DOT/FAA/CT-83/2

Engineering and Development Program Plan
Aircraft Digital Systems

January 1983

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U.S. Department of Transportation
Federal Aviation Administration
Technical Center
Atlantic City Airport, N.J. 08405

Technical Report Documentation Page

1. Report No. DOT/FAA/CT-83/2	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle AIRCRAFT DIGITAL SYSTEMS - PROGRAM PLAN		5. Report Date January 1983
		6. Performing Organization Code ACT-340
7. Author(s) Flight Safety Research Branch, ACT-340		8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration Flight Safety Research Branch, ACT-340 Aircraft Safety and Airport Technology Div., ACT-300 Atlantic City Airport, New Jersey 08405		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. 182-340-100
12. Sponsoring Agency Name and Address U.S. Department of Transportation FAA Technical Center Atlantic City Airport, New Jersey 08405		13. Type of Report and Period Covered Program Plan
		14. Sponsoring Agency Code

15. Supplementary Notes

This program plan is related to the following documents:
FAA-ED-18-3, May 1978
DOT/FAA/CT-81/189, September 1981 (revised March 1982)

16. Abstract

Aircraft development in the past has been influenced by the desire for imporved performance usually through more efficient aerodynamic designs or propulsion systems. However, one of the most noteworthy advances has been the development of the command and control electronic devices which are utilized in the application of active controls and other advanced aeronautical and avionic systems and concepts. Many of the advanced concepts offer the potential of improved aircraft performance through inceased energy efficiency. It appears that active controls and other advanced flight control and avionics systems, including digital concepts, will significantly influence aircraft technology, and therefore, the Federal Aviation Adminstration (FAA) must examine the impact of these advances on airworthiness criteria and certification procedures. The FAA technology program discussed in this report and entitled, "Aircraft Digital Systems" was established in order to support these responsibilities and aid in implementing activities in the research area. This program plan has evolved from several earlier plans and is intended to provide for initiation of new (or continuation of ongoing) FAA projects related to software-based digital systems, validation and verification, failure modes and reliability, new aircraft designs and active controls, and aircrew/aircraft interface issues. Emphasis is directed toward those activities that have a flight safety impact and the potential of aiding and supporting the certification process through the dissemination of data and information and acquistion of pertinent criteria and procedures. In addition, this program also covers Cockpit Visibility including the development of the system measurement capability, the development of criteria, and the conduct of the surveys.

17. Key Words Digital Systems, Advanced Aircraft Systems, Active Controls, Handling Qualities, Validation and Reliability, Verification, Cockpit Visibility	18. Distribution Statement Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

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EXECUTIVE SUMMARY

INTRODUCTION.

This program plan entitled "Aircraft Digital Systems" is developed based on the projects and schedules outlined in the Technology Development and Program Support Project (Projects 6 and 15) in the Red Book, and is related to a previous approved plan outlined in Federal Aviation Administration (FAA) Report Number FAA-ED-18-3 dated May 1978. This plan conforms to ongoing development and certification activities, and reflects progress achieved to date, project scopes, and priorities as they relate to implementation of digital systems in the current generation and the next generation of civil transport aircraft.

BACKGROUND.

During the past several years the aviation community has witnessed an ever increasing pace to introduce advanced technologies, new aircraft design concepts, and sophisticated high-integrity integrated electronic systems. These advanced concepts have impacted many technology areas that are pertinent to the digital systems program; namely, "flight-critical" and "flight-essential" electronic systems which include the following types of software-based digitial systems: stability and control augmentation systems, active control systems, advanced displays, new aircraft designs, the aircrew/aircraft interface, and aircraft handling qualities and flight characteristics. The FAA is confronted with the task of reviewing, revising, and updating its airworthiness assessment criteria, certification procedures, maintenance-inspection requirements, operational considerations, etc., in order to assure a minimum level of safety for aircraft utilizing new design concepts and advanced systems technology; and as such must revise and prepare advanced new regulatory and guidance material which reflects the impact of these technologies. This digital systems program is the result of efforts initiated in 1975 to obtain data and information to aid and support the airworthiness processes cited above.

PROGRAM GENERAL FOCUS.

The general focus of the aircraft digital systems program is the impact of advanced and new technologies on the aircrew and aircraft and not on the air traffic control (ATC) system. The effort identified herein is in Program 18 — "Aircraft Safety Program." Therefore, the program is charged to focus on efforts that will provide data and information to aid and support aircraft airworthiness assurance techniques, certification procedures, and other pertinent regulatory and safety issues applicable to the operation of an aircraft and its systems by the crew in the National Airspace System (NAS).

OBJECTIVES.

The overall objectives of the aircraft digital systems program are:

(a) To conduct studies, investigations and analyses, that will provide data and information to support certification and regulatory activities pertaining to implementation of software-based digital systems.

(b) To coordinate and disseminate materials and findings within the FAA and industry as appropriate.

(c) To be responsive to specific aircraft safety needs.

(d) To establish and maintain expertise in aircraft digital systems technology.

(e) To establish and maintain the capability and expertise to conduct cockpit vision surveys.

MAJOR PROGRAM ELEMENTS.

This program plan is divided into three major program elements covering a wide range of projects that are of both near- and far-term concern to the FAA. They are:

1. Digital Systems Studies.

2. Validation Methodology.

3. Cockpit Vision Surveys.

TECHNICAL APPROACH.

The program elements, projects, and tasks delineated for this plan are judged to be of FAA concern, and where efforts are needed, to meet airworthiness criteria, certification procedures, and safety assessment requirements. A majority of the information and data needed may be acquired by monitoring and maintaining close coordination with other performing organizations, jointly funded projects based on interagency agreements, and FAA "in-house" studies and funded contracts as necessary.

The studies outlined in this plan utilize: (a) the Reconfigurable Digital Flight Control System Facility at the NASA-Ames Research Center jointly developed by FAA and the NASA-Ames Research Center under interagency agreement DOT-FA77WAI-738 (1978 to 1982) for the purpose of conducting experiments and studies related to digital systems, (b) the validation laboratory at the FAA Technical Center which will be augmented with F&E funds (FY-84 to FY-86) to conduct studies related to validation issues and methodologies involved in the implementation of bus architecture-based systems; (c) the cockpit vision survey camera (system) at the FAA Technical Center which will be procured during FY-84 and FY-85.

END ITEM PRODUCTS.

The end item products are generic information, and recommendations from which the FAA can establish or change certification requirements,guidelines, advisory circulars, FAA internal directives/orders, notices, handbooks, engineering flight test guides, and maintenance alerts, and technical standard orders.

PROGRAM MANAGEMENT.

The management of the program at the FAA Technical Center, is within the Aircraft and Airport Systems Technology Division (ACT-300) and the Flight Safety Research Branch (ACT-340).

SCHEDULES AND FUNDING.

An overview of the schedules and needed funding for the planned efforts are shown in figure ES-1. More detailed information on schedules, milestones, and funding is shown with each project in the body of the plan.

	FY-83	FY-84	FY-85	FY-86	FY-87	FY-88	FY-89	FY-90
I. Digital Systems Studies								
• Contract Funds (FE&D)		150.0K	175.0K	225.0K	225.0K	300.0K	———	———
• Staffing (Man-Years)		1.25	1.25	1.25	2.0	2.0		
II. Validation Methodology								
• Contract Funds (F&E)		195.0K	420.0K	920.0K	750.0K	500.0K		
• Contract Funds (FE&D)		115.0K	115.0K	140.0K	175.0K	200.0K	225.0K	275.0K
• Staffing (Man-Years)		1.75	1.75	1.75	1.75	2.25	2.75	2.75
III. Cockpit Vision Surveys								
• Contract Funds		205.0K	10.0K	10.0K	15.0K	15.0K	15.0K	20.0K
• Staffing (Man-Years)		.75	.75	.75	.75	.75	.75	.75
TOTALS								
• Contract (F&E)		195.0K	420.0K	920.0K	750.0K	500.0K	———	———
• Contract (FE&D)		470.0K	300.0K	375.0K	415.0K	515.0K	240.0K	295.0K
• Staffing (Man-Years)		3.75	3.75	3.75	4.5	5.0	3.5	3.5

FIGURE ES-1. CONTRACT FUNDING AND STAFFING FY-83 to FY-90

PROJECT FUNDING REQUIREMENTS.

Contract funding and in-house manpower levels in figure ES-1 are totals by fiscal years from 1983 through 1990, and include monies for interagency agreements as well as FAA contracts. Figure ES-1 reflects FAA monies only, and does not include contributions by NASA and DOD to joint work done under interagency agreements with the FAA.

1. GENERAL.

This program plan entitled "Aircraft Digital Systems" is designed to carry out issues related to digital systems that were envisioned and approved in the Advanced Integrated Flight Systems Program Plan (FAA-ED-18-3, May 1978). It updates those original visions and contains substantial changes to reflect current priorities, and most importantly, innovations and applications in digital technology in current and new generation aircraft. The overall goal of this plan is to provide a mechanism for establishing the necessary data and information required to update and change existing regulations, as needed, to insure the safe implementation of new digital technologies.

1.1 BACKGROUND.

This plan details efforts needed to achieve certain Federal Aviation Administration (FAA) research, engineering, and development (RE&D) program goals related to current and future needs of the agency with respect to the implementation of digital systems in civil aircraft. The information and data that will be acquired will aid and support the airworthiness assurance assessment processes, certification procedures, and the safe operation of these aircraft and systems by the crew in the National Airspace System (NAS).

The work detailed in this plan is part of the FAA RE&D Program 18 — the Aircraft Safety Program (General Fund: Facilities, Engineering and Development (F,E&D) monies). This activity is located at the FAA Technical Center at the Atlantic City Airport, New Jersey, and is now being performed by the Flight Safety Research Branch (ACT-340) within the Aircraft Safety and Airport Technology Division (ACT-300).

This plan sets forth the project elements, schedules, and funding levels needed to meet FAA research requirements in support of certification and operation of current and future aircraft which incorporate advanced integrated flight control and avionics systems. These advanced concepts involve "flight-critical" and "flight-essential" software-based digital systems which include: stability and control augmentation systems, active control systems, advanced displays, primary flight control and avionics systems, and aircrew/aircraft interface requirements. The FAA is confronted with the task of reviewing and updating its airworthiness criteria, certification procedures, maintenance-inspection requirements, and standards in order to assure a minimum level of safety as aircraft designs and technology advance and employ new system technology. This new generation of systems and digital technology is now appearing on derivative airplanes and new helicopters seeking approval for instrument flight. It is a fact that rapid implementation of these new systems will continue as new generation aircraft designs and modifications are introduced.

1.2 INTRODUCTION.

Historically, civil aircraft have incorporated independent hardware (black boxes) for each system implemented and installed in the aircraft; and the FAA's present standards address certification procedures and criteria from the concept of separate engineering disciplines. It is clear that derivative and new generation aircraft which incorporate integrated flight control and avionics systems are dependent, in a complex manner, on the aircrew/aircraft interaction as a total integrated system. For the FAA to meet its safety and certification responsibilities, a concentrated effort is needed to research this technology area, with emphasis on the total integrated system, in order to acquire and disseminate important data and information within the FAA to assure that certification criteria and procedures are valid and current with advanced technology. Many of the new integrated systems are being planned for, or are already implemented on, new derivative aircraft such as the DC-9-80 and the L-1011-500, and will be utilized on the current generation of new transport aircraft to improve efficiency and performance. These advanced systems also are being used, to an increasing degree, on other new aircraft such as commuters, general aviation aircraft and rotorcraft.

The introduction of software based digital flight control and avionics technology in the current generation of aircraft presents a problem for traditional certification techniques, especially with the increasingly wide-spread implementation of integrated systems which use bus architectures for intersystems and intrasystems communication of data and information. Within this advancing technology, many of the current certification methods may still be applicable, however, new test techniques and methodologies must be used to evaluate and analyze the operational and reliability issues of their software programs which include, executive, operational, and interface routines.

The extreme flexibility afforded by these software based digital information transfer systems presents significant problems in assuring that the software structure including compilers, higher-order languages, and architectural design is not adversely affected by changes in the "firmware" or software during the implementation or maintenance life of the systems. It is possible, with these new systems, to make changes to the systems structure such that the basic certification criteria are altered and the flight control system and aircraft safety may be subject to errors or initiation of unintended functions which result in failures. Therefore, it is necessary to establish testing and configuration management practices to insure that the systems and integration of systems are not vulnerable to errors in design or implementation, by providing regulation and guidance material to design and maintenance engineers which will insure that systems retain the degree of reliability and operational integrity established during the initial certification activity.

In order to insure this integrity, it is necessary that the FAA establish and maintain the data bases, information, and regulatory material related to this technology.

The FAA, within the last year (1982) has published three advisory circulars (AC) which recognized the implementation of this new technology, and especially the importance of software based systems. These three AC's are:

AC 25:1309-1	System Design Analysis
AC 20-115	RTCA Document DO-178
AC 120-28C	Criteria for Approval of Category III Landing Weather Minimums

They set forth an acceptable means of compliance for certification of certain digital systems, however, the FAA needs to establish additional data bases and information in order to provide technical guidance and regulatory criteria for the certification and assurance assessment of the new generation of digital systems in the next generation of civil aircraft.

This technical guidance will be in the form of AC's that deal specifically with the integration of the digital systems. One such AC will provide the criteria for evaluating software and hardware used in establishing bus architectures and will provide guidance in evaluating the data packages developed by the manufacturer and/or integrator and submitted during the STC or TC process. Additional advisory material will be developed which can be used by the certification directorates as guidelines, minimum performance specifications, and worked examples for comparison against data delivered for evaluation and approval with respect to the criteria established in AC 25:1309-1.

This program plan addresses development of these new required data bases and information.

1.3 MAJOR PROGRAM ELEMENTS.

The major program elements discussed in the body of this Program Plan are:

a. Digital Systems Studies.

b. Validation Methodology.

c. Cockpit Vision Surveys.

These elements represent the current divisions of activity for the program; however, as requirements change, they will be modified according to the timely dictates of the agency's needs.

1.4 TECHNICAL PROGRAM.

Table 1 presents the emerging technology which can be expected to be included in the design of the current and next generation civil aircraft. These technologies are all dependent on "software" or "firmware" for interconnection and integration of the modules and systems, and requires assurance methodologies and tools to assess their validity, reliability, and ultimately the safety of the aircraft. These technologies have been emerging since the middle 1970's and are expected to be the predominant driving force in design and life cycle considerations through the early decades of the 21st Century (e.g., 2010-2015). The payoffs, problems, and primary certification issues for these technologies are addressed in table 2.

The FAA's ability to properly conduct investigations for functional assessment of new aircraft and systems, verify their intended function and specified performance, define failure modes and effects, and develop hardware/software validation procedures is critical to the total safety certification process.

A primary objective of the FAA Technical Center will be to aid and support the certification process and the assessment of airworthiness and operation safety issues through development and implementation of efforts to:

a. Conduct comprehensive analyses of existing software-based digital flight control and avionics systems to assess reliability, validation, and criticality issues, and identify potentially vital problem areas.

TABLE I. TECHNOLOGY DEVELOPMENT AND IMPACT ON CIVIL AIRCRAFT DESIGN AND IMPLEMENTATION

Technology	Availability 1980	Availability 1985	Availability 1990	Architecture/ Design	Life Cycle Cost	Reliability	Integration
• Microprocessor	X			X			
-- Multiple Designs							
-- Multiple Languages							
-- Diverse Capability							
-- ARINC 7XX Design							
• Point-to-Point Data Transfer	X						
-- ARINC 429 - 5/6							
-- Shielded Twisted Pair							
• 10 K/Bit							
• 100 K/Bit							
• Bus Architecture	X			X			
-- MIL-STD-1553B							
-- Shielded Twisted Pair							
• 1 M/Bit							
• Display Technology	X	X	X	X	X	X	X
• Distributed Computer Networks		X	X	X	X	X	X
• Fault Tolerant Computers		X	X	X	X	X	X
-- SIFT							
-- FTMP							
• Fault Tolerant Software		X	X		X	X	
-- Analytical Redundancy							
-- Functional Partitioning							
-- Recovery Blocks							
• High Speed Transmission Media		X	X	X	X		X
-- Co-axial Cable							
-- Fiber Optics							
• VLSI/VHSIC Microcircuits			X	X	X	X	
• Electro-Mechanical Servo Mechanisms			X	X	X	X	
• Electronic Sensors			X	X	X	X	
• Validation Methodology	X	X	X		X	X	

TABLE 2. PAYOFFS, PROBLEMS, AND PRIMARY CERTIFICATION ISSUES

Technology	Payoff	Problems	Certification Issue
• Microprocessor -- ARINC 7XX	• Increased Flexibility • Lower Life Cycle Costs • Less Weight/Power Required	• Multiple Designs • Multiple Languages • Diverse Capability • Validation Issues Emerging • Data Base (Problems/Failures) Not Yet Established	• Configuration Management DO-178 • System Safety AC 25.1309-1 • Certification Criteria Emerging -- Special Conditions
• Point-to-Point Data Transfer -- ARINC 429-5/6 • Shielded Twisted Pair Media: -- 10 K/Bit -- 100 K/Bit	• Standard Specification	• Limited Bandwidth • System Validation Incomplete • Software Complexity • Broadcast Transmission	• No Published Evaluation Criteria
• Bus Architecture -- MIL-STD-1553B	• Standard Specification • High Bandwidth	• Cost of Implementation • System Validation Incomplete	• No Published Evaluation Criteria (Remote Terminal Test Plan Completed--Not Validated)
• Display Technology	• Multi-Function Capability • Increased Flexibility • Increased Information Content	• Lack of Standardization • Validation Issues Emerging	• No Published Evaluation Criteria
• Distributed Computer Networks	• Reduced Complexity (Hardware) (Less Black Boxes) • Better Redundancy Management	• Higher Bandwidth Required • Increased Dependence on Real Time Executive Software • System Validation More Complex	• No Published Evaluation Criteria
• Fault Tolerant Computers	• Increased Reliability • Increased Fail Operational Capability • Increased Modularity • Common Processing	• Real Time Executive Software More Complex • System Validation More Complex	• No Published Evaluation Criteria
• Fault Tolerant Software -- Analytical Redundancy -- Functional Partitioning -- Design Language; (e.g., ADA, etc.), Developed/Validated	• More Reliable Software • Improved Software Design/Practices • Solve Generic Software Problems • Standard Software Core Modules • Standard Algorithms • Increased Fault Coverage	• Initial Software Development May Be More Expensive • Quantitative Evaluation More Difficult • Requires New Software Metric Tools To Be Developed • System Validation More Complex • May Require New Hardware Developments/New Architecture/Designs	• No Published Evaluation Criteria

TABLE 2. PAYOFFS, PROBLEMS, AND PRIMARY CERTIFICATION ISSUES (Continued)

Technology	Payoff	Problems	Certification Issue
• High Speed Transmission Media -- Co-Axial Cable -- Fiber Optics	• Higher Bandwidth • Lighter Weight (Less Wires) • Improved Architecture with Decentralized Processing • Lightning/EMI/EMP Immunity	• Initial Cost of Bus Interface Units Expensive • Reliability of Transmit/Receive Devices not Yet Established • Standards Not Yet Developed • System Validation More Complex	• No Published Evaluation Criteria
• VLSI/VHSIC Microcircuits -- 5000-15000 Gates -- 10000-50000 Gates -- 100000 Gates	• More Complex Functions Per Device • Reduced Space, Weight, and Power • Increased Speed • Redundancy Management in Hardware Design • Reduced Maintenance • Less Complex Software	• System Validation More Complex • Increased Risk of Environmental Effects • Test Case Design Very Complex • Reliability Issues Emerging	• No Published Evaluation Criteria
• Electro Mechanical Servo Mechanisms (Actuators) -- Digitally Commanded Analog/Actuators -- Digitally Driven Motors, Valves, etc.	• Ability To Be Commanded Using Digital Buses • Allow Distributed Architectures • Improved Feedback/Monitoring • Lighter Weight/Less Power	• System Validation More Complex • Reliability Issues Emerging • High Risk Technology • Severe Environment -- High Temperature -- High Stress	• No Published Evaluation Criteria
• Electronic Sensors	• Direct Interface via Buses • Reduced EMI/EMP • Reduced Noise/Less Drift • Increased Accuracy • Improved Monitoring	• System Validation More Complex • Requires Accurate Signal/Conversion	• No Published Evaluation Criteria
• Validation Methodology	• Increased System Reliability • Reduced Design Costs • Standard/Automated Tools • Reduced Design Errors • Decreased Life Cycle Costs	• Standardized Methodology Not Developed/Approved • Increased Development Costs • Reliability Models Not Fully Developed for Hardware/Software Interfaces • Requires Highly Reliable/Validated Languages/Compilers	• Evaluation Criteria Emerging

b. Identify prototype module/subsystem/system failure modes and effects for "flight-essential" and "flight-critical" applications analysis techniques, and implementations of these techniques.

c. Identify and establish hardware and software configuration control concepts, reliability, configuration management techniques, etc.

d. Evaluate the possible impact of transients, intermittents, errors, latents, upsets, and other induced failures and faults and their effects on the digital systems.

e. Provide handbooks and other guidance material which contain data bases and information critical to assessing the safety and airworthiness of the new technologies and their integration into new and derivative aircraft.

f. Conduct cockpit vision surveys in support of certification activities and to provide data to FAA and others on visibility criteria.

1.5 FACILITIES AND EQUIPMENT.

In order to conduct the investigations and studies which will provide the necessary data bases, this program will utilize three facilities: (1) The Reconfigurable Digital Flight Control System (RDFCS) at the NASA-Ames Research Center; (2) the validation laboratory at the FAA Technical Center; and (3) the binocular camera (and/or the new cockpit visibility survey system) at the FAA Technical Center.

The RDFCS facility at NASA-Ames Research Center was jointly developed by the FAA and NASA-Ames Research Center for the specific purpose of using system simulation to investigate validation and failure effects technology for digital flight control and avionics systems. The RDFCS contains state-of-the-art avionics processors (e.g., the same as the L-1011-500 and B-767/757) and is capable of meeting the requirements of the 1980 to 1990's aircraft configurations through "software" or "firmware" changes or modifications (figure 1).

The validation laboratory at the FAA Technical Center was developed to investigate bus architectures and software interface configurations using state-of-the-art microprocessors and the ARINC 429 and MIL-STD-1553B architectures (figure 2).

In addition to these facilities, this program will also be interfacing with the AIRLAB facility at the NASA-Langley Research Center and the SEAFAC facility at the Wright-Patterson Air Force Base. These facilities are currently being established to investigate digital technology issues and the research to be conducted in these facilities will provide data and information which will be used in establishing certification criteria for civil aircraft.

The binocular camera developed 30 years ago by the CAA is located at the FAA Technical Center (figure 3).

The RDFCS facility and the validation laboratory have been established either with FAA partial funding through interagency agreements and mutual cooperative efforts (e.g., the RDFCS facility) or by utilizing equipments, supplies and personnel that have been funded and established by other FAA programs (e.g., the validation laboratory). These facilities are utilized by other programs within both NASA and

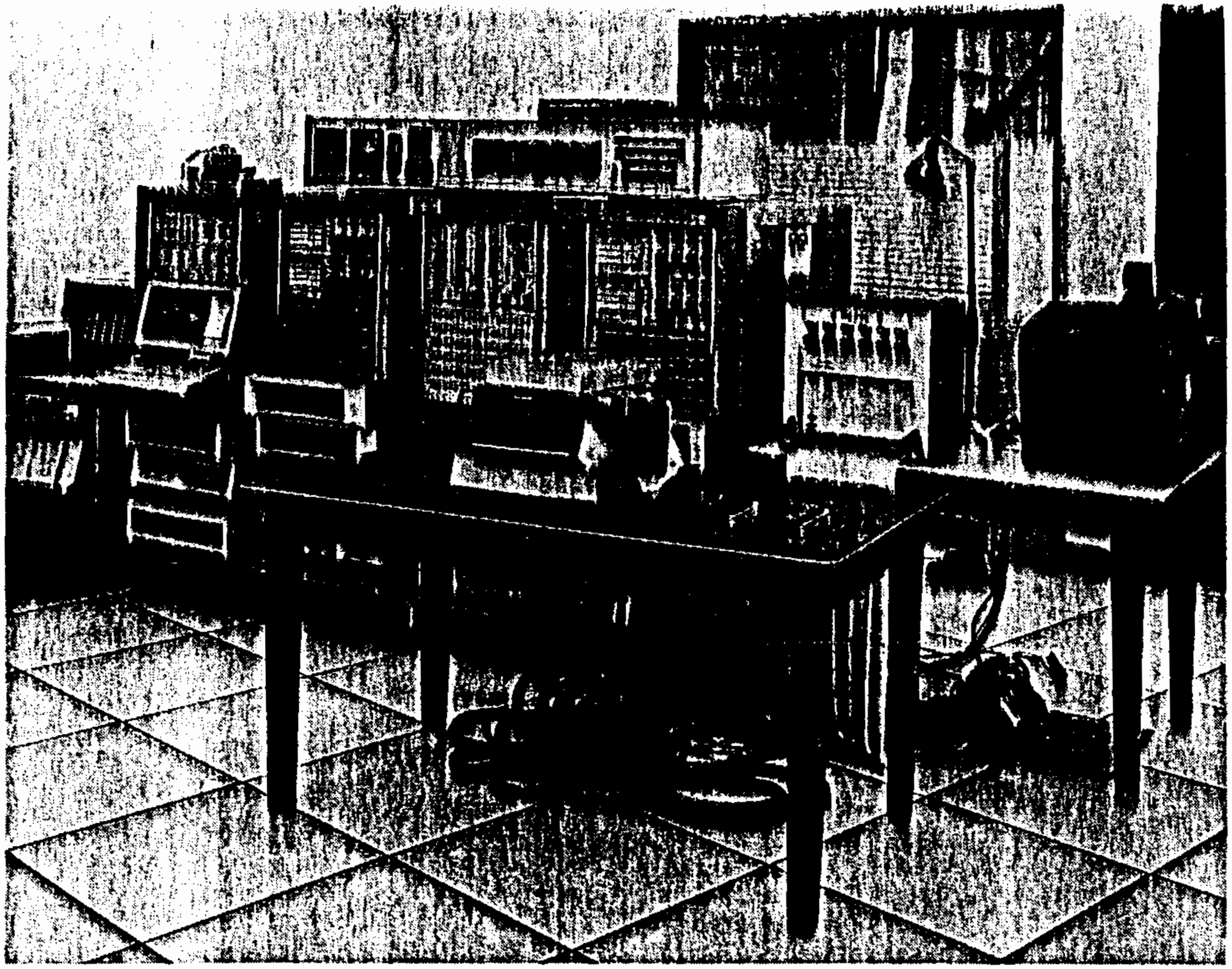

FIGURE 1. RDFCS FACILITY

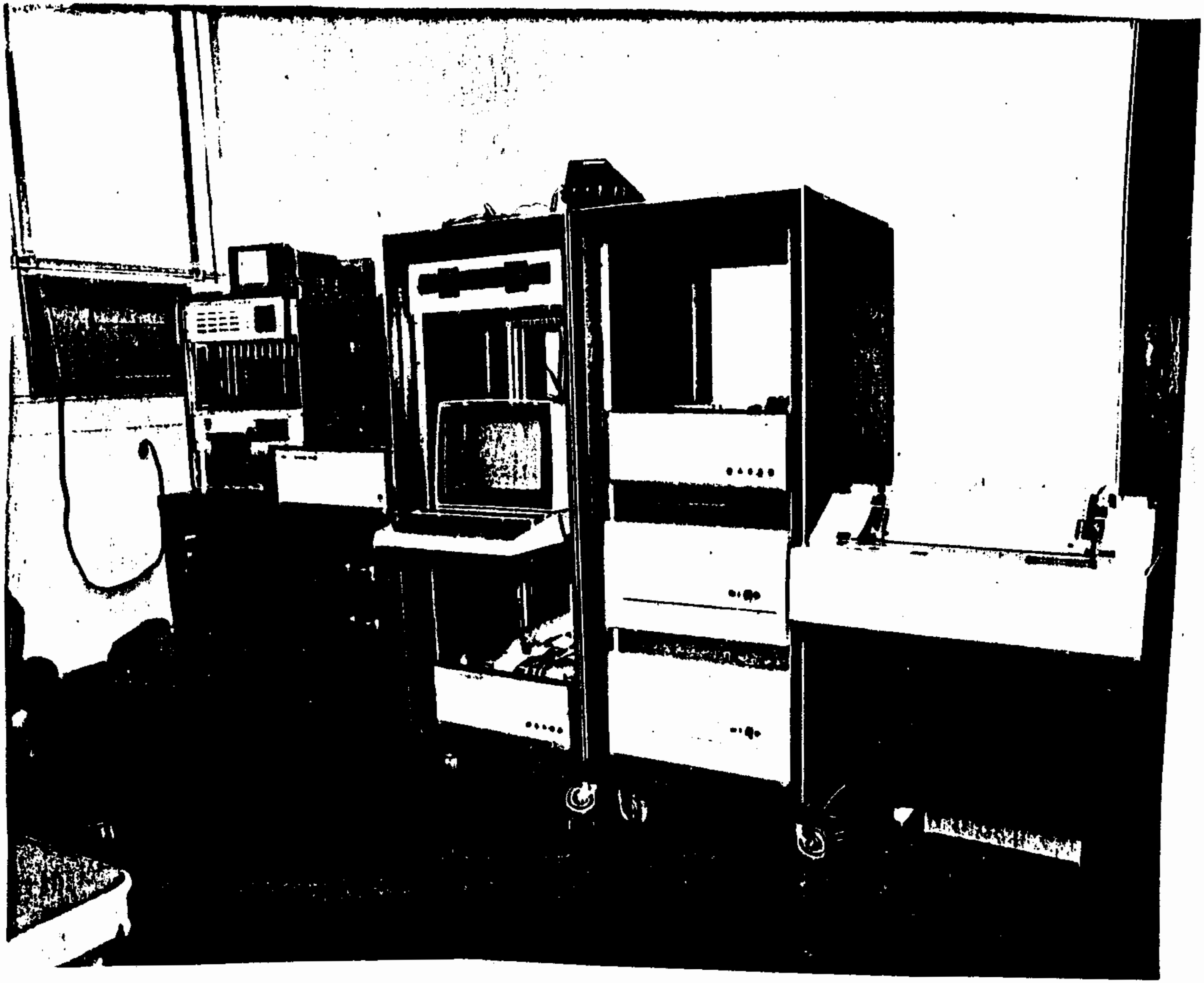

FIGURE 2. VALIDATION LABORATORY

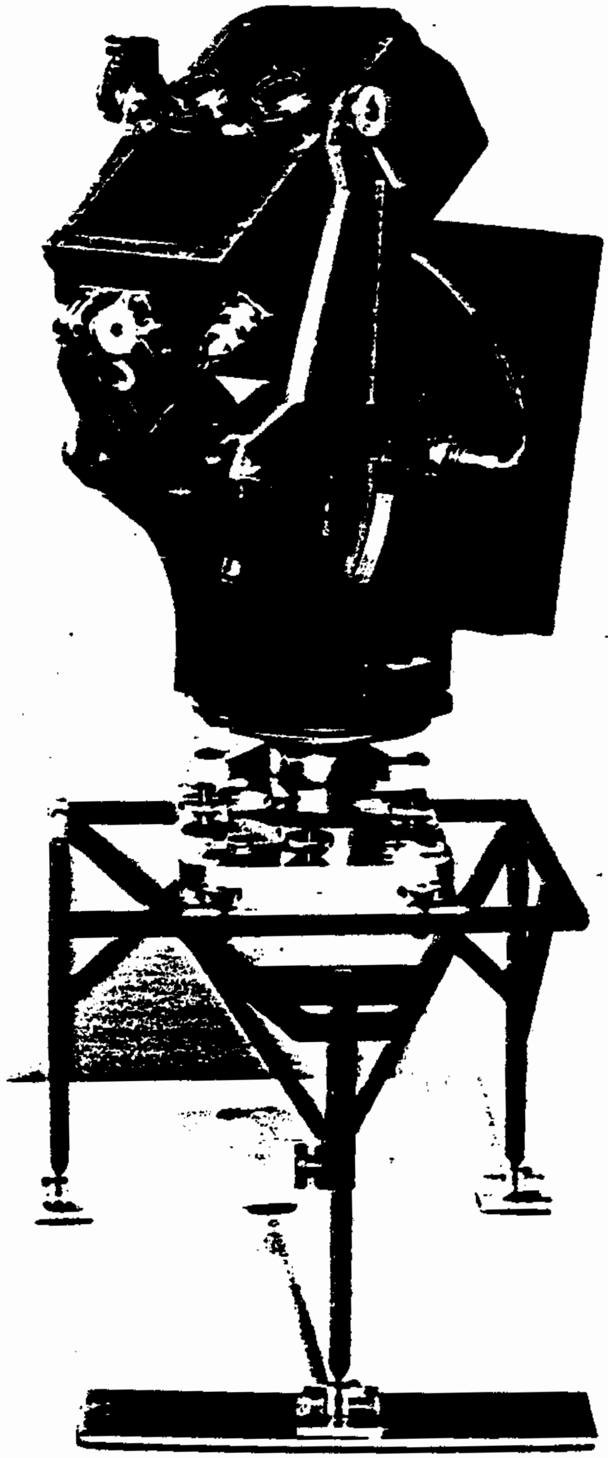

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FIGURE 3. BINOCULAR CAMERA

the FAA and in some cases, the data and information developed by these other programs directly contributes to the needs of the digital system program; and as such, provide a greater return to the FAA than is represented by the funding levels available within this program.

1.6 PROJECTS.

Table 3 provides a list of the studies which are either currently being conducted or will be conducted in FY-84 through FY-88 using the above facilities. This table has been established, based on the availability and implementation of the new technology, and will result in data packages being developed which will have an impact on certification issues which are emerging. The funds are estimated, based on FY-83 dollars and are only intended for planning purposes. The F&E funds are based on required facility developments or improvements which are necessary in order to conduct the identified studies.

Figure 4 presents investigations and studies using the RDFCS facility. These studies are expected to be completed by FY-88 using the present hardware and software configurations. After FY-88, it will be necessary to redesign the pallet due to the anticipated developments in digital technology. At the present time, the technology is changing completely every 3 to 5 years, and in order to maintain a state-of-the-art capability, it is necessary to anticipate for this change almost as soon as the initial capability is established.

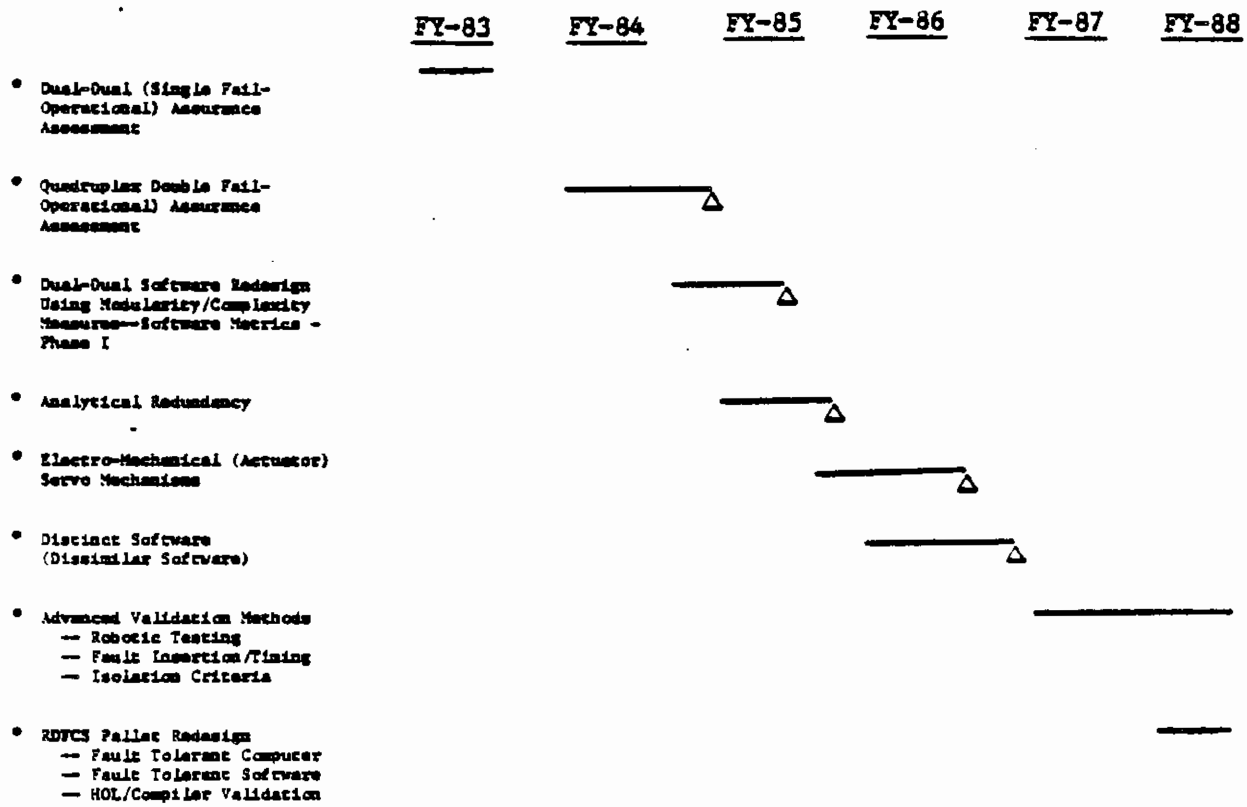


FIGURE 4. INVESTIGATIONS USING THE DIGITAL FLIGHT CONTROL SYSTEM SIMULATOR (RDFCS)

TABLE 3. STUDIES TO BE CONDUCTED FY-84 THROUGH FY-87

ACTIVITY	TIME	FACILITY	PROJECT	FUNDS	
				FED	F&E
1.	FY-82	RDFCS	Dual-Dual (Single Fail-Operational Assurance Assessment)	Completed	
2.	FY-84	RDFCS	Quadruplex (Double Fail Operational Assurance Assessment)	Contract 60.0K Facility (25.0K)	
3.	FY-85	RDFCS	Dual-Dual (Software Redesign Using Modularity/ Complexity Measures - Software Metrics	Contract 50.0K Facility 25.0K	
4.	FY-85	RDFCS	Analytical Redundancy	Contract 50.0K Facility 25.0K	
5.	FY-84	Validation Laboraotry	Complete Phase I Hardware/Software		Contract 195.0K
6.	FY-84	Validation Laboratory	Initiate Bus Evaluation Criteria Study	Contract 50.0K	
7.	FY-85	RDFCS	Electro-Mechanical Servo Using Bus Transfer via 429 Bus	Contract 50.0K Facility 25.0K	
8.	FY-85	RDFCS	Distinct Software	50.0K 25.0K	
9.	FY-85	Validation Laboratory	Software Fault Tolerance Using Triplex SIFT Architecture	Contract 50.0K	225.0K
10.	FY-86	Validation Laboratory	Evaluation of Transmission Medium/Access Method for Bus Transmission	Contract 50.0K	225.0K
11.	FY-86	RDFCS	Robotic Testing Fault Insertion Isolation Criteria	100.0K 50.0K	
12.	FY-87	Validation Laboratory	Artificial Intelligence Remote Processing Advanced Controls	200.0K	750.0K

Figure 5 presents the development schedule and studies using the validation laboratory at the FAA Technical Center. The development efforts and the initial studies are expected to be completed prior to FY-90 and result in the establishment of criteria to be used for the evaluation of bus architectures including the transmission media and access methods which will soon be implemented on civil aircraft.

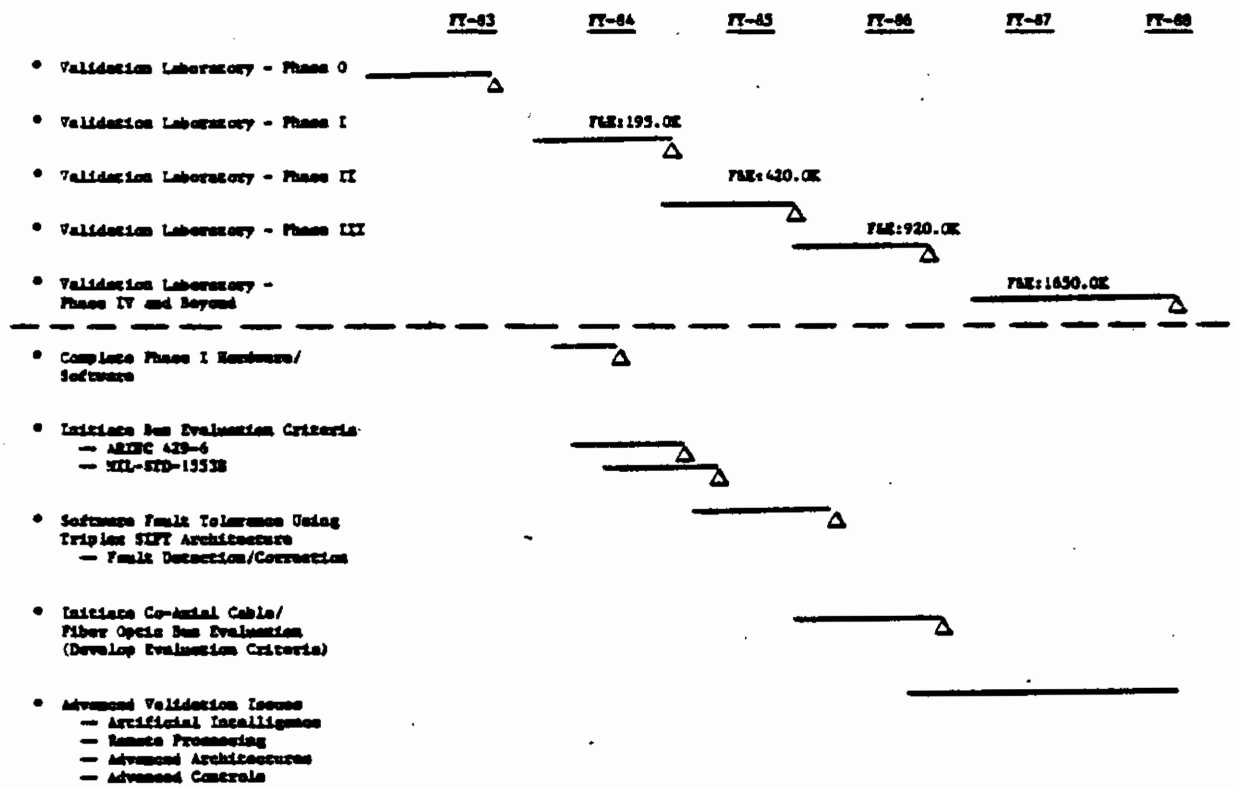


FIGURE 5. DEVELOPMENT OF THE VALIDATION LABORATORY/STUDIES TO BE CONDUCTED USING THE LABORATORY

Appendix A contains a detailed description of the issues related to digital transfer mechanisms, architectures, and networks which will be studied using the validation laboratory. Appendix A also contains FY-84 cost estimates and rationale for the F&E funding necessary for the validation laboratory.

1.7 VALIDATION ISSUES.

The digital systems program has developed a handbook which is intended to be used as a guidance document for certification engineers in assessing the validation and certification issues associated with the implementation of digital flight control and avionics systems (reference: "Handbook—Volume I, Validation of Digital Systems in Avionics and Flight Control Applications," DOT/FAA/CT-82/115). The purpose of this handbook is to identify techniques, methodologies, tools, and procedures in a systems context that may be applicable to aspects of the validation and certification of digital systems at specific times in the development and implementation of software-based digital systems to be used in flight control and avionics applications. The application of these techniques in the development of discrete units and/or systems will result in completion of a product or system which is verifiable and can be validated in the context of the existing regulations/orders of the government regulatory agencies. The handbook uses a systems engineering approach to the implementation and testing of software and hardware during the design, development, and implementation phases.

In summary, the handbook:

1. Identifies and presents the issues related to the design, development, and implementation of software-based digital systems.

2. Identifies specific approaches applicable to all aspects of the verification and validation procedures at specific times in the development and certification portion of the system life cycle.

3. Provides the government regulatory agencies (especially the Federal Aviation Administration (FAA)) as well as industry with a set of tools/procedures, in a systems engineering context which may be of value in the validation/certification process.

This Handbook has been developed as a working document and to remain effective must be modified and updated as the technology advances. Figure 6 presents a schedule of activities for updating and maintaining the "Handbook — Volume I." Volume II of the handbook will include data relating to maintenance and modifications of the currently certificated systems, as well as data on new technology validation and assurance methodology issues. It is expected that these data bases will evolve as experience and utilization increases. The efforts being conducted using the RDFCS and validation laboratory facilities will result in the development of data packages and information which address validation and certification issues which have developed during the introduction of software based digital systems into the current generation of civil transport aircraft.

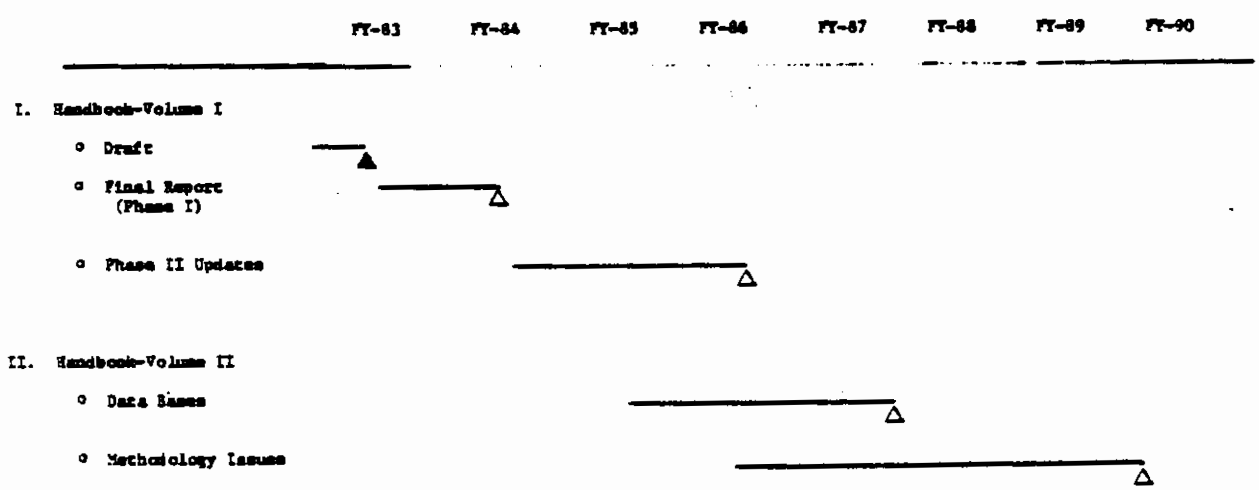


FIGURE 6. SCHEDULE OF ACTIVITIES FOR UPDATING AND MAINTAINING THE HANDBOOK

In addition, data packages developed by NASA, DOD, and industry will be evaluated and added to the handbook as they become available. It is expected that Volume II will include these data packages as worked examples which represent the current practices, procedures, and methodologies employed in the validation and safety assessment of the new technologies.

Efforts are planned to work with the Avionics Maintenance Conference (TG-104), ARINC, and the Airlines Electronics Engineering Committee (AEEC) to define the issues and problems associated with the implementation of software based digital systems in civil aircraft.

The manpower and contract dollars required to maintain and implement this activity are presented in figure 7.

	FY-83	FY-84	FY-85	FY-86	FY-87	FY-88	FY-89	FY-90
I. Digital Systems Studies								
• RDFCS Facility								
— Contract Funds								
• Maintenance/Modifications		50.0K	50.0K	75.0K	75.0K	100.0K	—	—
• Studies/Investigations		100.0K	125.0K	150.0K	150.0K	200.0K	—	—
— Staffing (MY)								
• Electronic Engineer		.5	.5	.5	.75	.75		
• Aerospace Engineer		.25	.25	.25	.5	.5		
• Software Engineer		.5	.5	.5	.75	.75		
II. Validation Methodology								
• Validation Laboratory								
— Contract Funds								
• F&E		195.0K	420.0K	920.0K	750.0K	500.0K	—	—
— Contract Funds								
• Maintenance/Modifications		15.0K	15.0K	15.0K	25.0K	25.0K	50.0K	50.0K
• Studies/Investigations		50.0K	50.0K	75.0K	75.0K	100.0K	100.0K	125.0K
— Staffing (MY)								
• Electronic Engineer		.5	.5	.5	.5	.75	.75	.75
• Software Engineer		.5	.5	.5	.5	.75	.75	.75
• Aerospace Engineer		.25	.25	.25	.25	.25	.50	.50
• Validation Issues								
— Contract Funds		50.0K	50.0K	50.0K	75.0K	75.0K	75.0K	100.0K
— Staffing (MY)		.5	.5	.5	.5	.5	.75	.75
III. Cockpit Vision Surveys								
• Contract Funds								
— System Procurement		200.0K						
— System Operation/Maintenance		5.0K	10.0K	10.0K	15.0K	15.0K	15.0K	20.0K
• Staffing (MY)								
— Electronic Engineer		.5	.5	.5	.5	.5	.5	.5
— Software Engineer		.25	.25	.25	.25	.25	.25	.25

FIGURE 7. CONTRACT FUNDINGS, STAFFING, AND SKILL LEVELS REQUIRED TO COMPLETE THE TASKS AND PROJECTS

"The Handbook — Volume I" is currently being reviewed and used by the FAA and by the United States Air Force (Wright-Patterson Air Force Base). It is planned that the Handbook — Volume I be revised and reformatted into a draft advisory circular on digital systems and will be responsive to the material included in draft AC 29-X (Certification of Transport Category Rotorcraft) as well as other ongoing draft ACs.

1.8 COCKPIT VISION SURVEYS.

1.8.1 Introduction.

The original (one-of-a-kind) binocular camera developed by the Civil Aeronautics Administration (CAA's) Technical Development and Evaluation Center over 30 years ago measures aircraft (general aviation, helicopter, transport) cockpit visibility patterns in terms of angles-of-vision as seen by a pilot. As described in the CAA Technical Development Report Number 153, "Development of an Instrument for Measuring Aircraft Cockpit Visibility Limits," dated January 1952, a binocular strip-film camera was a practical means to record visibility. A black and white photographic record showing the outlines of the windows in aircraft cockpits, as seen by the pilot when he turns his head from extreme left to extreme right, can be easily and quickly made with the camera. The camera automatically superimposes a grid of horizontal and vertical lines on the picture and records angles of vision in aircraft cockpit to compare with FAR recommended minimum standards (figure 8).

The vision criteria, still in use today after 30 years of aircraft evolution, are to be found in the Civil Aeronautics Manual 4B (CAM 4B). A comparison of standards contained in CAM 4B with those more recently established by the Society of Automotive Engineers (SAE), (Aeronautical Specification (AS) 580B, and SAE Aerospace Recommended Practice (ARP) 268E) and the United States Military Standard 850B reveal that differences are generally insignificant. Draft AC 25.773-8 is seeking to revise transport minimum standards. Certification directorates are also interested in revising or developing minimum standards for helicopter and general aviation.

This need is critical in that the FAA requires the capability to more effectively and timely support NTSB/DOD accident investigations, FAA certification directorates, litigation actions, and industry in the design, development, and certification process. Contributing to that criticality and urgency is the aging binocular camera (only one in existence); uses special high cost and unreliable film (requiring Administrator procurement approval authority) — current film supply is 5 years old (life outdated); mandatory, unique, and high risk processing (now not available at Technical Center); requiring special refrigeration and treatment, handling, and illustrative processing. A new camera system is desperatly needed to support this capability.

1.8.2 Objectives.

a. To provide cockpit visibility surveys and technical support to FAA headquarters and certification directoratee in the update and/or development of cockpit visibility criteria/standards.

b. Support development of new or revised requirements for cockpit visibility for all categories of aircraft.

c. Conduct timely and effective cockpit visibility surveys of aircraft (general aviation, helicopter, transport, military) in support of NTSB, DOD, FAA accident/incident investigations, certification directorates, and industry in the design, development, and certification process.

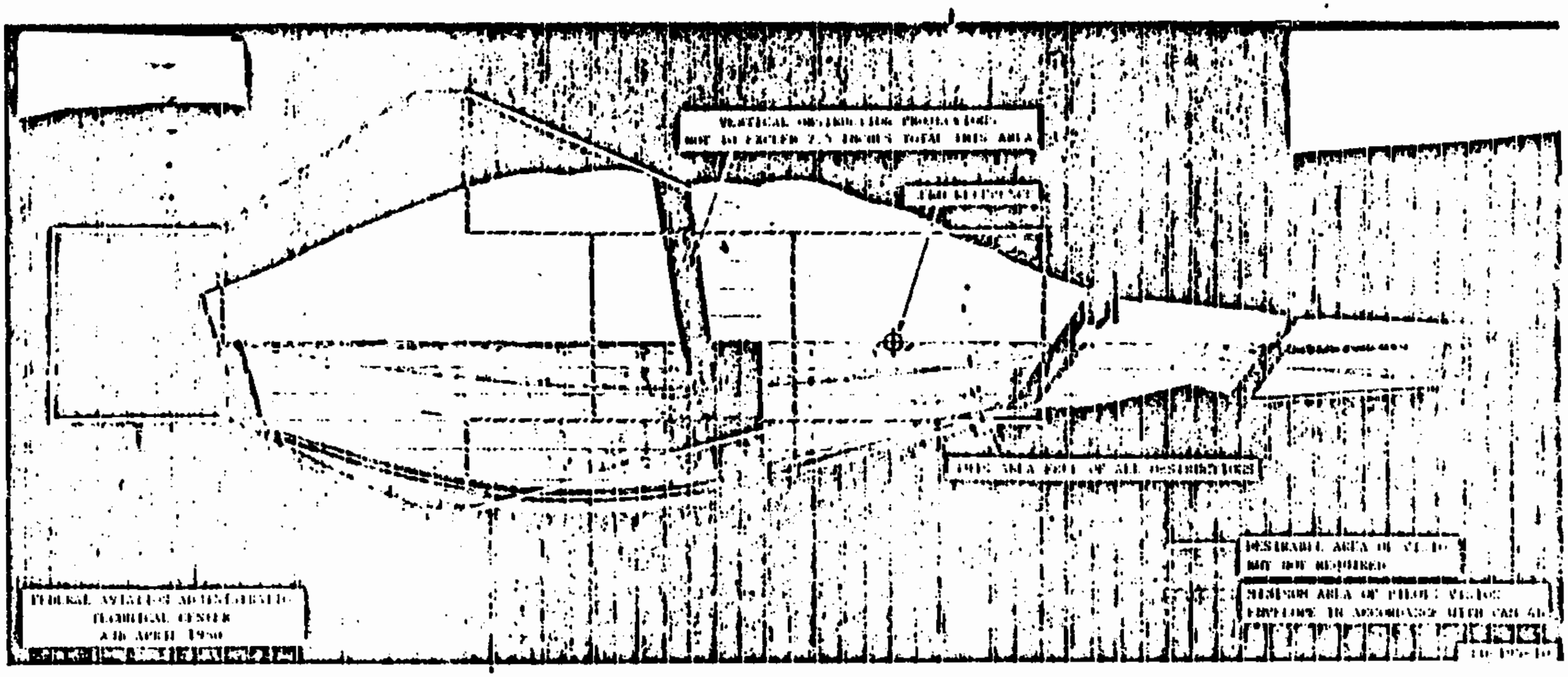


FIGURE 8. PILOTS EYE POSITION

d. Provide a state-of-the-art engineering special effects camera (or device) which can produce a calibrated photograph (or electronic) record of the binocular field-of-view of a pilot/crew as would be observed from his/their cockpit location.

1.8.3 Approach.

a. Provide survey and technical support as requested.

b. Continue to support requesting organizations in a timely manner.

c. Propose criteria for revising or developing minimum standards for visibility requirements in general aviation, helicopters, and transport aircraft.

d. Establish the necessary priorites and funding which will support the design, development, and procurement of the state-of-the-art engineering special effects camera (or device) which can produce a calibrated photograph (or electronic) record of the field-of-view of a pilot/crew as would be observed from his/their cockpit location. The new camera (or device) will be used for accurate measurement of cockpit visibility requirements as associated with aircraft design, development and airworthiness standards, accident/incident investigations, flight safety, etc.

Basic design study considerations for the new camera system include the vital characteristics embodied within the original camera, state-of-the-technology applications (i.e., "off-shelf" black and white or color film; portability, lightweight, and use by one person; simple set-up, adjustment, level, position; precise images and grids under various light conditions; and adjustable time delays, left eye/right eye only pictures, reliability and repeatability), plus a capability to record general aviation, helicoptar, transport (civil and military) cockpit visibilities.

1.8.4 Schedule.

Figure 9 presents a schedule of activities for: (a) The design, development, and procurement of the cockpit vision survey equipment; and (b) the ongoing support to the FAA, NTSB, and DOD for the conduct of the vision surveys.

The manpower and contract dollars required to maintain and implement this activity are presented in figure 7.

1.9 Funding/Manpower.

Figure 7 presents the contract funding (including F&E and F,E&D dollars), the staffing (in-house manpower in man-years), and the skill levels required to complete the tasks and projects outlined in this program plan.

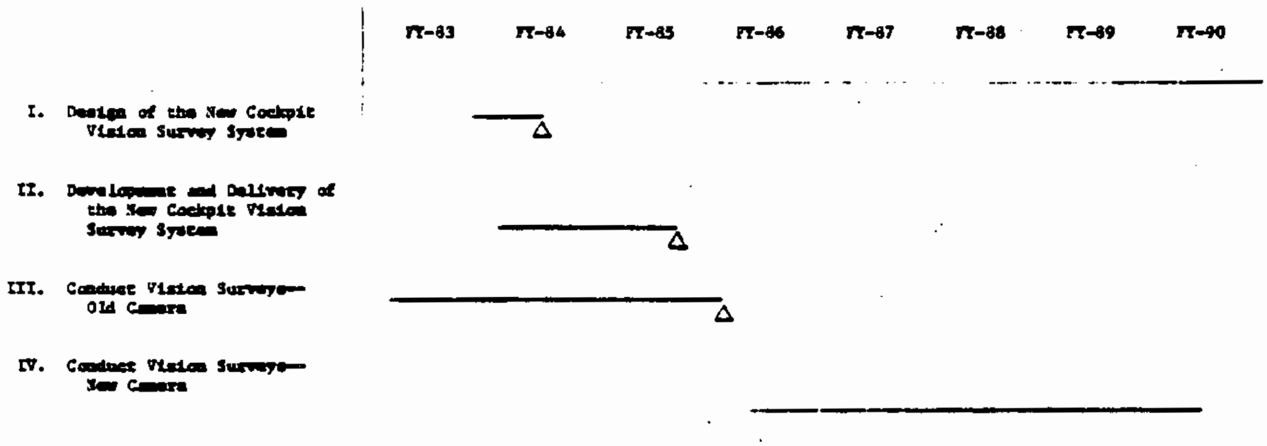


FIGURE 9. SCHEDULE OF ACTIVITIES FOR THE COCKPIT VISION SURVEY CAMERA IMPLEMENTATION AND USE

APPENDIX A

VALIDATION LABORATORY

APPENDIX A

VALIDATION LABORATORY

DIGITAL TRANSFER MECHANISMS, ARCHITECTURES, AND NETWORKS

Problem: Digital Buses and microprocessors are used extensively in the current generation of civil aircraft. These buses and processors are used in flight control and avionics applications to transfer data and to perform complex calculations. The Federal Aviation Administration (FAA), at the present time, has no published criteria or procedures for evaluating these complex systems. Currently, the data bases and information necessary to develop the regulations, criteria, and procedures required to certificate these systems are not avialable.

Background: Digital systems in the new generations of civil aircraft will require interconnect using digital buses which will require revised interface standards, specifications, and architectural considerations in order to provide data to central and remote processors. These digital buses will interconnect microprocessors, sensors, and servo mechanisms using diverse network topologies in order to increase their fault tolerant designs and interfaces. Table A-1 presents some of the conventional topologies and their characteristics.

TABLE A-1. CONVENTIONAL TOPOLOGIES AND THEIR CHARACTERISTICS

Topology	Reliability	Interface Complexity	Modularity	Flexibility	Cost
Unconstrained	Very Good	Very High	Moderate	Poor	High
Star	Poor	Simple	Moderate	Poor	High
Ring	Moderate	Simple	Good	Moderate	Moderate
Bus	Good	Moderate	Good	Good	Low
Tree	Good	Moderate	Good	Good	Low

The network topologies and their associated hardware will be interconnected using three main types of transmission media. These three media and their characteristics are included in table A-2.

TABLE A-2. DATA TRANSMISSION MEDIA CHARACTERISTICS

Transmission Medium	Bandwidth	Distance	Topology Versatility	Ease of Installation	Cost	Noise Immunity
Twisted Pairs	Low (6 MHz)	Short	High	Moderate	Low	Low
Coaxial Code	Medium (300 MHz)	Moderate	High	Easy	Moderate	High
Optical Fibers	High (300 GHz)	Long	Moderate (Bus and Tree are difficult)	Moderate	Moderate	Very High

When a network topology is established and the transmission media selected, the designer must implement a network access method. The access method is the mechanism by which any of the nodes (e.g., controllers, remote terminals, monitors) acquire and/or transfer data and information within the network. Table A-3 includes the existing access methods and their characteristics.

TABLE A-3. NETWORK ACCESS METHODS

Access Method	Degree of Contention	Bandwidth	Flexibility	Modularity	Message End-to-End Delay
Space Division Multiplex	Low	Poor	Poor	Moderate	Low
Frequency Division Multiplex	Low	Poor	Poor	Moderate	Low
Time Division Multiplex	Low	Poor	Poor	Moderate	Low.
Token Ring	Low	Good	Moderate	Moderate	Moderate
Slotted Ring	Low	Good	Moderate	Moderate	Moderate
Carrier Sense Multiple Access	High	Good	Good	Good	Non-Deterministic

The current generation of microprocessor based avionics systems (as represented by the Boeing 757/767; the Lockheed L-1011-500; the Aerospatiale HH-65A helicopter; and the Airbus A-310) use bus architectures based on either the ARINC 429 or the MIL-STD-1553B specification and standards. These buses use shielded twisted pair wires for the transmission media and interconnect to microprocessors which primarily use bit slice processors (as represented by the AMD-2901 type LSI chip) which provide the required internal processing speed (7-14 MHz chock rate) and the inherent reliability and flexibility required for flight essential/flight critical control systems. In this generation of digital systems, the individual processors are run in a bit or frame synchronized manner and data are exchanged between redundant computers via dedicated serial buses; and internally by high speed dedicated transfer buses/back planes.

The next generation of digital systems will change dramatically and will be characterized by multiple microprocessors in each computing channel with more local processing within a processor and the transfer of preprocessed data within the bus network. In addition, the system architecture will make use of sophisticated LSI chips (as represented by the Z8000 series, the MC 68000 series, and others) which will use Multibus, VERSAbus, Standard bus, VME bus, and other bus architectures for internal processor-to-processor interfaces and exchange of data and information. Table A-4 includes a summary of some of these bus characteristics. In addition, these processors and their fault tolerant schemes will make use of global memory and functional partitioning of software to decrease the software complexity and increase the reliability of the system.

TABLE A-4. SUMMARY OF BUS CHARACTERISTICS

	VMEbus	VERSAbus	Multibus	Q-Bus	S-100 Bus
Bus Type	Asynchronous Non-Multiplexed	Asynchronous Non-Multiplexed	Asynchronous Non-Multiplexed	Asynchronous Multiplexed	Synchronous Non-Multiplexed
Address Width	24 Standard 32 Expanded	24 Standard 32 Expanded	20 Standard 24 Expanded	16 Standard 18 Expanded	16 Standard 24 Expanded
Data Width	8, 16, 32	8, 16, 32	8, 16	8, 16	8, 16
No. of Pins on Primary/Secondary Connector	96/96	140/120	86/60	36	100
Voltage (V)	+5, ±12, +5 Standby	+5, ±12, ±15 +5 Standby	+5, ±12	+5, ±12, +5, +12 Backup	+8, ±16
Interrupt Levels	7	7	8	4	8
Arbitration Levels	4	5	1	1	16
Multiprocessor?	Yes	Yes	Yes	DMA only	Yes
Error Signals	AC Fail, System Fail, Bus Error	AC Fail, System Fail, Bus Error, Add Data Parity	Non	DC Power OK Power OK	Power Fail, Bus Error
Special Cycles	Read Modify/Write Block Transfer Access Privilege Levels	Read Modify/Write Block Transfer Access Privilege Levels	Lock	Refresh Read Modify/Write Event Interrupt	None
Extendable Modes for Future	Yes (Address) Modifiers)	Yes (Address) Modifiers)	No	No	No
Separate Serial Bus	Yes	Planned for Reserved Pins	No	No	No

Furthermore, the transfer mechanism, as represented by the bus controller/bus interface module, will play an increasingly more important role in the integration and redundancy associated with the architecture of the system. The interface circuitry, whether it is implemented using LSI/VLSI chips, or dedicated modules, will be controlled by one or more processor modules and will be implemented in redundant configurations to increase the reliability of the data transfer system. It is possible, with the available technology, to develop a single string module which has dual, triple, or quadruplex path capability and can exist as an integral part of the processor module. This capability combined with ongoing microprocessor development and advances in internal/external bus architectures provides the basis for the development of highly integrated, highly redundant, highly survivable computer network architectures in the framework of the "all electric" aircraft of the 1990-2010 time frame.

Solution: In order to provide the data bases and to develop the regulatory material and procedures, it is necessary to establish a "Digital Systems Validation Laboratory" which is capable of initiating and completing studies and experiments which will provide the required data bases. This facility and the studies to be conducted in the facility will not only provide the necessary data but as importantly will be abla to provide a "hands-on" capability for training certification engineers in new technologies. The laboratory, as designed, will include the current bus architectures (e.g., ARINC 429 and MIL-STD-1553B) utilizing the shielded twisted pair transmission media as a baseline system. The laboratory will also be designed to evaluate technologies to be used on the next generation of aircraft digital systems such as the Software Implementation Fault Tolerant (SIFT) architecture, state-of-the-art microprocessors (e.g., Z 8000, MC 68000, and AMD 2901/29016 LSI processors) and their attendant internal bus architectures, and the implementation of higher bandwidth transmission medias.

The "validation laboratory" is an F&E based facility which has been planned with a multi-year phased approach as follows (reference table A-5):

TABLE A-5. FACILITY DEVELOPMENT PHASES

Phase	Time	Facility	Cost
Phase 0	FY-83	Existing "Hot Bench" Equipment	—0—
Phase I	FY-84	Multiplex Serial Buses Interface Equipment, Bus Mount on Hardware, Data Collection Capability	195.0K
Phase II	FY-85	Digital Flight Control Computer Aerodynamic Processor, Full Authority Electronic Engine Controller	420.0K
Phase III	FY-86	Cockpit Integration "Pilot in the loop" Flight Management Systems	920.0K
Phase IV	FY 87-89	As Required Systems	1650.0K

Table A-5 indicates the development phases and the F&E dollars required to develop the facility in order to conduct the necessary studies. As soon as this facility is developed, the following studies will be conducted:

Initiate studies to provide current bus architecture evaluation criteria	50.0K
Initiate studies to examine fault tolerance using SIFT architecture--provide evaluation criteria	75.0K
Initiate study to evaluate coaxial cable bandwidth/real-time executive interaction	75.0K
Initiate study to evaluate fiber optic transmission media	75.0K
Establish criteria for evaluating existing transmission media in terms of airworthiness criteria	50.0K
Initiate studies to examine remote processing, advanced controls architectures, and the role of artificial intelligence	150.0K
Initiate "hands-on" workshops in the areas of bus architectures, fault tolerance, artificial intelligence, and robotic testing	50.0K

Remarks: The validation laboratory will serve as a focal point for demonstrating technology initiatives and advancements and will provide a facility which will establish the necessary information for developing the certification criteria for advanced digital systems which can be expected to be implemented in the 1990-2010 aircraft.

In addition, this facility will serve as a training vehicle for certification engineers and will provide state-of-the-art facilities for development of benchmarks for regulatory and guidance material in the area of software based digital systems in flight control and avionics applications.

FY 84 COST ESTIMATES

ITEM SUMMARY

RIS: BU 2500-6

DATE 5/26/82

SUB ITEM	PROGRAM IDENTIFICATION / PROJECT CODE: FACIL.		WORK CODE	SUF	PRG. ORG.	FY	S
1-2	3-6	7	8-10	11	12-13	14-15	16

DESCRIPTION AND JUSTIFICATION

AIRWORTHINESS PROGRAMS - FACILITIES IMPROVEMENTS
DIGITAL SYSTEMS VALIDATION LABORATORY

PROBLEM:

In order to meet certain FAA obligations in airworthiness and certification of current and future aircraft (general aviation, helicopter, and transport) flight operations and aviation safety, comprehensive program(s) requirements identify the need for a digital systems validation laboratory. This laboratory must reproduce "real world" advanced aircraft concepts which cover areas included by software-based digital systems, stability and control augmentation systems, active control systems, advanced displays, primary flight control and avionic systems, engine control systems, aircraft/airmen/systems interface, and flying qualities. For the FAA to meet its certification and safety responsibilities, concentrated efforts must be initiated and maintained in this applied research area in order to acquire and disseminate pertinent data, information, and knowledge within the FAA certification directorates and headquarters, and to assure that certification criteria and procedures are valid and keep pace with the technology. In addition to providing technical data, the laboratory could train certification engineers, avionices inspectors, and Technical Center supporting research engineers in advanced systems integration, recertification issues, and inspection-maintanance considerations. NOTE: At the present time, the FAA (nor NASA or DOD) does not have the capability to conduct digital systems investigations in support of the certification process.

SOLUTION:

To develop a "hot-bench"/systems validation capability at the FAA Technical

LN. NO.	ACTION	PROJECT SRV. ORG.	PROJECT REG. LOC.	LOCATION ID	LOCATION	SUF	RUNWAY NO.	RUNWAY LTR.	ACTY NO.	SCB	LOCATION NAME -OR- SUPPLEMENTAL DATA	STATE	NO. OF UNITS	COST ESTIMATE	SPEC. CODE	SUBM. PAGE NO.	CON DES	
17	18	19-20	21-22	23-25	26-27	28	29-32		33-36	37	38-57	58-60	60-62	63-68	69-72	73-77	78-79	80
4																		
4																		
4																		
4																		
4																		

LN. NO. 17 | AC 18 | NEW HEADER ☐ | PROGRAM TITLE | TEXT

1 DIGITAL SYSTEMS VALIDATION LABORATORY

2 | REG/CTR/SVC. | PAGE NO.

FAA Form 2500-20-1 (2-78) SUPERSEDES PREVIOUS EDITION

C FAA AC 78-1707

Page 26 of 44

FY 84 COST ESTIMATES

RIS: BU 2500-5

DATE: 5/26/82

Description and Justification:

Center to monitor and characterize multiplex bus (MIL-STD-1553, ARINC 429, etc.) performance, fault/failure injection and effects study, and initial pilot-in-the-loop interface; conduct advanced digital systems and dynamic simulations of complex flight control and propulsion systems; full-mission/pilot-in-the-loop simulation studies for aircraft, systems, and aircrew interrelationships. A mulitple year phased approach to develop a "hot-bench"/system validation capability is planned as follows:

Page 27 of 44

Initial Facility Development (Minimum Equipment Procurement Only)	Estimated Cost	Revised (6/83)
Existing Hot-Bench-"spare" DACS, PGG, DNSS, HSI/HSD, etc.	$ 0	—
FY-84 Phase I multiplex bus: Interface equipment; bus monitor; analyzer, etc.	160.0	195.0
FY-85 Phase II flight control computer aerodynamic model processor (including propulsion and atomospheric)	330.0	420.0
FY-86 Phase III cockpit integration flight management; engine control; NAV/COMM systems, etc.	695.0	920.0
FY-87-89 Phase IV cockpit; Visual displays controllers; force field/control loader; digital autopilot, etc.	3,550.0	1650.0
	$4,685.0	

REMARKS:

The above problems (and solutions) may be investigated by NASA-Ames Research Center and/or NASA-Langley Research Center: (1) NASA-Ames has the most advanced capability, the Redundant Digital Flight Control System (RDFCS), which is a Collins digital flight control system similar to the Lockheed L-1011-500 (recently certified) CAT-III autoland system (without cockpit). The key difficulties in using the NASA-Ames facility are different from FAA research interests and due to continuous utilization of The RDFCS by the USAF-Hughes/General Research software verification recearch, and the NASA-Ames-Lockheed Georgia/Collins research efforts. The FAA Technical Center activity is sprinklad in with the other projects; thus, facility, manpower, and funding limitations constrain timely execution of certification issues/problem solving; (2) the NASA-Langley Research Center's Avionics Integration Research Laboratory (AIRLAB) is possibly a viable facility being developed to support aircraft systems research for the 1990's. Again, NASA-Langley's advanced flight control "basic and fundamental" research interests preclude FAA's applied technology problem solving.

PROGRAM TITLE	SUB-ITEM	PROJECT CODE
DIGITAL SYSTEMS VALIDATION LABORATORY		
LOCATION:	ADDITIONS:	PAGE NO.

FAA Form 2500-70 (9-71) supersedes previous edition

U.S. GOVERNMENT PRINTING OFFICE

FY 84 COST ESTIMATES

RIS: BU 2500-5

DATE: 5/26/82

Description and Justification:

Therefore, in order to be responsive to the certification issues and problems, it is appropriate to consider the establishment of a Systems Validation Laboratory here at the Technical Center. The FAA Technical Center's acquisition of the capability and the development of the necessary technical expertise is proposed as a multiphased/multiyear effort. The availability of the capability and technical expertise could be used to solve issues in a short and future time frame.

The multiphased development and associated minimum equipment procurement costs and proposed schedule are generally identified in the multiple year phased approach listed in the above SOLUTION.

PROGRAM TITLE	BUD. ITM.	PROJECT CODE
DIGITAL SYSTEMS VALIDATION LABORATORY		

LOCATION: | REGION: | PAGE NO:

FAA Form 2500-70 (9-71) supersedes previous edition

U.S. GOVERNMENT PRINTING OFFICE

APPENDIX B

RED BOOK PROJECT SHEETS

APPENDIX B
RED BOOK PROJECT SHEETS

AIRCRAFT SAFETY & SECURITY

Project No. 6

TITLE: Digital Systems, Electromagnetic Hazards and Flying Qualities

OBJECTIVE: To assess new aircraft digital technology and examine EMI effects on digital technology and composite airframe structures. Also, examine airworthiness and certification criteria for new aircraft designs and advanced stability and flight control systems.

APPROACH: Conduct studies, simulation and flight tests that will provide data and guidelines for certification of software-based digital systems. Lightning and EMI effects will be examined by models developed for aircraft generated and meteorological interference. New aircraft designs and advanced flight control systems will require possible updating of flight test techniques and evaluation criteria for airworthiness certification.

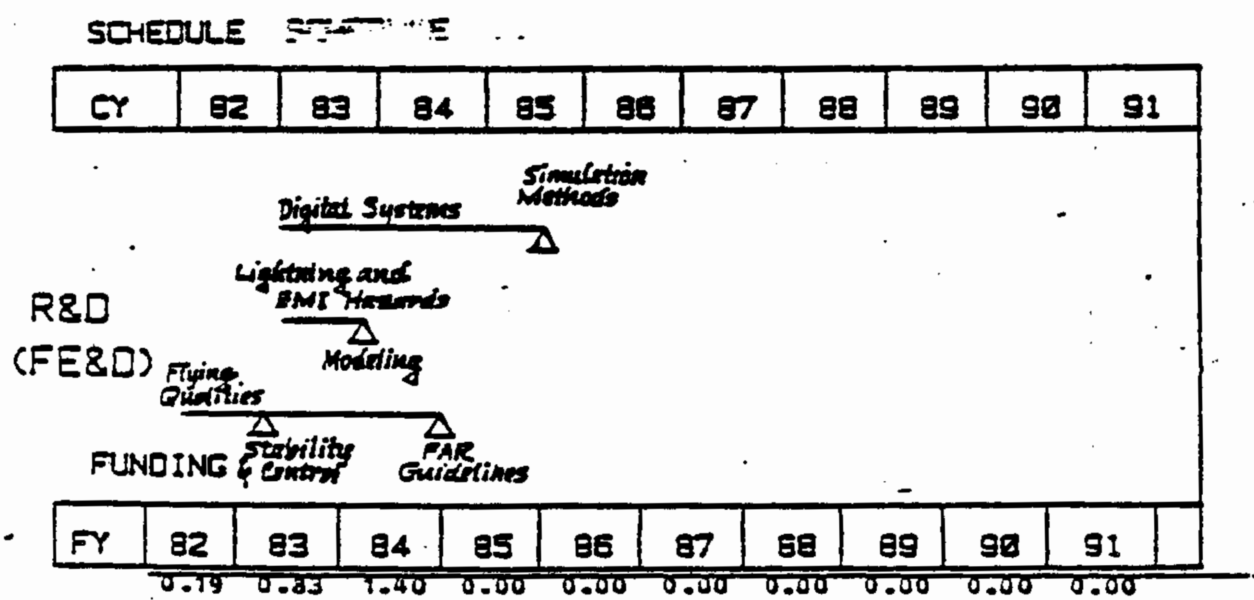
OUTPUT: Updated fuel system lightning protection advisory circular; lightning threat characterization guidance material; guidelines and certification data for software based digital system; test techniques for advanced aircraft stability and flight control systems.

KEY ASSUMPTIONS: N/A

TARGET QUANTITIES: N/A

RELATED PROGRAMS: Rotorcraft airworthiness; Advanced Materials

COST: $2.425M



AIRCRAFT SAFETY & SECURITY

Project No. 15

TITLE: Technology Development and Program Support

OBJECTIVE: Develop data and guidelines to support certification of new generation aircraft and advanced flight systems technology. Provide follow-on research and development, engineering data as may be required to support program deliverables.

APPROACH: As new technology becomes available, assessments will be made (through studies, simulations, flight tests) as to the validity of use for certification of flight systems and aircraft. Data will be provided to allow for updating standards and advisory circulars, as required.

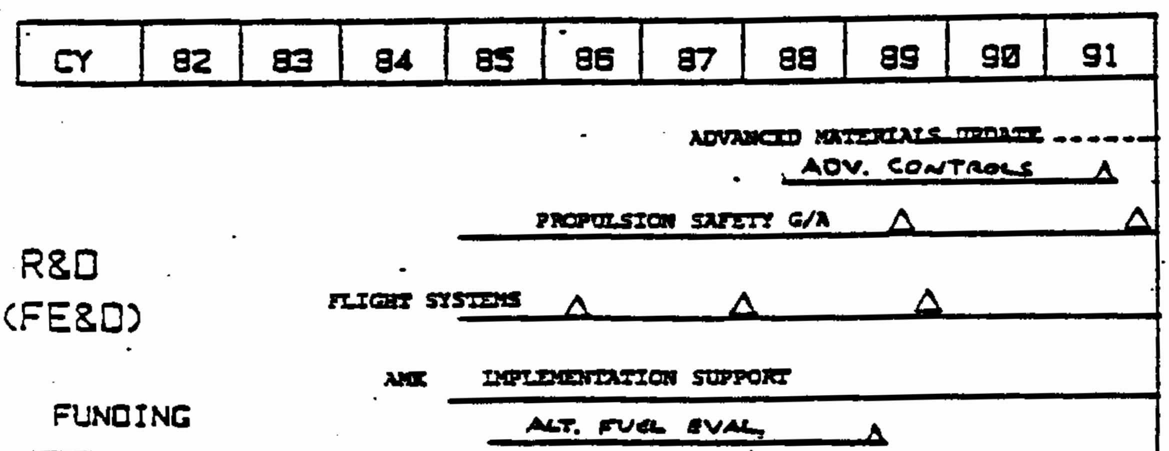
As decision points are reached in various programs, the research and development, cost benefit studies, engineering feasibility, and engineering aspects will be performed to support in the implementation of the system. Examples of this type of effort are as follows:

- Determine effect of alternate fuels and advanced controls on operational use in general aviation aircraft.

- Determine impact of the use of future fuels on the antimisting fuel program concept including the use of advanced fuel system concepts.

OUTPUT: Data and recommendations to support certification of advanced flight systems, continual assessment of technologies as applicable for criteria development, engineering data to support decisions of technical programs.

SCHEDULE



FUNDING

FY	82	83	84	85	86	87	88	89	90	91
	0.00	0.00	0.00	3.51	4.19	3.71	3.70	3.67	4.29	4.52

AIRCRAFT SAFETY & SECURITY

KEY ASSUMPTIONS: Emerging technology will require continual assessment as to applicability to civil aviation aircraft.

TARGET QUANTITIES: N/A.

RELATED PROGRAMS: Advanced Materials; Propulsion Safety; Flight Systems Safety; Antimisting Fuels; Emergency Evacuation.

COST: $27.586M

Project No. 7

TITLE: Airworthiness Programs - Facilities Improvement

OBJECTIVE: To provide and/or enhance facilities to meet future research and development project requirements, improve and control test environment, and reduce operating costs.

APPROACH: A. Using in-house Technical Center personnel, laboratories, facilities, and contractor support, expand and enhance the existing hotbench/systems validation laboratory capability under a multiyear, multiphased program. B. Provide an addition and building modifications to provide an engine fuel test laboratory to accommodate two test stands for operational testing of engine fuel system components. C. Provide a new equipment and control building and an engine test pad for turbine engine/nacelle testing at a remote outdoor location. The building will accommodate test equipment, instrumentation and controls for the wing spillage rig and the remote engine test pad. D. Provide a universal test rig for bird ingestion testing. E. Provide an Electronics Control Bench Breadboard Comparator to simulate engine electronic control systems.

OUTPUT: A test facility with capability to support (A) certification directorates for airworthiness standards and compliance procedures, guidance material and flight safety considerations; (B) engine component compatability investigations; (C) large-scale testing of engines in propulsion safety program; (D) engine ingestion testing in support of propulsion safety program; (E) key power management comparisons on future engine development.

SCHEDULE

CY	82	83	84	85	86	87	88	89	90	91

F&E

DIGITAL SYSTEMS EXPERIMENTAL LAB

EXPAND ENGINE TEST FACILITY

EQUIPMENT AND CONTROL BUILDING

BIRD INGESTION RIG/FACILITY

ELECTRONIC CONTROL BENCH COMPARATOR

FUNDING

FY	82	83	84	85	86	87	88	89	90	91
	0.00	0.00	1.48	0.68	1.92	1.66	2.14	0.74	0.46	0.00

KEY ASSUMPTIONS: Current programs will continue and expand. Current facilities must be expanded for the Center to continue its role as a primary R,D,T&E facility.

TARGET QUANTITIES: N/A

RELATED PROGRAMS: All airworthiness projects.

COST: $9.072M

APPENDIX C

RESUMES

APPENDIX C
RESUMES

	ADL RESUME	Resume No. DL-95
Date of Resume: 11/24/82	Date Deferred/Cancelled:	
Date of Revision:	Final Completion:	

PROJECT TITLE:-

Digital Systems

PRINCIPAL SPECIALIST(S):

N. Fujisaki, APM-720, x60024

OBJECTIVE: Provide information and data on validation and verification of digital systems to certification engineers. Establish a base of expertise in digital systems and provide reports and laboratory facilities to assure questions related to digital architectures and their compliance with DO-178 (RTCA); AC 25: 1309-xx; FAR Parts 25:1309 and 29:1309; and the Arinc/Mil specifications for bus architectures. Conduct experiments, surveys and research into issues raised by the application of new procedure/software in digital flight control and avionic systems. Indepth evaluation of assurance technology/ methodology as they relate to V&V for airborne digital systems.

REQUIREMENT:

Criteria needed for certification of software-based digital systems. This results from emergence of microprocessor technology in new and derivative aircraft and the need to obtain/maintain safety assessment data and information.

MILESTONE SCHEDULE:

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
1. V.I Digital Sys. Valid Hdbk - Draft Compl.	1/83		
2. V.II Digital Sys. Valid Hdbk - Draft Start	1/83		
3. V.II Digital Sys. Valid Hdbk - Draft Compl.	3/84		
4. Integ. Assur. Assess(Dual-Dual Sys) Rpt. C.	11/82		
5. Integ. Assur. Assess(Quadruplex Sys)Rpt. C.	3/84		
6. Analytical Redundancy-Sensor Rpt. Compl.	10/85		
7. Bus Evaluation Criteria Rpt. Complete	9/86		

STATUS:

REMARKS/NOTES:

At the present time, FY 1983 funds are programmed for the quadruplex architecture evaluation using the Integrated Assurance Assessment methodology. The handbook - Vol. II is not funded in FY 1983. The validation laboratory is programmed for funding in FY 1984.

PROJECT: Computer Program Certification Control 1983 - 2001

Purpose: The airborne digital computer technology will be integrated into practically every aspect of aircraft equipment. The functions performed will rnage from optional equipment to full fly-by-wire airplanes in 2001. The digital computer programs (software) must be certified as to reliability of intended function. The present certification methods must be improved to assure that a software latent fault occurance would be extremely improbable in al lflight critical systems.

Approach:

a. Establish periodic RTCA review of of DO-178.

b. Expand present Technical Center research in software certification criteria using at least two independent non-government organizations.

Product:

a. Detailed guidlines that can be used by aerospace engineers in certification of aircraft systems.

b. Complete course materials for OKC training of personnel assigned to certify digital computer systems.

Related Programs:

Cost: 500 K

SCHEDULE

CY	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00
R & D																				

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AVS PROGRAM ACTIVITY RESUME

Date of Resume: Program Activity No.

PROJECT TITLE:

Cockpit Visibility

PRINCIPAL SPECIALIST:

- Richard M. Gough, AWS-160 8-426-8323

OBJECTIVE:
Develop and implement an enhanced capability to measure, record, data reduction and analysis of cockpit visibility surveys; conduct surveys; and support the updating and development of cockpit visibility criteria/standards.

REQUIREMENT:
An accurate measurement and record of the field-of-view of a pilot/crew as observed from his/their aircraft (general aviation, helicopter, transport) cockpit location in support of cockpit visibility minimum standards, design and development, airworthiness/certification, flight safety, and accident/incident investigations.

MILESTONE SCHEDULE:

Major Activities	Initial	Current	Completed
1. Binocular Camera Design, Development, and Procurement	2/82	84	
2. Cockpit Visibility Surveys	(as required)		
3. Cockpit Visibility Criteria/Standards Support	(as required)		

STATUS:
Item 1 above activity is delayed for FY-82 due to lack of (zero out) contract funds. A design RFP package is in progress for issuance in FY-83 (anticipated funding available)

APPROACH:
The cockpit visibility project will initiate a competitive contract for binocular camera, conduct surveys (in-house project personnel), and data reduction and analysis (by industry contract), and technical support to headquarters and certification directorates.

REMARKS/NOTES:

- Reference E&D Number: 134-340-400