAF/ARF determined visual capability will be single visual system from Project 2360. Availability of Project 2360 production visual systems dependent upon ARF priority versus A-10/F-16 priority.

5. ASD evaluation of Published ROC amendment forwarded to Hq AFSC on 28 September 1977. RRG review scheduled for December 1977 or January 1978.

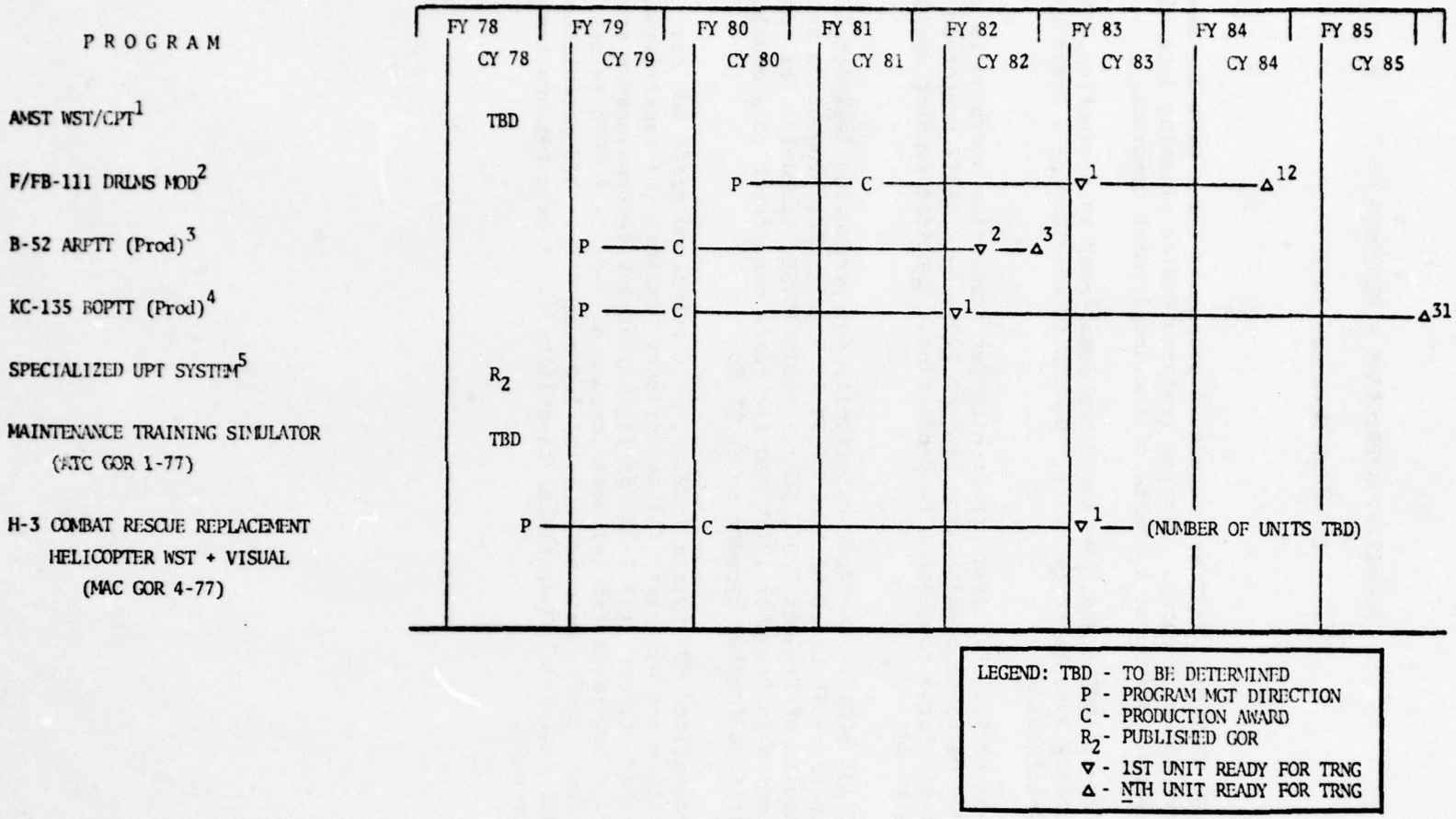


Figure IV-3. Acquisition Programs - Proposed

ACQUISITION PROGRAMS - PROPOSED

As of 30 November 1977

NOTES:

1. AMST WST/CPT. AMST has requested proposals for a Mini-Engineering Development Program. Aircrew training device planning data will be defined subsequent to award of the development contract.

2. F/FB-111 DRLMS Mod. No Air Force commitment to production. Earliest funding appears to be FY 81. Hq SAC is considering a Draft ROC for FB-111 DRLMS.

3. B-52 ARPTT. Earliest opportunity for production decision is January 1979 based on results from Project 2201, B-52 ARPTT prototype IOT&E. No Air Force commitment to production. Earliest funding appears to be FY 80.

4. KC-135 BOPTT. Earliest opportunity for production decision is January 1979 based on lack of FY 79 funding for production and results of Project 2201, KC-135 BOPTT IOT&E, scheduled for completion in December 1978. No Air Force commitment to production. Earliest funding appears to be FY 80.

5. Specialized UPT System (SUPTS). ATC submitted draft ROC for replacement aircraft: (a) new primary trainer; (b) tanker/transport/bomber trainer, (c) T-38 for fighter/attack/reconnaissance trainer. Draft ROC requests: (a) modification of T-37/T-38 OFTs to new trainer configurations, and (b) low cost CPTs. ATC established 1986 as Initial Operational Capability (IOC) date for new trainer aircraft.

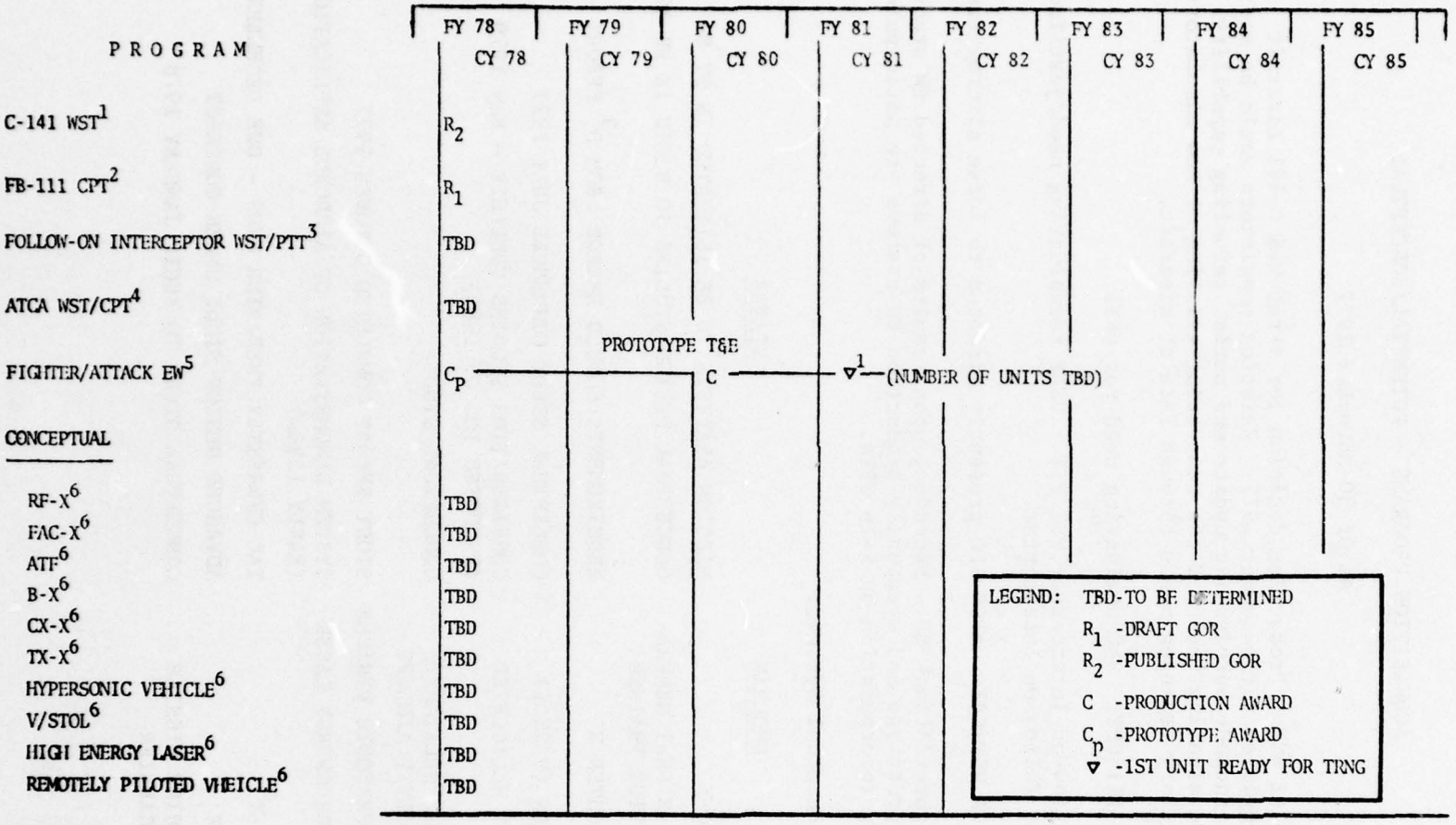


Figure IV-4. Acquisition Programs - Potential/Conceptual

ACQUISITION PROGRAMS - POTENTIAL/CONCEPTUAL

As Of 30 November 1977

1. C-141 WST. Production decision for stretched C-141 aircraft scheduled for December 1977. Existing simulators would be modified to include aerodynamic update and aerial refueling capability. MAC reevaluating the need for renovating existing or new simulators to satisfy training needs through life of aircraft.

2. FB-111 CPT. SAC evaluating need for CPT.

3. Follow-on Interceptor WST/PTT. USAF reevaluating need/justification for Follow-On Interceptor.

4. ATCA WST/CPT. ATCS SPO presently directed to lease aircrew training.

5. Fighter/Attack EW. Dependent upon results of directed EW study, a prototype and eventually production EW systems are anticipated for incorporation on F-16 OFTs.

6. Conceptual Systems:

PROGRAM	STATUS
FAC-X	MISSION ANALYSIS TO BE INITIATED IN FY 80
TX-X NEXT GENERATION TRAINER	CONCEPTUAL DESIGN STUDIES TO BEGIN IN FY 80
FIGHTER X	REQUIREMENTS SHOULD EMERGE FROM S^3 EFFORT - FY 82
C-LX (V/STOL)	CONCEPTUAL STUDY COMMENCED JULY 1977
H-X HELICOPTER	CONFIGURATION STUDIES COMPLETE - May 1979 (PROPOSED IOC OF 1985)
C-XX MILITARY/ CIVIL AIRLIFT	CONCEPTUAL STUDY
HYPERSONIC VEHICLE	STUDY EFFORT COMPLETED OCTOBER 1977
HIGH ENERGY LASER	SYSTEM DEMONSTRATION OF AIRBORNE APPLICATION (EARLY 1980s)
RF-X	TAC CURRENTLY PREPARING MENS - DUE DECEMBER 1977
B-X	ADVANCED DESIGN STUDY UNDER CONTRACT
CRUISE MISSILE CARRIER	CONCEPTUAL STUDY TO BEGIN JANUARY 1978

2. Technology

The schedules for the development programs synopsized in Section III.D.3 are shown in Figure IV-5. The numbering system and technology program titles contained in Figure IV-5 are identical to those of the text material contained in subparagraphs to Section III.D.3 (e.g., a. Visual and a.1. Improved CIG Edge Utilization Study). The schedules shown in the figure are the current best estimates and dependent on many factors such as funding availability, prioritization, degree of dependence on other programs, and the annual and periodic review cycles. It should be cautioned that the programs listed in Figure IV-5 are not prioritized either by area or within areas.

3. Program Interactions

A frequently posed question concerning research and development (R&D) for aircrew training simulation (and the approval/funding for such), is the applicability of R&D on future acquisition programs. Previous editions of the Master Plan have attempted to show this R&D/acquisition program tie-in through a Table of Criticality. In the R&D environment, however, there are many efforts in the 6.1 and 6.2 areas which do not directly impact any particular acquisition programs. There are also 6.3 programs which primarily feed other 6.3 and 6.4 programs. This section of the Master Plan provides a pictorial representation of R&D/acquisition programs.

The interrelationships and interdependencies of technology programs and their application to acquisition programs (directed through conceptual), are shown diagrammatically in Figures IV-6a through IV-6h. The links between technology to technology and technology to acquisition programs are depicted as either strong or weak depending upon their predicted impact on a given program initiation. However, while this method is representative based on program initiation, it must be recognized that these links may be slightly misleading in terms of ultimate user requirements. Therefore, in the Air Force's prioritization of technology programs, it must consider not only acquisition starts, but also user requirements.

It can be observed in Figures IV-6.a through IV-6.h that most of the R&D which is currently being conducted in the 6.2 and 6.3 areas will not significantly impact ongoing and near-term procurements. They can, however, have a pronounced effect on future acquisition programs which are currently in the conceptual planning phases. In addition, these technology programs could provide the option to later modify/retrofit aircrew training devices subsequent to technology attainment.

It should be noted that the interactive representations depicted in Figure IV-6.a through IV-6.h are but one simplistic method of indicating the applicability of R&D to acquisition programs. However, this technique does represent a viable and visible means from which one can gain an appreciation of the complex nature of the subject. The interactions shown are temporal and are highly dependent upon program

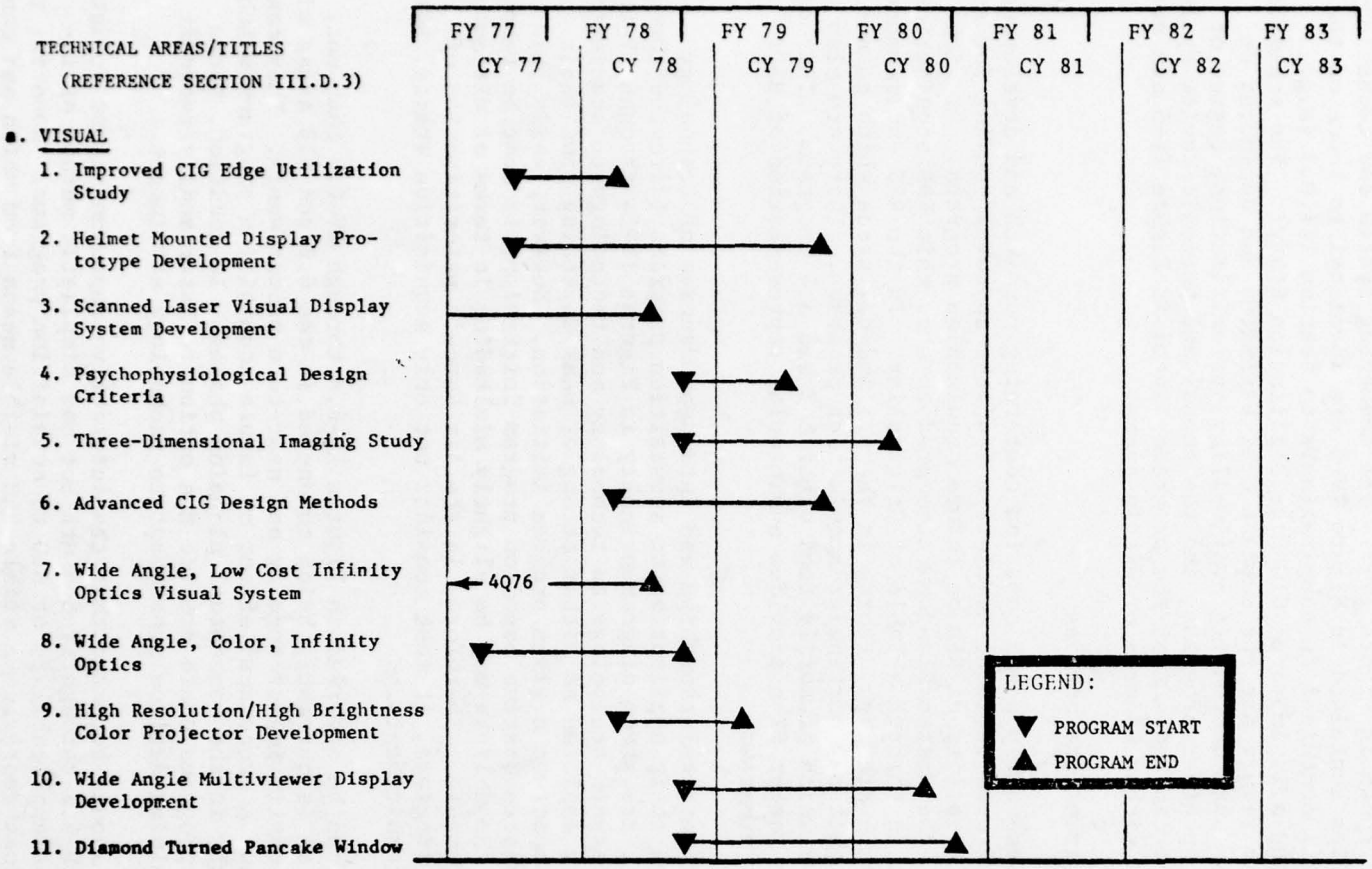


Figure IV-5. Schedules of Planned Simulator Technology Development Program

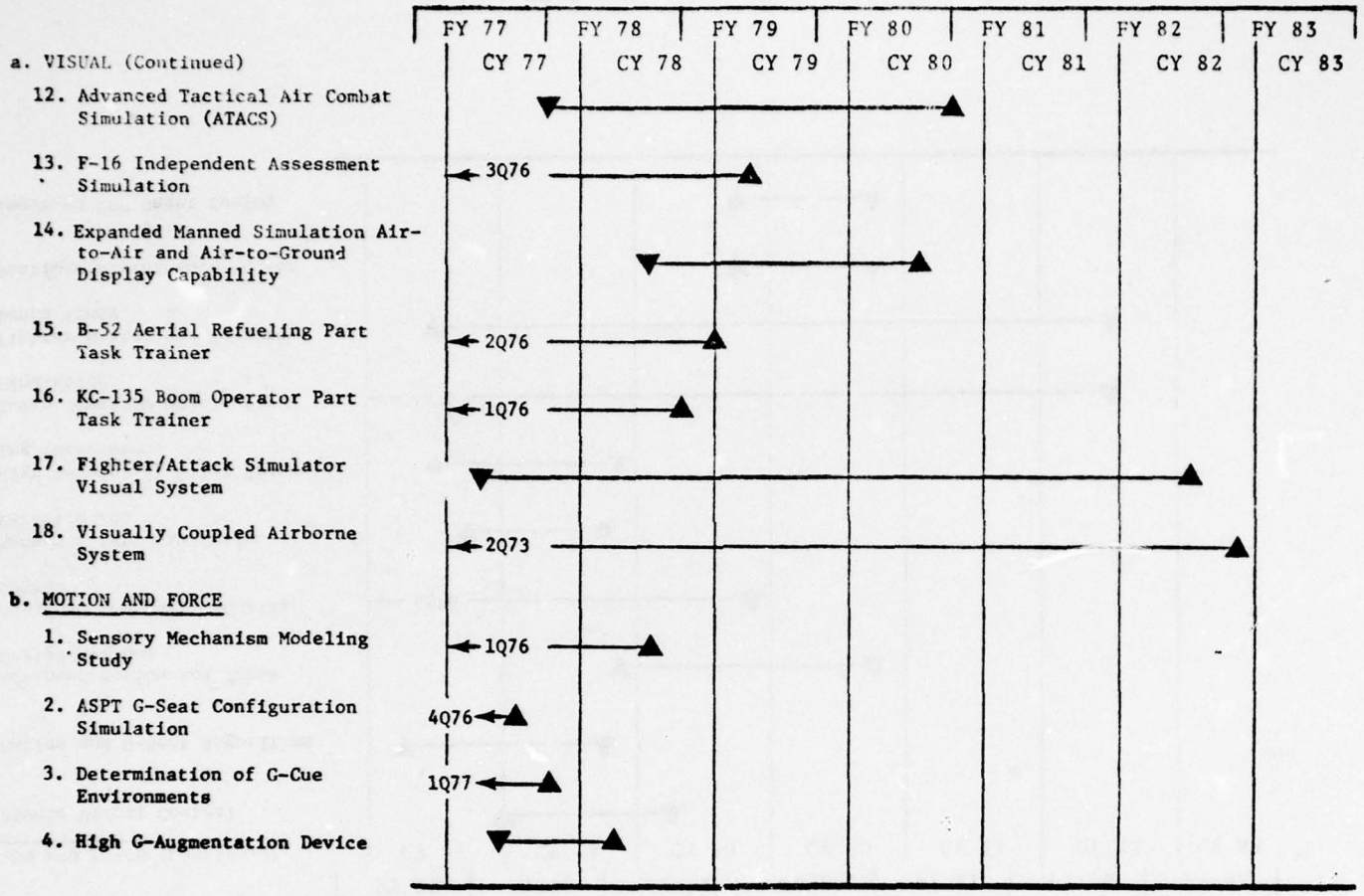


Figure IV-5 (Continued)

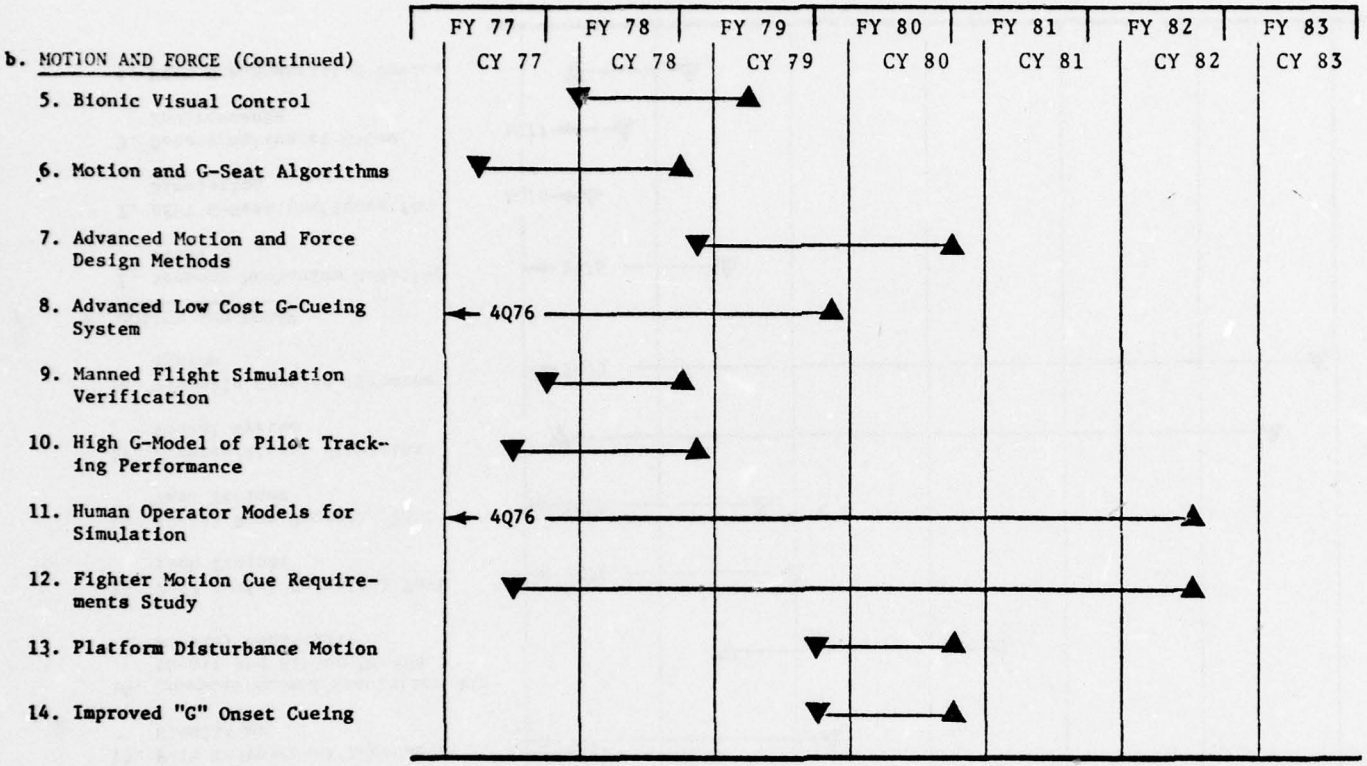


Figure IV-5 (Continued)

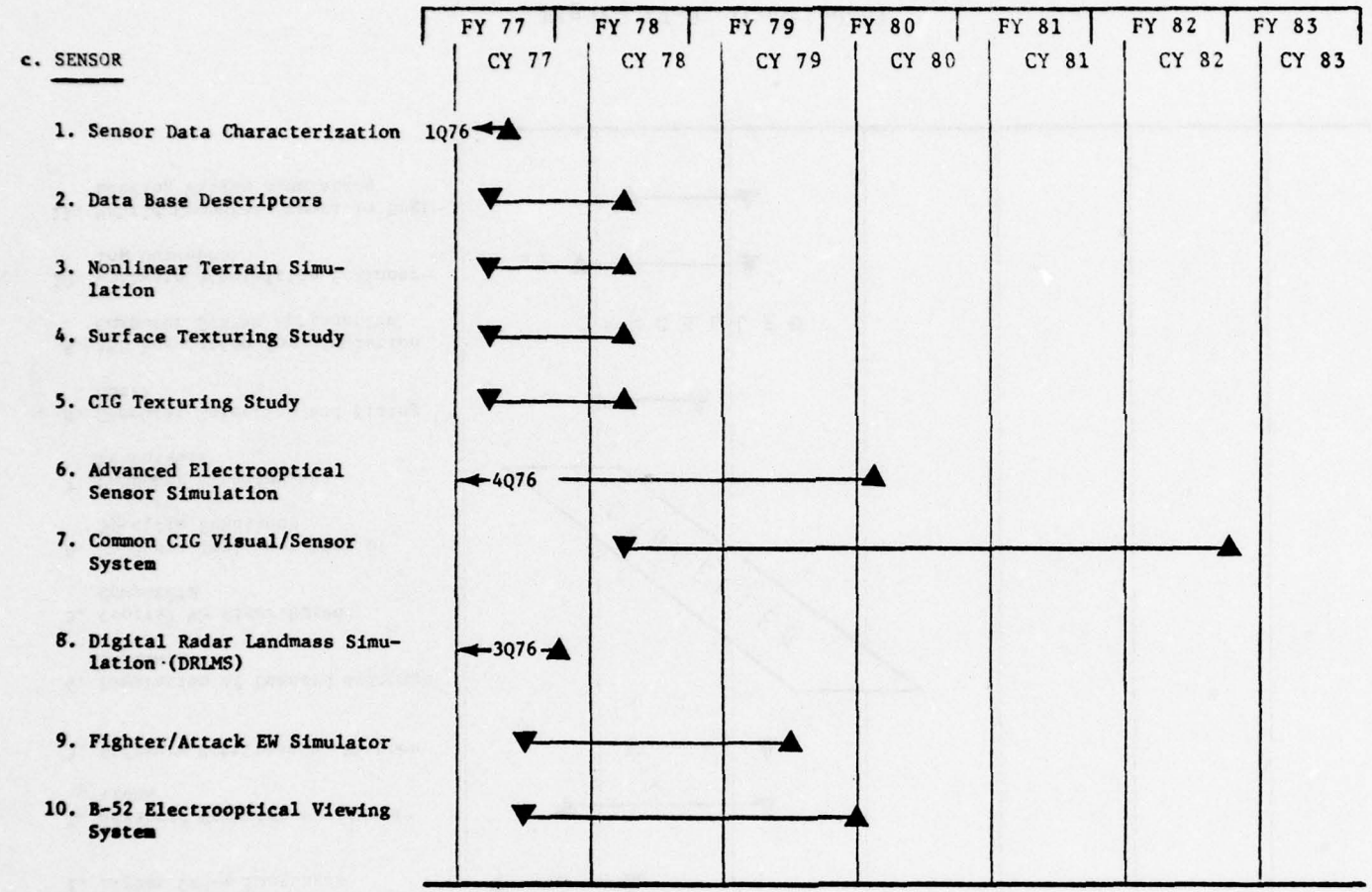


Figure IV-5 (Continued)

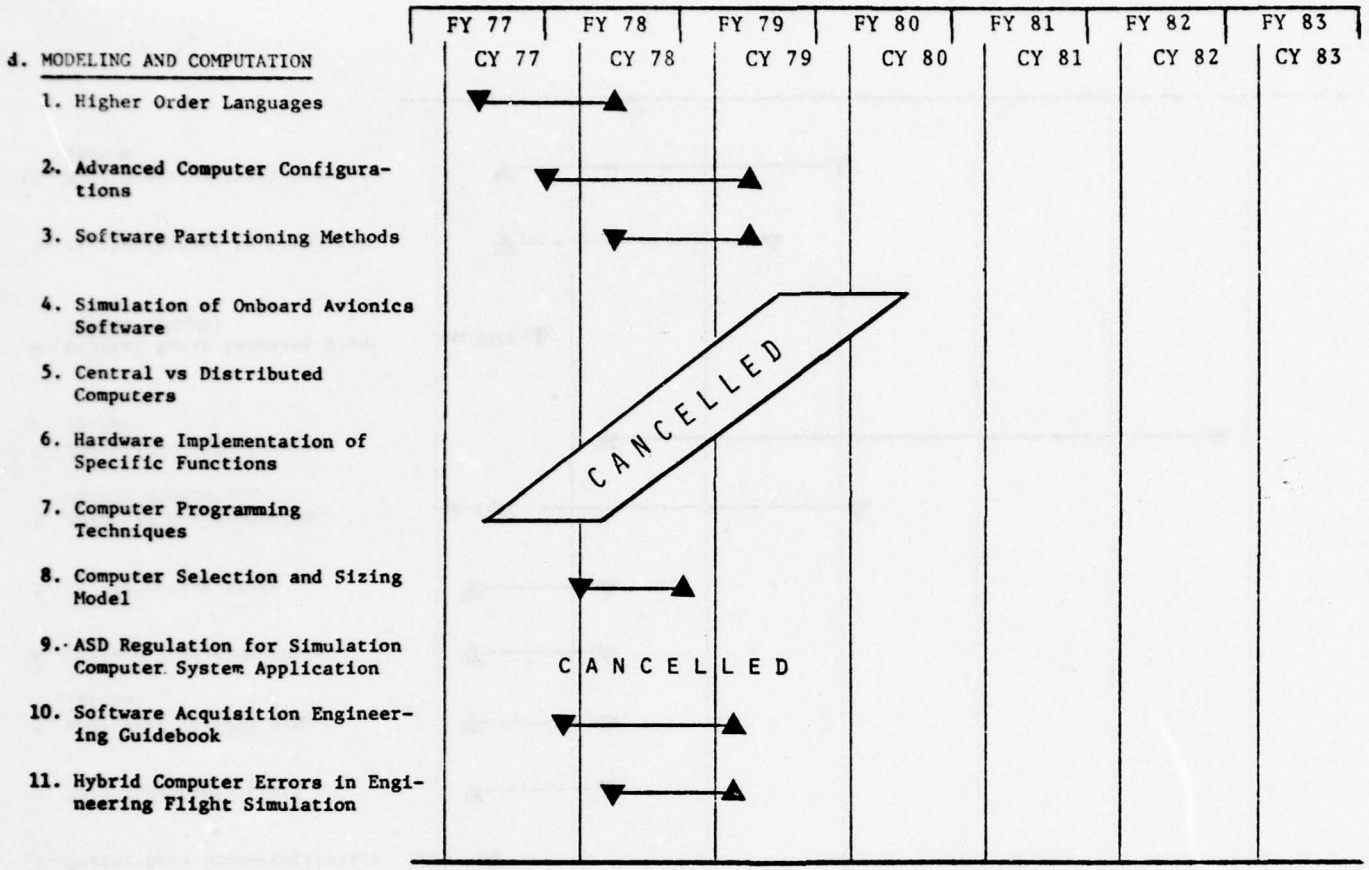


Figure IV-5 (Continued)

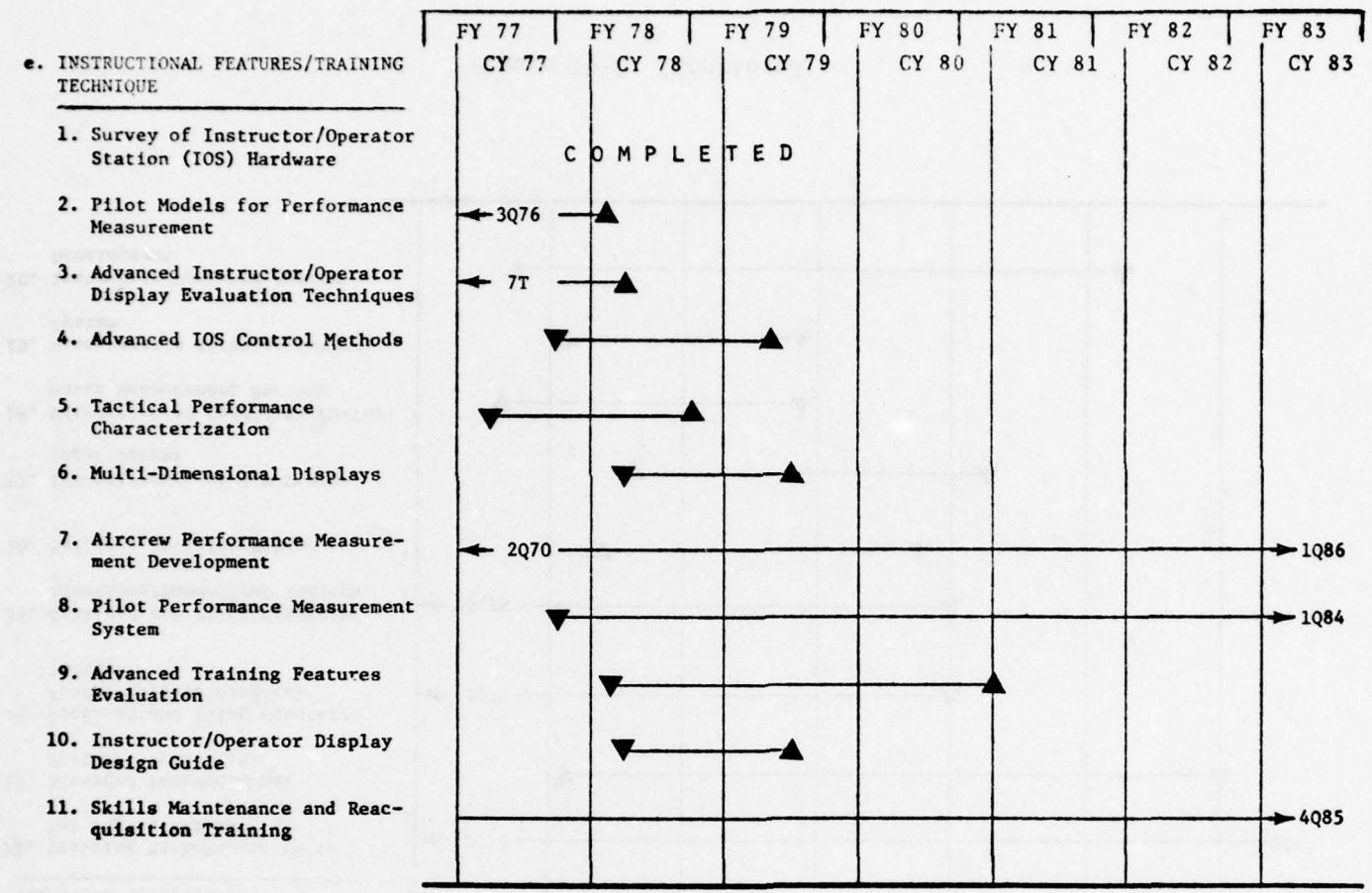


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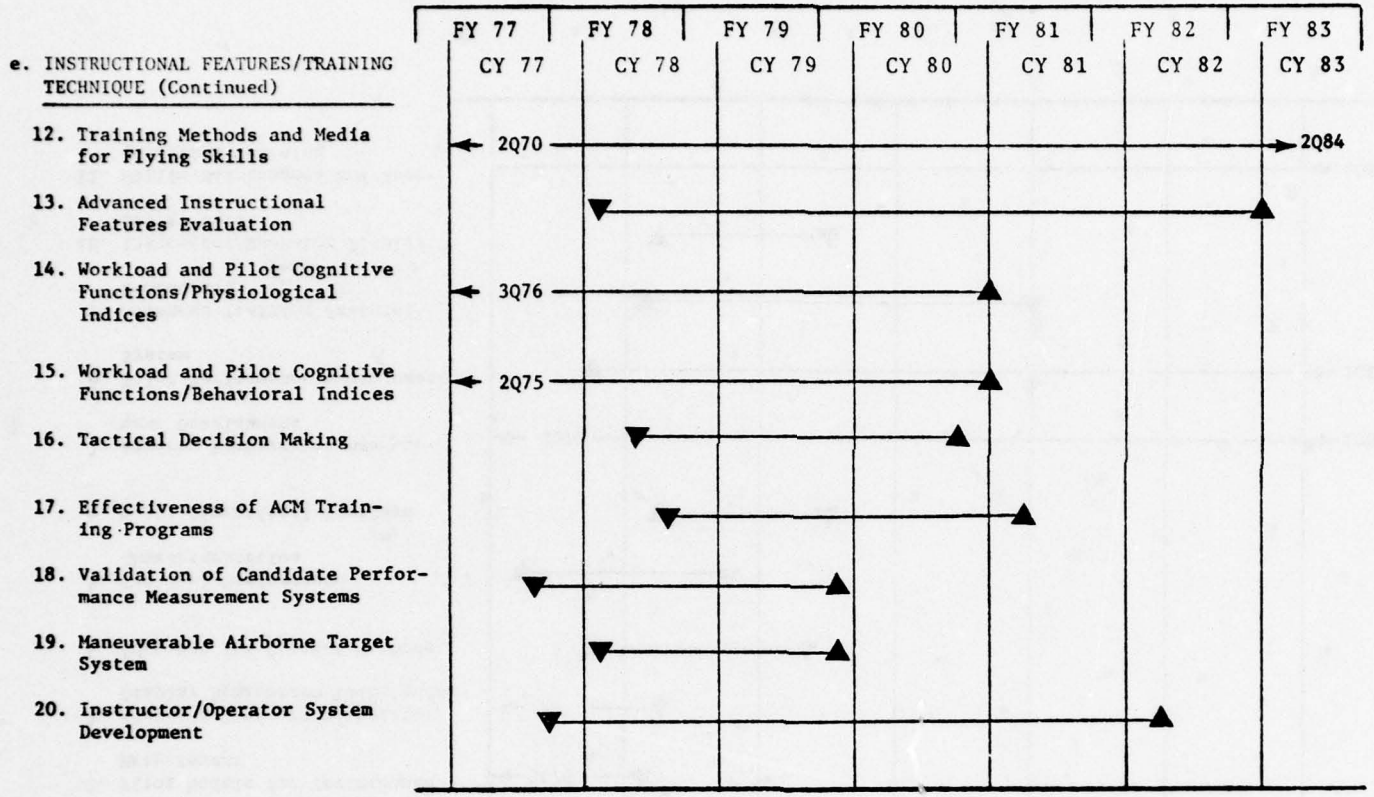


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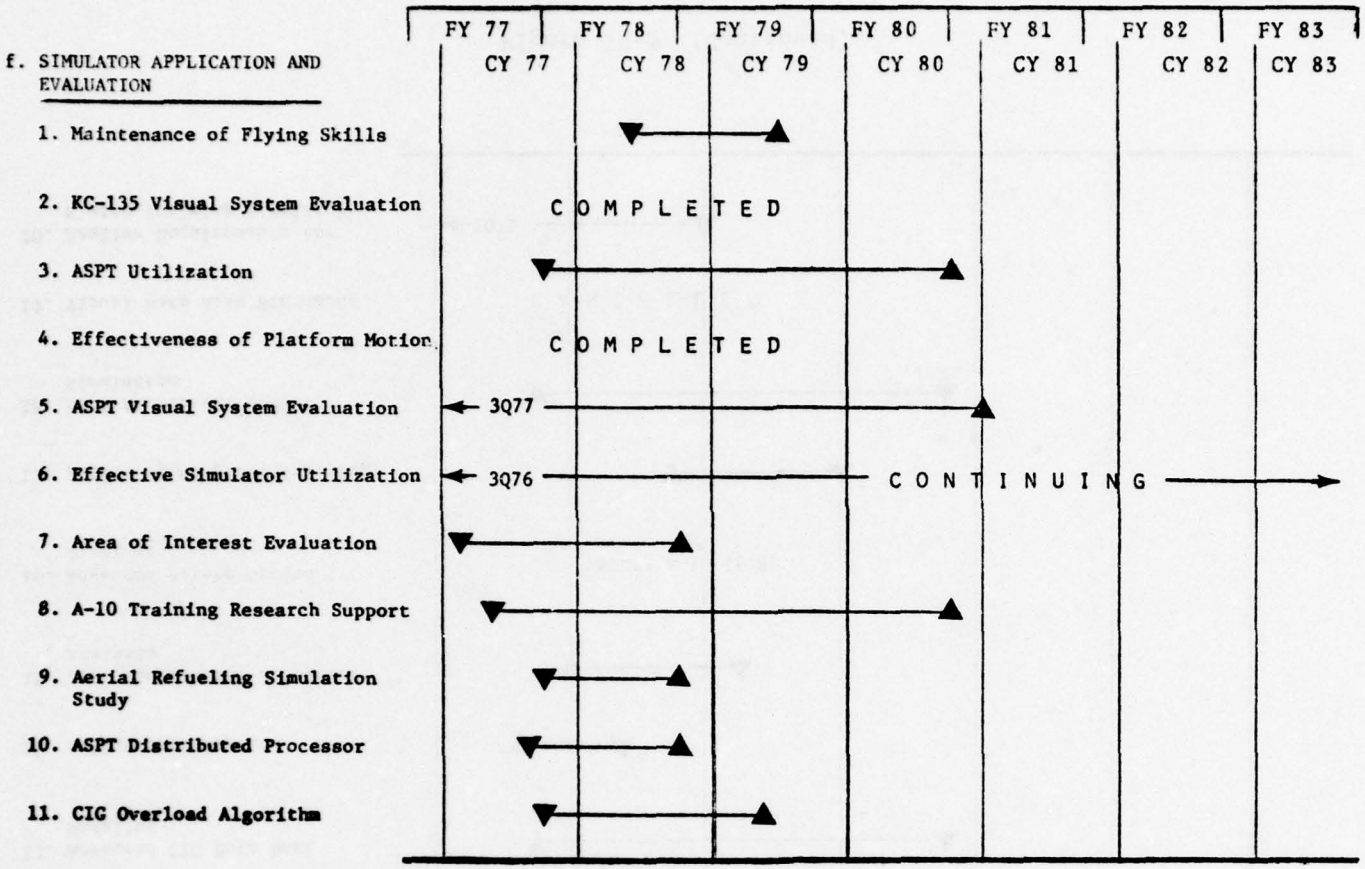


Figure IV-5 (Continued)

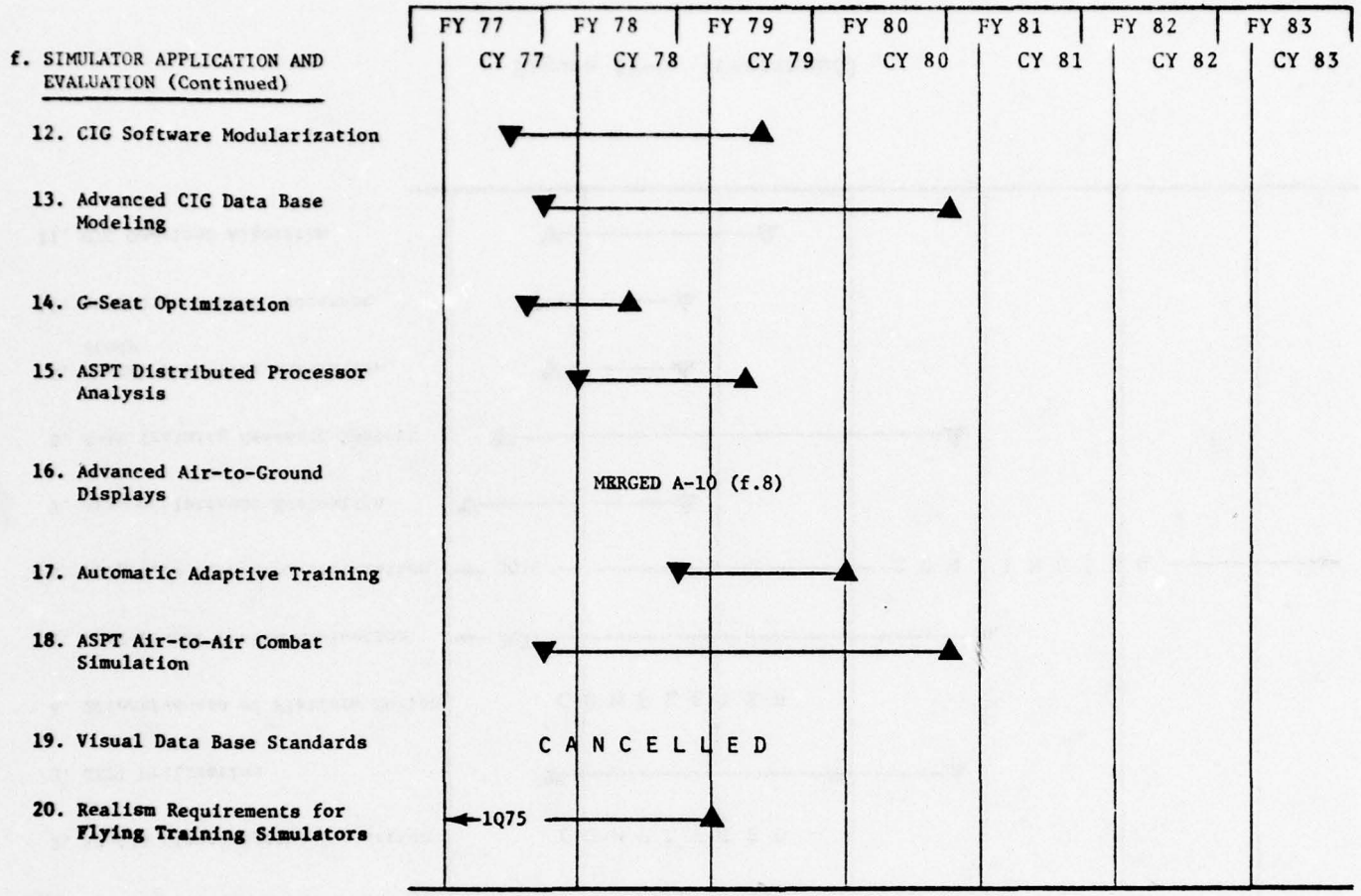


Figure IV-5 (Continued)

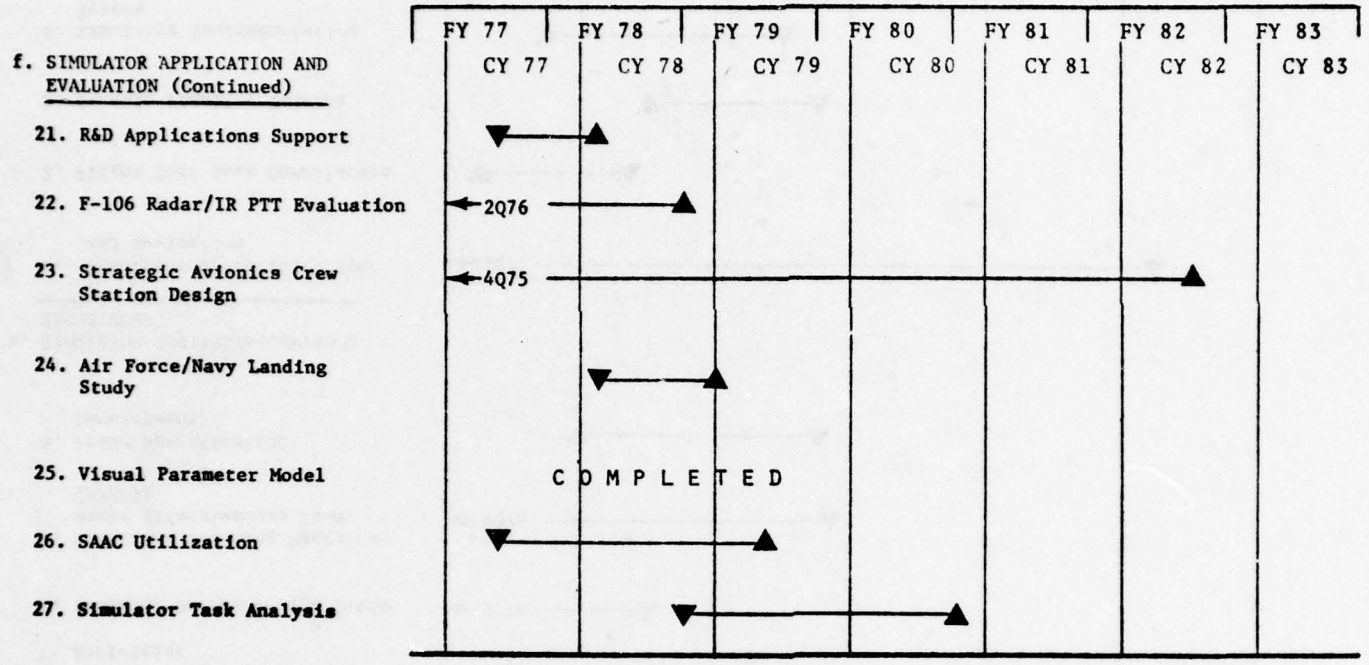


Figure IV-5 (Continued)

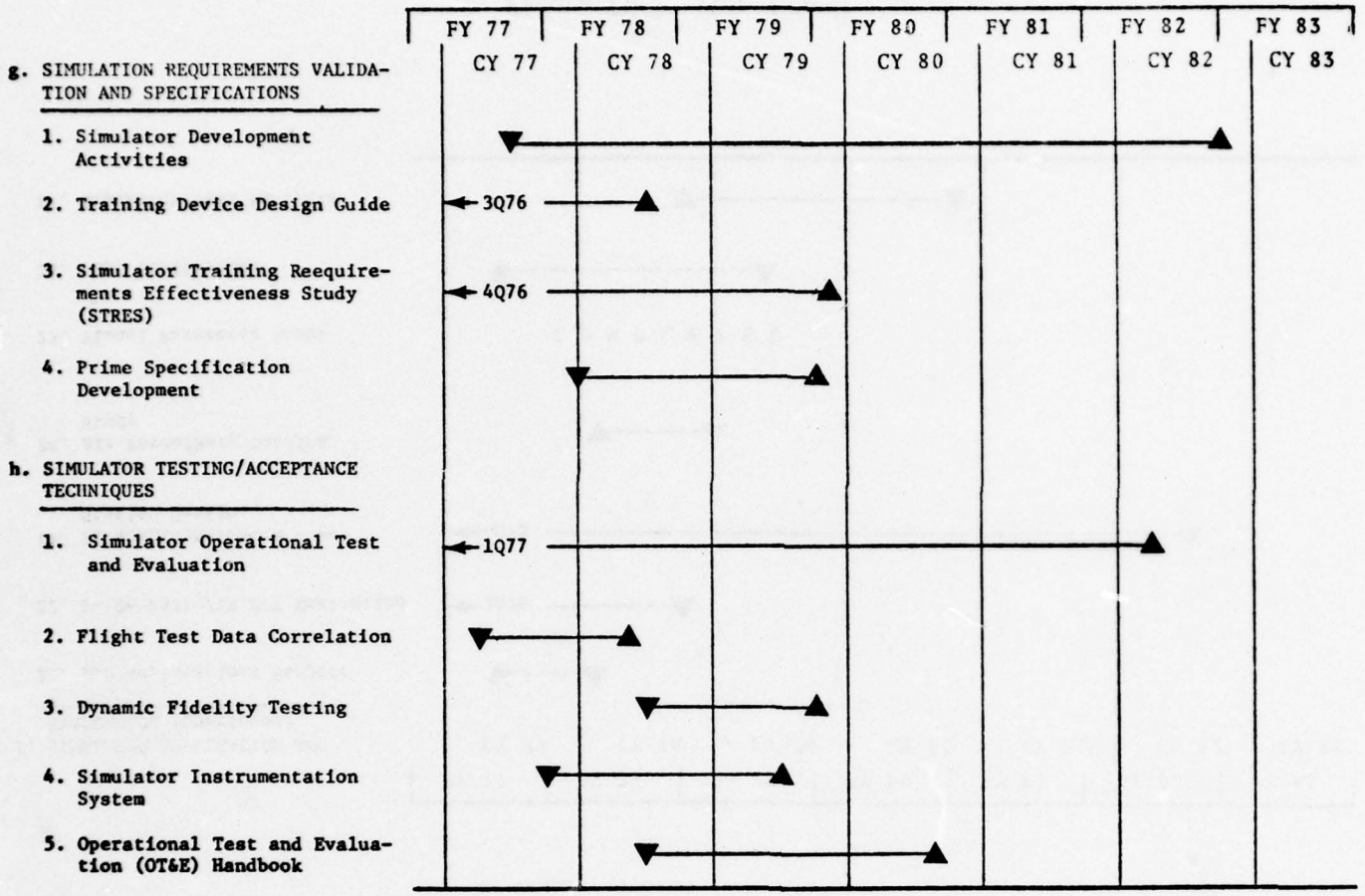


Figure IV-5 (Continued)

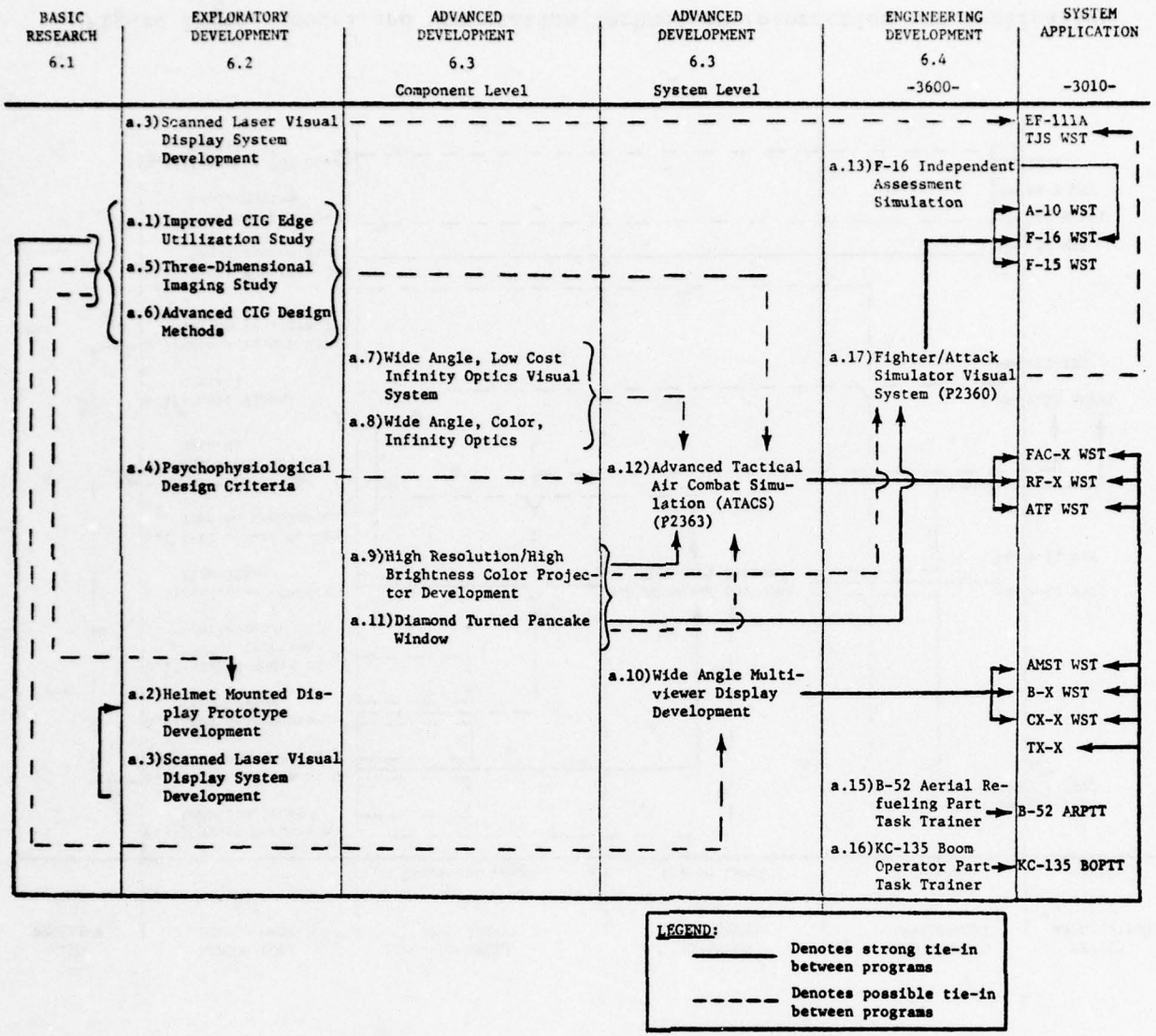


Figure IV-6a. Model and Computation Technology Interaction and Application

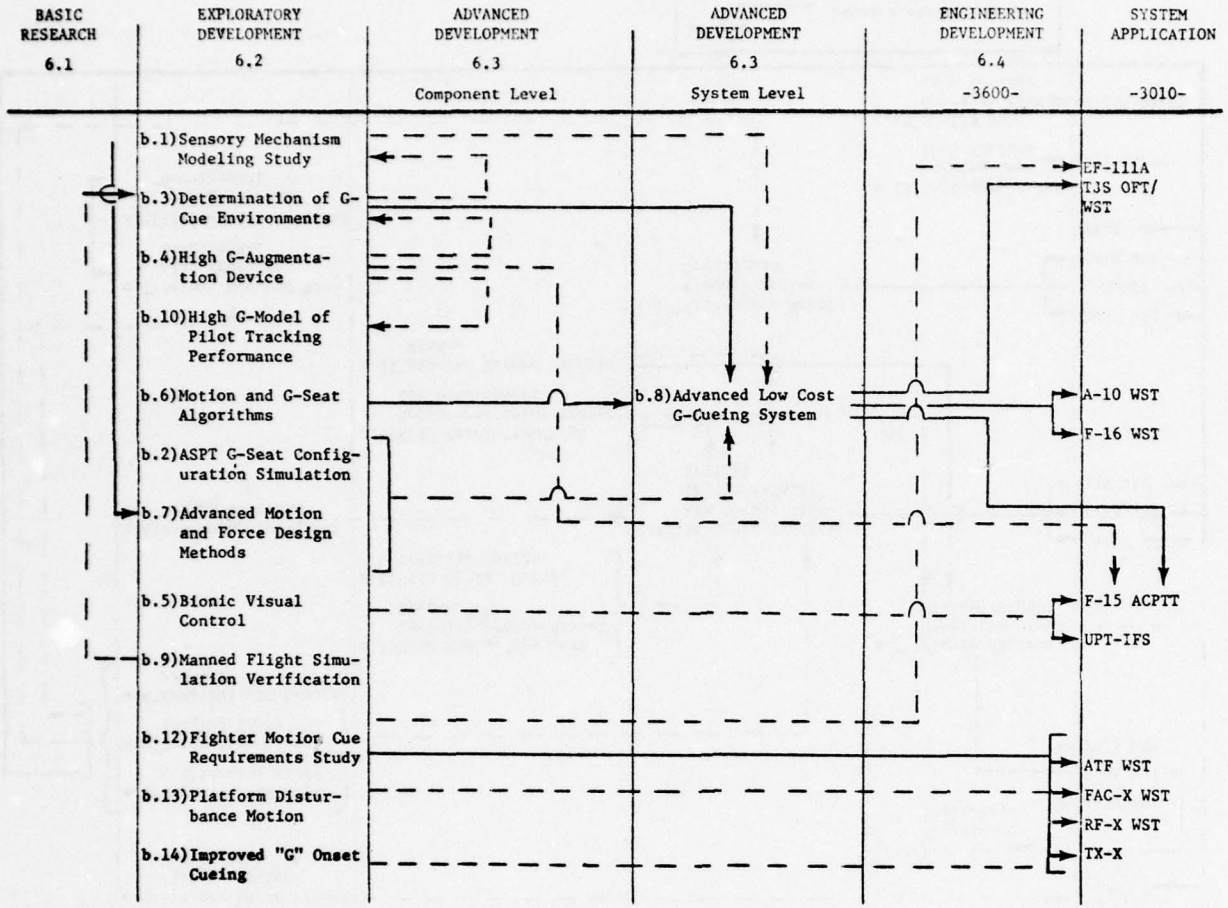


Figure IV-6b. Model and Computation Technology Interaction and Application

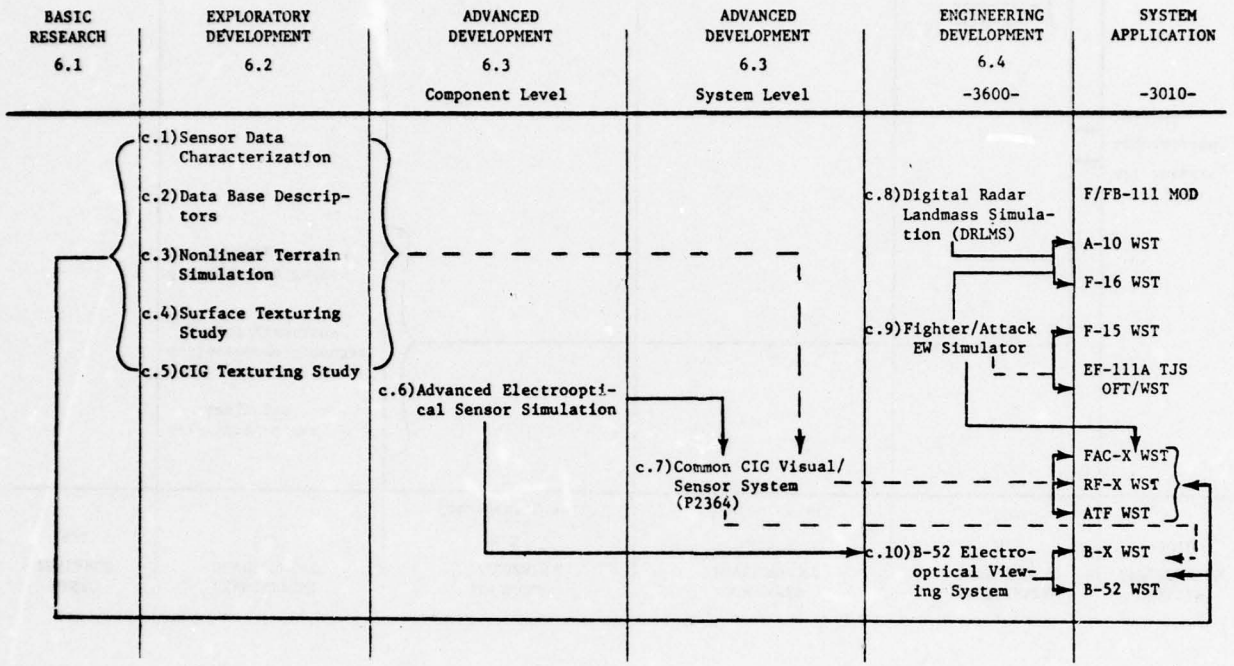


Figure IV-6c. Model and Computation Technology Interaction and Application

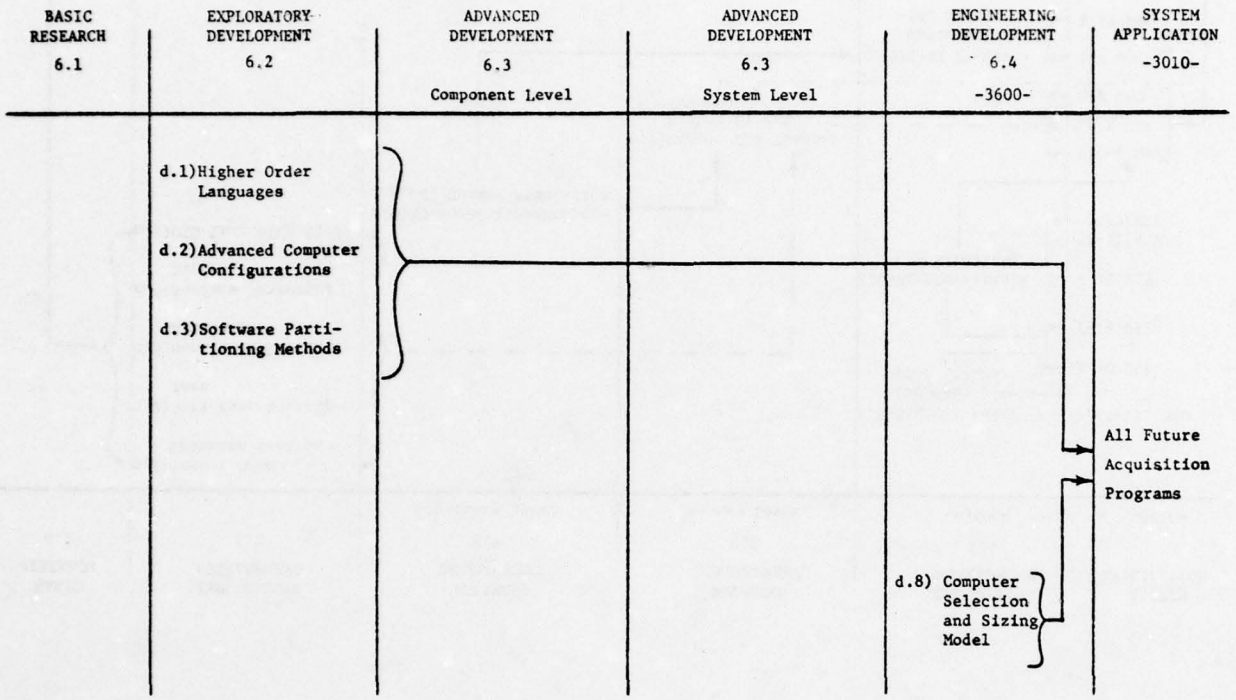


Figure IV-6d. Model and Computation Technology Interaction and Application

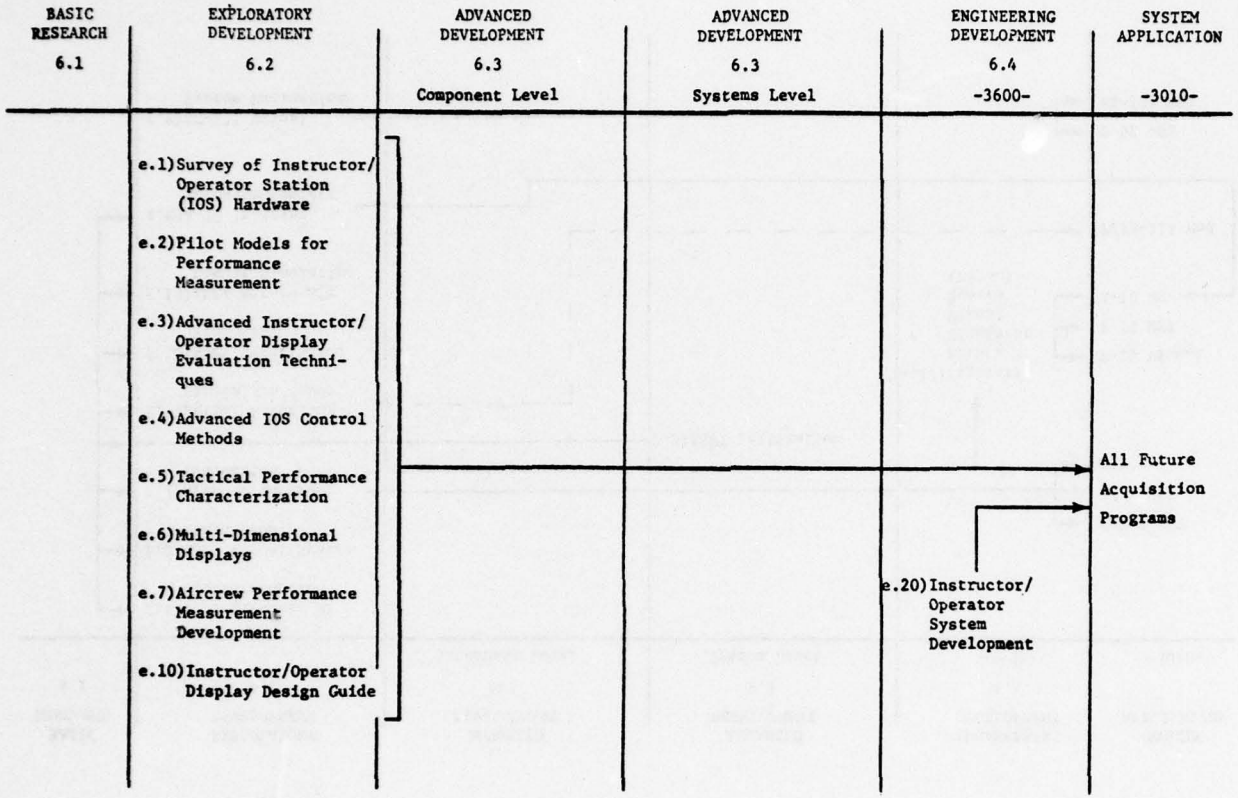


Figure IV-6e. Model and Computation Technology Interaction and Application

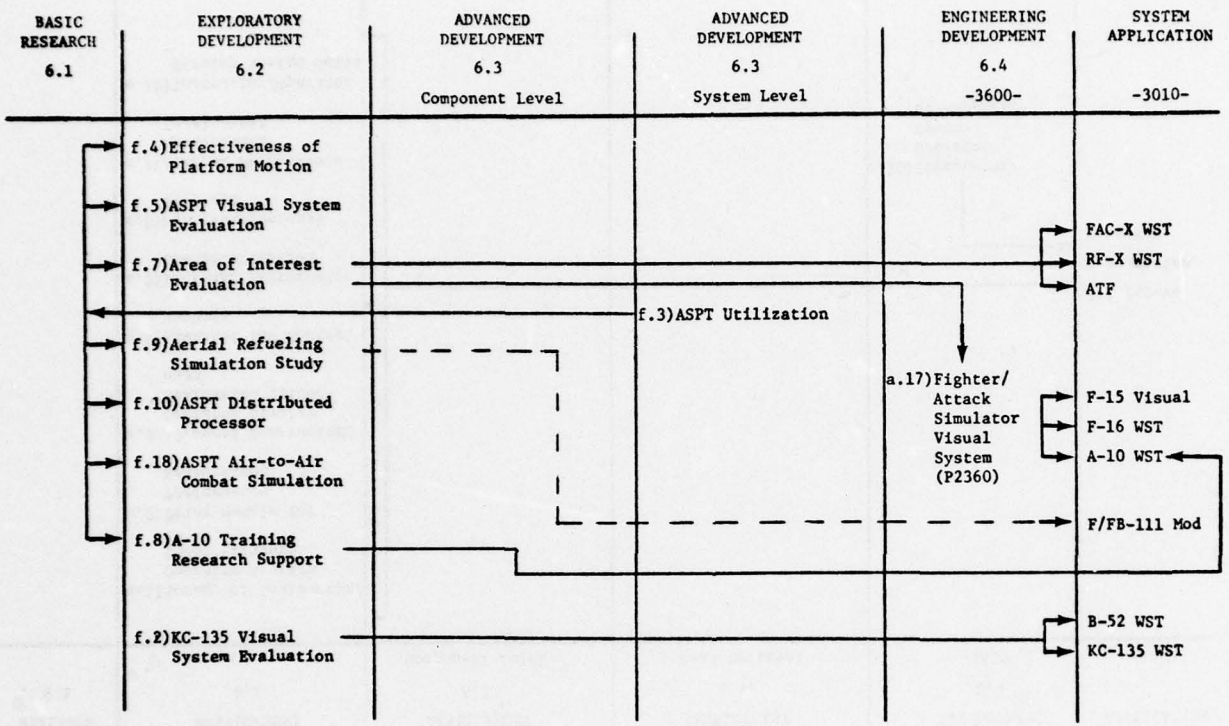


Figure IV-6f. Model and Computation Technology Interaction and Application

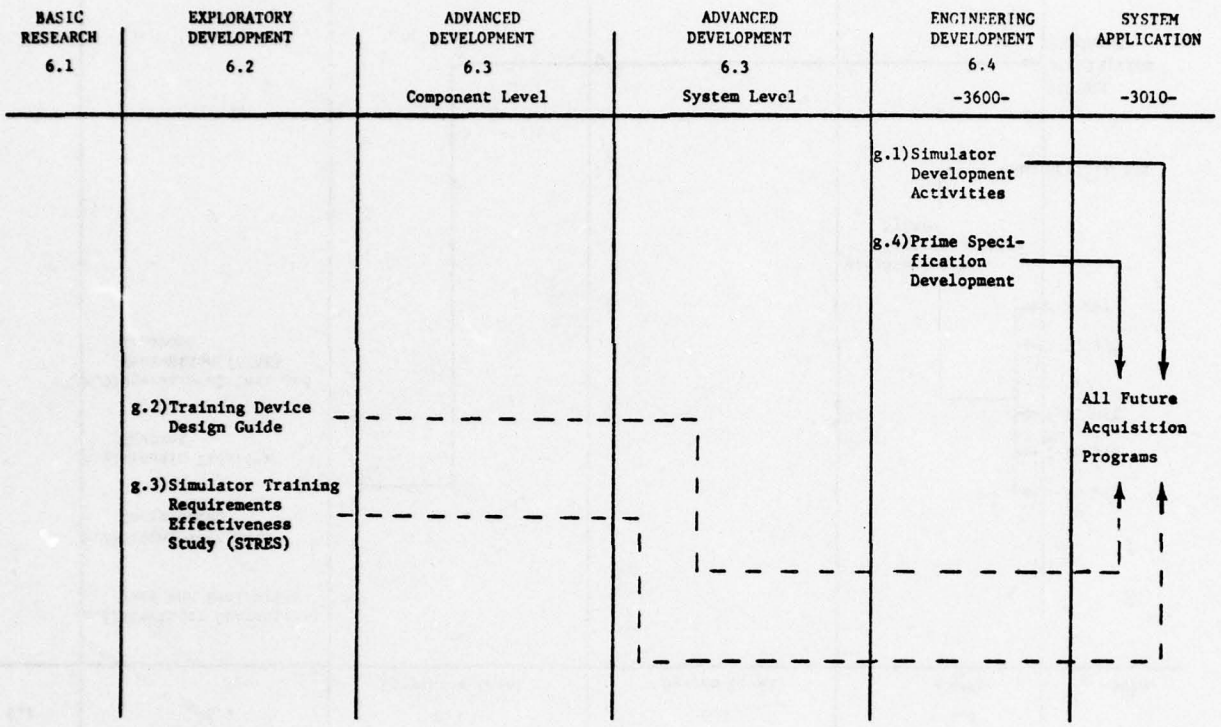


Figure IV-6g. Model and Computation Technology Interaction and Application

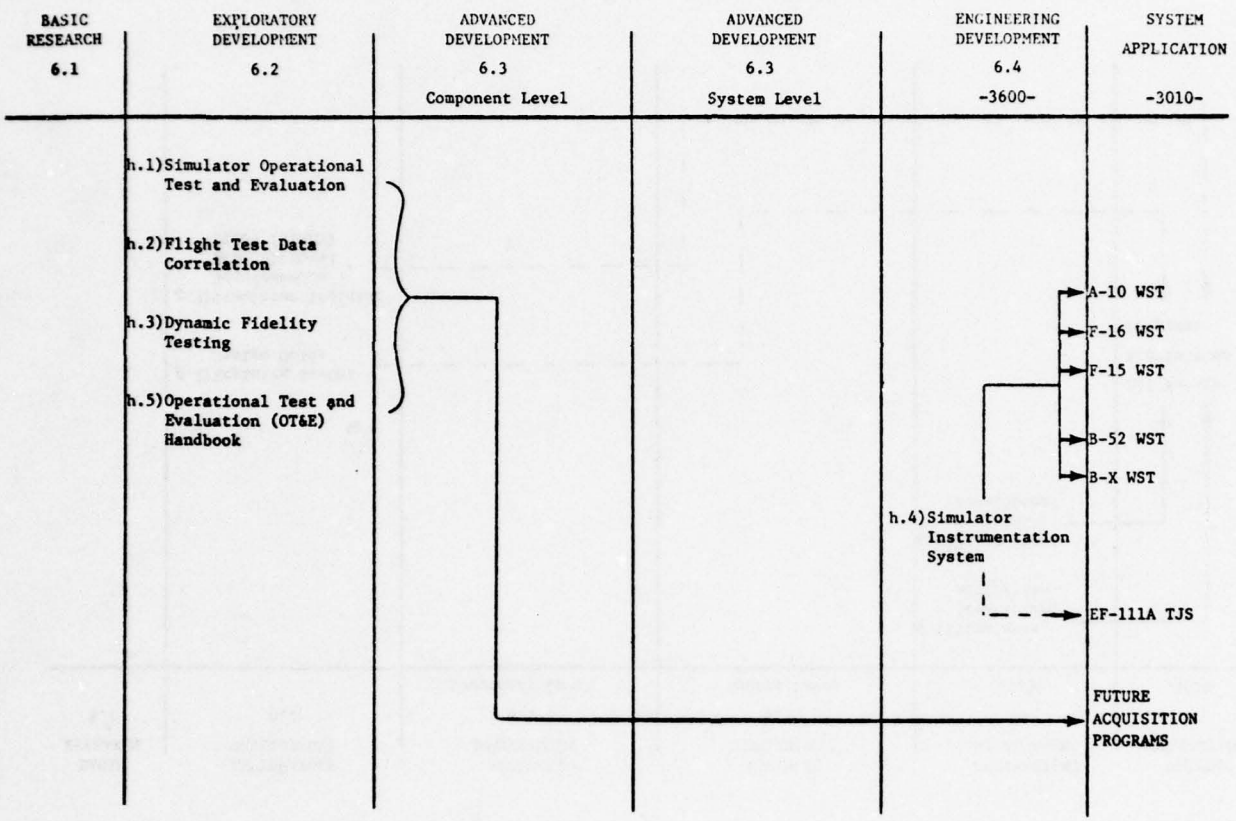


Figure IV-6h. Model and Computation Technology Interaction and Application

approval, funding, scheduling, direction and redirection. Therefore, periodic updating must be accomplished as relevant data becomes available.

With the aforementioned in mind, the solid lines shown in Figure IV-6 indicates that a planned research effort could play an important role in a major simulator acquisition program. The dashed lines show possible area where research can impact. These solid or dashed lines are determined by establishing the probability that a research effort will be of benefit based on the ability to accomplish the task with enough lead time to permit testing and risk assessment.

INTRODUCTION TO COMMAND SECTIONS

The material contained in the sections to follow represents the results of a concerted effort to identify Command needs and to translate these needs into action programs. Several significant points which were made in prior sections are noted again for emphasis:

- Simulators have been and will continue to ba an integral part of each Command's training program; they cannot replace actual flying training until they are fully integrated into the training syllabus in a deliverate and considered manner. This implies not only acquisition of equipment, but the acquisition of knowledge and confidence from the exploitation of advanced development programs now underway.

- A continuing commitment by management at all echelons must be made to effect the transition to increased simulator usage by clarifying roles and missions, adopting permissive regulations for simulator substitution for credited flying training, and providing the organizational resources needed to support the systems procured.

- Synthetic training devices must have the following characteristics if they are to achieve effective and economical training:

  - High reliability and utilization rate;
  - Fidelity to the cockpit environment;
  - Expansion into the visual and sensor domains;
  - Improved instructional features; and
  - Proven training value.

In general, the Major Commands have accepted the principle of a goal oriented reduction of flying training. The time for achievement and the magnitude of any given level of reduction is paced by Command judgment and by realistic acquisition program schedules in association with scheduled exploitation of ongoing advanced development programs related thereto.

The program data should be looked upon as a planning overview of essential programs which collectively could move toward the specified goals of the individual commands. It is, of course, highly improbable that all of the financial needs of the Commands will be met in their entirety; it is recognized that trades will evantually be made between performance requirements and financial capability. Individual program cost and schedule data are highly temporal; however, a total picture of all programs serves to outline and underline the scope of this undertaking.

The Commands have established a prioritized listing of the programs needed to accomplish their objectives. The optimum allocation of funds across Commands requires a good deal of subjective judgment to determine the optimization criteria. A number of criteria are possible and perhaps equally valid: the continuing emphasis on energy conservation, particularly as it applies to petroleum products suggests fuel savings is an important consideration; the magnitude of returns on investment in terms of dollar savings; the speed with which returns can be realized, either in fuel or dollar resources; the effectiveness of the training provided in reducing aircraft accidents; and, any "free assets" which might accure to reduction of demand on the aircraft inventory to supply training missions.

In general, the quantities of simulators specified by the Commands include consideration of the anticipated training load for active force personnel and Air Force Reserve and Air National Guard personnel. An excerpt from AFR 45-1 states that ". . . Major Commands must ensure that the ANG and AFRes Units are in a state of readiness to function effectively when mobilized to support the mission of the gaining commands . . . " The operational readiness of the Air Reserve Forces (ARF) is partially ensured by the efforts of the gaining commands in establishing training standards and objectives.

V. AIR TRAINING COMMAND (ATC)

A. GENERAL

The "Mission Analysis on Future Undergraduate Pilot Training" published early in 1972 was a comprehensive systems approach program which is being used by the Air Training Command to guide utilization and planning efforts in Undergraduate Pilot Training (UPT). Information from that study effort supplemented by additional planning and analysis formed the basis for the Command input to the Master Plan. Included is the role simulation equipment can play in upgrading and improving the efficiency of other ATC formal flying training courses; viz, Pilot Instructor Training (PIT), Undergraduate Navigator Training (UNT), and Electronic Warfare Officer (EWO) training.

The Air Training Command recognizes the potentials of simulation in flight training programs and plans for improved and more economical training through increased reliance on simulators. The programs outlined in this section are viewed as reasonable extensions to programs now in the acquisition phase which will form a plateau of capability over the next decade. Future improvements are based upon the successful completion of associated advanced development programs and the careful integration of these capabilities into the training syllabus by application of ISD activities. As noted in other sections of this Plan, the estimates of flying hour reductions are predicated upon the substantiation of training transfer capability by hands-on experience. The reduction of the flying portion of the syllabus must be undertaken with care to avoid the transference of an undue burden on the receiving commands where flying training would be accomplished at greater cost and greater risk.

The current and projected student entries associated with the noted formal training programs are shown in Table V-1. Numbers of equipments required were based upon a theoretical production capability of 2,400 for UPT, 800 for PIT, and 1,500 for UNT. These same nominal loadings were used for computations of fuel savings accruing to the substitution of simulator hours for flying hours in the projected training syllabi.

The Air Training Command currently is using the T-4/T-26 Flight Instrument Trainers in UPT/PIT. Table V-2 provides a summary of terms which will be used to describe the training equipment resources of the Command. The T-4/T-26 Instrument Flight Trainers consist of the cockpit section of the training aircraft complete with consoles, panels, controls, ejection seat, and windshield bar. Most instrumentation for aircraft systems as well as all engine systems and flight dynamics are operational and indications are generally representative of the aircraft and systems performance. These instrument flight trainers employ analog computers to achieve real time control response. No

TABLE V-1. PROGRAM ENTRIES[1]

	PIT[2,5]		PIT[3]		UNT[4]
	T-37	T-38	T-37	T-38	T-37/T-43
FY 77	1387	1370	316	289	690
FY 78	1324	1217	262	278	664
FY 79	1831	1493	376	428	719
FY 80	2332	1961	343	385	840

1 Numbers are current estimates only (include USAF, ANG, Res, and FORN entries into standard UPT).

2 Production rate is approximately 90% of the entry rate for the T-37 and 95% for the T-38 (UPT).

3 For PIT the numbers are mutually exclusive.

4 Production rate is approximately 90% of the entry rate.

5 Entries do not include T-37/T-38 Security Assistance Training Program (SATP).

REFERENCE: USAF Program Flying Training 79-2, Vol 1, Jun 77.

TABLE V-2. ATC TRAINING EQUIPMENT AND GLOSSARY OF TERMS

AIRCRAFT			TRAINER/SIMULATOR			
DESIGNATION	USE	STATUS	TRAINER TYPE	USE	STATUS	FEATURES
T-37	UPT, PIT & UNT	CURRENT USE	T-4	IFT	CURRENT USE	COCKPIT CONTROLS & DISPLAYS, NO MOTION NO VISUAL
			T-50*	IFS	IN PROD/ CURRENT USE	MOTION + VISUAL WITH COCKPIT
T-38	UPT, PIT	CURRENT USE	T-7/T-26	IFS	CURRENT USE	COCKPIT CONTROLS & DISPLAYS, NO MOTION, NO VISUAL
			T-51*	IFS	IN PROD	MOTION + VISUAL WITH COCKPIT
T-43	UNT	CURRENT USE	T-10	BOMB/NAV FOR B-52 G/H	CURRENT USE	
T-41	BASIC TRAINER	CURRENT USE	T-40	UNT	CURRENT USE	
			T-4	EWOT	CURRENT USE	
			T-5(SEWT)	EWOT	CURRENT USE	
			T-45	UNT	CURRENT USE	

* UPT-IFS

UNT = UNDERGRADUATE NAVIGATOR TRAINING
IFT = INSTRUMENT FLIGHT TRAINER
IFS = INSTRUMENT FLIGHT SIMULATOR
UPT = UNDERGRADUATE PILOT TRAINING
PIT = PILOT INSTRUCTOR TRAINING
EWOT = ELECTRONIC WARFARE OFFICER TRAINING

motion base or visual system is employed. The system is able to simulate most normal and emergency procedures. The T-4/T-26 trainers are used as part task instrument trainers and procedures trainers. Aircraft instrument sorties are preflown in the trainer with skill in instrument procedures being derived from trainer exposure and practice. Familiarity and practice in normal and emergency procedures is also achieved in the trainer. Money spent on motion or visual systems would not be cost-effective since most of these trainers have exceeded their design lifetime.

The Undergraduate Navigator Training (UNT) program has undergone major changes since 1975. Beginning with the entry of UNT Class 76-19 on 17 October 1975, all students received the fully integrated T-43/T-37 and T-45 Ground Simulator curriculum. Prior to this point, technical problems and resultant T-45 delivery delays necessitated continued or increased use of existing training devices and additional T-43 flight missions. This interim measure, Modified Undergraduate Navigator Training (MUNT) was terminated on 26 May 1976. Table V-5B depicts this transition graphically. The implementation of the T-43/T-37/T-45 UNT program has reduced total flying by 74.5 hours and other training devices by 51 hours.

The T-45 Ground Simulator has provisions for 52 student stations (13 complexes with four students each, one instructor, and one operator per complex). Each student station duplicates the master station of the T-43 aircraft in form, fit, and arrangement. The 13 complexes may be operated independently with a total of 52 different mission tracks in progress at any one time. Missions may be planned over the entire northern hemisphere at speeds up to Mach 2.0 and altitudes to 70,000 feet. Digital radar coverage of the continental United States is available to each student with a resolution of 250 feet or 1,500 feet depending on individual radar range selected. Each student in the simulator acts as "lead" navigator at his station and can "fly" missions using any combination of navigational aids available. The T-45 performance exceeds that of the T-43 aircraft in providing the student with a full range of mission profiles covering current and future weapon system capabilities.

Navigator/Bombardier Training (NBT) requires a new simulator to replace the T-10 simulators now in use. The simulators are ground-based replicas of the navigator/bombardier stations within the B-52G/H model aircraft and have been in continuous service over ten years. Though adequate for the current time frame, their usefulness is limited to training navigator/bombardier students for only the B-52. Simulator requirements for the future call for a new navigator/bombardier simulator in the NBT course. The course will be required to train navigator/bombardiers for the more advanced weapon systems. This will necessitate a simulator more closely aligned to the current state-of-the-art in avionics than is possessed by the ASQ-38 T-10. There are no additional tradeoff possibilities for simulators in lieu of flying time since the NBT program is now a no-fly course; however, research is required to meet the advanced system training needs of future USAF aircraft.

The Simulator for Electronic Warfare Training (SEWT) is a general task, computer controlled, electronic warfare simulator capable of simultaneous training and evaluation of eight students. Each student station includes generic EW equipment representative of that used in Air Force aircraft. The simulated environment consists of a 2000 X 2000 nautical mile gaming area, at altitudes of 0-100,000 feet and airspeeds up to 2000 knots. The signal environment consists of up to 63 simultaneous emitters created from 126 radio frequency sources which include communications, navigation, and friendly and hostile radar signals. Although the SEWT was initially conceived as a simulator to supplement flying in Electronic Warfare Officer Training (EWOT), this concept was changed on the basis of an ATC study in 1971/1972 which evaluated the feasibility of a nonflying EWOT program. Accordingly, with the introduction of the SEWT in January 1974, EWOT became a nonflying program utilizing the SEWT and the AN/ALQ-T4 Electronic Countermeasures simulator. In the original concept, 50 hours of SEWT training were to supplement approximately 70 hours of flying. Under the nonflying program; SEWT training was increased to 98 hours, T-4 training was also increased, and EWOT flying training was eliminated. As a result of this increased utilization requirement, increased production and surge capability requirements, and lower than predicted simulator reliability, ATC ROC 3-74 for SEWT expansion was prepared by ATC on 24 May 1974, and subsequently, validated at the Air Staff level. The expansion includes a computer, instructor console, interface, and associated peripherals. PMD R-R4060(1) 81114F, dated 16 December 1974 pertains. Contract was awarded on 25 May 1976, and delivery/installation completion is scheduled for November 1978. The time frame for SEWT replacement is, in large part, dependent upon the technology and capability of future weapons systems. SEWT replacement remains identified as a long-term requirement, tentatively projected for the early to middle 1980s time frame.

Table V-3 provides the current flying training portions of the formal training programs just described. These figures are used as the base line for projection of flying hour reductions which could conceivably be achieved by the full integration of simulators into the appropriate curricula.

TABLE V-3. FLYING HOURS/STUDENT (CURRENT PROGRAMS)

	UPT	PIT	UNT
T-37	90	60	6.5
T-38	120	65	--
T-43	--	--	105

B. TRAINING DEVICE STATUS AND REQUIREMENTS

The achievement of future flying hour reductions is predicated upon a set of prerequisites to achieve substitution of simulator hours for flight hours withoutdegradation. Tables V-4, V-5A and B, and V-6 provide a representation of the planned reductions. Table V-4 presents the reductions in terms of simulator utilization for the largest (in

TABLE V-4. SIMULATOR UTILIZATION SUMMARY (HOURS/STUDENT)

	CURRENT		FUTURE			
	T-4 (T-37)	T-7/T-26 (T-38)	T-4 (T-37)	T-7/T-26 (T-38)	T-50 (T-37)	T-51 (T-38)
UPT [1]	36.8	36	24.0	29.6	35.2	38.4
PIT [2]	22.4	12.0	9.0	10.5	12.0	13.0

1 - Approved Test Syllabus 2 - Draft Syllabus

flying hours) of the ATC training programs, UPT, and PIT, with theoretically 2400 and 800 students graduating from these programs per year. Tables V-5A and B show the progressive reduction of flying hours accruing to simulator substitution into the UPT/PIT and UNT curricula. Note that the UNT, NBT, and EWOT programs which were discussed earlier are not expected to offer further flight reduction possibilities in the foreseeable future since the NBT and EWOT programs are nofly programs, and the UNTS equipment is just now in active use and the progression shown in Table V-5B is considered a part of future planning.

TABLE V-5A. FLYING HOURS/STUDENT

	UPT [1]		PIT [2]	
	CURRENT	FUTURE	CURRENT	FUTURE
T-37	90	71.8	60	48
T-38	120	98.2	65	52
TOTAL	210	170.2	*	*

1 - Approved Test Syllabus 2 - Draft Syllabus

* PIT course consists of training in only one mission aircraft.

TABLE V-5B. UNT FLYING AND SIMULATOR HOURS/STUDENT

TRAINING AREA	UNT (N-V6A-A)	UNTS (N-V6A-B	MUNTS (1) (N-V6A-B)	MUNT (2) (N-V6A-0)	UNT (N-V6A-D)
T-29	186	40	40	0	0
N-3	26	18	20	0	0
T-10	18	0	14	14	0
D-2	7	0	0	0	0
T-43	0	105	120	120	105
T-45	0	80	0	0	80
T-37	0	0	0	6.5	6.5
TOTAL FLYING	186	145	160	126.5	111.5
LAST CLASS	75-07		76-02(3)	76-18(4)	

(1) MODIFIED UNDERGRADUATE NAVIGATOR TRAINING SYSTEM

(2) MODIFIED UNDERGRADUATE NAVIGATOR TRAINING

(3) LAST CLASS TO FLY T-29s GRADUATED 28 AUGUST 1975

(4) LAST CLASS TO RECEIVE PARTIAL USE OF T-45 SIMULATOR

Table V-6 gives a breakdown of the flying hour programs associated with UPT and PIT for the current curricula and for the future. This breakdown in terms of training segments indicates the area of interest applying to future reductions.

TABLE V-6. UPT/PIT FLYING HOURS/STUDENT

PHASE UPT [1]	CURRENT T-37	CURRENT T-38	FUTURE T-37	FUTURE T-38
Basic	10.4	--	2.6	2.4
Contact	40.7	36.0	44.6	34.8
Instrument	14.3	22.1	1.3	0
Formation	15.6	44.7	14.3	44.0
Navigation	9.0	17.2	9.0	17.0
TOTAL	90.0	120.0	71.8	98.2
PHASE PIT [2]	**CURRENT T-37**	**CURRENT T-38**	**FUTURE T-37**	**FUTURE T-38**
Contact	27.5	25.2	27.0	28.6
Instruments	14.3	15.4	7.5	3.8
Formation	13.0	18.2	13.5	19.6
Navigation	5.2	6.2	0	0
TOTAL	60.0	65.0	48.0	52.0

1 - Approved Test Syllabus 2 - Draft Syllabus

1. Future Reductions

From an equipment standpoint, future reduction consists of the T-50 and T-51 Instrument Flight Simulators (UPT-IFS); the Undergraduate Navigator Trainer, T-45; the T-43 UNT aircraft; and, the Simulator for Electronic Warfare Training (SEWT).

The UPT-IFS system consists of two T-50 and two T-51 simulator complexes per UPT base with one T-50 and one T-51 complex at the PIT base. The T-50 simulator models the T-37 aircraft and the T-51 simulator models the T-38 aircraft. The T-50 and T-51 simulators are identical except for the respective cockpit sections and aerodynamic computer software. Each IFS complex consists of four simulated aircraft cockpits mounted on six-degrees-of-freedom motion bases. Each cockpit is equipped with an on-axis infinity visual display and an on-board instructor station. The complex is supported by a single digital computation system and a single two-man operator station. Visual scenes are provided to the cockpits by either a terrain model board (TMB) or a night only computer-generated image (NOCGI) visual system. Each UPT base will have two complexes each of TMB and NOCGI providing a 50/50 mix of visual systems on the T-50 and T-51. The PIT base will be equipped with TMB only. Two image generators will time share either a TMB or NOCGI system within a complex. Additionally, an electronic horizon generator is provided for each cockpit display to simulate "VFR on top" when not utilizing a TMB or NOCGI visual display.

One simulator complex for each aircraft at the first installation is configured with additional software and hardware features to provide software support for both the T-50 and T-51 simulators. The equipment design is fully integrated into the basic computer configuration as an additional processing capability without redesign or reassignment of the basic peripheral interface design. The purpose of the IFS Software Support Center is to provide software support for specific mission-related operations requirements and functional hardware/software-related logistic requirements. The UPT-IFS program will not be fully implemented until late 1980 under present procurement schedules. As the IFS system is implemented at each site, all instrument training flights will be accomplished in the simulator with the exception of validation flights. This equates to approximately a 19 percent substitution of simulation for total programmed flying time within the UPT course. As experience is gained with the equipment and training validation data is accumulated, the substitution ratio will be adjusted.

Substitution beyond this level is difficult to forecast and will depend on FOT&E results for the UPT/IFS. Additional flying hour reductions in UPT will not occur until transfer of training is validated using the proposed simulator.

C. IMPACT OF NEW TRAINING CAPABILITIES ON TRAINING PROGRAMS

A cautious approach to simulator substitution for flying training must be adopted to prevent loss of graduate proficiency and assure the receiving commands of students prepared for transition training. The Air Training Command has postulated a progressive program which has the potential of reducing flying training in UPT and PIT to the levels summarized in Table V-7, which shows the relationship between simulator time and flying time for the two major programs.

TABLE V-7. TRAINING PROGRAM SUMMARY

	CURRENT		FUTURE	
	SIMULATOR TIME*	FLIGHT TIME	SIMULATOR TIME*	FLIGHT TIME
UPT [1]				
PER STUDENT	72.8	210	137.2	170.0
STUDENTS/YEAR	2400	--	2400	- -
TOTAL/YEAR (1000 HOURS)	174.7	504	329.3	408
PERCENT CHANGE	--	--	+ 88.5	- 19.0
PIT [2]				
PER PILOT	36.4	125	44.5	100.0
PILOTS/YEAR	800	--	800	- -
TOTAL/YEAR (1000 HOURS)	29.1	100	35.6	80.0
PERCENT CHANGE	--	--	+ 22.3	- 20.0

1 - Approved Test Syllabus 2 - Draft Syllabus

* Simulator time includes all ground based flight crew training devices.

COMMAND PRIORITIES

1. UNTS for UNT (A)
2. UPT-IFS for UPT/PIT (A)
3. SEWT expansion for EWOT (B)
4. Full mission simulator for NBT (D)
5. SEWT replacement for EWOT (D)

D. COMMAND PRIORITIZATION

The Air Training Command has established a priority listing for the acquisition of training devices considering the relative importance of each program along with the urgency of the requirement. The prioritization is provided below along with a Command technology assessment using the following code:

- A - In use or in procurement.

- B - Modification of existing equipment.

- C - New capability needed: Technology is state-of-the-art.

- D - New capability needed: New technology is required.

VI. TACTICAL AIR FORCES (TAF)

A. GENERAL

The Tactical Air Command is the focal point for aircrew training in the Tactical Air Forces. TAC conducts combat crew training squadrons/ replacement training units (CCTS/RTU) using course syllabi developed through the instructional systems development (ISD) approach to training. CCTSs/RTUs conduct formal initial qualification training (IQT) and mission qualification training (MQT) through Basic Operational Training, conversion from one tactical weapon system into another, transition (between different models of the same aircraft), and instructor courses. Tactical mission training is conducted in operational squadrons, after graduation from CCTS/RTU, as continuation training. CCTS/RTU and continuation training programs are summarized in Table VI-1.

TABLE VI-1. TAF FORMAL AIRCREW TRAINING PROGRAMS

AIRCRAFT	CREW MEMBERS (1)	TYPE TRAINING	FLIGHT HOURS PER CREW	NUMBER OF CREWS/YR (2)
F-4D/E	AC, WSO	CCTS/RTU CONTINUATION (3)	26-91 228	640 1777
RF-4	AC, WSO	CCTS/RTU CONTINUATION (3)	15-76 253	174 239
F-111A/D/F	AC, WSO	CCTS/RTU CONTINUATION (3)	23-93 264	125 372
A-7D	P	CCTS/RTU CONTINUATION (3)	19-80 240	79 256
E-3A	AC, CP, N, FE	CCTS/RTU CONTINUATION (3)	65 240	17 71
F-15	P	CCTS/RTU CONTINUATION (3)	29-67 319	176 194
F-4GWW	AC, EWO	CCTS/RTU CONTINUATION (3)	37-58 264	- -
A-10	P	CCTS/RTU CONTINUATION (3)	17-92 276	137 -
EF-111A	AC,EWO	CCTS/RTU CONTINUATION (3)	81 264	- -
F-16	P	CCTS/RTU CONTINUATION	114 387	- -

(1) AC, Aircraft Commander; P, Pilot; CP, Copilot; WSO, Weapon Systems Officer; FE, Flight Engineer; N, Navigator; and EWO, Electronic Warfare Officer.

(2) FY 78 (Includes IPs). (3) Annual Requirement.

TAC has implemented the ISD approach in all major formal training programs and has achieved significant reductions in flying hours through increased use of available simulators and training devices. Simulators were considered as one ingredient along a continuum of media (from study carrels through aircraft) according to the "least cost training device first" concept. The impact of ISD upon TAC CCTS/RTU simulator utilization and flying hours is summarized in Table VI-2. Further flying hour

TABLE VI-2. IMPACT OF ISD APPROACH ON TAC CCTS/RTU AIRCREW TRAINING

AIRCRAFT	FLYING HOUR REDUCTION HOURS (1)	SIMULATOR INCREASES HOURS (1)
F-4 D/E	19.6	39.0
RF-4	34.9	34.0
F-111 A/D/F	4.3	33.6
A-7D	14.6	30.5
A-10	10.0	28.0
F-15	8.5	16.0
F-16	12.6	22.0

(1) Per pilot crewmember.

reductions through increased simulation will be considered carefully so as to have the least risk to individual operational capability (including aircraft maintenance and supply). Projected CCTS/RTU continuation training programs, based upon proposed future simulator capabilities, are summarized in Table VI-3.

In order to precisely determine what simulators can do to fulfill training needs, TAC has initiated a comprehensive simulator certification program (SIMCERT). Aircrew simulator certification is the process of specifying the training capability of a ground-based device (simulator) in a given aircrew training program. SIMCERT is expected to achieve the following objectives:

a. Establishment of performance standards that will ensure simulators are operated and maintained at certified standards;

b. Initial certification to determine the actual tasks or events that can be accomplished wholly or in part in the simulator;

TABLE VI-3. TAC TRAINING PROGRAM SUMMARY(1)

	CURRENT (2)				PROJECTED (3)			
	CCTS/RTU		CONTINUATION		CCTS/RTU		CONTINUATION	
	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME
F-4D/E	39	91	36	228	39	91	36	228
RF-4C	34	75	36	253	34	75	36	253
F-111A/D/F	44	93	36	264	53	80	60	240
A-7D	25	80	36	240	25	80	36	240
F-15	33	74	36	319	55-85	66	60	264
A-10	N/A	92	N/A	276	58-68	68-78	60-64	192-228
F-16	N/A	114	N/A	387	55-85	86	72	325
F-4GWW	N/A	N/A	N/A	N/A	58	60-90	72	240
E-3A (Flt Sim)	40	65	36	240	40	63	36	384
EF-111A TJS	N/A	N/A	N/A	N/A	50	81	82	240

(1) Exact flying hour reductions will depend on the proven utility of each simulation system.

(2) AS of FY 77.

(3) Simulators described in paragraph B.

c. Training effectiveness assessment to determine the degree or amount that training (by task and event) accomplished in the simulator can be transferred to use in the aircraft and credited to each aircrew's total experience level; and

d. Decision criteria and recertification procedures to ensure the certification data base is updated following major modifications or training program changes.

The SIMCERT program is under demand to provide immediate answers, while the means of obtaining these answers is relatively undeveloped. Consequently, the thrust of this early program is to provide more immediate, subjective information while simultaneously developing objective methodology. It is assumed that the confidence placed on simulator certification findings will increase as more objective methodology is developed and applied. Further, a major goal implicit to this program is to implement simulator certification in the shortest time with minimum cost and least expenditure of resources, while assuring acceptable confidence in the findings. Therefore, early efforts to implement a certification program will use an austere methodology that causes minimum disruption to existing management/organizational structures as much as possible, and yet leaves room for growth and change. SIMCERT program development and initial SIMCERT investigations are being accomplished on the F-15 Flight Simulator and the E-3A Flight and Mission Crew Simulators.

The TAF goal is maximum use of available training resources based on training requirements, equipment performance capabilities and maintenance costs. As weapon systems transition from active to reserve forces, training devices from the current inventory (simulators, CPTs, EPTs and PTTs) dedicated to aircrew training in support of these systems, will be transferred with them. Because reserve force units are traditionally more widely dispersed than active units, a shortage of training devices will occur. Training devices which have been shared by several units will suffer reduced utilization because sharing of common assets among widely separated units is not desirable or economically feasible. Additional training devices will be required to support the dispersed locations.

B. TRAINING DEVICE STATUS AND REQUIREMENTS

Five basic tasks are common to both commercial and military aviation: (1) takeoff/land; (2) normal operating procedures; (3) emergency procedures; (4) instrument training; and, (5) navigation. Trainers in use today are oriented toward commercial aviation, and with the addition of off-the-shelf visual systems designed for the airlines, will perform these tasks well. This is where the similarity between commercial and military aviation ends. The following required tasks are unique to military aviation: (1) formation; (2) air refueling; (3) weapons delivery (air-to-air and air-to-surface); (4) tactics; and, (5) electronic warfare. State-of-the-art trainers can provide limited training in these areas. Aircrew training is based upon a "building block"

approach which utilizes various training media including simulators (trainers) and aircraft. Each training device has tasks that it can train best and, therefore, cannot be completely replaced by other media. The following list provides the current status of TAF trainers and provides comments, where applicable, concerning training capabilities:

1. F-4C/D/E

F-4C Operational Flight Trainer (OFT) 4 each
Mfg: Singer (LINK)
Motion: 2 degrees (pitch, roll)
Visual: No
EW: No
Automatic Scoring: No
Location: Torrejon, Boise, Hickam, Capitol MAP

F-4D Operational Flight Trainer (OFT) 10 each
Mfg: Simulation Products Division, Singer (LINK)
Motion: 2 degrees (pitch, roll)
Visual: No
EW: ALR-46A RFT Oct 79
Automatic Scoring: No
Locations: Spangdalem (1), Bentwaters (1), Nellis (1), Luke (1), Holloman (2), Kadena (1), Birmingham (1), Hill (1), and Kunsan (1)

F-4E Operational Flight Trainer (OFT) 16 each
Mfg: LINK
Motion: g-seat/g-suit RFT Jan 79
Visual: TAF ROC 320-74 partially funded, RFT Oct 78
EW: RHAWS, ECM (ALR-46A update RFT Dec 78)
Automatic Scoring: RFT Sep 78
Locations: George (2), Seymour Johnson (1), MacDill (2), Clark (1), Homestead (2), Luke (2), Moody (1), Eglin (1), Hahn (2), Ramstein (1), and Elmendorf (1)

The F-4 trainers are capable of providing good instrument training and effective mission procedures training. The motion system and analog radar have marginal fidelity. Modification of the 16 F-4E OFTs and acquisition of limited three-window dusk/night visual systems will permit training in takeoffs, approaches, landings, and limited air-to-surface weapons delivery in visual conditions. Present motion systems will be deactivated when visual systems are placed on the trainers. Motion cues will be provided by g-seat/g-suit modifications.

2. RF-4C

RF-4C OFTs 7 each
Mfg: LINK
Motion: 2 degrees (pitch, roll)
Visual: No

EW: RHAWS, ECM, (ALR-46A update RFT Jun 78)
Automatic Scoring: No
Locations: Shaw (2), Alconbury (1), Lincoln MAP (1), Bergstrom (1), Kadena (1), Ramstein (1)

The current flight trainers have serious deficiencies which result in use of the simulator as a procedures trainer. Deficiencies including position, attitude, and navigation errors (up to 10 miles between the radar, navigation aids and INS) result from use of an analog computer system, with its inherent gear train lag, slip, and flyback, coupled with an analog radar data base. It also has limited motion and no visual system.

Its instructional capabilities do not include the capability to score a mission on the accuracy of the radar navigation to achieve planned photography. Age and configuration control pose a serious compromise to continued use of the trainers, even for training procedures, as new and improved avionics and sensor systems are procured for the RF-4C. Future systems, now under evaluation and test, cannot be adequately simulated in the existing devices. As the RF-4C is expected to be in active inventory for some time the trainers will require extensive modification to be able to provide adequate training support throughout the life of the aircraft. A modular ROC is being developed to request the required modifications in stages, based upon the need to correct existing deficiencies and provide the improved capabilities of updates to the RF-4C aircraft.

3. F-111A/D/E/F

F-111A Operational Flight Trainer (OFT) 2 each
Mfg: LINK
Motion: 5 degrees (pitch, roll, yaw, vertical, lateral)
Visual: SAC ROC 13-72 funded, RFT Oct 78
EW: RHAWS, ECM, ECCM
Automatic Scoring: No (ROC in development)
Locations: Mt Home (2)

F-111D Operational Flight Trainer (OFT) 2 each
Mfg: LINK
Motion, Visual, ECM, Scoring same as F-111A
Location: Cannon (2)

F-111E Operational Flight Trainer (OFT) 1 each
Modified F-111A, features similar
Location: Upper Heyford

F-111F Operational Flight Trainer (OFT) 1 each (second in procurement)
Mfg: LINK
Motion, Visual, ECM, Scoring same as F-111A
Location: Lakenheath

The current trainer has no visual capability and only a limited radar capability. The addition of a limited visual system, with a growth potential to wide angle and high resolution digital radar to the existing seven trainers and an additional F-111F trainer will permit training in visual and instrument takeoffs, landings, approaches and low-level navigation and limited air-to-ground capability.

4. A-7D

A-7D Operational Flight Trainer (OFT) 5 each
Mfg: McDonnell Douglas Electronic Corp (MDEC)
Motion: 4 degrees cascade (pitch, roll, heave, lateral)
Visual: TAC ROC 11-72 partially funded, RFT May 78
EW: ALR-46A, ECM, ECCM
Automatic Scoring: RFT Nov 78
Locations: Davis Monthan (1), England (1), Myrtle Beach (1)
Buckley (1), Rickenbacker (1)

The current trainer has no visual capability. Addition of a three window, dusk/night visual system to the three TAC and two Air National Guard devices will permit training in visual takeoffs, approaches, landings, navigation and limited air-to-surface weaponry.

5. F-15

F-15 Operational Flight Trainer (OFT) 4 each
Mfg: Goodyear Aerospace Corporation
Motion: 6 degrees synergistic (all axes)
Visual: ROC submitted
EW: TEWS, ECM, ECCM
Automatic Scoring: Yes (limited)
Locations: Luke (1), Langley (1), Bitburg (1), Holloman (1)

The first Cockpit Procedures Trainer (CPT) completed its acceptance test on 8 May 1975, and was delivered to the 58TFTW, Luke AFB, Arizona. Current plans call for seven dual-dome visual air-to-air combat trainers, in addition to the seven OFTs.

6. A-10

A joint TAC/AFSC A-10 Aircrew Training Devices Trade Study was completed in April 1975. The Trade Study identified training devices required to conduct A-10 aircrew training, considering training effectiveness, cost effectiveness, and ecological benefits. Based on preliminary trade study data and the urgency to procure long lead training devices, direction was given in January 1975, to procure two operational flight trainers (OFT) and six dual cockpit weapon system trainers (WSTs); in addition to previously planned CPTs, EPTs, and study carrels. The two OFTs will contain state-of-the-art one window, dusk/night visual display systems.

The WSTs will include a full field-of-view visual system capable of presenting airborne flight targets as well as a wide variety of ground targets, including moving vehicles. A prototype development program (Project 2360), discussed in Section III, will be conducted to develop two competing candidate visual systems. A "fly-off" type test and evaluation will be conducted to select the successful visual system for production. The OFTs will be located at the A-10 TFTW and permit training in all phases of instrument and limited visual flight training, takeoffs and landings, IFR navigation missions, limited air-to-ground weapons delivery, electronic warfare countermeasures, and dynamic integration of aircraft emergency procedures into flight situations.

The WSTs will permit additional training in IFR and VFR takeoffs, landings and approaches (including overhead patterns, and closed patterns); close, route and tactical formation with at least one other aircraft; offensive/defensive aerial combat maneuvering; escort formation; enemy defenses, such as AAA and SAM; air refueling; and, full ground attack roles.

The trade study projected the following flying time reductions:

a. Ten-hour student and support time reduction in CCT with the instrument flight simulators (from 102 hours to 92 hours and from 74 hours to 64 hours),

b. Thirty-four-hour student and twenty-eight-hour support time reduction in CCT with the weapon system trainer. (From 102 hours to 68 hours and from 74 hours to 46 hours), and

c. Ninety-six-hour operational pilot reduction per year with the weapon system trainer (from 288 hours to 192 hours).

The exact reduction will depend on the proven utility of the simulation system.

7. F-16 Combat Fighter (ACF)

a. TAF Requirements

(1) Weapon System Trainer - must provide realistic representation of the mission environment to include the cockpit identical to aircraft configuration and external references including all key visual, audible, and sensory cues. To provide an opponent for air combat and a partner for flight tactics training in both air-to-air and air-to-ground roles, the simulator must be designed as a dual unit consisting of two basically independent cockpits, and displays capable of interacting during other than single ship training.

(2) Two weapon system trainers (WSTs) will be required for the training wing, and one WST for each operational wing.

(3) Cockpit Procedures Trainer - A nonfunctional cockpit procedures trainer similar to those being employed in F-4 and F-15 training. The CPT must be a full-scale mockup of the cockpit with all controls (throttle, stick, knobs, levers) operating with a response and feel similar to those of the aircraft. The controls, however, perform no function. All indicators, gauges, and lights are realistically represented, but also nonfunctional. Visual cues are provided by a reverse projector 35 MM slide display located above the instrument panel. A cassette audio tape player capable of programmed slide advance and pause will control the slide display and provide instructional programs, exercises, and audio cues. Adjacent to the slide display should be a color video tape (3/4") display. Programs requiring dynamic display should be selected for this media.

(4) Four CPTs are required for the Training Wing and one CPT is required for each operational wing.

b. Procurement Plan

On 11 November 1977, a contract was awarded to Singer/LINK, Binghamton, NY for the design, development, and fabrication of the F-16 Operational Flight Trainer (OFT). Delivery of the initial OFT is scheduled for May 1980. The OFT design will incorporate provisions for the following: Digital Radar Landmass Simulation; Adaptive Training; Electronic Warfare Simulation; and, a full-field-of-view visual system (Project 2360). Each OFT will be capable of "stand alone" training, and as growth provisions become available, the OFTs will be paired to form WSTs. The F-16 Cockpit Procedures Trainer is planned to be ready for training by May 1978.

8. E-3A

E-3A Flight Simulator (FS) 1 each
Mfg: Redifon Electronics Ltd., UK
Motion: 6 degrees synergistic (all axes)
Visual: Color takeoff and landing/air refueling, 48 degrees horizontal x 36 degrees vertical, pilot/copilot dual view, camera model
EW: N/A
Automatic Scoring: Yes (limited)
Location: Tinker (1)

E-3A Mission Simulator (MS) 1 each
Mfg: Boeing Company
Motion: Fixed base
Visual: No
EW: ECCM
Automatic Scoring: Yew (limited)
Location: Tinker (1)

The Boeing Company has developed three major training devices:

(1) The Flight Simulator

The Flight Simulator is being utilized in training the two pilot and lfight engineer crew members of the flight crew. There is no provision in the simulator for training the navigator flight crew member. The simulator features a six-degree-of-freedom synergistic motion system, a digital computer and a 36 X 48 degrees-field-of-view visual system (model board). The visual system permits training in instruments and visual takeoffs, approaches, landings, navigation, station keeping and air-to-air refueling. The flight simulator is configured to the Boeing 707-320B aircraft and includes E-3A instrumentation and flight characteristics.

The visual air refueling envelope is limited to the extent dictated by the television model board visual systems. It is considered adequate to provide training from 2 NM behind, and 1000 feet below the tanker to actual hookup. Once the receiver pilot is out of the envelope, he will lose visual contact with the tanker. The flight simulator has a capability for "Split Training." When operating in the "Split Training" mode, pilots may be trained without a flight engineer on-board and vice versa. Additionally, pilots and flight engineers can receive independent training on the same simulator flight.

(2) The Mission Simulator

The Mission Simulator is utilized in training ten of the thirteen mission crew personnel (AFSCs 1716, 1744D, 1744G, 276XD, and A305X4). There is presently no capability to train the following mission crew members in the simulator: Airborne Radio Operator (AFSC A293X3), Avionics Communications Technician (AFSC A328X0), and the Radar Maintenance (AFSC A328X2). TAC identified a requirement to add the Radio Operator and Radar Maintenance Technician positions to the simulator, along with an associated fault insertion capability, which was deleted due to excessive cost. The simulator, as currently designed, will support integrated mission crew training in the control of air-to-air intercepts, close air support, air-to-air refueling, aerial delivery missions, maritime surveillance, aerial surveillance and surveillance of ground forces.

(3) The Individual Positional Trainer (IPT)

IPT is currently scheduled for delivery to TAC at Tinker AFB, Oklahoma in October 1977. The IPT is primarily designed to train AFSC's 17XX and 276X0 in AWACS multipurpose console (MPC) switchology and symbology, but will also allow some computer operator (AFSC A305X4) training.

9. F-4GWW

F-4G Wild Weasel WSTS
Mfg: LINK
Motion: g-seat/g-suit RFT Oct 78
Visual: TAF ROC 320-74 funded, RFT Apr 79
EW: APR-38 IOC Apr 79
Automatic Scoring: RFT Dec 79
Location: F-4E sims at George candidates for modification

A go-ahead to modify four F-4E simulators to APR-38 configuration was given to Ogden ALC and a contract was awarded on 21 July 1977. The Digital Scan Converter Group (DSCG) is to be included in the APR-38 contract; the F-4GWW simulators are to receive modifications presently planned for the F-4E simulators; e.g., g-seat/g-suit/buffet, AFTS and limited field-of-view visuals.

10. EF-111A

A requirement exists for training devices to support EF-111A aircraft training programs. Effective employment of EF-111A aircraft will depend on effective aircrew training programs. The electronic environment (radars, navigational systems, communications networks, etc.), in which this system is designed to operate, is both dense and varied. There are no ranges or alternative facilities which approach this environment in either density or variety. Simulation will provide the only possible avenue of training for many aircrew tasks. Training devices required to support EF-111A aircrew training programs include study carrels, cockpit procedures trainers, part task trainers, and weapon system trainers. A statement of need for these devices has been prepared as an amendment to TAF ROC 315-73, EF-111A Tactical Electronic Warfare Support (TEWS) Aircraft, 30 April 1973.

C. PROGRAM DATA

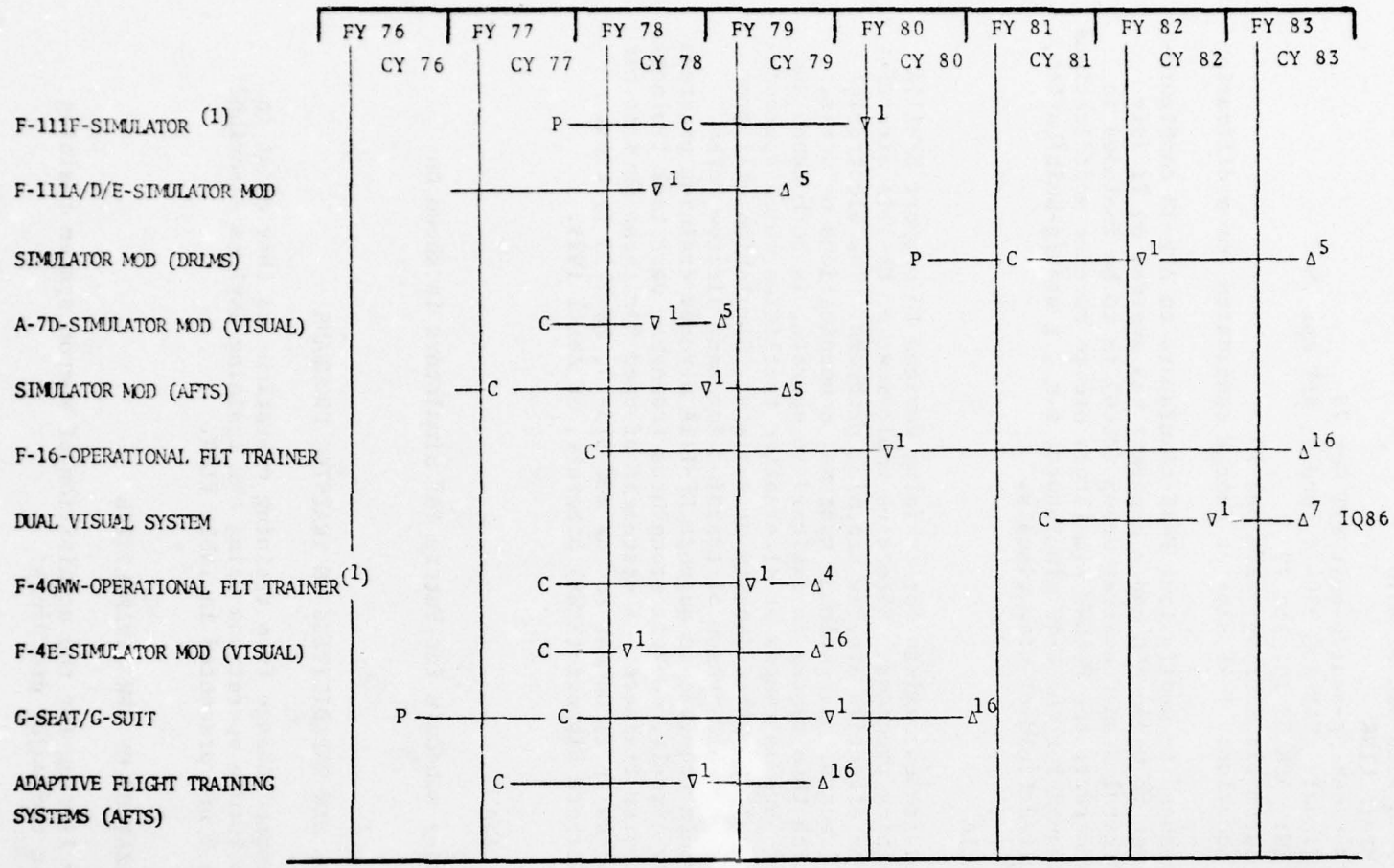
The summary schedule for Future TAF Simulators is shown on Figure VI-1.

D. IMPACT OF NEW CAPABILITIES ON TRAINING PROGRAMS

The estimated change from training operations as they exist in FY 77 versus future operations using the training devices described in paragraph B are presented in Table VI-3.

E. PRIORITIZATION OF NEW CAPABILITIES

Priority listing for the acquisition of weapon system training devices is in two major groupings:



Legend: R = ROC Submission
P = PMD
C = Contract Award

∇ = 1st Delivery Ready for Training
Δ = Last Delivery Ready for Training
(1)= Contract will include Visual, G-Suit and AFTS Mod Under F-4E Program

FIGURE VI-1. Schedule Summary - Future TAF Simulators

GROUP 1 - New Training Equipment for New Weapon Systems

a. A-10 - Operational Flight Trainers, dual cockpit weapon system trainers, CPTs and EPTs.

b. F-16 - Weapon System Trainers and CPTs.

c. F-4G Wild Weasel - Operational Flight Trainers (APR-38 modification to F-4E OFTs under procurement).

d. F-15 - Dual-dome visual air-to-air trainers.

e. EF-111A Tactical Jamming System (TJS) - Weapon System Trainers.

GROUP 2 - New Simulators or Modification of Existing Trainers to Support Existing TAF Training Programs

a. F-4E - Modify existing OFTs to add limited visual system, g-seat/g-suit/buffet, configuration update, and adaptive flight training systems (AFTS). (Under procurement for modification in CY 78).

b. F-111A/D/E/F - Add visual systems, DRLMS, configuration update, and AFTS.

c. A-7D - Add visual systems, configuration update, and AFTS (under procurement for modification in CY 77-78).

d. RF-4C - Add digital computer, configuration update, and AFTS (ROC in process).

F. ADVANCED SYSTEMS

ASD Project 2360 (fighter/attack simulator visual system) will identify the production visual system to be used on A-10, F-16 and other fighter/attack aircraft. This system will be capable of simultaneous performance of air-to-air and air-to-surface operations.

G. TAF MAINTENANCE CONCEPT FOR AIRCREW TRAINING DEVICES

1. Objective

Maximum support of the oeprational requirements by the Air Force with minimum resources is the objective of the maintenance program. Systems design should enable rapid repair at the organizational level and fast restoration of equipment at the intermediate level. Depot level requirements must be kept at a minimum. This must be achieved by designing maintainability and reliability into the simulator. Adequate

documentation must be provided. The simulator must be maintainable at the using unit level by the Air Force technicians to allow for maximum utilization. All simulator technicians must be thoroughly trained.

2. Training

A maintenance task analysis is required to identify the complete maintenance training program for each major system; i.e., visual system, modeling, optics, projection, motion, console, operations, computer, etc., to include part task maintenance trainers and training. Training programs will also include technical maintenance data, such as handouts, alignments, operation of equipment, and software update/modification procedures. Sufficient hands-on training must be provided. Type 1 training will be required for simulator operation and maintenance to include development or modification of visual images and the training required to organically perform software/hardware update and control.

3. Technical Data

Technical publications must be maintenance oriented, prepared, numbered, and distributed using the same procedures currently outlined in Air Force directives. Commercial publications are acceptable if approved by the using command. Simple, straight-forward maintenance instructions and formats must be used to enhance maintainability. Publications must contain the information necessary to enable technicians to test, troubleshoot, remove, repair, replace, adjust, and operate the system/components with the tools, test equipment, and spare parts authorized for the appropriate level of maintenance. The technical data must enable fault isolation to the component at each level of maintenance. In addition, the following are software documentation requirements:

a. Detailed data is required to allow the capability for generation or construction of new visual images (hardware or software);

b. Detailed software support documentation must be included to allow the capability for organic software updating. All software routines utilized by the contractor must be provided. All routines and subroutines provided must include complete documentation (i.e., user manuals, program manuals, mathematical models, program narratives, flow diagrams, detail listings, etc.) to be delivered with the simulator, and

c. The Air Force is to become the sole manager of the hardware and software configuration and base line data.

4. Supportability

a. Reliability and maintainability must be demonstrated during the first 1000 hours of aircrew utilization. Mean time to repair should not exceed 30 minutes. Continuous operational hours should not accumulate more than 0.2 maintenance hours per hour.

b. Source coding, provisioning, and AGE are required to fault, isolate and repair to the bit and piece level. Contractor should provide spares support for a two-year period. This accumulated spares data will provide the basis for future provisioning. Partial provisioning may be required for long lead/high usage items prior to testing and acceptance of the first device.

c. Automatic test equipment should possess the capability for unambiguous fault isolation to include malfunction detection to the module, chassis wiring or chassis mounted component level. To achieve this end, self-test programs must be supplemented with technical data of sufficient range and depth to test loop diagrams in the test procedure. Maximum use of self-calibrating circuitry should be incorporated. The use of proprietary equipment, software or designs must be avoided through the judicious design of the device.

d. The complexity of the maintenance and supply tasks should be minimized by the use of simple design which includes optimum interchangeability; e.g., circuit cards, and use of standardized equipment which meets or exceeds specification requirements.

e. The design must provide for rapid and positive recognition of equipment malfunction or marginal performance. It must also provide for rapid and positive identification of the replaceable defective part/assembly or component and provide for minimum numbers and types of tools and test equipment required to perform maintenance.

f. Requirements for soldering should be reduced by the use of plug-in circuits/components. Special tools or equipment must be held to an absolute minimum. Removal of one accessory component should not require removal of others to facilitate accessibility.

g. Scheduled calibration and alignment requirements for the system or its components should be obviated through maximum use of self-calibrating circuitry.

5. Inspection Requirements

The simulator should be designed toward a goal of no scheduled inspections for electronics or performance characteristics. The areas shall be checked through automated test and calibration programs. Automated routines should be provided that perform daily readiness, performance evaluation, and simulator calibration checks. Daily readiness checks are used to ensure complete systems operation prior to daily operations. These are designed to quickly ascertain subsystem operations and must not exceed a total of 15 minutes. Performance evaluation checks are designed to exercise the total simulator system and subsystems (i.e., input/output devices, computers, motion, etc.). These programs are intended as an in-depth check, as required, to ascertain total systems performance. Calibration checks are designed

to ensure correct subsystems operation conditions under program control using known inputs. Time limitations for performance evaluation and calibration checks should not exceed two hours and should be on an as-required basis. These programs should be designed to operate with minimum operator intervention and once started will sequence under computer control. However, the program should be designed to check functional areas independently. This does not negate the requirement for inspections of hydraulics, mechanics, etc. Any of these scheduled inspections should not require more than one-half hour to accomplish with a crew of two five-level specialists.

6. Operational Flight Program Update Capability

If any on-board computers are used in the aircraft, the simulator must have the capability to be updated in approximately the same amount of time as that required for changing the aircraft computer program itself.

7. Stabilized Power Requirement

The device must be designed to be compatible with the utility and support systems normally encountered at an Air Force installation. Unusual device requirements will be avoided through judicious design of the hardware.

Where they cannot be avoided, peripheral equipment will be provided with the device to satisfy the requirements. For example, ordinary commercial power is normally supplied to flight simulators on Air Force installations. While voltage and frequency are normally held within fairly close tolerance, this does not preclude momentary power interruptions and transients on the circuitry due to lightning and other external disturbances. If the device is sentitive to these conditions, the device must have the capability to:

a. Filter input spikes so no equipment damage shall occur, and

b. Protect itself through such programs as core memory save features and automatic restart procedures.

VII. MILITARY AIRLIFT COMMAND (MAC)

A. GENERAL

1. Command Philosophy

ISD studies have identified numerous synthetic training devices which are essential to both improve the quality of training while reducing training cost and to further progress toward the goal of efficient, individualized training. The MAC goal is to acquire synthetic training devices capable of "bridging the gap" from inanimate mockups and familiarization trainers to the complex and comparatively expensive simulators with dynamic system response and full system interface. A fully individualized program that progresses from simple to complex with programmed student exercises on training devices early in the training program will accelerate learning and enhance retention. MAC must continue to develop efficiently programmed training systems that make optimum use of synthetic training devices if we are to further progress toward the goal of quality, cost-effective, individualized training.

2. Planning Considerations

Numerous factors and events have generated our ever increasing requirement for synthetic training devices.

a. ISD identifies the requirements for a family of trainers to provide training in the least cost device capable of providing the training prior to progressing to more costly media.

b. The crew ratio has experienced large fluctuations which have resulted in an overall increase in training requirements during the build-up phase.

c. Changes in crew structure and responsibilities (tasks), such as the institution of Systems Operator (SO) training has resulted in fundamental program changes in both initial and continuation training.

d. Increased centralized training now includes AC/IP upgrade in the C-5, C-141, and C-130, in-flight refueling in the C-5, and airdrop training in the C-141.

e. Visual systems greatly increases the number of synthetic training tasks that were previously untrainable in these devices.

f. Minimum flying hour training programs results in increased emphasis on the use of the simulators to supplement proficiency.

g. The energy crisis impact demands greater attention to fuel conservation through reduction of unilateral flight training hours.

h. MAC continues to exploit all methods of acquiring synthetic training capability ranging from in-house fabrication to contracting from commercial agencies. For example:

(1) Rendezvous tasks associated with in-flight refueling are trained in the C-5 simulator and a tanker model has been added to the existing visual systems to provide more pilot training,

(2) A commercial simulator with visual tanker model has been leased with excellent results being attained in our C-5 air refueling training program;

(3) New commercial simulators (military configuration) will greatly expand capability in the T-39 and C-9, and

(4) Similarly, simulator improvements in other commercial simulators have expanded capability/requirements.

i. The technology which improves the fidelity of simulator hardware and the computer software driven system response has steadily improved for all simulators. As the fidelity increases, management's confidence in the capability to replace aircraft training tasks also increases. More important, student acceptance of the training and the resultant transfer of skill also increases. Technology has greatly improved the repertoire of instructor tools; for example, adaptive training features in our newer simulators include automated demonstration profiles, evaluation with hard copy print, maneuver record, and replay capability. Instructors now have complete control of the training situation which economizes training as well as increases the number and complexity of training maneuvers available.

j. Increased aircraft acquisition and operating costs highlight the inherent ecomomy and efficiency of synthetic training.

k. Prohibited training maneuvers that cannot be accomplished in the aircraft increase synthetic training time requirements.

3. Key Issues

a. Flying Hour Avoidances

The original impetus to apply ISD to flying training programs was to save money and the application of ISD has resulted in more efficient training. Often overlooked, however, is the ability of the ISD process to significantly improve the quality of the student. By systematically identifying all tasks required to accomplish the mission and determining the most effective method to train, the level of readiness can be increased. A great deal of the defense budget is expended to improve the quality of our military hardware to make our weapon systems more effective. It is reasonable to assume, therefore, that increasing the quality of those that operate the hardware which will also increase weapon system effectiveness is also in the national

interest. Continued flying hour or manpower tradeoffs should not be the sole requirement to justify procurement of training devices when the enhancement of the training program will significantly improve the performance of the weapon system. Any flying hour avoidances achieved through ISD and the use of simulation will result from efficiently programmed training systems that make maximum use of these devices. Neither the training transfer value of specific devices nor the effects of the integration of several devices into a training program can at this time be finitely determined without exhaustive testing. Future projected avoidances are best estimates based on past experiences and must be used with caution. These projections are subject to periodic revision as new knowledge and operational efficiency is gained. Forecast reductions are based on the following assumptions:

(1) All hardware requirements will be met. The MAC plan is for development of a complete instructional system with interdependent parts,

(2) Continuation of the ongoing ISD efforts will be supported with adequate manpower and funds,

(3) MAC and Air Force Regulations will be changed to allow more currency and evaluation requirements to be accomplished via synthetic media in the simulator,

(4) Actual mission flying will be sufficient to maintain pilot proficiency. If the day-to-day requirement for airlift and rescue sorties is significantly reduced, there will not be enough simulator time available to allow proficiency to be maintained in the simulator. Any reduction in mission flying or any increase in proficiency requirements will cause more simulators to be needed,

(5) The number of crews will remain at or below presently projected levels for each weapon system. An increase in the number of assigned crews would cause a corresponding requirement for additional synthetic training devices,

(6) Crew member performance requirements will remain essentially unchanged. Should crew members be required to become proficient in additional skills, planned numbers of simulators may not be sufficient to accomplish required training,

(7) Currency requirements will remain essentially the same as currently established, and

(8) Aircrew flying program cannot be reduced below the level that will result from maintaining airlift system readiness.

b. Formal Aircrew Training Programs

Formal transition training syllabi have been established for MAC aircraft as shown in Table VII-1.

TABLE VII-1. MAC FORMAL TRANSITION AIRCREW TRAINING

Aircraft	Crew Positions	Crews/ Year	Location Formal Training
C-5	Pilot, Navigator, Flight Engineer, Loadmaster	37*	Altus AFB OK
C-141A	Pilot, Navigator, Flight Engineer, Loadmaster, System Operator	145*	Altus AFB OK
CH-3	Pilot, Pararescue, Flight Mechanic	28*	Kirtland AFB NM
HH-53	Pilot, Pararescue, Flight Mechanic	20*	Kirtland AFB NM
UH-1	Pilot, Pararescue	48*	Kirtland AFB NM
TH-1F	Pilot	31*	Kirtland AFB NM
C-130	Pilot, Navigator, Flight Engineer, Loadmaster	360***	Little Rock AFB AR
HC-130	Pilot, Navigator, Flight Engineer, Radio Operator, Loadmaster	18*	Kirtland AFB NM
C-9	Pilot	28*	Long Beach CA (Flight Safety Inc)/Scott AFB IL
T-39	Pilot	167*	St Louis MO (Flight Safety Inc)/Scott AFB IL
C-12	Pilot, Flight Mechanic	25**	Wichita KS (Beech Acft Corp)/ Andrews AFB MD

*FY 77 and beyond based upon the crew position with highest training requirement.

**MAC responsible for all USAF C-12 initial training. One class for MAC; 24 for other users.

***Pilots Phase I transitional course plus pilot upgrade/requalification. Does not include pilot tactical.

c. ISD Activities

Military Airlift Command initiated Instructional System Development (ISD) projects for its flying training programs in February

1972. By using ISD methods, the command has already achieved significant flying hour avoidances in its formal aircrew training programs through the use of synthetic training devices. A summary of these avoidances is shown in Table VII-2. The percentage figures refer to percent change in pre-ISD flying hours devoted to initial training. Initial ISD efforts were oriented toward particular crew positions. Studies now in progress and planned for the future will be oriented toward weapon system crews. The command views ISD as a continuing effort through which efficient and effective training can be achieved.

TABLE VII-2. IMPACT OF ISD INITIAL TRAINING

AIRCRAFT	FLYING HOUR AVOIDANCES/ CREW HOURS	PERCENT ORIGINAL COURSE	NUMBER CREWS/ YEARS	TOTAL ANNUAL FLYING HOUR AVOIDANCES	ANNUAL FUEL SAVED MILLIONS GALS/ YEAR
C-5	12	30	37	444	1.53
C-141	8	22	145	1160	2.53
UH-1*	19	100	25	475	.03
CH-3	36	29	28	1008	.16
HH-53	36	29	20	720	.20
C-130 (PHASE I)**	5	13	240	1200	.94
				TOTAL	5.21

*Saving realized through ISD elimination of H-1 lead-in course for UHT graduates only.

**Original ISD effort conducted by TAC. Avoidances shown are only those realized after consolidation of C-130 under MAC.

NOTE: Flying hours shown reflect change in curriculum hours. Avoidances will be slightly higher based on proficiency graduation.

d. Air Force Simulator Certification (SIMCERT) Program

In October 1977, Hq USAF published AFR 50-11 directing commands to implement a program which allows certification of initial and continuation training maneuvers for performance in the simulator versus the aircraft. For MAC, the affected simulators include the C-5, C-141, WC-135B, CH-3, HH-53 simulators and the upcoming C-130 simulator system. The MAC position may be summarized as follows:

(1) MAC will support the program;

(2) Incorporation of valid simulator acceptance test data in usable format is a prerequisite for optimum and consistent training device performance; and

(3) MAC must keep control of:

(a) Simulator training programs;

(b) Simulator use priorities;

(c) Instructor qualifications; and

(d) The "how much" portion of event substitution in the simulator which is essentially an ISD validation function.

e. Request for Personnel Research (RPR)

MAC currently has two active RPRs which have been validated in accordance with AFR 80-51 and are included in the AFHRL technical program.

(1) RPR 76-20, Aircrew Performance Measurement System

A priority of "urgent" has been assigned this RPR. The stated objective for this project is to evaluate the feasibility of automated performance measurement, as applied to a transport aircraft, in a flight mission simulator. MAC regrets that this otherwise thorough project does not include provisions for objective measurement in the actual aircraft. Development of aircraft instrumentation which could be installed on a noninterference basis would not only complement this project, but would immeasurably contribute to the success of the Air Force Simulator Certification Program (SIMCERT). With the current emphasis on simulation substitution for aircraft proficiency events, we collectively remain delinquent in defining and measuring the parameters involved in "transfer in learning."

(2) RPR 76-21, Prototype Responder Unit for USAF Learning Carrels

This RPR has been validated as a "priority" requirement for research in accordance with AFR 80-51 for inclusion in the AFHRL technical program. The program of adding responder capability to learning carrels has been actively sought by both MAC and ADCOM. Most of MAC's learning carrels were designed for this capability. However, the specific responder unit for which they were designed is no longer being manufactured. Preliminary investigations by AFHRL/TTT and MAC have tentatively identified a replacement responder device. The purpose of the RPR is to obtain a minimum set of the equipment to determine reliability, maintainability, and usability, and to develop procedures and techniques for its potential use.

B. TRAINING DEVICE STATUS AND REQUIREMENTS

Simulators and training devices now owned by MAC are being utilized to the maximum extent possible in accordance with performance characteristics, maintenance requirements, and training requirements.

1. Airlift Aircraft

a. AMST Simulators, Cockpit Procedures Trainer, and Part Task Trainer

Based on planning factors established in the employment concept for the advanced medium STOL transport, June 1975, and experience gained through the systems approach to training in other weapon systems, a broad spectrum of synthetic training device requirements are envisioned for the AMST. Should changes occur in any one of the planning factors; such as, the number of operational locations, crew ratio, aircraft utilization rate, the number of aircraft to be delivered, the crew complement, etc., it will dictate necessary adjustments in the training plan. Also, new innovations in the field of education and training or advances in technology may dictate additional changes to this plan.

(1) Training Unit:

Weapon System Trainer	3
Cockpit Procedures Trainer	2
Part Task Trainer	2
Loading/Rigging Trainer	1

(2) Operating Units:

Simulators	6 (1 each wing)
Cockpit Procedure Trainer	6 (1 each wing)

Weapon System Trainer

This simulator must realistically reproduce the wartime situations for which the AMST is designed. The simulator must be a replica of the AMST with the addition of instructor stations. Whenever possible the actual instruments should be stimulated rather than functionally simulated. Visual systems should provide sufficient field-of-view, content, and resolution to allow low-level navigation in the 50 feet to 2000 feet AGL flight regime. It should also provide the proper perspective and relative movement to give both pilots sufficient cues for landing and other close-in maneuvers such as aerial refueling and formation. The motion system must provide proper somatic, kinesthetic, and prospective cues to provide sufficient realism to enable a pilot to make smooth positive corrections during normal and emergency situations. Emphasis should be placed on proper control loading and yaw cues primarily in low speed maneuvers. In addition, the visual and motion systems should have no perceptible lags. Aural

cues pertinent to task confirmation such as system activation, touch down and receiver connection during aerial refueling must be included. The instructor station should include all of the state-of-the-art advances in CRT display systems to relieve the instructor workload. Such features as software generated terrain charts and approach profiles with a hard copy reproduction capability should be included. Also, preprogrammable system faults to include controllable circuit breakers are to be provided. For proficiency training, some form of adaptive training with instructor identified and controlled parameters should be considered. This station must also have computer generated demonstration capability. Finally, a replay of the mission highlighting improper responses and out of tolerance maneuvers should be provided. A hard copy of these results should be available for training and standardization records.

Cockpit Procedures Trainer

These trainers must be a full-scale replica of the AMST cockpit capable of demonstration and practice of all normal and emergency procedures. All controls and indicators must function as they do in the aircraft; however, no motion, visual, or aerodynamic performance capability is required. The instructor will have adequate controls to place the trainers in any preprogrammed configuration, altitude, air speed, geographic position, or emergency situation to provide realistic normal and emergency training and evaluation of student responses. Student responses to these situations will result in the actual electromechanical and aural indication as found in the aircraft.

Part Task Trainer

These trainers will be system/functionally separated to provide normal procedures and critical task performance on the individual system. They will duplicate normal indications and selected fault indications to provide interactive training in preparation for CPT and MFS training. Computer Aided Instruction (CAI) should be considered whenever it is feasible and cost-effective. A slide-tape presentation to introduce the material and review the appropriate procedures is required. The student shall have a basic understanding of the system's operation from previous academic classroom training. These trainers will be used to confirm understanding of these systems and should provide some objective scoring capability. It should also prepare the student for malfunction analysis and other complex tasks performed in the CPT and MFS.

Loading/Rigging Trainer

This device should be an exact replica of the AMST cargo compartment with an operable winch and functionally simulated loadmaster equipment that is permanently installed in the aircraft (oxygen, PA, lights, etc.). Actual life support equipment should be capable of being installed and removed. Floors should be stressed

with properly located tie-down fittings, rails, locks, and rollers to enable actual equipment to be on-loaded, tied down, and off-loaded. The trainer should also accept proper airdrop, bulk POL, and aeromedical configurations. All doors and plugs must open and close as they do in the aircraft to provide emergency egress training (the pressure, petal, and ramp doors may be functionally simulated, but must provide for malfunction analysis training). This trainer will be used to train loadmasters, aerial port personnel, and combat control teams in the basic technical skills required to safely perform their duties.

b. C-5 Cockpit Procedures Trainers (MAC ROC 2-73)

A contract was awarded in November 1976 for construction and installation of three C-5 CPTs. Units are scheduled for delivery as follows:

Location	Ready for Training Date
Altus AFB	August 1978
Dover AFB	October 1978
Travis AFB	January 1979

MAC ROC 2-73 also included a requirement for three independent satellite navigation stations (ISNAVs). These units were to consist of complete duplicate setups of navigator and instructor stations to be located outside the actual simulator cab. The main simulator computer drives the navigation exercise, and the route is independent of that flown by the simulator. The requirement was validated based on the current situation where approximately 40 percent of available C-5 simulator time is dedicated exclusively to training navigators. During the 10 December 1976 PRC meeting, the triple redundant Inertial Navigation System (INS) was approved for the C-5 force. Based on this change in avionics configuration and the anticipated decrease in navigator training requirements, AF/RDP asked MAC to reevaluate the required ISNAVs and if still found justified, to brief the Simulator Panel on 18 March 1977. Hq MAC advised on 14 February 1977, that due to the uncertainty of the final navigation station configuration and the training requirements remaining at this station, the ISNAVs in current specified configuration could not be justified. However, some type of independent training device may be required when the crew station configuration and resulting training objectives become known.

c. C-141 CPTs (MAC ROC 21-70)

Procurement of seven C-141 CPTs remains in a delayed status due to multiple revalidations of the functional navigator station requirement. At this time the PMD specified four units without any navigator stations and three units with nonfunctional navigator stations. The requirement for physical separation is included for the benefit of group instruction. Functional separation (each crew station can operate independently) was deleted due to excessive cost. Provisions for audio-

visual self-paced instruction at the pilots and engineer station are included. Request for proposal is anticipated on 1 May 1977 with contract award scheduled for approximately 30 September 1977. First unit should be ready for training in May 1979; seventh unit in June 1980. Time spent in these devices will prepare crew members to more effectively use mission flight simulators thus freeing the more complex devices for tasks which optimally utilize their unique simulation capabilities. CPTs will provide engine run training for maintenance personnel, engineer preflight training, and normal and emergency procedures practices for the entire crew. These procedures can be practiced at regular intervals and can be certified as satisfactory before using the simulator.

d. Limited Visual Systems for C-5 and C-141 Flight Simulators Assigned to Airlift Wings (MAC ROC 5-73, PMD R-Q-5093-(1)

This modification will provide visual displays for three C-5 simulators and seven C-141 simulators at operational strategic airlift wings. A state-of-the-art night/twilight computer generated image (CIG) system was found to be adequate for the continuation training of qualified crews and a contract was awarded on 21 February 1977 for seven Redifon Novaview 6000 units to be installed as follows:

WST	Location	Ready for Training	Remarks
C-5	Travis AFB	August 1977	Prototype
C-141	Travis AFB	August 1977	LINK Prototype
C-5	Travis AFB	October 1977	
C-141	Charleston AFB	November 1977	
C-5	Dover AFB	November 1977	
C-141	McGuire AFB	February 1978	
C-141	Norton AFB	March 1978	Curtiss-Wright Prototype
C-141	McChord AFB	March 1978	

This modification will allow training which requires a more complete set of visual cues to be accomplished in the simulators. The visual system is expected to increase the synthetic training value of existing simulators, improve efficiency, and reduce unilateral flying training. Annual continuation and upgrade training are forecast to decrease by about four hours per C-5 pilot and by about four hours per C-141 pilot when these systems become operational. The potential payoff is large in comparison to the acquisition cost.

e. C-130 Mission Flight Simulator/CPT (MAC ROC 22-71/TAC ROC 16-71).

Hq MAC was advised on 25 January 1977 that a contract had been awarded for one pilot production/test C-130E mission flight

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simulator and two CPTs. A contract option exists and is funded for an additional nine simulators including the HC-130P, H model and E-AWADS configruations. First buy units will go to Little Rock AFB with follow-on units to be located as follows:

Type	Location	Ready for Training
C-130E	Little Rock AFB	November 1980
C-130E	Little Rock AFB	December 1980
HC-130P	Kirtland AFB	January 1981
C-130E AWADS	Pope AFB	February 1981
C-130H	Dyess AFB	March 1981
C-130E	McChord AFB	April 1981
C-130E	PACAF	May 1981
C-130E AWADS	Little Rock AFB	June 1981
C-130E	Little Rock AFB	July 1981

In addition to providing better and safer training for C-130 crews, this device is expected to yield savings in fuel and O&M cost both in initial and continuation training. The simulators will have the capabilities of six-degrees-of-freedom motion base and visual. It will include pilot, copilot, and flight engineer positions and will be capable of all normal and emergency procedures training to include all in-flight malfunctions. A multiwindow, multichannel day/night computer generated image visual system has been identified as optimum for the C-130 simulators to satisfy tactical training requirements. This visual system will be procured under separate contract but be interfaced with the simulators prior to delivery due to the shorter lead time required. The day/night system will allow simulator training in tactical maneuvers, LAPES, station keeping and airdrop.

2. Rescue Aircraft

a. Ch-3/H-53 Flight Simulator Visual System (MAC ROC 1-73)

MAC has two helicopter flight simulators to train Aerospace Rescue and Recovery Service (ARRS) CH-3 and HH-53 crews. These simulators incorporate state-of-the-art technology except that no visual systems have been provided. The fact that ARRS helicopter operations are largely conducted in conditions of visual contact with the ground makes the addition of visual systems a potentially great improvement to the training effectiveness of these devices. The Air Staff Board Simulator Panel recommended coordination to view systems used by other services. The development of computer image software capable of simulating the many aspects of ARRS helicopter mission was until recently beyond the state-of-the-art. However, it is now technically feasible to provide the required capabilities using day/night computer generaged imagery visual system hardware currently available. Image generation

software designed to provide appropriate cues for tasks such as probe and drogue aerial refueling, mid-air retrieval system, radar homing and warning system operations, and confined area and seascape maneuvers requires development and demonstration which is considered a moderate to low risk effort. Three possible configurations were discussed by representatives of USAF/RDQPS, MAC, ARRS, 1550 ATTW, OO-ALC, and ASD/SD24 during a meeting held at Hq MAC on 19-20 January 1977:

(1) Alternative A is a day/night raster scan system consisting of seven windows for each simulator which provides full field of-view for both the pilot and copilot;

(2) Alternative B, also a day/night raster scan system, consists of five windows per simulator. The pilot's field-of-view is the same as Alternative A. The copilot is provided only the straight ahead forward view; and

(3) Alternative C is a day/night calligraphic system using the same window arrangement as Alternative B. Revised procurement milestones call for contract award in October 1978 and ready for training during the last quarter of CY 1980.

b. CH-3/HH-53 Cockpit Procedures Trainers

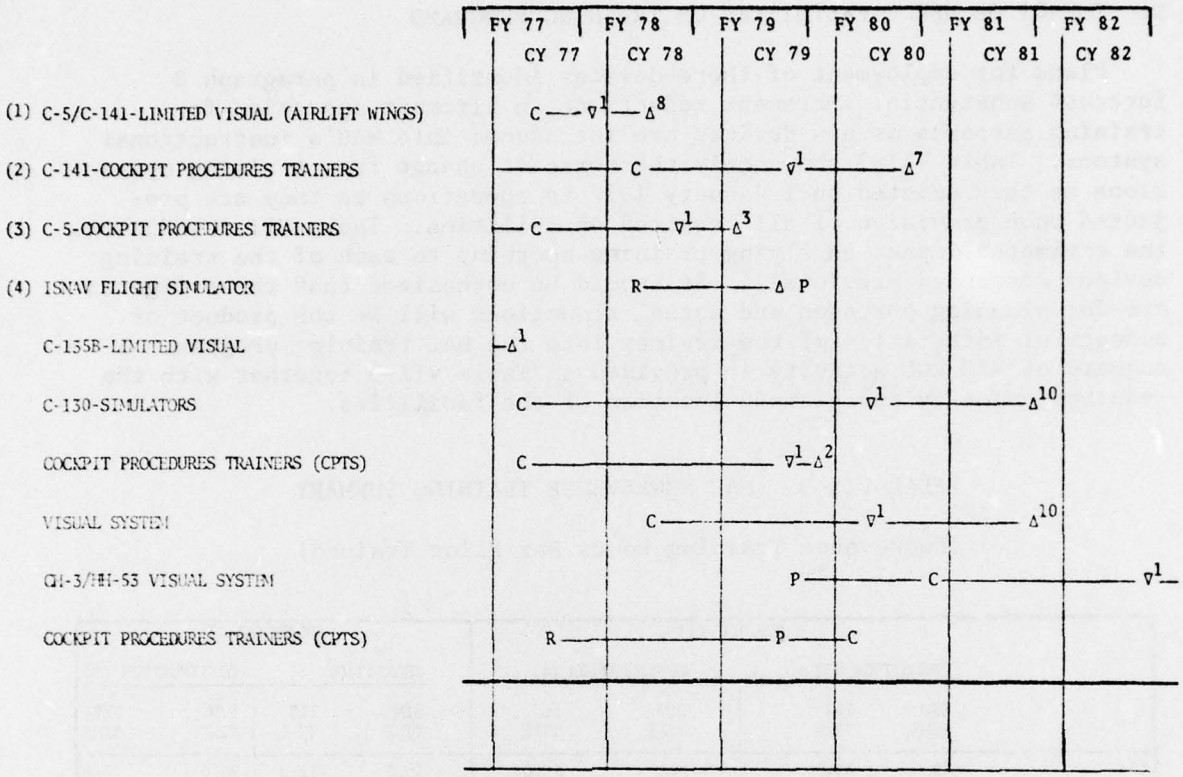
The acquisition of one CH-3 CPT and one HH-53, which incorporate full instrumentation and working indicators, will allow procedural training now conducted in aircraft to be performed in simulators. It is expected to allow extensive reductions in flying time necessary for both initial transition training and annual continuation and upgrade training for CH-3 and HH-53 pilots. The extent of the reduction possible will depend on both the fidelity of simulation and on changes to existing regulations.

3. Commercial Contract Simulators

For those weapon systems that are too limited to justify Air Force ownership of the simulator or that we have previously been unable to justify on a cost-effective basis, such as T-39/C-9/VC-6/VC-137/VC-140, we annually acquire simulator training through commercial contracts. Although excellent training is provided, noteworthy deficiencies in these programs are the configuration differences between civilian and military aircraft and the uncontrollable cost variables of the contract. MAC ROC 7-74 for a C-9 simulator was terminated by the MAC Council on 12 October 1976. Contract renewal for T-39 simulator training was approved on 24 February 1977.

C. PROGRAM DATA

Figure VII-1 is the planning schedule for future MAC simulators.



Legend: R = ROC Issued
P = PDM
C = Contract Award
∇ = 1st Delivery (RFT)
Δ = Last Delivery (RFT)

(1) Contract for Redifon Novaview 6000 Night/Twilight Visual Systems Awarded on 22 February 1977.

(2) Program in Delay Status due to INS Configuration and Effect on Crew Complement.

(3) Contract Awarded in November 1977.

(4) Independent Separated Navigator Stations for use with C-5 Flight Simulators in Delay Status due to Triple INS Modification for C-5 Fleet.

FIGURE VII-1. MAC Planning Schedule

D. IMPACT OF NEW CAPABILITIES ON TRAINING PROGRAMS

Plans for employment of those devices identified in paragraph B forecast substantial increment reductions in aircraft operation for training purposes as new devices are introduced into MAC's instructional systems. Table VII-3 shows only the forecast change from training operations as they existed on 1 January 1977 to operations as they are projected upon provision of all required capabilities. Table VII-4 indicates the estimated impact on flying training accruing to each of the training devices discussed previously. It should be emphasized that these figures are for planning purposes and actual reductions will be the product of successful integration of the devices into the MAC training program. A summary of MAC ROC activity is provided in Table VII-5 together with the required quantity and planned location of the facilities.

TABLE VII-3. MAC NONREVENUE TRAINING SUMMARY

(Nonrevenue Training Hours Per Pilot Trained)

	CURRENT (1)				PROJECTED (2)			
	TRANSITION (3)		CONTINUATION (4)		TRANSITION (3)		CONTINUATION (4)	
	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME
C-5	22.5	14.0	14.0	22.0	36.0	12.0	20.0	14.0
C-141	22.5	15.0	14.0	22.0	42.0	2.5	20.0	10.0
H-1	0	43.0	0	50.0	0	43.0	10.0	40.0
CH-3	25.5	45.0	7.5	47.0	51.0	25.5	15.0	33.0
HH-53	25.5	45.0	7.5	47.0	51.0	25.5	15.0	33.0
HC-130	0	38.0	8.0	95.0	20.0	19.0	22.0	30.0
C-130	17.0	37.5	12.0	52.5	20.0	21.0	22.0	26.5
C-9	10.0	12.0	8.0	6.0	16.0	4.0	26.0	2.0

(1) As of 1 January 1977.

(2) When all planned modifications and new procurements of training devices have been implemented into the training program.

(3) Per pilot, since other devices primarily affect the availability of training devices for pilot use.

(4) Hours per pilot per year.

NOTE: Proposed 10-hour H-1 continuation training to be conducted with Army.

TABLE VII-4. ESTIMATED FLIGHT TIME REDUCTIONS DUE TO SIMULATORS

ROC NUMBER	TITLE	TRANSITION FLIGHT TIME	CONTINUATION FLIGHT TIME
21-70	C-141 COCKPIT PROCEDURES TRAINER	2	4
22-71	C-130/HC-130 SIMULATOR/CPT	16.5/19	26/65
1-73	H-3/HH-53 VISUAL SYSTEM (HILL)	19.5/19.5*	14/14
2-73	C-5 COCKPIT PROCEDURES TRAINER	2	4
5-73	C-141/C-5 LIMITED VISUAL SYSTEM (AIRLIFT WINGS)		4/4
DRAFT	C-141 SIMULATOR	10.5	4

* With the advent of simulators at Hill for the H-3 and H-53 program, flight time decreased from 88 hours in both courses to 45.0 in the H-3 and H-53. Both courses now require 25.5 hours in the simulator. The visual system will further reduce requirement to 25.5 per course.

TABLE VII-5. SUMMARY - MAC ROC ACTIVITY

ROC NUMBER	TITLE	SUBMITTAL DATE	QUANTITY	ANTICIPATED FMD	BASE
27-70	C-141 COCKPIT PROCEDURES TRAINERS	12 OCT 70	7	16 JAN 74	2 ALTUS 1 EA AIRLIFT WING
22-71	C-130 SIMULATOR/CPT	23 SEP 71	10/2	19 JUN 72 T-Q 2-141	5/2 LITTLE ROCK, 1 HILL, 1 POPE, 1 DYESS, 1 MCCHORD, 1 PACAF
1-73	H-3/HH-53 VISUAL SYSTEM (HILL)	21 APR 73	2	16 NOV 73 R-Q 4-033	2 HILL
2-73	C-5 COCKPIT PROCEDURES TRAINERS	30 MAR 73	3	16 JAN 74* R-Q 4-54	1 ALTUS, 1 DOVER, 1 TRAVIS
5-73	C-141/C-5 LIMITED VISUAL SYSTEM (AIRLIFT WGS)	27 AUG 73	8	14 MAR 74 R-Q 4-54	1 DOVER, 3 TRAVIS, 1 MCGUIRE, 1 MCCHORD, 1 NORTON, 1 CHARLESTON
DRAFT	C-141 SIMULATOR	JAN 78	6	JUN 80	1 EA AIRLIFT WG
STUDY	C-5 SIMULATOR	JAN 78	3	JUN 79	1 DOVER

* Contract awarded Hydrosystems, Inc., November 1976.

E. COMMAND PRIORITIZATION OF NEW CAPABILITIES

Due to the interdependency of the individual devices in a total training system, it is not possible to adequately prioritize requirements based strictly on projected savings. For example, the procurement of visual systems will not allow an appropriate reduction of flying hours until an additional device (CPT or additional simulator) is provided to free the presently fully utilized simulator for additional visual training. Devices are prioritized below:

1. Near Term Delivery of Validated and Identified ROCs:

   a. Limited visual systems for airlift units (MAC ROC 5-73);

   b. Ten C-130 simulators and two CPTs (MAC ROC 22-71);

   c. Visual system for helicopter simulators (MAC ROC 1-73); and

   d. C-5/C-141 cockpit procedures trainers (MAC ROC 2-73 (C-5) and MAC ROC 21-70 (C-141)).

2. Equipment Required to Provide Increased Training Capabilities:

   a. Six additional C-141 simulators (Draft ROC);

   b. C-5 simulator (planning stage); and

   c. Cockpit procedures trainers for CH-3/HH-53 (planning stage).

VIII. STRATEGIC AIR COMMAND (SAC)

A. GENERAL

1. Command Philosophy of Training

SAC, as a specified command, has an overall mission to deter aggression by developing and maintaining a viable, responsive, nuclear retaliatory force. This force is composed of operationally ready weapon systems, each designed to satisfy a particular Emergency War Order (EWO) objective. Successful deterrence is based upon credibility of the weapon system, and the key to weapon system credibility rests with the man/machine interface (the sum total of vehicular and crew performance). Thus, an untrained crew member compromises the integrity of the entire weapon system.

Operational crews are managed as organic subsystems. It is the responsibility of the Operations and Training Directorate to prepare the aircrew for performance in combat. The training concept is divided into three phases of development: initial qualification; mission qualification; and, continuation combat crew training.

Initial qualification of aircrews consists of transition training into the actual aircraft in which the crew is to become qualified. Initial qualification crew resources are obtained from undergraduate school or some other weapon system.

The initial qualification phase, commonly referred to as Combat Crew Training (CCT), consists of the application of discrete behavioral disciplines which adapt previously learned skills to the new weapon system. The training strategy employed consists of: (1) defining the objectives of the CCT phase of training; (2) working back through ISD (Instructional System Development, AFM 50-2 and AFR 50-8) analysis to define specific behavioral objectives or training tasks; and, (3) selecting the most cost effective training media which meet these objectives. CCT training media range from mockups and carrels, to advanced simulators, and the aircraft itself. Adequacy and efficiency of the training devices are judged on their capacity to effectively implant in the student the proper reaction to the sum total of sensory cues presented. Subjective as this transferability is, history has indicated that the learning experience is a direct function of the fidelity of the specific device.

Tactical/mission qualification, the second phase, is aimed at certifying the student in his specific unit's mission. The unit mission is dynamic and changes as requirements change. Training tasks of this phase must, therefore, change as the mission changes. Because of these variances in training tasks and objectives, the training syllabi must be dynamic and adaptable. The training media, therefore, must be flexible in order to adapt to these changes.

The continuation phase, the third phase, consists of recurring skill maintenance activity. The purpose of this training is to provide the optimum exposure to specific behavioral objectives to ensure necessary skills are retained. Bomber aircrew training programs are constrained by the inability to practice tactics in the EWO environment. Simulators of the required fidelity can provide training in a realistic, simulated EWO environment which will enhance aircrew combat readiness.

The ever increasing number of aerial refuelable aircraft in the Air Force inventory has made the inflight refueling training program the largest in the free world. Significant reductions in inflight refueling training are potentially attainable if training program managers make positive commitments to the use of ground-based devices to train the aerial refueling task.

2. ISD Activities

SAC has historically employed concepts similar to ISD in developing and updating its training programs. ISD efforts, between 1973-1975 included contracts for analysis of the B-52 and KC-135 training syllabi. The outcome of these contracts was a base line training syllabus for each aircraft with defined and quantified training equipment requirements. Prior to contract completion, weapon system ISD teams were organized, consisting of a mixture of rated Curriculum Development Managers and ISD advisory/technical personnel. These teams will complete the ISD work at each operational Combat Crew Training Squadron (CCTS).

The B-1 ISD began with a SPO funded contract. The result was a training syllabus and definition of training equipment. SAC training managers analyzed CALSPAN's Systems Approach to Training Report, modified training equipment configuration consistent with current state-of-the-art equipment, and refined hardware requirements for the B-1 aircrew training devices. This work is being phased out due to recent decisions by the President relative to the B-1 program.

It is expected that the flying training ISD team efforts will result in better prepared aircrews, effective use of existing and future training devices and a reduction in actual inflight training time while maintaining or improving flying safety standards.

Although the equipment required for all programs will be a combination of egress trainers, audio-visual training stations, part-task trainers, procedures trainers and simulators, only the simulator and more sophisticated crew station trainer requirements are addressed further in this document. The other training media are less expensive and are designed as logical training media progressions leading to the simulator.

In an effort to define B-52 and KC-135 skill maintenance needs, rigorous tests are conducted using various training media with cross

sections of qualified aircrews. An example of this type of analysis was the GIANT SAMPLE test program. A fundamental objective of this test was to determine if aircrews at selected test units could maintain a desired level of proficiency through increased use of existing simulators and decreased flight exposure. SAC collected and analyzed raw data on test group proficiency levels by individual crew position. The comparison between test and standard/control units was based upon the number of hours flown and the frequency of event accomplishment. An accurate assessment of test group performance degradation was not possible due to an inability to measure crew member performance in the existing simulators. This deficiency will be corrected in the advanced B-52/KC-135 mission simulators.

3. Simulator Certification

The command is actively engaging in extensive program development for simulator certification and validation of aircrew training devices. This effort has been formally initiated through AFR 50-11, Management and Utilization of Aircrew Training Devices, which was published in October 1977. The implementation milestones and command guidance will first appear as a programming plan and be followed by a series of SAC supplements to the Air Force Regulation.

The Strategic Air Command utilizes a wide range of aircrew devices to accomplish initial skill acquisition and continuation instruction. The current inventory includes simple cockpit familiarization trainers, cockpit procedures trainers and mission trainers. Ongoing procurement actions will provide the added capability of part-task trainers and new weapon system trainers to the command's future instructional programs. Each of these devices will be incorporated into the certification process.

Although much of the necessary base line data to implement such a program is not currently available for present day devices, action is being taken to develop the required information and to ensure future system procurements provide this documentation.

It is anticipated that simulator certification will furnish the command with a more suitable means of maintaining aircrew training devices while achieving maximum training utility through effective application.

a. New Device Procurements

For new procurements, SIMCERT will start during the conceptual stage with the objective of justifying the training requirements which necessitate the acquisition of the new or modified device. SIMCERT will continue throughout the development, procurement, and life cycle of new devices. SIMCERT will be an integral part of Initial Operational Test and Evaluation (IOT&E), Operational Test and Evaluation (OT&E), and Follow-On Operational Test and Evaluation (FOT&E).

During IOT&E, formal certification and documentation gathering will begin. Not only will the device hardware and associated software be evaluated, but the training curriculum must also be certified. The results will provide certification of the training system and will ensure that the hardware can satisfy operational requirements. The SIMCERT program will provide objective data to assist in further production decisions or necessary system configuration changes effecting training.

During CT&E/FOT&E and throughout the systems life cycle, periodic evaluations will be made of the device and curriculum to ensure that training requirements are being met.

b. Existing Devices

For devices that already exist in the Command's inventory, training requirements, and performance standards developed through actual use of the system must be documented and certified. The devices will then be certified on a continuing basis.

c. Problems Envisioned

The SIMCERT program, as published, is no panacea for the unknowns associated with modern training devices or accompanying training programs. SIMCERT compounds some of the existing problems in documentation of training requirements, establishment of hardware performance standards, software validation, and the administration of transfer of learning studies necessary to certify the system. The operational utility of these state-of-the-art training systems can only be determined through actual experience.

This program will require extensive assistance and support from the Air Force Human Resource Laboratory (AFHRL) in the conduct of learning studies and in rendering expert behavioral science opinions. Hopefully, through the combined efforts of AFHRL and the expertise existing in the command, these problems will be solved so that a realistic and viable SIMCERT program will result.

4. Impact of High Fidelity Simulation

A majority of training devices currently supporting SAC aircrew training programs is based on 1950 simulation technology. An inability to provide periodic update and subsequent device replacement has resulted in the necessity to maintain instructional systems consisting primarily of high cost inflight activity. Recent technological advancements in the areas of flight simulation and aircrew training can reverse this trend and contribute to sizable reductions in the flying time required for aircrew initial skill acquisition and proficiency maintanance training programs.

The capability to accurately generate representative aerodynamic information and handling characteristics in simulators provides

broad, new training dimensions within SAC programs. Simulators provide the vehicle to practice combat and emergency procedures prohibited inflight by safety constraints. Aircraft emergencies and aircrew corrective actions heretofore restricted to the classroom will become routine additions to the simulator training syllabus. The ability to create a realistic environment for low-level flight will provide the opportunity for each aircrew member to develop, experience and evaluate the necessary skills to successfully perform an Emergency War Order (EWO) mission. This need for a low-level capability is becoming more critical as ecological and air space saturation limit the establishment of low altitude training routes.

A major shortcoming of SAC's current training devices is the lack of realistic radar landmass simulation. The mission requires low altitude flight in a high threat environment in all weather conditions. Simulation of radar, electrooptical viewing systems and terrain following radar sensors is critical to SAC aircrew training. With current development of the Defense Mapping Agency Digital Data Base and advancements in technology, digital radar landmass simulators can provide the ground training capability required to reduce inflight training in the critical aircrew skills.

One of the most costly maneuvers generated in support of aircrew training is that of aerial refueling. The addition of high fidelity air refueling simulation to Air Force training programs is anticipated to make significant decreases in future receiver training requirements. Specifically, there is confidence that there will be excellent transfer of training for refueling simulation. Hence, it will be possible to reduce SAC receiver requirements approximately 60 percent. This reduction represents not only a decrease in flying hours for the receiver training program Air Force-wide, but is also a significant contribution toward reducing the KC-135 flying time required to support user training activity. In order to maximize the benefits inherent in flight simulation, it is imperative that an air refueling capability be included in future ground-based media for receiver aircraft.

Weapon System Trainers (WSTs) will improve skill and knowledge of each crew member while saving flying training dollars by reducing required inflight training hours, however, this represents only a portion of the overall impact of the proper implementation of flight simulation. Conservation of the Nation's scarce resources, preservation of the environment, airframe life extension, and personnel safety all make it mandatory that every effort be made to ensure future aircrew training programs incorporate the full benefits derived through ground-based simulation.

B. TRAINING DEVICE STATUS AND REQUIREMENTS

1. At present, SAC conducts combat crew training for aircrews of the following aircraft: B-52D/G/H; KC-135; RC/EC-135; FB-111; U-2; and,

SR-71. An aircrew training program for the B-1 was being developed to support an initial qualification course which would have produced combat ready aircrews beginning in FY 80.

a. B-52

The B-52D, G and H aircraft are projected to have a service life extending into the mid to late 1990s. The training devices in use are analog units procured during the 1950s. Static trainers are utilized at the CCTS while static or rail mounted units serve the operational wings. These devices are being utilized to the maximum extent possible. Continued utilization at this rate is hampered by the increasing difficulty being experienced in procuring spare parts. The vendors, at least those that still exist, have long ago ceased production of similar analog units.

The current SAC training program summary is presented in Table VIII-1.

TABLE VIII-1. SAC TRAINING PROGRAM SUMMARY

	CURRENT				PROJECTED			
	TRANSITION		CONTINUATION		TRANSITION		CONTINUATION	
	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME	SIM TIME	FLT TIME
B-52D								
PILOT/COPILOT	39	159.1	24	264				
OFFENSIVE SYSTEM	18	159.1	36	264	SAME	SAME	SAME	SAME
DEFENSIVE SYSTEM	36/37*	159.1	42/44*	264				
B-52G								
PILOT/COPILOT	39	159.7	24	264	195	79.8	143	204
OFFENSIVE SYSTEM	18	159.7	36	264	175.2	79.8	160	204
DEFENSIVE SYSTEM	36/37*	159.7	42/44*	264	187.2/181.2*	79.8	142/146*	204
B-52H								
PILOT/COPILOT	39	159.7	24	264	195	79.8	143	204
OFFENSIVE SYSTEM	18	159.7	36	264	175.2	79.8	160	204
DEFENSIVE SYSTEM	36/37*	159.7	42/44*	264	187.2/181.2*	79.8	142/146*	204
KC/EC/RC-135								
PILOT/COPILOT	37	76	24	176	100	38	103	144
NAVIGATOR	8	76	0	176	75	38	114	144
BOOM OPERATOR	0	88	0	176	79	38	84	144
FB-111								
PILOT	70	61	56	150	SAME	SAME	SAME	SAME
NAVIGATOR	63	29	56	150	SAME	SAME	SAME	SAME

* EWO/GUNNER

(1) Flight Trainer

The existing flight trainers are actually cockpit procedures trainers (CPTs). No motion system is provided. Performance characteristics are based upon empirical data. No visual system is incorporated, nor is there any electrooptical capability. Three of these CCTS owned analog CPTs have upgraded cockpit configuration and new digital computers, but still do not have visual or motion system.

SAC ROC 7-73 has been validated for a limited air-to-air refueling part task trainer. A prototype production program is underway with delivery to SAC scheduled for March 1978. This device will provide the test base for Air Force-wide receiver refueling trainers.

The training devices needed for adequate training in conjunction with reduced flying are digitally controlled simulators which incorporate the following: a six-degree-of-freedom (DOF) motion base; a 140 x 30 degrees visual system for takeoff, landing, and air-to-air refueling; and, a coordinated presentation of the radar, low-light-level television (LLLTV) and forward looking infrared (FLIR) systems (SAC ROC 8-74).

The B-52 will have incorporated electrooptical (EO) technology for which there is no adequate simulation today. Planned mission profiles indicate heavy reliance upon the EO systems. Therefore, proficiency in the interpretation and utilization of these systems is a critical training objective.

R&D must be accomplished before the FLIR and LLLTV associated tasks can be effectively introduced into ground-based training systems. Until this capability is acquired, B-52 flying time reductions will be limited. In the interim, the training will have to be accomplished in the aircraft. Airframe structural deterioration, excessive fuel utilization, and possible ecological disturbances will be encountered while these EO simulation capabilities are undergoing research and development.

(2) Offensive System Trainer

The Offensive Systems Trainers in use are devices built for the B-29 and subsequently modified for the B-36 and B-52. The trainer is severely limited as a training tool because the primary sensor (radar) simulation provides an unrealistic presentation, offers no capability to practice low-level terrain avoidance flight or to breakout radar targets at short ranges. Interface between the SRAM inertial measurement unit and the trainer has proven inadequate. There are no capabilities for FLIR or LLLTV simulation.

The requirement for improving the quality of training for B-52 Offensive Systems Operators is outlined in SAC ROC 8-74.

Trainer capabilities required include Digital Radar Landmass Simulation (DRLMS), FLIR, SRAM and LLLTV simulation. DRLMS, FLIR and LLLTV simulation capabilities require R&D efforts. In addition, the new Offensive Systems Trainer will have to be capable of providing training in conjunction with the Flight Station and Defensive Station or in the independent mode. This flexibility will provide the capability to train the integrated crew which is presently only possible during aircraft training flights.

(3) Defensive Systems Trainer

The current B-52 Electronic Warfare Trainer is a DC analog device which provides fairly realistic simulation of electronic warfare operation aboard the aircraft. The system is capable of simulating 54 hostile electronic emitters and high fidelity aircraft countermeasures operation.

The shortcomings of this trainer are: its age and associated supply difficulties; its lack of interface with other crew stations; and, the requirement to use tapes of actual electronic emitters for updating of the trainer's programmed threat display.

A single gunnery trainer is available at each wing and at the CCT Squadron. Training is limited to the presentation of ten preprogrammed targets and programming flexibility is very limited. No interface with the Electronic Warfare Officer or other crew/stations is provided.

The Defensive Station of the Weapon System Trainer required by SAC must incorporate digital computation in order to expand the threat presentation and provide flexibility for modification of the threats and equipment. The trainer should duplicate the actual aircrew functional environment by combining the Electronic Warfare Officer and Fire Control System stations. Aerial threats could then be coordinated between the EWO and gunner. Furthermore, the threats can be varied with each student mission. Interface with the landmass data base would provide terrain occulting to more accurately duplicate the actual low-level mission.

b. KC-135

The KC-135 aircrew trainers are of 1950 vintage and face the same supply difficulties as the B-52 trainers. The trainers are being fully utilized in their present configuration. USAF ROC 6-74 requests a low cost visual modification to provide training in the critical engine-our on takeoff maneuver. This capability will also be used to support pilot upgrade activity.

(1) Flight Trainer

The KC-135 Flight Trainers are cockpit procedures trainers affording adequate instruction in normal and emercency

procedures. Lack of a visual or motion system restricts any training associated with flying characteristics.

SAC's requirements, in support of a decreased flying training program, are for up-to-date flight simulator with a six DOF motion system and a visual system for takeoff, approach, landing and runway operations. The visual system must be a high fidelity day/night system for the CCTS simulators. Requirements of the operational units may be satisfied by employment of a night only system. Detailed requirements are reflected in SAC ROC 10-74.

(2) Navigation Trainer

The existing navigation trainer provides initial orientation to KC-135 CCT navigators in the aircraft's radar operation. SAC's stated requirement is for an aircraft-identical station with high fidelity radar simulation. A DRLMS-type system and real time celestial information for simulation of the navigation function are desired. Interface with the flight simulator is required.

(3) Boom Operator Trainer

At present, the aircraft is the only media available in which to train boom operators in the motor skills associated with aerial refueling. SAC ROC 2-74 identified the need for a prototype training device to be used in the conduct of transfer of learning studies. This ROC was validated by the Air Staff and program direction was received for ASD/SD24 to develop, in-house, a device capable of performing these functions. This device will be delivered to Castle AFB and be ready for training by February 1978. A favorable production decision could result in a competitive procurement of up to 31 devices. These devices will be cited at CCTS and collocated with KC-135 WST units.

c. RC/EC-135

All ground training for RC/EC-135 aircrews is accomplished in KC-135 training devices. The flying portion of CCTS is accomplished on the KC-135 aircraft. Initial introduction of the RC/EC aircraft systems is accomplished in a "difference course" accomplished at the operational unit.

(1) Flight Simulator

All requirements for the KC-135 Flight Simulator apply to this system. The EC/RC-135 simulator would have RC-135 cockpit configuration and EC-135 flight and engineer characteristics. Pilot difference training from EC to RC will not be extensive.

(2) Navigation Trainer

Two navigation stations (one EC configuration and one RC configured) would be provided with the EC/RC-135 simulator to permit realistic training for two different navigation roles.

(3) Aerial Refueling Trainer

Two alternatives are under consideration for receiver aerial refueling training in theEC/RC-135 difference and continuation training programs. A separate EC/RC-135 configured part task trainer will satisfy the receiver refueling requirement under SAC ROC 7-73. The second option is to provide a day/night visual system with aerial refueling capability with the EC/RC-135 weapon system trainer under SAC ROC 10-74.

(4) EW Mission Trainer

The RC-135, in pursuit of its electronic intelligence (ELINT) gathering mission, includes three Electronic Warfare Officers in its crew. No device is available today for either initial or recurring training of these crew members in the operation of the equipment on board the aircraft. Normal aircraft training flights cannot provide the training required for proficient mission performance. SAC ROC 9-74 addresses this subject.

d. FB-111

The FB-111 simulators are among the best operational training devices in use today. Flight controls, instrument indications, navigation, bombing and a limited motion system are integrated to realistically portray actual flight conditions.

A day/night computer generated visual system is now being procured to improve the FB-111 simulator training capability. The visual system will provide takeoff, landing, aerial refueling and formation training requirements identified in SAC ROC 13-72.

Two major weaknesses of the FB-111 trainers are the inadequacy of the present analog light optic radar simulator and the limited capacity of the simulator computational system. The analog radar landmass (ARLMS) provides attack and terrain following radar imagery to the simulator. Inherent weaknesses of this system include a lack of detailed radar imagery at short ranges, terrain computations which are too coarse to support TFR training, and inadequate correlation between the TFR and the attack radar. Implementation of improved radar simulation through digital radar landmass simulator (DRLMS) technology would improve the training value of the FB-111 mission trainers.

The SIGMA V computer which provides main frame computations is rapidly approaching obsolescence. Replacement of the SIGMA V

computers with state-of-the-art computers would improve the ability to maintain simulator currency and increase simulator availability.

These modifications are required to upgrade the quality of the training. Flying time reductions are not the primary driving force in this submission. However, reduced flying requirements are expected upon implementation of these modifications. The present FB-111A mission simulator workload negates further flying reductions without added training capabilities.

e. B-1

A prior SAC requirement called for a total instructional system integrated to support the three categories of training. The hardware included carrels, familiarization trainers, procedures trainers, avionics software trainers, and weapon system trainers.

The nature of the B-1 aircraft and the anticipated fuel constraints during the life cycle of the weapon system demanded high fidelity simulation to maintain aircrew proficiency. With the exception of FLIR simulation, SAC requirements were within the current technological capability. FLIR simulation in the B-1 weapon system trainers depended on the results of the B-52 EVS R&D effort.

(1) Avionics Software Trainers

The complexity of the B-1 offensive and defensive systems software pointed to the need for a device for specialized avionics system management training. Programmable as an Offensive System Operator or Defensive System Operator trainer, the avionics software trainer was to be used at the Main Operating Base (MOB) to maintain the operational skills requisite for integrated mission operation both in the airplane and the WST.

(2) Flight Simulator

The flight simulator was seen as a device for training the entire four-man crew. DRLMS and FLIR would have been incorporated in this device. The pilots would have needed a visual system for take-off, landing and air-to-air refueling. The capability for individual or integrated training for any or all crew stations would have maximized the training potential of the system.

f. U-2 Training Program

There are highly experienced pilots flying the U-2. Two models of the aircraft, each with markedly different cockpit configurations and handling characteristics, are being utilized. The pilots fly one or the other model, but not both.

Recurring flying training requirements are four landings per month for pilots with less than 300 hours in the aircraft and three landings per month for those pilots with more than 300 hours.

Because of the limited number of pilots in the program and their high experience and capability levels, no other training devices are required.

g. SR-71 Training Program

The SR-71 training program is similar to the U-2 in the limited number of crews flying the aircraft (total of ten crews), and the experience and capability levels of those crews. However, SAC has an integrated/stand-alone mission simulator for the aircraft and it is being utilized for initial training of new crew members. In addition, the simulator is used as a medium for pre-flying each mission flown from the CCTS base, whether that mission is for initial training or for operational purposes.

The utilization rate of the simulator and number and expertise of the crews makes any modification or addition to the simulator economically undesirable.

2. Prioritization of New Capabilities

In developing the equipment requirement as set forth in this plan, SAC has adopted as an objective, the reduction of flying time as set forth in the OMB study of 26 July 1973. This translates into a 50 percent reduction in CCT flying and a 20 percent reduction in continuation flying training accomplished at the operational units. The Command feels that the 50 percent CCTS flying reduction is optimistic; it is confident that an overall 25 percent reduction to a zero simulator base line can be demonstrated by 1981. Further, SAC believes that the crews will be better trained by increasing their exposure to the realms of the mission which today are restricted because of ecological or safety considerations.

Current and projected flying hour programs are given in Table VIII-1 for aircraft affected by this Plan.

SAC's prioritization of new training systems is based on maximizing investment returns of weapon system packages at the earliest date. The order of priority for trainers identified is:

a. B-52 CCTS devices and supporting R&D efforts;

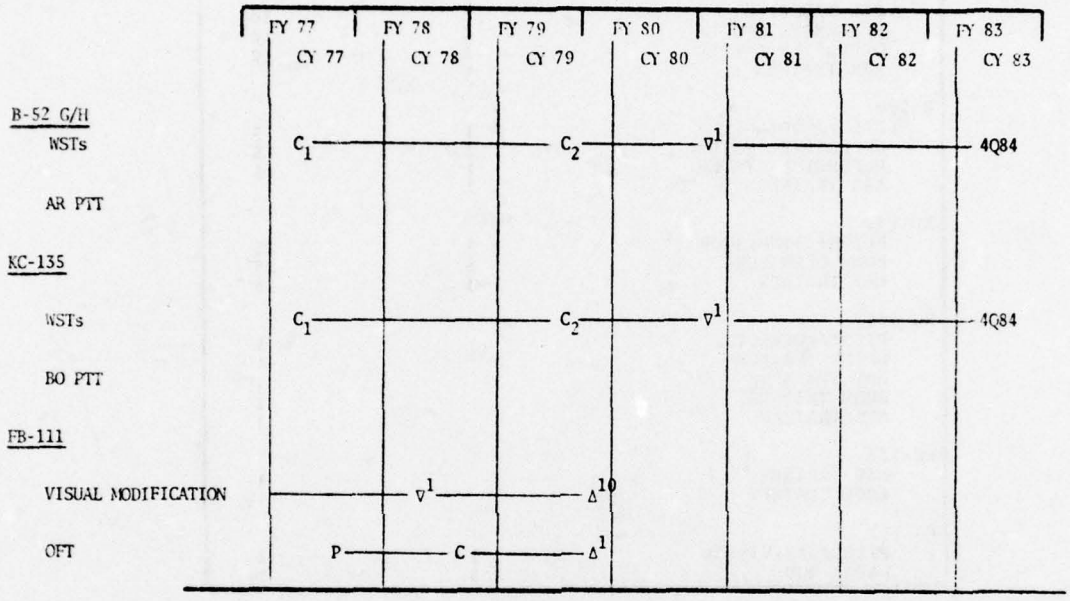
b. KC-135 CCTS devices;

c. B-52 unit equipage; and

d. KC-135 unit equipage.

C. PROGRAM DATA

Program schedules are illustrated in Figure VIII-1. Deployment of the simulators is listed in Table VIII-2.



C	=	Contract Award	P	=	PMD
C_1	=	Phase 1	∇	=	First Delivery
D_2	=	Phase 2	Δ	=	Last Delivery

FIGURE VIII-1. SAC Planning Schedule

Several significant assumptions were made in estimating quantities of equipments. These were:

1. Projected simulator to flying time ratios were set at 2.0 and 1.6 for the CCTS and in-unit training, respectively. However, there

TABLE VIII-2. REQUIRED SIMULATION DEVICES DEPLOYMENT

	COMBAT CREW TRAINING STATION	RECURRING
B-52D		
AAR TRAINER	1	
B-52G		
PILOT/COPILOT	2	10
OFFENSIVE SYSTEM	4	10
DEFENSIVE SYSTEM	2	10
AAR TRAINER	1	
B-52H		
PILOT/COPILOT	1	5
OFFENSIVE SYSTEM	3	5
DEFENSIVE SYSTEM	1	5
AAR TRAINER	1	
KC-135		
FLIGHT SIMULATOR	3	25
BOOM OPERATOR	5	25
NAV TRAINER	3	25
RC-135		
PILOT/COPILOT		1
ELINT TRAINER		1
NAV TRAINER		1
BOOM TRAINER		1
AAR TRAINER		1
EC-135		
NAV TRAINER		1
BOOM TRAINER		1
FB-111		
PILOT/NAV-VISUAL	1	2
RADAR MOD	3	1

has been no proven ratio for simulator transferability and SAC chose to adopt a more conservative approach than did OMB in its realization of training benefits from simulators.

2. The RC and EC-135 flight simulators are seen as variations to the KC-135 simulator. Delivery of these and the two associated navigation and boom operator trainers is assumed to be made in FY 80.

3. In general, the cost estimates reflect high levels of sophistication. Whether or not the sophistication is warranted depends upon the training value of the device. Until trade offs between the cost of each training capability and the value of that capability are made, the economic justification will be impossible. These trades cannot be assessed until ISD data can be collected and analyzed using actual samplings of student crews and the operational simulator hardware. The feasibility and timing of the B-52G and H Offensive Systems Trainer is especially tenuous since the electrooptical simulation R&D they will require has not been started.

4. Except for the B-52 ARPTT and KC-135 boom operator trainer, all schedules assume that production contracts are let at the beginning of the program. This is a high risk schedule in that there is considerable uncertainty associated with every new simulator, especially in the visual systems that many of these devices incorporate. There will normally be a year to two years delay between delivery of the prototype and the first production article.

D. AIR RESERVE FORCES (ARF)

The Strategic Air Command is currently engaged in the transfer of a number of KC-135 assets to the Air National Guard and Air Force Reserve forces. As the single manager of tanker operations and the gaining command for ARF resources during wartime, SAC retains the responsibility for directing the required training necessary to maintain aircrew proficiency.

Initial unit checkout is accomplished through a combination of resident attendance at the KC-135 CCTS and in-unit instruction by SAC instructor personnel. Each ARF unit is served by a mobile pilot cockpit procedures trainer for the first 60 days of transition, with continuation training provided through the use of a collocated SAC device or by TDY travel to the nearest KC-135 trainer. The new WST will support the crews of Air National Guard and Air Force Reserve, with ARF utilization extremely dependent upon mission tasking and training participation.

IX. AEROSPACE DEFENSE COMMAND (ADCOM)

A. GENERAL

The Aerospace Defense Command conducts conversion and operational training for the F-101, F-106, EB-57, EC-121 and T-33 aircraft. The one F-4C squadron assigned to ADCOM is provided conversion training by the Tactical Air Command (TAC) with ADCOM providing required operational training. Training of aircrews for T-37 aircraft, in support of AFA Cadet Orientation Programs, is conducted at Peterson Air Force Base, Colorado. Although ADCOM has responsibility for defining training requirements for the F-101 weapons system, both conversion and operational training are provided by the Air National Guard (ANG). Worldwide Air Defense Enhancement (WWADE) training is conducted at the Air Defense Weapons Center for USAF pilots assigned to the Air Defense mission. The contact for all aircrew trainer activities within ADCOM is the Instructional Technology Division (Hq ADCOM/DOXI, Autovon 692-3181). Lateral ccordinating agencies within ADCOM are XPAW, LGMW, DOOT and the Air Defense Weapons Center Instructional Systems Development Team (ISDT). ADCOM ISD efforts have been directed throughout the aircrew training program and have resulted in a number of training advancements, including new trainers and contractual training efforts.

B. TRAINING DEVICE STATUS AND REQUIREMENTS

In assessing its aircrew trainer requirements, ADCOM concluded that only the F-106 and follow-on interceptor aircraft satisfy the ground rules established for projecting future aircrew trainer requirements. Other ADCOM aircraft do not satisfy these ground rules because of the limited quantity, short remaining life, considerable training being accomplished via target support, and/or the low operating cost. Large investments for training devices and improvements in associated facilities for these weapon systems are not justified.

1. F-106 Trainer

a. Limitations of the existing MB-42A trainer confine the primary benefits to procedural training in most normal aircraft operating procedures, aircraft emergency operating procedures, and limited areas of the fire control system operations. The MB-42A has no capability to duplicate contact flying, such as visual takeoffs/landings, patterns, formation, air refueling and air combat maneuvering. In addition, severe limits exist in fire control system duplication for low altitude intercept training, tactical data link and target characteristics.

b. In a major effort to update the MB-42 without undue dollar investment, a modification program was initiated, approved, and funded. During 1976 all existing (active and ANG) F-106 aircrew trainers (total fourteen) were modified with 23 separate modifications under this program to bring the MB-42 more in line with the aircraft. Increased aircrew proficiency and reduction of improper training were used to justify the installation of these modifications.

c. A further effort to update the MB-42 was completed at Tyndall AFB. A commercial contractor evaluated the feasibility of adding a limited visual system to the trainer. Results of the evaluation and associated engineering study were briefed to Hq ADCOM/DO and indicated that for the following reasons, a visual update to the MB-42 was not feasible:

(1) The trainer's slow flight dynamics were unacceptable when interfaced with a visual scene;

(2) Projected cost per installed visual scene and digital interface was excessive and change of operator acceptability would be no greater than 50 percent; and

(3) To update the host computer to accept a visual scene generator would exceed the original cost of the MB-42 trainer.

d. Increased utilization of the MB-42 over current rates will not provide additional learning benefit, nor can further flying hour avoidances be addressed without degradation in aircrew proficiency. Hq USAF issued PMC No. R-Q5013-(6) in February 1975, stating that the ADC ROC 6-74 for an Advanced Interceptor Simulator (AIS) could not be approved for the F-106. The ROC was, however, endorsed as being consistent with force structure planning and resubmittal was suggested when the Follow-On Interceptor (FOI) was identified.

2. Follow-On Interceptor Trainers

a. A ROC for a family of FOI aircrew trainers has been drafted, coordinated with other MAJCOMs and is now being readied for submittal to Hq USAF. This ROC was developed by the ADCOM ISD Team, and the capabilities required of FOI aircrew trainers are based on an extensive mission analysis for each level of training (operational and student). Regardless of the aircraft ultimately identified to replace the F-106, interceptor aircrews will be required to maintain proficiency in six basic mission areas. Specific events within these mission areas were addressed as to whether or not they can be cost effectively performed in a ground trainer. Briefly, FOI trainer requirements are:

(1) A dual-cockpit mission trainer is required at CCTS. This trainer will allow training in such areas as aerial refueling and 1V1 aerial combat. Training in such events as radar and weapons

system operation, employment tactics and emergency procedures will be accomplished in less sophisticated flight trainers and part task trainers;

(2) At the fighter interceptor squadron (FIS) level, events such as aerial refueling, instrument approach and landing training, formation flying, systems operations and emergency procedures training will be practical in a flight trainer, with the aircraft remaining the verification device; and

(3) Aircrew motion cueing from trainers at both the CCTS and FIS level have been identified, but the best method by which the cues are to be provided must be determined by the research community. A schedule for the FOI trainer procurement is not firm at this time, and therefore, is not shown in this section.

3. F-106 Radar/IR Part Task Trainer (PTT)

An ISD analysis of the F-106 CCTS ground training program identified the need for a radar/IR PTT. Training in such areas as low altitude intercepts, chaff and system malfunctions was not possible in the MB-42 and consumed valuable airborne training time to teach the basics of associated training events. AFHRL/ASR now is conducting an extensive evaluation of this PTT to determine its effectiveness as an aircrew trainer. Student and instructor acceptance thus far has been excellent, and efforts are underway to evaluate and determine if submittal of a ROC to Hq USAF for such a trainer at each FIS location is economically feasible.

4. F-106 Aerial Gunnery Part Task Trainer (AGPTT)

a. The F-106 Snapshoot Gunsight is unique and requires a considerable amount of aircrew familiarization in gunsight dynamics prior to actually firing the gun. To simply teach gunsight dynamics in the aircraft is extremely wasteful of airborne time which could better be used for actual gun firings. An organic capability to teach gunsight dynamics to F-106 students with a ground trainer is required at the CCTS level. Although this training has been accomplished via a contractual effort, the cost per hour if AGPTT training was available at CCTS could be reduced. ADCOM has formally submitted a ROC to Hq USAF for the procurement of an AGPTT.

b. Submission has been made to Hq USAF/ACM for funds to procure the AGPTT under the Fast Payback Capital Investment Program. This was done in an effort to expedite the procurement of the AGPTT, since the ROC process has not been responsive to low cost trainer needs and the short lead time usually associated with that need.

5. Contractual Training

ADCOM is currently training aircrews in Air Defense Combat Tactics (ADCT) via a contract with Vought Corporation. Similar to

the TAC ACES Program, aircrews receive extensive training in 1V1 aerial combat utilizing the F-106 HUD and Snapshoot Gunsight. Future training plans call for all ADCOM pilots to attend the ADCT training program.

C. PART TASK TRAINER PROCUREMENT

ADCOM has expressed concern regarding procedures for obtaining part task trainers. The Command hosted a meeting of training equipment personnel from ADCOM, ATC, TAC, SAC and ASD during which an alternate method (in lieu of the GOR) of obtaining command funded training equipment was formulated. The method essentially urged the use of primarily in-house capability to fabricate and maintain such equipment. The proposal was submitted to the Simulator Advisory Group which determined that there is only one PTT awaiting funding/development. As a result the SAG concluded that there appears to be no requirement to modify the GOR process to expedite procurement of PTT devices.

D. FLYING HOUR AVOIDANCES

1. As is implied in the previous paragraphs on the MB-42 trainer, additional flying hour avoidances without an advanced mission trainer to replace the MB-42 or without greatly enhancing the current simulator are questionable. Utilization and training benefits are optimum given its current condition and capabilities. However, an ADCOM study conducted during May 1974 for Hq USAF/XOO showed that with no MB-42 at the CCTS level, an additional 12 hours per student of airborne training time would be required, assuming graduation proficiency levels were to remain unchanged. At a nominal skill level for the mission ready aircrew, an additional 10 flying hours per year per pilot would be needed if no MB-42 were available. Also, the impact on emergency procedures training would be significant, and the safety aspect is obvious, but an associated dollar impact was not developed. Based on the nonavailability of the MB-42, ADCOM would need to increase current flying hour requirements by approximately 2400 hours. So, although the MB-42 is severely limited, compared to state-of-the-art trainers, it does provide ADCOM aircrews valuable training.

2. With the advent of the FOI, the associated family of aircrew trainers will allow a considerable amount of airborne training time to be avoided. This avoidance is based on the fact the ADCOM interceptor pilots must be proficient in all areas of the weapons system operation and applicable scenarios. Given the base level of flying training required with no FOI aircrew ground trainers, a 30 percent reduction of that level can be achieved if the FOI family of trainers is provided as defined in the ROC. Associated hours, costs and specific training events are identified in the FOI trainer ROC.

3. There are two additional aspects of the flying hour avoidance question possibly unique to ADCOM. The first is the interrelation of

interceptors and ground environment in a complete air defense system. It is essential to develop linked aircrew and controller training facilities to ensure adequate intercept controller training. The second aspect is the vital need to have an adequate target force available for required airborne training, including exercises for the entire air defense system. The targets are presently provided in large by EB-57 and T-33A aircraft, which, while providing this function, also provide significant training for their aircrews. This aspect, rather than the controller training, drives the flying EB-57 and T-33A hour requirements, and considerably reduces the need for increased simulation training in these mission support aircraft.

4. ADCOM fully recognizes the increasing impact of limited fuel and dollar resources on airborne training. The near future will require a normalizing and reduction of fuel consumption for training purposes. Extreme caution must be exercised, however, to ensure the proficiency level of operational aircrews is not reduced during the process. Through valid research and wise management, a force of certified trainers can provide a considerable amount of aircrew training.

E. SIMULATOR RELATED ISD EFFORTS

ISD studies are well underway within ADCOM, with many interceptor training courses completely rewritten utilizing the ISD process and associated task analysis. Table IX-1 provides a current status of ADCOM weapon systems training. As mentioned earlier, the FOI family of trainer requirements was developed by the ADCOM ISDT. In addition, the F-106 radar/IR PTT and AGPTT training programs are a result of ISD efforts.

TABLE IX-1. PROGRAM STATUS OF ADCOM WEAPONS SYSTEMS TRAINING

PRINCIPAL TRAINEE(S)	WEAPON SYSTEM	TRAINING	SIMULATOR AVAILABLE	STATUS OF ISD EFFORT
PILOT	F-106	COMBAT CREW TRAINING	PART TASK TRAINER RADAR/IR PTT	COMPLETE - FEB 1974 IN IMPLEMENTATION PHASE ONGOING
PILOT/WDO	EB-57	SQUADRON CHECKOUT	NO	INITIATED - FEB 1974 COMPLETION - JAN 1975
PILOT	T-33	QUALIFICATION COURSE	INSTRUMENT TRAINER	INITIATED - APR 1975 COMPLETION - MAR 1976
PILOT/ NAVIGATOR/ CONTROLLER	EC-121	COMBAT CREW TRAINING	YES	AFRES
PILOT/WSO	F-4C	COMBAT CREW TRAINING	YES	ACCOMPLISHED BY TAC SPINOFF TO ADCOM
PILOT/WSO	F-4D/E	WWADE	YES	INITIATED MAY 1975 AND CONTINUING
PILOT/WSO	F-101	COMBAT CREW TRAINING	YES	VALIDATION STAGE

F. ADCOM SIMCERT

1. ADCOM simulator certification efforts in the future will be guided largely by a recent USAF regulation (AFR 50-11). However, ADCOM has since 1975 had a major program in existence to improve the quality of simulator training. This program is very akin to the proposed program in Regulation 50-11. Our efforts started by periodically requiring a quality control inspection of the simulator to identify systems not performing up to standards. Problems, once identified, were fixed locally or submitted via the quick modification program. In some cases, the ISD interaction identified systems which, even if modified, could not provide cost effective aircrew training.

2. Until AFR 50-11 was published, the following procedure was used in ADCOM to certify trainers. Certification procedures/parameters consisted of a qualified team of three aircrew members flying the trainer in all its assigned tasks/desired operational capability and evaluating its fidelity and operational status. From the above quality control inspection it was determined whether any failures were caused by design deficiency or malfunction. Dependent upon the determination made, action items were assigned to either the MAJCOM/intermediate test facility for development/prototype of quick modifications to update the trainer to an acceptable level, to the unit to correct the malfunctions, or to the depot, as applicable.

LIST OF REFERENCES

1. Special Report of the USAF Scientific Advisory Board, Visit with the Airline Industry, January 1969.

2. USAF Ad Hoc Review of Airline Pilot Training attached to letter dated 16 June 1969, "Review of Airline Training," Chief of Staff, General J. P. McConnell.

3. Office of Management and Budget (OMB) Staff Study, "Department of Defense Aviation Program Savings Possibilities through Increased Emphasis on Flight Training Simulation," dated 26 July 1973.

4. AFR 173-10, "USAF Cost and Planning Factors (U)," 6 February 1975.

5. ASD/XR-TR-75-25, "Air Force Master Plan - Simulators for Aircrew Training," Wright-Patterson AFB, Ohio, December 1975.

GLOSSARY

A

AAA	-	Antiaircraft Artillery
ACM	-	Air Combat Maneuvering
ACPTT	-	Air Combat Part Task Trainer
ACS	-	Assistant Chief of Staff
ACES	-	Aerial Combat Engagement Simulation
ADCOM	-	Aerospace Defense Command
ADCT	-	Air Defense Combat Tactics
AF	-	Air Force
AFAL	-	Air Force Avionics Laboratory
AFALD	-	Air Force Acquisition Logistics Division
AFB	-	Air Force Base
AFC	-	Air Force Council
AFFDL	-	Air Force Flight Dynamics Laboratory
AFHRL	-	Air Force Human Resources Laboratory
AFLC	-	Air Force Logistics Command
AFM	-	Air Force Manual
AFR	-	Air Force Regulation
AFRes	-	Air Force Reserves
AFSC	-	Air Force Systems Command
AFTEC	-	Air Force Test and Evaluation Center
AFTS	-	Adaptive Flight Training System
AGE	-	Aerospace Ground Equipment
AGL	-	Above Ground Level
AGPTT	-	Aerial Gunnery Part Task Trainer
ALC	-	Air Logistics Center
ALCOGS	-	Advanced Low Cost G-Cueing System
AMRL	-	Aerospace Medical Research Laboratory
AMST	-	Advanced Medium STOL Transport
ANG	-	Air National Guard
AOI	-	Area of Interest
APR	-	Airman Performance Report

ARF	-	Air Reserve Forces
ARLMS	-	Analog Radar Landmass Simulation
ARPTT	-	Aerial Refueling Part Task Trainer
ARRS	-	Aerospace Rescue and Recovery Service
ASB	-	Air Staff Board
ASD	-	Aeronautical Systems Division
ASPT	-	Advanced Simulator for Pilot Training
ASUPT	-	Advanced Simulator for Undergraduate Pilot Training
ATACS	-	Advanced Tactical Air Combat Simulator
ATC	-	Air Training Command
ATD	-	Aircrew Training Device
AWACS	-	Airborne Warning and Control System
AWADS	-	All Weather Air Delivery System

B

BOPTT	-	Boom Operator Part Task Trainer

C

CAI	-	Computer Aided Instruction
CCTS	-	Combat Crew Training Squadron
CFT	-	Cockpit Familiarization Trainer
CGI	-	Computer Generated Imagery
CIG	-	Computer Image Generation
CPT	-	Cockpit Procedures Trainer
CRT	-	Cathode Ray Tube
CSAF	-	Chief of Staff Air Force

D

DCS	-	Deputy Chief of Staff
DDR&E	-	Director of Defense Research and Engineering
DID	-	Data Item Description
DMA	-	Defense Mapping Agency
DMS	-	Differential Maneuvering Simulator
DOC	-	Desired Operational Capability

DoD	-	Department of Defense
DRLMS	-	Digital Radar Landmass Simulator
DSCG	-	Digital Scan Converter Group
DSO	-	Defensive Systems Operator

E

ECCM	-	Electronic Counter Countermeasures
ECM	-	Electronic Countermeasures
ELINT	-	Electronic Intelligence
EO	-	Electrooptical
EPT	-	Egress Procedures Trainer
ESM	-	Electronic Warfare Support Measures
EVS	-	Electrooptical Viewing System
EW	-	Electronic Warfare
EWO	-	Electronic Warfare Officer
EWOT	-	Electronic Warfare Officer Training

F

F/ASVS	-	Fighter/Attack Simulator Visual System
FIS	-	Fighter Interceptor Squadron
FIST	-	Functional Integrated System Trainer
FLIR	-	Forward Looking Infrared
FMS	-	Full Mission Simulator
FOI	-	Follow-On Interceptor
FOT&E	-	Follow-On Operational Test and Evaluation
FOV	-	Field-of-View
FSC	-	Force Structure Committee
FUPT	-	Future Undergraduate Pilot Training

G

GCA	-	Ground Controlled Approach
GOR	-	General Operational Requirement

H

HOL - High Order Language

HUD - Heads Up Display

I

IFR - Instrument Flight Rules

IFS - Instrument Flight Simulator

IFT - Instrument Flight Trainer

IG - Image Generator

INS - Inertial Navigation System

IOS - Instructor/Operator Station

IOT&E - Initial Operational Test and Evaluation

IP - Instructor Pilot

IPT - Individual Positional Trainer

IQT - Initial Qualification Training

IR - Infrared

IR&D - Independent Research and Development

ISD - Instructional Systems Development

ISNAV - Independent Satellite Navigation Station

L

LAMARS - Large Amplitude Multimode Aerospace Research Simulator

LAPES - Low Altitude Parachute Escape System

LLLTV - Low Light Level Television

M

MAC - Military Airlift Command

MAJCOM - Major Command

MFS - Mission Flight Simulator

MOB - Main Operating Base

MPC - Multipurpose Console

MQT - Mission Qualification Training

MTBF - Mean Time Between Failure

MTTR - Mean Time to Repair

MUNT - Modified Undergraduate Navigator Training

N

NASA	-	National Aeronautics and Space Administration
NBT	-	Navigator/Bombardier Training
NGB	-	National Guard Bureau
NM	-	Nautical Miles
NOCGI	-	Night Only Computer Generated Imagery
NOCIG	-	Night Only Computer Image Generation
NTEC	-	Naval Training Equipment Center

O

O&M	-	Operation and Maintenance
OFT	-	Operational Flight Trainer
OMB	-	Office of Management and Budget
OPR	-	Office of Primary Responsibility
OSD	-	Office of the Secretary of Defense
OSO	-	Offensive Systems Operator
OT&E	-	Operational Test and Evaluation
OUT	-	Operational Utilization Test

P

PA/BA	-	Purchase Authority/Budget Authority
PIT	-	Pilot Instructor Training
PMD	-	Program Management Directive
POL	-	Petroleum, Oil and Lubricants
PTT	-	Part Task Trainer

R

R&D	-	Research and Development
RFP	-	Request for Proposal
RFT	-	Ready for Training
RHAWS	-	Radar Homing and Warning System
ROC	-	Required Operational Capability
RPR	-	Request for Personnel Research
RRG	-	Requirements Review Group
RTU	-	Replacement Training Units

S

SAAC	-	Simulator for Air-to-Air Combat
SAB	-	Scientific Advisory Board
SAC	-	Strategic Air Command
SAG	-	Simulator Advisory Group
SAM	-	Surface to Air Missile
SEWT	-	Simulator for Electronic Warfare Training
SIMCERT	-	Simulator Certification
SIOP	-	Single Integrated Operational Plan
SMART	-	Skills Maintenance and Reacquisition Training
SO	-	Systems Operator
SPO	-	System Program Office
SRAM	-	Short Range Attack Missile
STG	-	Synthetic Terrain Generator
STRES	-	Simulator Training Requirements Effectiveness Study

T

TAC	-	Tactical Air Command
TAF	-	Tactical Air Force
TEWS	-	Tactical Electronic Warfare Support
TFS	-	Trainer Flight Simulator
TFTW	-	Tactical Fighter Test Wing
TJS	-	Tactical Jamming System
TMB	-	Terrain Model Board
TOT	-	Transfer of Training
TR	-	Technical Report
TV	-	Television

U

UK	-	United Kingdom
UNT	-	Undergraduate Navigator Training
UPT	-	Undergraduate Pilot Training
USAF	-	United Stated Air Force

V

VFR	-	Visual Flight Rules
VPM	-	Visual Parameter Monitor
VTOL	-	Vertical Takeoff and Landing

W

WAC	-	Wide Angle Collimated
WSO	-	Weapon Systems Officer
WST	-	Weapon System Trainer
WWADE	-	Worldwide Air Defense Enhancement

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