TSC Staff Study

AVIATION BEHAVIORAL TECHNOLOGY PROGRAM

COCKPIT HUMAN FACTORS RESEARCH PLAN

JANUARY 15, 1985

FEDERAL AVIATION ADMINISTRATION
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WASHINGTON, DC 20591

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AVIATION HUMAN FACTORS PROGRAM PLAN

1.0 EXECUTIVE SUMMARY

The safety, reliability, and efficiency of the National Airspace System depend upon the men and women who operate and use it. Aviation human factors research is the study of how these people function in the performance of their jobs as pilots, controllers, or maintenance and ground-support personnel. Increasing automation and system complexity are placing new and different demands on staff of the nation's air transportation system. Concern over human performance in safety has been raised in Congress, industry, and the academic community. Aviation safety areas which have been the subject of recent attention include both the air traffic control and the cockpit aspects of the system.

In the past, the development and application of new aviation system technology both in ATC and flight systems has been directed toward increasing the traffic through-put capacity of the NAS. With a few notable exceptions, such as Traffic Alert and Collision Avoidance System (TCAS) and Ground Proximity Warning System (GPWS), advances in technology have not been applied directly toward the improvement of flight safety. This proposed program is intended to develop and apply advanced behavioral analysis and technology to improve flight safety and promote civil aviation.

The successful application of technology to safety problems in any system as complex as the NAS system requires an integrated approach.

The FAA currently has an active and integrated air traffic control research and development program, but has not developed a centralized and systematic approach to improving flight crew performance has yet to be developed. The purpose of this Aviation Human Factors Research Plan is to address that need by focusing on cockpit- and pilot-related problems and develop an integrated approach to such problems.

Pilot error has been identified as a causal factors in 66 percent of air carrier fatal accidents, 79 percent of commuter fatal accidents, and 88 percent of the general aviation fatal accidents. AVS is concerned with the causal factors these statistics represent and the trends that they reflect, and recognizes the importance of a better understanding and greater consideration of the human factors aspect of aviation.

The projects that are presented in the research plan were identified primarily through discussions held with users of the National Airspace System at human factors workshops held specifically for that purpose. A review of the proceedings of six FAA-sponsored human factors workshops revealed 137 cockpit-related human performance problem areas that could be addressed through human factors research. Thirty of these 137 items were selected as being particularly important to the promotion of aviation and to aviation safety. Descriptions of these 30 items were sent to the members of SAE's Aerospace and Behavioral Engineering Technology Committee, who were asked to rank them according to their importance to civil aviation.

The 30 areas were categorized into the following five areas for research shown according to importance as ranked by the SAE committee:

- Advanced cockpit technology;
- Pilot error;
- Rotorcraft display and control issues;
- Crew training;
- Regulatory activities.

The body of the research plan is comprised of descriptions of 23 research projects proposed to address the 30 human factors problems. The projects address the following research objectives:

1. Develop cockpit certification criteria for advanced technology based upon objective measures of crew performance.

2. Develop an objective and quantifiable method of measuring aircrew workload.

3. Develop intra-agency design review requirements and evaluation methods to insure that the modernization of the NAS, automation and related

changes in cockpit design do not influence pilot workload to the detriment of flight safety.

4. Develop guidelines for the use of voice-activated flight management systems in aircraft cockpits; develop performance criteria which must be satisfied before such systems can be certified.

5. Determine whether the cockpit flight data information system is adequate to support safe reversion from automated to manual operation when required; and determine if the information available to the pilot in the cockpit is adequate to permit safe reversion to manual flight.

6. Identify the information required by aircrews to fly modern aircraft safely in the evolving NAS and to ensure that the information is presented to them efficiently and in a manner promoting the maximum degree of transfer.

7. Establish human performance checklists for use by procedure specialists and flight inspection pilots in the development of instrument approach procedures, SIDs (Standard Instrument Departure Procedures, abatement procedures) and STARs (Standard Terminal Arrival Procedures); and to improve the speed and accuracy of information transfer from instrument approach charts through chart redesign.

8. Identify weather information requirements of pilots, and compare those requirements with the weather data to be provided in the developing NAS.

9. Develop, coordinate, and maintain a program dedicated to identifying the causes of pilot error and to creating a data base on flight crew performance. Develop and apply methods for collecting crew performance data that will support the creation of standards and guidelines for certifying cockpit flight control and navigation systems.

10. Identify the characteristics of automated flight management systems that influence their compatibility with human operators.

11. Develop standards and procedures for use with currently available digital data input devices which minimize pilot error. Develop requirements for training flight crews in the use of these procedures.

12. Identify the extent to which the use of automated systems may degrade a pilot's ability to fly manually; if there is a potentially significant degradation of skills, determine what training is necessary to ensure maintenance of manual capability in the event of the failure of automated flight systems.

13. Improve the effectiveness of communication and coordination between cockpit and cabin crews to increase flight safety and passenger comfort during all phases of flight.

14. Increase the effectiveness of line oriented flight training (LOFT) for training crews in emergency procedures, for identifying shortcomings in training procedures, and for improving crew coordination.

15. Develop and evaluate training materials and evaluation techniques for improving pilot judgement.

16. To determine the level of simulator fidelity that is necessary for training pilots in selected aviation tasks; determine how much training is required at specific levels of simulator fidelity to qualify for credit toward regulated flight training.

17. Identify the extent to which inexpensive simulators and part-task trainers can be utilized in the training of pilots.

18. Increase the effectiveness of simulation training for developing and maintaining flying proficiency.

19. Modify and clarify the federal aviation regulations in order to develop a regulation reference system or manual which can be easily used during time-critical flight situations by aircrews to resolve uncertainties regarding their legal responsibilities.

20. Determine the effects of fatigue on crew interaction, and develop countermeasures to neutralize adverse effects.

21. Assess the impact of economic difficulties on the quality and quantity of recurrent training provided by the commercial airlines.

22. Update the process of selection, training, and licensing to reflect the advances in aviation technology.

23. Develop human factors criteria which can support new technology to improve standardization of displays and control unique to helicopters. This could include criteria for non-standard instrument displays and advanced flight controls such as fly-by-wire, fly-by-night, and side-arm controllers.

Each project description as found in Section 3 provides a brief discussion of the problem area, a statement of needs or requirements for the work, a proposed approach to doing the required work, and products which are expected to result from the work.

Implementation of this plan will represent a formal programmatic commitment of the Federal Aviation Administration to address human performance-related aviation safety issues. Results of the research will influence nearly every aspect of air transportation, including safety, reliability, and efficiency in general as well as commercial aviation activities.

The program represented by this work will be directed by the Associate Administrator for Aviation Standards and will be managed by the Office of Flight Operations. The effort will be supported by the Transportation Systems Center's Operator/Vehicle Systems Division. A specially selected FAA human factors review committee, comprised of AVS and ADL, and TSC human factors program managers will monitor the program process and its relationship to ongoing and anticipated FAA programs.

The development and identification of research priorities will continue and will actively involve a wide-ranging aviation constituency including government officials, manufacturers, airlines and operators, labor and trade organizations, researchers, and public interest groups.

COCKPIT HUMAN FACTORS RESEARCH PLAN

2.0 INTRODUCTION AND OVERVIEW

The safety, reliability, and efficiency of the National Airspace System depend upon the men and women who operate and use it. Aviation human factors research is the study of how these people function in the performance of their jobs as pilots, controllers, or maintenance and ground-support personnel. Concern over human performance has been raised in government, industry, and the academic communities. Aviation safety areas which have been the subject of recent attention include both the air traffic control and the cockpit aspects of the system. Computer failures and near misses brought increased attention to air traffic control, and the crew complement issue has brought attention to cockpit issues.

In the past, the development and application of new aviation system technology both in air traffic control (ATC) and flight systems has been directed toward increasing the traffic through-put capacity of the NAS. With a few notable exceptions, such as Traffic Alert and Collision Avoidance System (TCAS) and Ground Proximity Warning System (GPWS), advances in technology have not been applied directly toward the improvement of flight safety. The proposed program is intended to develop and apply advanced behavioral technology to promote civil aviation to improve flight safety.

The FAA currently has an active and intergrated air traffic control research and development program underway, but a centralized and systematic approach to improve flight crew performance has yet to be developed. This Cockpit Human Factors Research Plan is proposed to address that need by focusing on cockpit- and pilot-related problems. Research conducted through this program of work will:

- o Promote the advancement of cockpit technology and flight systems through the development and application methods for measuring and understanding the pilot's capability for assimilating information from advanced display systems and for using and monitoring automated flight systems;

- o Increase flight safety through the identification and mitigation of conditions resulting in pilot error; and
- o Develop increased awareness within the aviation community of the role of human factors issues in flight safety.

Implemenation of the plan will be directed by the Associate Administrator for Aviation Standards and will be managed by the Office of Flight Operations. The effort will be supported by the Transportation Systems Center's Operator/Vehicle Systems Division.

A specially selected FAA human factors review committee, comprised of AVS and ADL, and TSC human factors program managers will monitor the research program and its relationship to ongoing and anticipated FAA programs in associated engineering and research and development areas.

Adoption of this plan will represent a formal programmatic commitment by the Federal Aviation Administration to address human performance-related aviation safety issues. The resulting program will influence nearly every aspect of air transportation, including safety, reliability, and efficiency in general as well as commercial aviation activities.

The development and identification of research priorities will continue to actively involve a wide-ranging aviation constituency including government officials, manufacturers, airlines and operators, labor and trade organizations, researchers, and public interest groups.

2.1 GENERAL

Questions about the effects of human performance on aviation safety frequently are raised in forums such as Congressional Hearings and safety review committees. Recent concerns have been related to:

- o Aircraft crew complement;
- o Management of cockpit automation;
- o Crew fatigue/workload/stress;
- o Cockpit resource management; and
- o Pilot judgment.

This brief list illustrates the nature of the concern within the aviation community about human factors problems. These are all associated with pilot error.

Pilot error has been identified as a causal factors in 66 percent of air carrier fatal accidents, 79 percent of commuter fatal accidents, and 88 percent of the general aviation fatal accidents. AVS is concerned with the causal factors these statistics represent and the trends that they reflect, and we recognize the importance of a better understanding and greater consideration of the human factors aspect of aviation.

Although automation is seen as a method of eliminating human error related failures, no system that has the potential of placing human life at risk can be allowed to operate without human supervision. Although there are many situations where automated systems outperform human operators (e.g.,human error rates in the performance of rote tasks clearly exceed those of automated systems), there is still no substitute for human ability to deal with new, complex, and unusual situations and make judgments on partial information. Therefore, it is essential that advanced aviation systems continue to include the "man-in-the" loop and that their designs reflect an understanding of human strengths and limitations.

With the current emphasis on the use of automation to increase system productivity, the challenge is to create conditions that will ensure continuing improvements in overall system safety. Achieving increases in both productivity and safety will require a better utilization of the humans in the system. This requires applied research on problems such as the design of pilot-compatible cockpit systems, pilot selection, and pilot training to support the management and operation of automated aircraft and ATC systems. This broad-based group of research, engineering, and regulatory activities requires a high order of coordination among the aviation agencies, users, industry, and research organizations.

2.2 PROGRAM OBJECTIVES

This proposed Human Factors Research Program addresses five aspects of civil aviation:

- o Advanced cockpit technology;
- o Pilot error;
- o Rotorcraft display and control issues;
- o Crew training; and
- o Regulatory activities.

Research is required in these areas because not enough is known about human performance and its interaction with aviation systems to:

- o Support and promote the advancement of new cockpit technology;
- o Identify the underlying causes of pilot error;
- o Support the development of certification criteria for equipment and training based upon pilot performance; and
- o Support the development and improvement of Federal Aviation regulations.

2.3 CRITICAL ISSUES

The proposed research program addresses thirty human factors issues which have been recommended by the aviation community for near-term attention because of their importance to civil aviation.

These issues were identified through a cooperative effort involving civil aviation pilots, aircraft manufacturers, government officials, aviation scientists, and other members of the civil aviation community. A four-step procedure was used to select these particular issues for near-term research attention.

(1) Six major national public workshops were held. Attendees were encouraged to discuss aviation human factors problems of concern to them.

(2) The proceedings of these workshops, as well as reports resulting from the deliberations of various aviation safety committees were reviewed. The reviewers identified 377 human factors issues, 134 of which were unique research issues concerned with cockpit operations.

(3) A panel of FAA program managers and human factors consultants in aviation examined these 134 items and selected 30 issues which are addressed in this proposed plan. The selection was based the importance of the issues to aviation safety, and their role in the promotion of civil aviation.

(4) The 30 selected items were then reviewed and ranked by members of SAE's technical committee on Aerospace Behavioral Engineering Technology.

The selected 30 aviation human factors research problems, as ranked from most important to least important by the SAE committee, are shown in the following list. An examination of the rankings indicates three broad areas of concern:

- o Advanced cockpit technology, including automation;
- o Transfer of information to flight crews; and
- o Study and measurement of pilot performance.

Human Factors Problem Areas Ranked According to Importance to Civil Aviation

1. Automation - Develop procedures to ensure that modernization of the NAS and cockpit designs does not increase pilot workload.

2. Monitoring Automation - Determine pilot information requirements for monitoring automated systems.

3. Cockpit Certification - Develop certification criteria for advanced technology cockpits which are based upon objective measures of crew performance.

4. Manual Reversion - Develop design philosophies and criteria for future automated systems that will facilitate reversion to manual operation.

5. Information Transfer - Develop standards for the structure, formatting, and presentation of flight system and navigation information in advanced cockpits.

6. Data Entry - Reduce operator error when using digital data input devices in the cockpit.

7. Aircrew Workload Measurement - Develop an objective and quantifiable method of measuring aircrew workload.

8. In-Flight Data - Establish procedures acceptable to the industry for collecting data to identify pilot-system automation incompatibilities, and to identify why some systems are operating well and others are not.

9. Pilot Error - Determine why pilots make the errors that they do and develop countermeasures where feasible.

10. Charts and Procedures - Develop human performance criteria for evaluating the design of charts, maps, and approach procedures.

11. Weather Data - Determine if the weather data to be provided by the developing National Airspace System will satisfy pilot requirements.

12. Pilot Proficiency - Identify the extent to which automation causes degradation of pilot skills. If warranted, determined the necessary corrective measures.

13. Accident Investigation - Conduct human error analyses of non-fatal accidents through interviews with surviving crew members as one means of determining why pilots make errors.

14. Data Link - Develop guidelines for presenting data link information to the pilot, and assess the the loss of the ATC "party line" on pilot performance and flight safety.

15. Rotorcraft Display/Control Design Standards - Develop operator performance criteria for use in the assessment and standardization of helicopter displays and controls.

16. LOFT - Increase the usefulness of line oriented flight training (LOFT) for reducing air carrier accidents.

17. Safety and New Technology - Use new technology to attain higher levels of safety through accident prevention.

18. Simulator Training - Determine the most effective methods of providing feedback to pilots during simulator training.

19. Pilot Judgment - Develop and evaluate training materials and assessment techniques for improving pilot judgment.

20. Crew Fatigue - Determine the effects of fatigue on crew interaction, and develop countermeasures to neutralize adverse effects.

21. Cockpit/Cabin Crew Coordination - Develop operational procedures and training methods for improved crew coordination.

22. Simulator Fidelity - Determine the level of simulator fidelity required for training in various aviation tasks.

23. Simple Simulators - Determine the extent to which inexpensive simulators and part-task trainers can be used for training pilots.

24. Maintenance Training - Update the training curricula required for aircraft mechanics to reflect the advances that have been made in aircraft design and construction.

25. Voice Systems - Develop guidelines for the use of voice-activated systems in aircraft cockpits and peformance criteria for certification of these systems.

26. Certification Testing of Aircraft Mechanics - Develop test instruments that evaluate the problem-solving ability as well as the memory of applicants for A & P certification.

27. ASRS - Enhance ASRS callback interviews to identify human performance safety issues.

28. A & P Licensing - Assess adequacy of the present licensing procedure.

29. FARs - Simplify federal aviation regulations to reduce the regulatory burden and the number of regulatory conflicts in existing regulations.

30. Economics and Flight Training - Assess the impact of economic stress on the quality of recurrent training provided by airlines.

2.4 TECHNICAL APPROACH

Technical approaches which will be selected for doing the required research will optimize the the use of available resources in order to address the greatest number of high priority problems in the near term. To the extent possible the program will build upon ongoing research within the Department of Transportation, the Department of Defense, and NASA. Where possible cooperative research efforts with other government agencies will be conducted to take advantage of existing expertise and facilities. Cooperative research efforts will be pursued with the aviation industry to tap their intimate knowledge of commercial operations and their access to professional personnel, their training facilities, and data gathering capabilities. The approaches selected will take advantage of the technical expertise and the operational experience of the various aviation professional and trade organizations.

2.5 PROGRAM MANAGEMENT

The Aviation Behavioral Technology Program is managed within the current organizational structure and according to AVS Order 9500.1, Figure 1 depicts the development and management sequence of the program. It represents the definition of the problems, the review and establishment of the projects, the management of research and development efforts, and the application or implementation of the results.

REQUIREMENTS IDENTIFICATION: The research efforts which are required under the program are generated by the AVS offices based on continuous review of AVS responsibilities. Human performance issues continue to be solicited from the aviation community and special interest groups. The focal point for the collection of proposed human factors reseach issues is AVS (AFO). This office, with the direct support of human factors staff at TSC, identifies and clarifies the issue, establishes an AVS resume on the subject, and introduces the resume into the AVS Research and Development Project Requirement Processing System (AVS Order 9500.1)

PROGRAM DEVELOPMENT: The Office of Flight Operations (AFO) screens the suggested research efforts and with the appropriate technical support of the

PROGRAM DEVELOPMENT & MANAGEMENT SEQUENCE

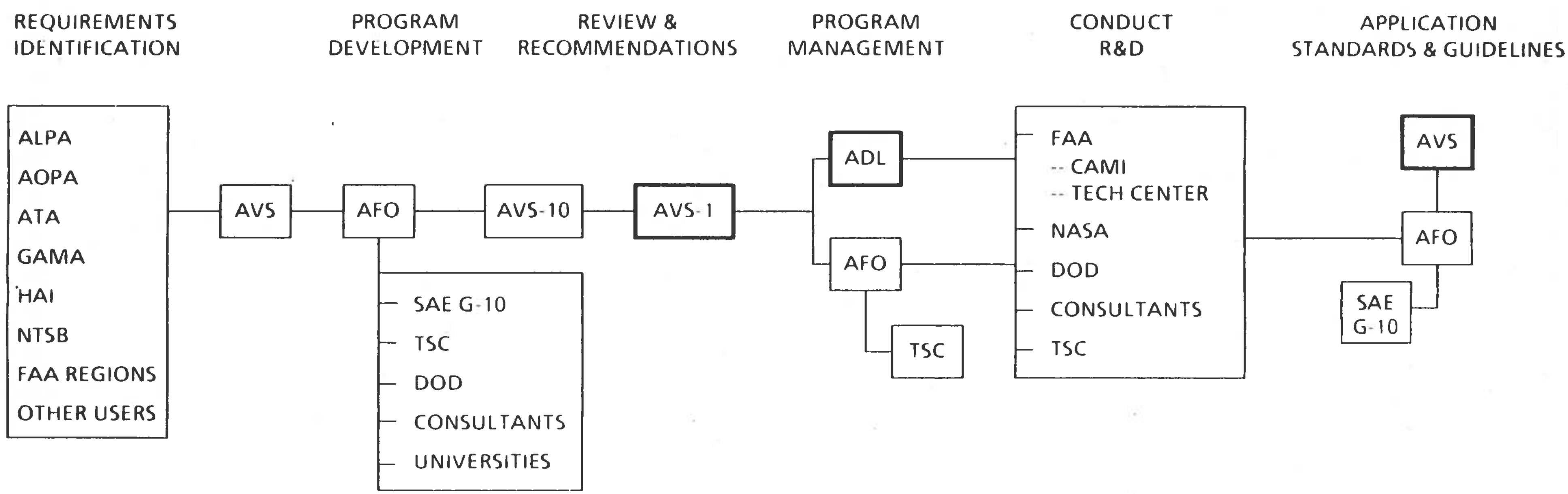


FIGURE 1

Society of Automotive Engineers' Behavioral Technology Committee (SAE G-10), the Transportation Systems Center, and the Aviation Safety experts in the Department of Defense, and other organizations concerned with aviation safety develop project descriptions.

REVIEW RECOMMENDATIONS: The project descriptions are submitted to the AVS Research and Development Requirements Group (AVS-10) for review and recommendations. Following review and discussions with the appropriate technical specialists, the project descriptions are sent with the group's recommendations for approval or disapproval to the Associate Administrator for Aviation Standards (AVS-1).

PROGRAM MANAGEMENT: Approved project plans are managed by appropriate offices under the jurisdiction of the Associate Administrator of Logistics (ADL-1) or under the Associate Administrator for Aviation Standards (AVS-1). Where ADL has been asked to provide project support, the activity would normally be assigned to APM-400. Projects not forwarded to ADL will be accomplished under AVS sponsorship. Such special studies may be conducted in-house, through cooperative efforts with other government agencies, or under contract.

CONDUCT OF RESEARCH AND DEVELOPMENT EFFORTS: The research and development efforts will be conducted by FAA, TSC, DOD, NASA, industry, and university laboratories as appropriate.

RESEARCH APPLICATIONS: The results of the research and development efforts will be used by AVS in the development of advisories, guidelines, and regulations in support of their programmatic and regulatory responsibilities both directly and in assisting non-government groups (G-10) also concerned with the promotion of safety of civil aviation.

3.0 PROJECT DESCRIPTIONS

This section of the plan includes descriptions of the research projects proposed to address the human factors problem areas presented in the introduction. For reader convenience, the project descriptions are divided among the four following problem areas:

- o Cockpit technology;
- o Pilot error;
- o Crew training; and
- o Regulatory.

Even though there is overlap among a number of the proposed research projects and some cases sequential dependencies, with some exceptions, the project areas are presented independently so that they be considered individually as they were proposed by the aviation community. After review of this document, the projects approved for research attention will be organized into cohesive and integrated research program areas. This will be done to ensure adequate attention to related critical problem areas, the efficient utilization of research resources, and that the problems and their solutions be viewed as a part of the whole cockpit system rather than as isolated areas of operational difficulty.

Twenty-three projects are described with some addressing more than one of the 30 human factors problem areas. The project descriptions provide a brief discussion of the problem area, a statement of need or requirements for work, a proposed approach to that work, and products which are expected from that work. An AVS program resume follows each program description. Each resume has two sets of numbers in the upper right corner. The Resume No. indicates the order in which the resume occurs in the plan. They are number 1 through 23. The numbers in parenthesis beneath the Resume No. indicate the human factors problem area covered by the resume. The numbers correspond to those shown to the left of the problems in the list presented in the introduction and indicated the rank of the problem area received in the G-10 committee review. An abbreviated description of the proposed project is provided in the body of the resume, and a list of work related to the problem area which is being conducted throughout the aviation community is presented at the bottom of the form. In addition, a schedule of work is included for each of the first ten projects. The duration of work, major tasks, and anticipated products are shown in these schedules.

3.1 COCKPIT TECHNOLOGY

This section is concerned with the design and evaluation of the modern aircraft cockpit. Work is proposed to ensure that flight crews are presented with the information necessary to fly their aircraft safely, and that the information is presented in a manner that will maximize its usefulness.

The work includes the development of crew information requirements, and the development of performance-based criteria for evaluation of displays, controls, and the completed cockpits.

3.1.1 COCKPIT CERTIFICATION CRITERIA

Objective:

Develop certification criteria for advance technology cockpits based upon objective measures of crew performance.

Background and Requirement:

The FAA implements its responsibilities for aviation safety under the Federal Aviation Act of 1958 through Federal Aviation Regulations (FARs), which are codified in Title 14 of the Code of Federal Regulations. The certification process begins with FAR part 21, which sets forth the procedures through which "any interested person may apply for a type certificate." Under Section 21.17, each applicant must show that the proposed aircraft meets all applicable requirements of the regulation then in effect..." Under Section 21.21, "an applicant is entitled to a type certificate" if the type design meets all applicable airworthiness requirements (or their equivalent) and "no feature or characteristic makes it unsafe for the category in which certification is requested."

Under Section 25.1501, an applicant must establish and conform with a set of operating limitations developed to ensure safe aircraft operation. One of the operating limitations specified pertains to crew complement. Under Section 25.1523, the applicant must establish a minimum flight crew that is sufficient for safe operations, considering the workload of the individual crew members, accessibility and ease of operation of necessary controls by appropriate crew members, and the kinds of operation to which the aircraft will be subjected.

To determine compliance with Section 25.1523, the FAA relies on a set of criteria presented in Appendix D to Part 25. Adopted in 1965, Appendix D enumerates the basic workload functions (e.g., flight path control, collision avoidance, and navigation), workload factors (e.g., number, urgency, and complexity of operating procedures), and operating air traffic control (ATC) environment, e.g., instrument flight rules (IFR), that the FAA considers in determining whether the minimum flight crew prepared by the applicant is adequate.

The applicant seeks to demonstrate compliance with the applicable requirement of Part 25 through a combination of flight tests, simulator tests, computer analyses, and other methods. Although Appendix D enumerates the flight conditions which must be exercised in the certification process, measures of task difficulty experienced by the fight crew while operating in the required flight regimes are not specified. Absolute standards are not available for interpreting the times necessary to accomplish required tasks, and no objective measures of cognitive workload are required. Such assessments currently are based upon the subjective judgements of the test pilot, who is asked to judge whether the flight system being tested is "better" or "worse" than a system to which it is being compared. The absence of objective measures of the difficulty of various flying tasks makes it difficult to develop pilot performance standards, to replicate test results, and to defend controversial certification decisions.

In 1980, the FAA certified the Douglas DC-9-80 as safe for operations with a two-person crew instead of the customary three-person crew. Professional pilots and engineers expressed concern over this decision and questioned the validity of the certification process that supported it. In response to the resulting controversy, a Presidential Task Force on aircraft crew complement was established and directed to recommend "whether operation of the new generation of commercial jet transport aircraft by two-person crews is safe and certification of such aircraft is consistent with the Secretary's duty under the certification provisions of the Federal Aviation Act of 1958 to promote flight safety." The following recommendations were made in the report of the President's Task Force on aircrew complement, dated July 2, 1981:

- o The latest state-of-the-art in workload measurement techniques should be used in aircraft certification;
- o Formal guidelines for evaluating the impact of the ATC system on crew workload should be established; and
- o The agency should complete and keep current Section 187 (minimum flight crew) of FAA Order 8110.8, Engineering Flight Test Guide for Transport Category Airplanes.

Contemporary advances in cockpit technology are producing revolutionary changes in cockpit design and changing the flight functions of aircrews. Correspondingly, conventional time-line analytic and pilot judgement methods of assessing crew workload are becoming increasingly unsatisfactory. Cockpit certification criteria based upon objective measures of crew performance are required to assure controlled, uniform, and valid assessments of the advanced cockpit.

The SAE G-10 Committee on Aerospace Behavioral Technology strongly suports the requirement to develop objective measures of crew performance that have application in the certification of advanced technology cockpits.

Approach:

Use the SAE G-10 Committee to identify candidate research methodologies for developing objective measures of crew performance. The committee will review the current regulatory requirements and objectives and recommend a research program to quantify performance criteria for advanced cockpit designs. Consideration will be given to the cockpit information integration requirements resulting from modernization of the NAS. Validation of performance criteria will be accomplished in advanced NASA and DOD cockpit simulators. The FAA B-727 simulator will be used to develop pilot performance data from which baseline values can be established. These values will be used as references against which the impacts of advanced technology cockpits upon crew workload can be measured.

Products:

Validated test results and methods and the resulting certification criteria will provide the basis for updating FAA Order 8110.8, Engineering Flight Test Guide for Transport Category Airplanes, Section 25.1523, and Appendix D to Part 25. In addition, an advisory circular wil be developed to make the public aware of acceptable compliance methods. G-10 committee participation in planning and executing this evaluation will assure that the methods are acceptable to the industry.

AVS RESUME **RESUME NO. 1 (3)**

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

COCKPIT CERTIFICATION CRITERIA

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Develop certification criteria for advanced technology cockpits, which are based upon objective measures of crew performance.

REQUIREMENT: (Brief description of why project is being undertaken)

Current flight deck and display certification decisions are based upon the subjective assessments of FAA test pilots. Few quantitative performance standards are available to objectify certification tests results either in terms of pilot effort required to fly with the new equipment or the level of performance that the pilot or crew can produce while flying with it. In the absence of specified and objective certification criteria, there are few guidelines from which manufacturers can develop design criteria that they are confident will result in certifiable products. This problem is particularly acute for novel or innovative equipment. Criteria are also needed to make it possible to verify the replicability of test results, and to defend controversial certification decisions.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion

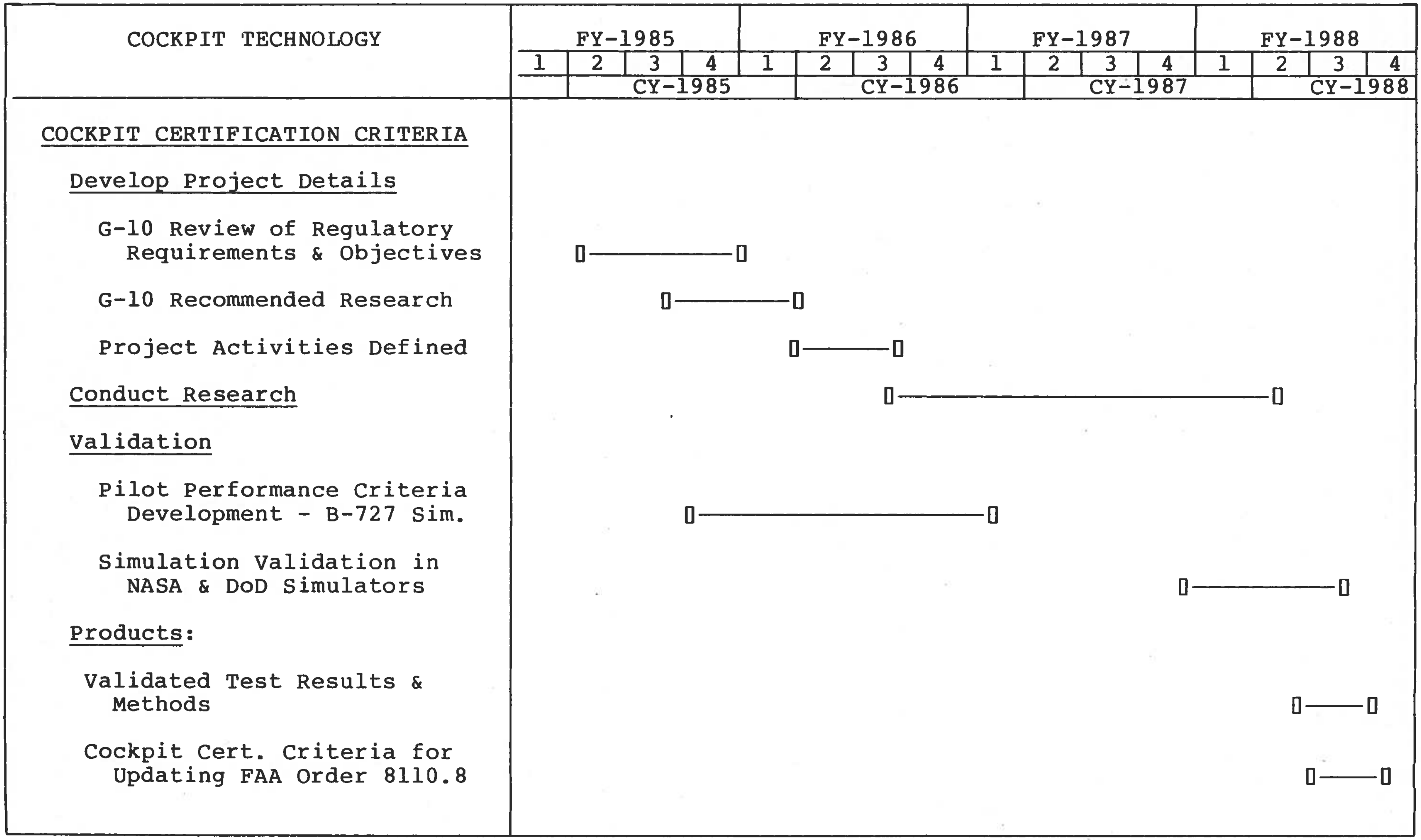
STATUS: (Enter current information)

G-10 recommendations.	1/15/86		

REMARKS/NOTES:

Related Work

- o Aircrew Workload Measurement, APM-430;
- o Identification of safety-related problems in existing cockpits, APM-430;
- o Task-matched metrics for workload assessments, USAF/AMRL; and
- o Basic research in workload assessment, NASA-Ames.


COCKPIT TECHNOLOGY
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
COCKPIT CERTIFICATION CRITERIA
Develop Project Details
G-10 Review of Regulatory Requirements & Objectives
G-10 Recommended Research
Project Activities Defined
Conduct Research
Validation
Pilot Performance Criteria Development - B-727 Sim.
Simulation Validation in NASA & DoD Simulators
Products:
Validated Test Results & Methods
Cockpit Cert. Criteria for Updating FAA Order 8110.8

3.1.2 AIRCREW WORKLOAD MEASUREMENT

Objective:

Develop an objective and quantifiable method of measuring aircrew workload.

Background and Requirement:

Current workload measurement techniques rely on timeline analysis and subjective judgements. Changes in aircraft design and in the NAS may result in critically high levels of workload for brief periods, and long periods with very low workload levels. Both of these conditions can have a negative impact on operational safety. Currently, certification with regard to workload is based on comparing new systems to existing systems. New technology cockpits will have greatly enhanced functional capability, placing the pilot in the role of system manager. In many cases, it will be impossible to compare the requirements of the new, highly automated systems to those of existing systems. In order to develop the data on which certification criteria could be based, it is necessary to have objective, quantifiable, and statistically reliable and valid measures of pilot workload.

Approach:

This effort will be done under contract.

- o Assessment of current workload measurement practices.
- o Survey the state-of-the-art in evolving workload measurement technology.
- o Identify candidate measurement techniques.
- o Develop standard flight scenarios and experimental designs for evaluation purposes.
- o Develop a prototype composite application-oriented methodology.
- o Evaluate the methodology in a flight simulator.

Products:

Advisory circular for objective workload measurment methodology acceptable for cockpit certification.

AVS RESUME **RESUME NO.** 2

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

AIRCREW WORKLOAD MEASUREMENT

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
P. Hwoschinsky, APM-430 (202) 426-3754

OBJECTIVE: (Brief description of what is to be accomplished)

To develop an objective and quantifiable method of measuring aircrew workload.

REQUIREMENT: (Brief description of why project is being undertaken)

The techniques currently used to assess workload rely on crew reports or observations of crew behavior. Objective methods of assessing total pilot workload are required for the following purposes:

1. To establish a baseline against which changes in cockpit task requirements can be assessed;
2. To facilitate objective control and display certification procedures; and
3. To produce performance criteria for use by aircraft systems designers.

MILESTONE SCHEDULE: (List significant events and dates during project life)

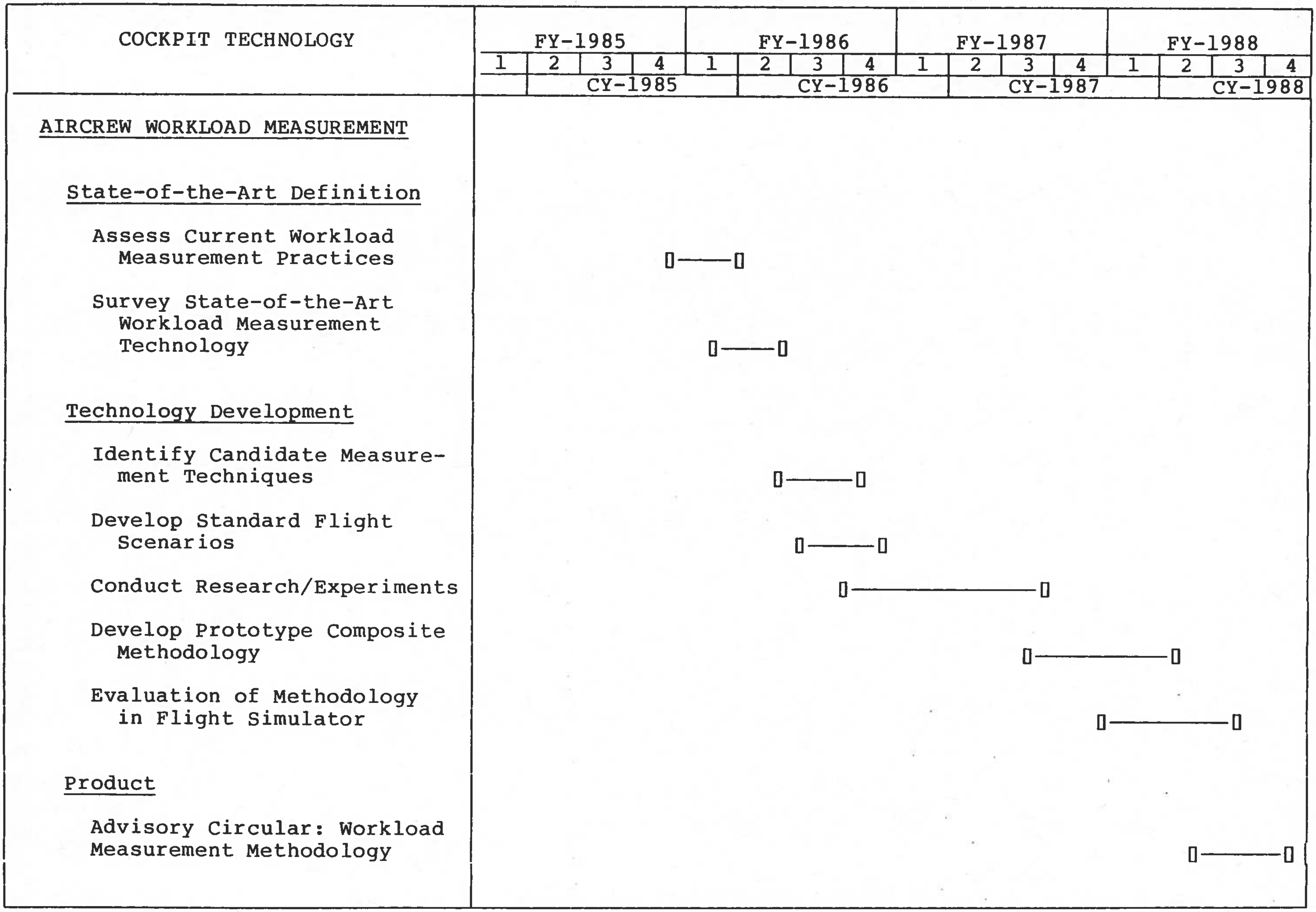
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
IAA USAF	3/85		
Contracted Study - Initiated	8/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Basic research in workload assessment, NASA-Ames;
- o Task-matched methods of workload assessment, USAF-AMRL:
- o Physiological correlates of operator workload, Douglas Aircraft; and
- o Applied methods of workload assessment, Boeing Airplane.


COCKPIT TECHNOLOGY
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
AIRCREW WORKLOAD MEASUREMENT
State-of-the-Art Definition
Assess Current Workload Measurement Practices
Survey State-of-the-Art Workload Measurement Technology
Technology Development
Identify Candidate Measurement Techniques
Develop Standard Flight Scenarios
Conduct Research/Experiments
Develop Prototype Composite Methodology
Evaluation of Methodology in Flight Simulator
Product
Advisory Circular: Workload Measurement Methodology

3.1.3 NAS/COCKPIT AUTOMATION

Objective:

Develop intra-agency design review requirements and evaluation methods to ensure that the modernization of the National Airspace System (NAS) automation and related changes in cockpit design do not influence pilot workload to the detriment of flight safety.

Background:

Since 1978, the Aviation Safety Reporting Program (ASRP) has received 140 pilot reports of automation failures that required corrective action by the crew during transition phases of flight. Recent NASA-Langley research has shown that increases in cockpit automation beyond some critical point increases pilot workload by increasing cognitive effort and head-down time. The potentially detrimental impact of increased automation on pilot workload has been ranked by the SAE's Committee on Aerospace Behavioral Engineering Technology as the human factors problem which should be given the highest priority for study.

Current planning and analytical efforts in designing automation for the National Airspace System do not consider the impact of changes in cockpit design on pilot workload. Cockpit automation and advanced display technologies have an increasing potential to overload flight crews, particularly during critical phases of flight. The changing emphasis in flight control requirements from sensory-motor performance to cognitive performance has increased the difficulty of assessing the impact of flight system changes on pilot workload.

Approach:

- Review and summarize the state-of-the-art and common practices in the following areas:
  - NAS development - user coordination activities and requirements;
  - Cockpit design and integration technology;
  - Flight function allocation;
  - Pilot skill requirements and assessment; and
  - Workload assessment methods.

- o Draft intra-agency coordination requirements for flight system design review and evaluation.
  - o Develop operator performance criteria for system test and evaluation; and
  - o Develop, test, and refine cooperative test and evaluation methodologies for simulation testing of ATC-cockpit systems and for flight testing.

  (Note that work on these efforts may be paced by work on Cockpit Certification Criteria and Workload Assessment Methodology.)

Products:

- o Design guidelines and criteria which define acceptable procedures for testing and evaluating automated and automation-related systems proposed for the cockpit.

- o Validated criteria for assessing the impact of NAS modernization on flight crew workload.

AVS RESUME **RESUME NO. 3**
(1)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

NAS/COCKPIT AUTOMATION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
T. Walsh, ADL-30 (202) 426-8794

OBJECTIVE: (Brief description of what is to be accomplished)

Develop intra-agency design review requirements and evaluation methods to insure that the modernization of the NAS, automation and related changes in cockpit design do not influence pilot workload to the detriment of flight safety.

REQUIREMENT: (Brief description of why project is being undertaken)

Planning and analytical efforts as currently practiced in designing automation for the National Airspace System do not consider the impact of this automation on cockpit design or pilot workload. Recent NASA-Langley research has shown that increases in cockpit automation beyond some measureable level increases pilot workload by increasing pilot cognitive effort and head-down time. This requirement includes single- and multi-pilot operations, especially in IFR, helicopter, and all FAR 135 operations.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Define User Requirements	4/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Cockpit Automation Technology (CAT), USAF-AMRL;
- o Human factors principles in automation, NASA-Ames;
- o SPIFR Crew Station Requirements, NASA-Langley Flight Management ATOP FY'85-505-35-13-10;
- o Aircrew Workload Measurement, APM-430; and
- o Evalutation capability provided by voice and data links between NASA-Langley air carrier simulator and the Technical Center ATC simulator.

COCKPIT TECHNOLOGY	FY-1985				FY-1986				FY-1987				FY-1988			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		CY-1985				CY-1986				CY-1987				CY-1988		
NAS/COCKPIT AUTOMATION																
Review and Summarize																
NAS Development							▯	—	—	▯						
Cockpit Design & Integration Technology							▯	—	—	▯						
Flight Function Allocation											▯	▯				
Pilot Skill Requirements & Assessment											▯	▯				
Workload Assessment Methods	(Results from Task 3.1.2)											▯	▯			
Agency Coord. Requirements																
Develop Operator Performance Criteria	(Results from Task 3.1.1)											▯	▯			
Develop & Test ATC/Cockpit Sys. Evaluation Methods												▯	—	—	▯	
Evaluation of Methodology in Flight Simulator													▯	—	—	▯
Products																
Automation Testing & Eval. Guidelines														▯	—	▯
Assessment Criteria														▯	—	▯

3.1.4 VOICE-ACTIVATED SYSTEMS

Objective:

Develop guidelines for the use of voice-activated flight management systems in aircraft cockpits; develop performance criteria which must be satisfied before such systems can be certified.

Background and Requirement:

Advances in flight control systems design have increased both pilot system management responsibilities and information needs. The pilot is called upon to function as a back-up element or as an active component of the semi-automated flight system. During phases of flight which entail high workload, a pilot cannot afford to spend too much "head-down" time adjusting flight management systems, nor can the pilot afford the errors that might occur from rushed programming of "R-NAV" systems or selection of navigation aid frequencies under these conditions.

Manufacturers are exploring the use of voice-activated systems to reduce workload and facilitate the pilots interaction with flight management systems. Experimental voice-activated systems are being tested in military aircraft and their near-term application to civilian aircaft is anticipated. The FAA must be prepared to guide the development of such systems and to develop certification criteria for these systems.

Approach:

- o Survey the state-of-the-art in cockpit voice recognition technology;
- o Inititate a cooperative intergovernmental agreement with the USAF to test and evaluate prototype voice-activated cockpit systems. This will include the:
  - o Identification of conditions under which voice-activated control systems will be used;
  - o Identification of strengths and weaknesses of voice systems in civil aviation through testing in LOFT, SPIFR, and helicopter conditions; and
  - o Conduct of a flight test for a prototype voice system.

Products:

- o Guidelines for using voice-activated systems in the cockpit.
- o Performance criteria that voice-activated systems must meet to be satisfied for cockpit certification.

AVS RESUME **RESUME NO. 4**
(25)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

VOICE ACTIVITED SYSTEMS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To develop guidelines for the use of voice activated systems in aircraft cockpits, and performance criteria which must be satisfied before such systems can be certified.

REQUIREMENT: (Brief description of why project is being undertaken)

Advances in flight control systems are increasing pilots' system management responsibilities and need for information. In some cases, physical involvement with the flight of the aircraft increases because the functions as a back-up or component of closely coupled semi-automated flight systems. A pilot operating with such systems during high workload phases of flight may not be able to afford the time, head-down status, or physical movements required to press buttons or dial knobs to update important visual displays.

In anticipation of such performance requirements, some manufacturers are exploring voice activited systems as a means of extending the pilots' ability to control his aircraft under high workload conditions. Experimental voice systems are being tested in military aircraft; their use in civilian aircraft in the near future must be expected.

To assure safe use of this technology in aviation, and support its constructive advancement by industry, the FAA must monitor the development of voice recognition systems for cockpit use and be able to recognize and certify safe systems when they appear.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Technology Survey	6/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o National Research Counsil Committee on Computerized Speech and Speech Recognition;
- o Advanced voice recognition systems, USAF-FDL;
- o Voice recognition systems, Sikorsky Aircraft;
- o General Aviation Application, NASA-Langley
- o Boeing advanced cockpit development.

COCKPIT TECHNOLOGY	FY-1985				FY-1986				FY-1987				FY-1988			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		CY-1985				CY-1986				CY-1987				CY-1988		
<u>VOICE ACTIVATED SYSTEMS</u>																
<u>Survey State-of-The-Art</u>				■	■	■	■									
<u>Initiate Interagency Agreement with USAF</u>				■	■	■	■	■								
Identify Applications in Cockpit																
Evaluate Systems																
Simulation																
Flight Test																
<u>Products</u>																
Guidelines for Cockpit Use								■								
Performance Criteria								■								

3.1.5 MANUAL REVERSION

Objectives:

- o Determine whether the flight data information system is adequate to support safe reversion from automated to manual operation when required; and
- o Determine if the information available to the pilot in the cockpit is adequate to permit safe reversion to manual flight.

Background and Requirement:

There has been considerable discussion about the merit of situational displays. Current instrumentation provides steering information that allows the pilot to operate the aircraft within the criteria specified in the design and specification of the automated system. An alternative approach would be to provide the pilot with situational information which allows continuous and dynamic assessment of the aircraft's status. At the 1980 DOT/FAA Human Factors Workshop on Aviation, held in Cambridge, Massachusetts, a panel of airline pilots expressed concern that they may not have sufficient information to anticipate or correct for emergency situations. When information is provided which only supports operation under automated conditions, pilots believe they may be unable to fulfill their responsibility for the safe operation of the aircraft under the FARs.

Approach:

- o Develop cooperative program with NASA-Ames.
- o Investigate the issue.
- o If warranted, develop a program plan to address the problems identified and evaluate potential solutions, e.g.:
  - situational displays;
  - special training; and
  - special procedures.

Products:

- o Report of the investigation.
- o Recommendations for further action, as appropriate.

AVS RESUME

RESUME NO. 5 (4)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

MANUAL REVERSION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Determine whether the cockpit flight data information system is adequate to support safe reversion from automated to manual operation when required; and determine if the information available to the pilot in the cockpit is adequate to permit safe reversion to manual flight.

REQUIREMENT: (Brief description of why project is being undertaken)

System automation without the ability for adequate crew monitoring was identified as one of the greatest areas of concern by a panel of airline pilots (ALPA) during the November, 1980 DOT/FAA Human Factors Workshop on Aviation, Cambridge, MA.

Safety-related recommendation number thirteen of the July 2, 1981 "Report of The President's Task Force on Aircraft Crew Complement" stated, "The researach conducted by FAA, NASA, and the Department of Defense on the impact of automation on the role of flight crews should be continued and expanded."

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Initiate validation of issue	4/85		

STATUS:

REMARKS/NOTES:

Related Work

- o Development of failure modes and effects analyses for automated avionics systems, ACT-340; and
- o Operator adaptation to automation failure, NASA-Ames.

COCKPIT TECHNOLOGY	FY-1985				FY-1986				FY-1987				FY-1988			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		CY-1985				CY-1986				CY-1987				CY-1988		
MANUAL REVERSION																
Develop FAA/NASA Investigation																
Investigate Issues			▯—	—▯												
Develop Project Plan (if warranted)				▯- -	- -▯											
Evaluate Potential Solutions						▯- -	- -	- -	- -▯							
Situation Displays																
Special Training																
Special Procedures																
Products																
Report of Investigation						▯—	—▯									
Recommendations for Future Action (as appropriate)								▯- -	- -	- -▯						

3.1.6 INFORMATION TRANSFER

Objective:

To identify the information required by aircrews to fly modern aircraft safely in the evolving NAS and to ensure that the information is presented to them efficiently and in a manner promoting the maximum degree of transfer.

Background and Requirement:

The information required by flight crews, the sources of information, and the means of presenting the information in the cockpit are rapidly changing. Crews require information from outside the aircraft regarding air traffic control, navigation, and weather. They need information from inside the aircraft regarding the status of aircraft support systems such as electronics and hydraulics and they need information on the flight control systems and the flight status of the aircraft. In addition they must coordinate flight activities among themselves and with the cabin crews. As technology increases, the conditions under which flight can be conduced and the complexity of the aircraft that operate within these conditions, flight crews increasingly require more information from both outside and inside the aircraft.

The information which can be presented to the crew is no longer limited by the fixed format of electromechanical displays. New advances in display technology make it possible to present more information to the crew than they can assimilate and such presentations can be made with an almost infinite variety of display formats using visual, tactual, and auditory techniques.

Faced with the requirement for presenting crews with increasing amounts of information and the technology for doing so, cockpit designers need specifications of information requirements, guidelines for display design, and human factors criteria with which to evaluate display designs and to select optimum designs from among a variety of design options. The guidelines and criteria must be developed to produce display systems which will optimize the transfer of information to the crews in a manner facilitating its use by making it easy to locate, interpret, and translate into the actions required.

Approach:

Information Requirements:

1. Conduct survey of current status of ATC system, anticipated changes within that system.
2. Conduct survey of current, emerging, and anticipated flight information systems to be used and monitored from the cockpit.
3. Determine information required by flight crews operating within the present and evolving NAS.
4. Test information requirement assumptions using representatiave flight scenarios in full mission simulator.
5. Validate simuation results in real flight.

Evaluation Criteria:

1. Development of standard test flight conditions.
2. Description of representative group of subject/test ATPs.
3. Development of objective and quantitative performance measures for evaluating pilot performance with prototype displays.
4. Test methods and measues in flight simulator and revise as required.
5. Validate results in actual flight.

Products:

- o Inventory of information required in the cockpits of generic aircraft to operate within the evolving NAS.

- o Methods and human factors criteria for use in evaluating cockpit information display design and layouts.

NOTE: The work to be accomplished in this program will include:

- o Identification of information required to conduct manual flight and to monitor automated flight; and
- o Identification of requirements for data link information, development of guidelines for presenting that information, and assessment of the pilots requirements for the "party line" information that would be lost if data link were implemented.

AVS RESUME **RESUME NO.** 6
(2, 5, 14)

Date of Resume: 7-16-84
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

INFORMATION TRANSFER

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To identify the information required by aircrews to fly modern aircraft safely in the evolving NAS and to ensure that the information is presented to them efficiently and in a manner promoting the maximum degree of transfer.

REQUIREMENT: (Brief description of why project is being undertaken)

To establish the information base-lines required to enhance total system efficiency throught utilization of integration techniques and technologies to maximize information transfer. Ths standardization requirements includes formats, displays, and information structures to accomodate the various levels of automation, and to aid the human operator in the decision making process.

MILESTONE SCHEDULE: (List significant events and dates during project life)

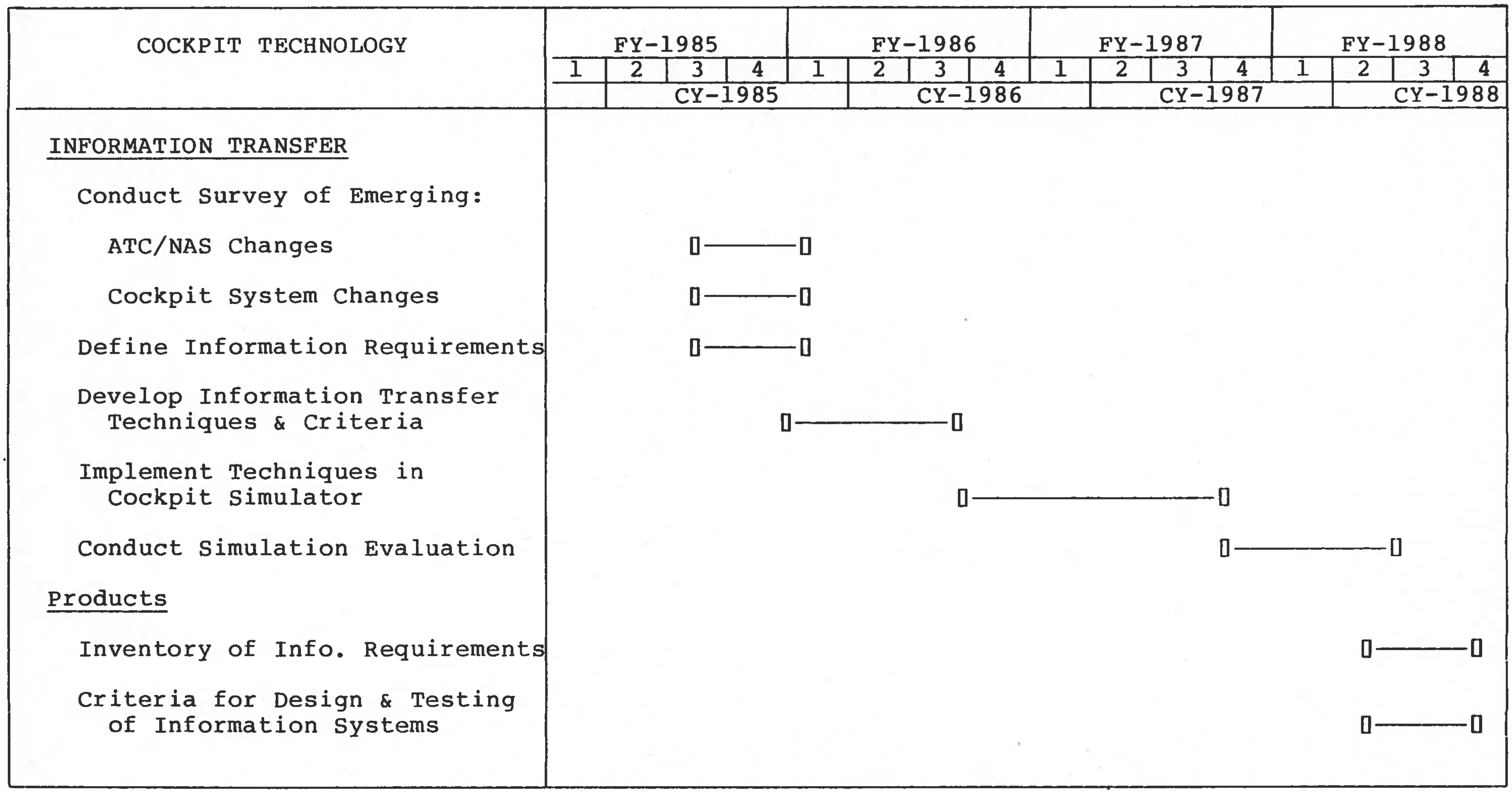
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Define Data Link Issue	8/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Cockpit data management and evolving ATC, APM-430; and
- o Flight Phase Status Monitoring, APM-430.


COCKPIT TECHNOLOGY
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
INFORMATION TRANSFER
Conduct Survey of Emerging:
ATC/NAS Changes
Cockpit System Changes
Define Information Requirements
Develop Information Transfer Techniques & Criteria
Implement Techniques in Cockpit Simulator
Conduct Simulation Evaluation
Products
Inventory of Info. Requirements
Criteria for Design & Testing of Information Systems

3.1.7 HUMAN PERFORMANCE CRITERIA FOR CHARTS AND PROCEDURES

Objective:

- o To establish human performance checklists for use by procedure specialists and flight inspection pilots in the development of instrument approach procedures, SIDs (including noise abatement procedures) and STARs; and
- o To improve the speed and accuracy of information transfer from instrument approach charts to aircrews through chart redesign.

Background and Requirements:

Problems with instrument approach plates -- as well as with certain type terminal procedures -- have been identified by safety recommendations made within the past few years.

Special Air Safety Advisory Group (SASAG) commissioned by the FAA in 1976 to study the air transportation system in the United States and make recommendations about how to improve safety criticized the charts as being over-complicated, cluttered, hard to read, impractical and stated they do not present all the information needed.

Safety-related recommendation number eleven of the July 2, 1981, "Report of The President's Task Force on Aircraft Crew Complement," stated: "Enroute, terminal area, and approach charts are frequently designed in a way that makes them difficult to use. The design and contents of these charts should be improved."

Based on a review of nine serious accidents -- each of which has resulted in recommendations to modify specific approach procedures or approach charts -- the NTSB has issued Recommendations A-82-91 and -92, stating that "an attack on the aggregate problem by aleviating individual approach procedure problems on a post-accident basis is not satisfactory." "A better, more efficient method would be to incorporate human factors design considerations into the development, design, and evaluation of all approach procedures and approach charts before accidents occur."

The Board recommended that human performance criteria be developed for the evaluation of instrument approach procedures and charts, and that human performance checklists or guidelines be established for use by procedures specialists and flight inspection pilots.

Approach:

Implement a development program which will:

- o Establish human performance checklists for use by procedure specialists and flight inspection pilots in the development of instrument approach procedures for both ILS and MLS landing systems, SIDs (including noise abatement procedures) and STARS;
- o Improve instrument approach chart information transfer and use efficiency through improved information flow and prioritized information sequencing/structuring;
- o Reduce the time required to sort and select needed information; and
- o Minimize the probability of misinterpretation of charted information.

The development program should include the following projects/tasks:

Survey, Analysis, Problem Definition, and Planning:

- o Conduct surveys and collect descriptive data for flight operations, avionic interface applications, and ATC operations;
- o Develop a detailed critique of the data collected to identify pilot user problems in flight operations associated with approach procedures, charting, and support materials;
- o Identify current problem areas related to approach procedures and approach charting; and
- o Develop a technical plan with schedules and time-phasing of the activities associated with all tasks within this project.

Instrument Approach Procedure Development and Construction:

- o Review present IFR procedures and identify problems associated with the construction and development of instrument approach procedures;
- o Specify area of procedure development which lack human performance criteria and make recommendations to include these criteria; and

- Develop formal human performance checklists or guidelines for the procedure specialists who design and construct procedures, as well as the flight inspection pilots who fly and evaluate the procedures.

Instrument Approach Procedure Charts:

- Review the approach procedure charts that are currently available for approach procedures within the United States and its territories;
- Identify specific problems which may exist on the current charts due to lack of human performance criteria considerations in the format, data requirements, symbology and overall design characteristics; and
- Develop recommendations to include human performance standards and design criteria for presentation of information on chart configuration to promote user/pilot interpretability and useability while considering such issues as visual detection, identification, coding, attention-getting characteristics and human memory constraints during normal and adverse flight conditions.

Pilot Education/Information Materials:

- Identify problems associated with pilot education/information publications which deal with the execution of instrument approach procedures; and
- Review these publications and develop recommendations to ensure that human performance criteria are utilized.

Avionics:

- Identify potential human performance problems which may be encountered with the various aviation electronic instruments currently available which are used in the execution of instrument approach procedures;
- Ensure that the newer digital type equipment is compatible with both procedure construction and charting; and
- Recommend changes to procedures, charting or avionics which eliminate human performance problems previously identified.

IFR Enroute Charts, SIDs, and STARS:

Identify problems and develop recommended human performance standards and design criteria for:

- o The construction of standard instrument departure procedures (SIDs) and standard terminal arrival procedures (STARs); and
- o The presentation of information and chart configuration to enhance interpretability by the user/pilot. This activity will include such issues as visual detection, identification, coding, attention-getting characteristics and human memory considerations that apply to both normal and adverse flight conditions for enroute and terminal area operations.

Visual Navigation Charts:

Identify problem and formulate recommendations regarding human performance factors in the development of visual charts as related to optimum inflight readabilty, interpretability, and useability. Factors should include chart formats, data, symbology, type, colors, and relief portrayal.

Products:

The expected products resulting from these development activities include:

- o Human performance checklists for developing instrument approach procedures, SIDs and STARs; and
- o Improved enroute and instrument approach chart information transfer and use efficiency.

AVS RESUME **RESUME NO. 7 (10)**

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:
HUMAN PERFORMANCE CRITERIA FOR CHARTS AND PROCEDURES

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To establish human performance checklists for use by procedure specialists and flight inspection pilots in the development of instrument approach procedures, SIDs (including noise abatement procedures) and STAR's; and to improve the speed and accuracy of informtion transfer from instrument approach charts to the pilot through chart design.

REQUIREMENT: (Brief description of why project is being undertaken)

Based on a review of nine serious accidents--each of which has resulted in recommendations to modify specific approach procedures or approach charts--the NTSB has issued Recommendations A-82-91 and -92, stating that "an attack on the aggregate problem by aleviating individual approach procedure problems on a post-accident basis is not satisfactory." The Board further states that "a better, more efficient method would be to incorporate human factors design considerations into the development, design, and evaluation of all approach procedures and approach charts before accidents occur."

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
1. Survey & Analysis (operators/ATC)	8/85		
2. Current Problems Identified	9/85		
3. Technical Plan Developed	2/86		
4. Instrument Approach Procedure			
a. Review procedures develop. & criteria	9/86		
b. Human perform. checklist development	11/86		
c. Simulation evaluation	3/87		
5. Instrument Approach Charts			
a. Review of charting techniques/styles	9/86		
b. Human perform. checklist development	11/86		
c. Simulation evaluation	3.87		
d. Avionics/cockpit displays	4/87		
e. Pilot education/info. materials	4/87		
6. IFR enroute charts, SIDs, and STARS	11/87		
7. Visual Navigation Charts	4/88		
8. Products - Human Performance Checklists			
a. Approach procedure charts			
b. IFR enroute charts, SIDS, and STARS	1/88		
c. Visual navigation charts	7/88		

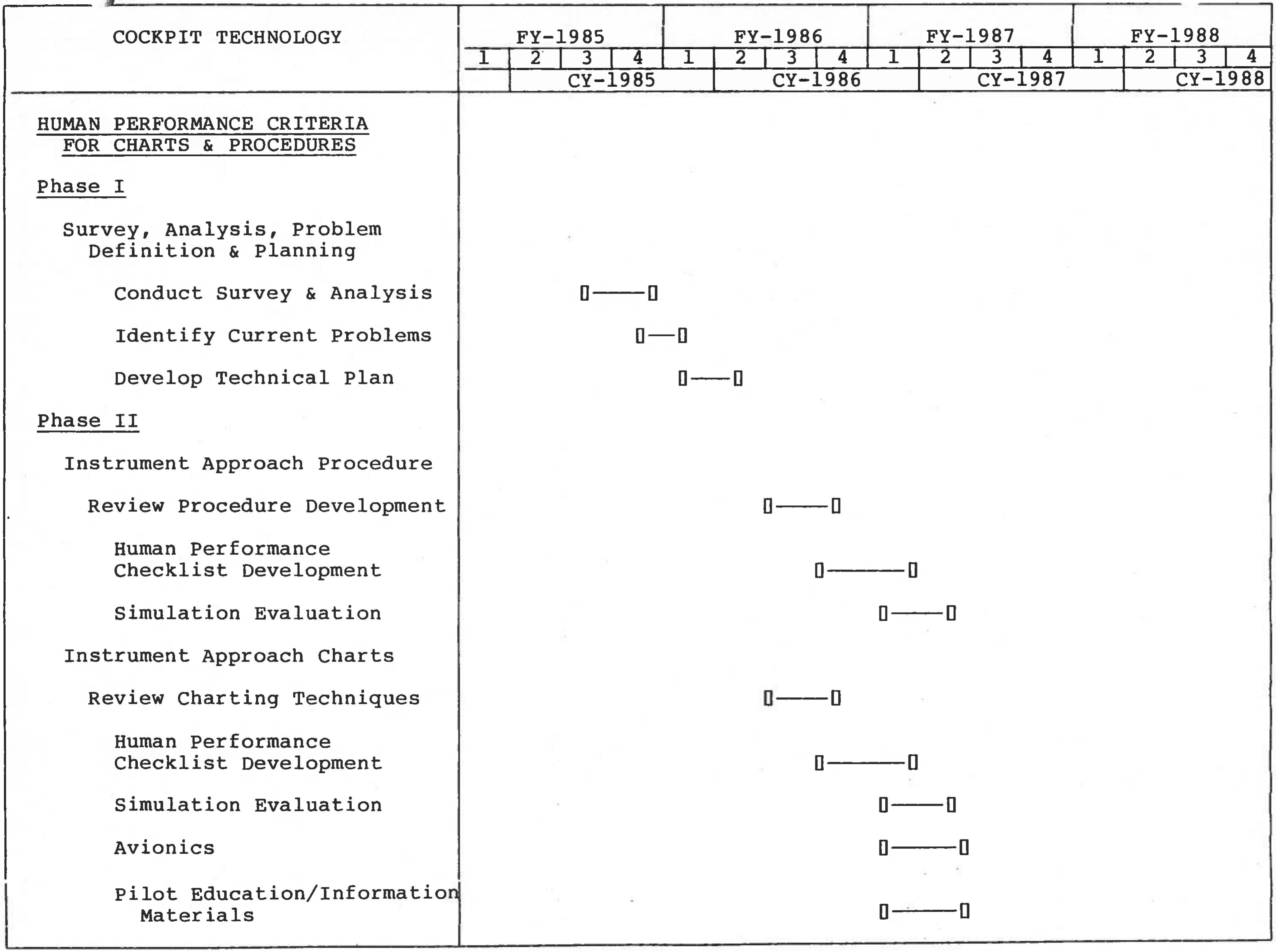
STATUS: (Enter current information)

Initiated 1/85

REMARKS/NOTES:

Related Work

- o VFR Chart Performance Evaluation Study, APM-430.


COCKPIT TECHNOLOGY
FY-1985
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FY-1987
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CY-1986
CY-1987
CY-1988
HUMAN PERFORMANCE CRITERIA FOR CHARTS & PROCEDURES
Phase I
Survey, Analysis, Problem Definition & Planning
Conduct Survey & Analysis
Identify Current Problems
Develop Technical Plan
Phase II
Instrument Approach Procedure
Review Procedure Development
Human Performance Checklist Development
Simulation Evaluation
Instrument Approach Charts
Review Charting Techniques
Human Performance Checklist Development
Simulation Evaluation
Avionics
Pilot Education/Information Materials

COCKPIT TECHNOLOGY	FY-1985				FY-1986				FY-1987				FY-1988			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		CY-1985				CY-1986				CY-1987				CY-1988		
<u>HUMAN PERFORMANCE CRITERIA FOR CHARTS & PROCEDURES</u>(cont'd)																
<u>Phase III</u>																
IFR Enroute Charts, SID'S & STAR'S											X	X	X			
<u>Phase IV</u>																
Visual Navigation Charts													X	X	X	
<u>Products</u>																
Human Performance Checklists																
Approach Procedure/Charts											X					
IFR Enroute Charts, SID'S & STAR'S													X			
Visual Navigation Charts															X	X

3.1.8 WEATHER INFORMATION COLLECTION AND DISSEMINATION

Objective:

To identify weather information requirements of pilots, and compare those requirements with the weather data to be provided in the developing NAS.

Background and Requirement:

There is substantial evidence in the ASRP of the need to improve the collection and dissemination of weather information. The major weather information-related problems are:

- o Lack of timely weather information, especially in deteriorating weather;
- o Lack of exact interpretations of weather information (visibility reports); and
- o Questionable judgement and attitude of pilots regarding flights in adverse weather.

The NAS modernization has not established a procedure for dealing with the collection and dissemination of PIREPS. Many PIREPS reported to enroute, approach, and departures central facilities may not be relayed to flight service for dissemination to pilots. Timely weather reports are most needed during periods when the weather begins to deteriorate, periods when the controllers are the busiest. There must be better coordination between ATC and FSS for relaying information. Clear operational requirements for the collection, formatting, and timely dissemination of weather information to pilots through the NAS are needed. This is particularly so for information reported by pilots (PIREPS).

Approach:

Develop clear statements of requirements to meet the needs related to the following:

- o Pilots:
  - o Improving weather recognition, especially with respect to estimates of visibility;
  - o Adopting a more professional approach to IFR flying;

    - Improving preflight planning, especially regarding runway information during winter months and planning alternatives in the event of weather changes; and
    - Developing a fuller understanding of the mechanics of weather observation and forecasting.
- ATC:
    - Improving the handling of nonroutine events caused by weather-related traffic diversions (e.g., sector coordination problems); and
    - Improving assistance to pilots who are confronting deteriorating weather.
- Weather information services:
    - More timely dissemination of weather information;
    - Improving pilots' access to weather information for flight planning purposes; and
    - Timely collection and distribution of PIREPS.

<u>Products:</u>

The products of this research will be requirements for the collection, dissemination, and use of weather information to be included in the NAS Operational Requirements Document.

AVS RESUME **RESUME NO.** 8 (11)

Date of Resume: 1/15/85
Date of Revision:
Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

WEATHER INFORMATION COLLECTION AND DISSEMINATION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To identify weather information required by pilots, and compare those requirements with the weather data to be provided in the developing NAS.

REQUIREMENT: (Brief description of why project is being undertaken)

Pilots are the ultimate users of aviation weather data. Weather data format, depth, and availability should be tailored to meet pilots' needs. Taking these needs into consideration in planning NAS weather information is vital if pilots are to be provided with weather data in formats that they can effectively use.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Validate Requirements	11/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- Aviation Weather Information: User Requirements, MITRE-83 W 156;
- Next Generation Radar, APM-310;
- Automated Route Forecast Program, APM-610;
- Interim Voice Response System, APM-610;
- Hazardous In-Flight Advisory Service, AAT-360;
- Terminal Doppler Weather Radar Program, APM-310; and
- Aviation Weather System Plan, FAA.

COCKPIT TECHNOLOGY	FY-1985				FY-1986				FY-1987				FY-1988			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
		CY-1985				CY-1986				CY-1987				CY-1988		
<u>WEATHER INFORMATION COLLECTION AND DISSEMINATION</u>																
Validate Info. Requirements (From Task 3.1.6)					—	—										
Coordinate with Development of Info. Transfer Techniques (Task 3.1.6)						—	—	—								

3.1.9 ROTORCRAFT DISPLAY AND CONTROL - IFR REQUIREMENTS AND STANDARDS

Objective:

To develop human factors criteria which can support new cockpit technology, IFR requirements, standardization of displays and controls unique to rotorcraft. This would include criteria for non-standard and advanced-technology instrument displays; and advanced-technology flight controls such as fly-by-wire, fly-by-night and side-arm controllers.

Background and Requirement:

Statistics from the National Transportation Safety Board Special Study, NTSB-AAS-81-1, "Review Rotorcraft Accidents, 1977 - 1979," show that pilot error is a major factor in rotorcraft accidents. From 1977 through 1979, the pilot was cited as a cause or related factor in 573 rotorcraft accidents; this is more than 64 percent of the rotorcraft accidents in which the NTSB cited a probable cause. Little is known about the real causes of the majority of these accidents since the terminology and classifications of accident investigations give few insights into needed corrective measures (see Section 3.7.1). However, several categories of human factors issues have been identified as being particularly relevant to helicopter operation, given the unique operations and flight maneuvers undertaken by helicopter pilots. These include issues relating to displays, visibility, controls, and anthropometry.

It is believed that improved design and standardization of rotorcraft controls and displays would enhance safety by reducing pilots' operating difficulties and workload, particularly in reduced-visibility landing conditions.

The NTSB Safety Recommendation A-78-23 recommends that the FAA "expand its proposed research plans on 'Cockpit Human Factors Problems,' particularly in the area of Human Capabilities and Limitations and Displays and Controls, to include problems peculiar to helicopter controls and displays.

At the FAA's Third Human Factors Workshop on Aviation, conducted in Cambridge, Massachusetts, representatives from the helicopter manufacturers and the International Helicopter Association identified display design, cockpit visibility, pilot seating, and aircraft control positioning as areas of particular relevance to helicopters that require human factors research.

Approach:

The approach to be undertaken by this research activity will include the following sub-tasks:

- Develop an analysis of the pertinent literature;
- Develop a forecast of expected technology applications to rotorcraft operations and cockpit design;
- Develop a review of current and projected needs for IMC operations, including deceleration-to-hover and hover-to-landing display/ guidance capabilities;
- Develop an analysis of helicopter low speed characteristics and low-speed sensing/indicating systems and concepts;
- Develop a task analysis of required pilot activities associated with the execution of IMC deceleration-to-hover approaches and landings;
- Determine the need for improved integration of displays and controls with the human operator;
- Develop criteria on visibility requirements for helicopter cockpits for reduced visibility, hover-landing operations;
- Identify current and anticipated (advanced-technology related) helicopter crew member human performance issues; and
- Develop human performance criteria to resolve issues identified.

Products:

A report documenting operator performance criteria for use in the assessment and standardization of helicoptor displays and controls will be prepared. The report will cover the following topics:

- Rotorcraft IMC operations;
- Rotorcraft control and display design;
- The relationship between fatigue, stress and rotorcraft cockpit design;
- Rotorcraft visibility requirements; and
- Human performance issues, considerations, and criteria.

AVS RESUME **RESUME NO. 9**
(15)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

ROTORCRAFT DISPLAY AND CONTROL - IFR REQUIREMENTS AND STANDARDS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
N. Fujisake, APM-710 (202) 426-3593

OBJECTIVE: (Brief description of what is to be accomplished)

To identify and resolve human factors issues associated with reduced landing minima, IFR deceleration-to-hover approaches and IFR hover-landing operations.

To develop human factor criteria to assess new display and control technology for cockpit designs which reduces workload in the IMC environment.

REQUIREMENT: (Brief description of why project is being undertaken)

NTSB has issued Safety Recommendation A-78-23, stating that the NTSB recommended that the FAA should "expand its proposed research plans on 'Cockpit Human Factors Problems,' particularly in the area of Human Capabilities and Limitations and Displays and Controls, to include problems peculiar to helicopter controls and displays."

The FAA's Third Human Factors Workshop on Aviation, held in Cambridge, MA., March 1981, identified—among problems relating to certification and standardization—the following: "These include the development of data to permit Human Factors considerations in the certification and standardization of new displays and new controls . . ."

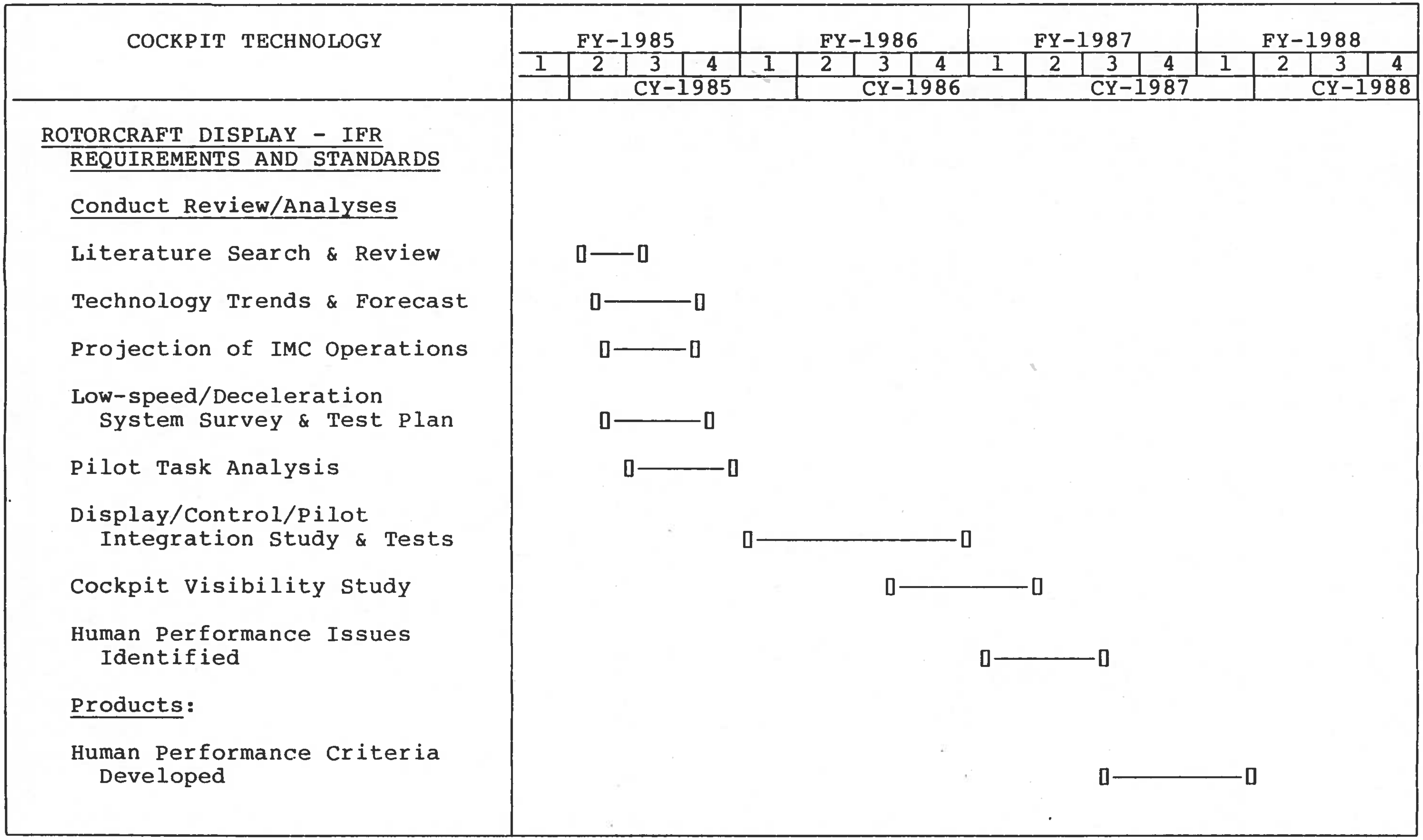
MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
1. Literature search and review	4/85		
2. Technology trends and forecast	8/85		
3. Projection of IMC operations/needs	7/85		
4. Low-speed/deceleration system survey and test plan	9/85		
5. Pilot task analysis	9/85		
6. Display/control/pilot integration study			
7. Cockpit visibility requirement study			
8. Human performance issues identified			
9. Human performance criteria developed			

STATUS: (Enter current information)
Initiated

REMARKS/NOTES:

Related Work
- o Rotorcraft Display Standardization Study, APM-430/APM-720/ARO.


COCKPIT TECHNOLOGY
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
ROTORCRAFT DISPLAY - IFR REQUIREMENTS AND STANDARDS
Conduct Review/Analyses
Literature Search & Review
Technology Trends & Forecast
Projection of IMC Operations
Low-speed/Deceleration System Survey & Test Plan
Pilot Task Analysis
Display/Control/Pilot Integration Study & Tests
Cockpit Visibility Study
Human Performance Issues Identified
Products:
Human Performance Criteria Developed

3.2 PILOT ERROR

This section is concerned with the study of pilot error as a means of identifying why pilots make errors that lead to aircraft accidents and for determining which aspects of automated cockpit systems produce errors and so should be redesigned.

It is proposed that accident-associated pilot errors be studied through the investigation of non-fatal aircraft accidents, by exercising the callback feature of the ASRP to explore further the causes of errors reported by aircrews which could, under certain circumstances, lead to fatal accidents, and through the development of methods of analyzing accident data bases which are designed specifically for selected types of aircraft accidents investigated.

Design induced errors could be identified throught in-flight data collection. Cooperative arrangements can be made between the FAA and commercial airlines to collect data in-flight for use in identifying characteristics of flight system automation which promote pilot error. Concurrently, those aspects of automation which are air-crew compatible also would be identified.

3.2.1 ACCIDENT/INCIDENT ANALYSIS

Objective:

Develop, coordinate, and maintain a program dedicated to identifying the causes of pilot error and to creating a data base on flight crew performance. Develop and deploy methods for collecting human performance data that will support the creation of standards and guidelines for certifying the cockpit flight control and navigation systems.

Background and Requirement:

The National Transportation Safety Board has determined that the percentage of aviation accidents associated with "pilot error" ranges from 60 percent for air carriers to 85 percent for general aviation. The percentage of accidents associated with operator error has been steadily increasing over the past several years.

The relative influences of system design and flight crew characteristics on the occurrence of pilot error are unknown. However, accident reconstructions and anecdotal data indicate that many of these accidents involve combinations of human cognition/decision/execution errors which are compounded by environmental and system factors. Furthermore, the errors contributing to these accidents occurred despite the use of elaborate automated systems to assist the pilot, the increased emphasis on detailed operational procedures, and intensive crew training.

Since the exact causes of pilot error accidents remain unidentified, accident data that could be used to improve the design of flight systems and training programs are not readily available. A broad programmatic effort is necessary to determine the operational, situational, and behavioral causes of pilot error.

Approach:

Develop, in cooperation with other government agencies, methods for collecting and analyzing accident and operational data that will permit the identification of flight systems and flight crew characteristics that induce pilot error. Initially, the following three approaches to data collection are proposed for implementation:

- o Develop a method for using existing accident data as a basis for a human factors data base and for determining the causes of pilot error;
- o Investigate non-fatal aircraft accidents to determine the causes of pilot error; and
- o Expand the use of ASRP "Callback" to identify system design and pilot error safety issues.

Data Base Analysis:

There are extensive aviation accident data bases that come from intensive investigation of each accident's physical aspects and interviews with surviving crew members and observers of each accident. Both the narrative information that resides in the accident investigation folders and the statistical information derived from these narratives are available for investigation.

The use of standard statistical methods for analyzing data bases has provided little real understanding of the causes of accidents due to pilot error. What is required is a method tailored specifically to each question of interest and the data bases to be examined. Systematic, efficient, and sharply focused methods for using the data bases to discover the behavioral correlates of pilot error accidents must be developed.

Approach:

- o Identify accident types of special interest (e.g., because of the flight conditions under which they occur).
- o Identify the appropriate data sources for investigating these particular accident types.
- o Develop a prototype analytical method that is appropriate for the specified accident types and data bases. Test, evaluate, and refine the method.
- o Determine the utility of this approach for the study of aviation crashes.
- o Conduct selected data base analyses.

Products:

A verified approach for using existing data bases to investigate the behavioral correlates of aviation accidents due to human error.

Accident Survivor Interviews:

Discussions with pilots involved in accidents may yield significant information regarding the contributions of human factors, equipment, and flight conditions to pilot error. This valuable source of information has not been fully explored.

Approach:

- o Conduct a study to identify those types of accidents where a follow-up interview with the pilot would determine the specific causal factors of human performance errors. This additional investigation would be accomplished on a voluntary, non-punitive basis.
- o Use the interview results to identify any significant patterns of human performance or system deficiencies.
- o Correlate the behavioral profiles obtained from these discussions with data in existing aviation safety data bases to see if such behavior explains why particular kinds of accidents occur.
- o Determine the implications of these findings for changes in the pilot selection process, training equipment design, operational procedures, and the environment that would enhance safety.

Products:

- o Identification of error-inducing system and equipment designs;
- o Training requirements that may be used to compensate for design limitations; and
- o Guidelines and standards for designing aviation systems and equipment.

ASRP "Callback":

The purpose of the ASRP program is to elicit information from users of the National Airspace System on dangerous flying conditions. Pilots and air traffic controllers are encouraged to report anything that interferes with the safe operation of the system. The events reported range from near-misses to hazardous procedures to poorly designed or functioning cockpit systems.

The reports are voluntary; the reporters remain anonymous to the FAA. However, there is a "callback" feature in the system which enables an outside analyst to contact the reporter, without compromising the reporter's anonymity, to obtain more complete details on the reported condition and to obtain information of special interest to the aviation community. Based on the data in these reports, a variety of special studies have been performed at the request of researchers, scientists, and engineers interested in aviation safety. The program has not been used to solicit information on issues of particular interest to aviation safety. Such a change would increase the utility of the system without compromising its protective aspects or its current benefits.

Approach:

- Identify human factors safety issues to be explored by the use of ASRP callbacks. The callback feature allows the system to be used for verification and development of human performance safety issues identified by:
  - The SAE G-10 committee;
  - Non-fatal accident investigation; or
  - Inquiries from NAS users or system designers.
- Develop a special purpose data collection questionnaire for each issue.
- Develop a method for selecting reports to receive special attention.
- Collect the data over a pre-determined time period; analyze and report the data for each issue.

Products:

This data will be used for the following purposes:

- o Definition of issues for further study;
- o Enhancement of accident investigation procedures;
- o Identification of man-machine interface problem areas to be addressed through system redesign and operator training; and
- o Identification of areas to be addressed through the development of design guidelines or certification criteria.

AVS RESUME **RESUME NO.** 10 (9, 13, 27)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

ACCIDENT/INCIDENT ANALYSIS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Develop, coordinate, and maintain a program dedicated to identifying the causes of pilot error and to creating a data base on flight crew performance. Develop and deploy methods for collecting crew performance data that will support the creation of standards and guidelines for certifying cockpit flight control and navigation systems.

REQUIREMENT: (Brief description of why project is being undertaken)

Pilot error continues to be the primary cause of aviation accidents. Existing accident and incident data do not show why pilots make errors. Innovative techniques are needed to determine the behavioral patterns which lead to and result in unsafe human performance. Once these patterns have been identified, an assessment of the selection process, training, equipment design, operational procedures, and the environment will be needed to determine what changes would enhance safety.

MILESTONE SCHEDULE: (List significant events and dates during project life)

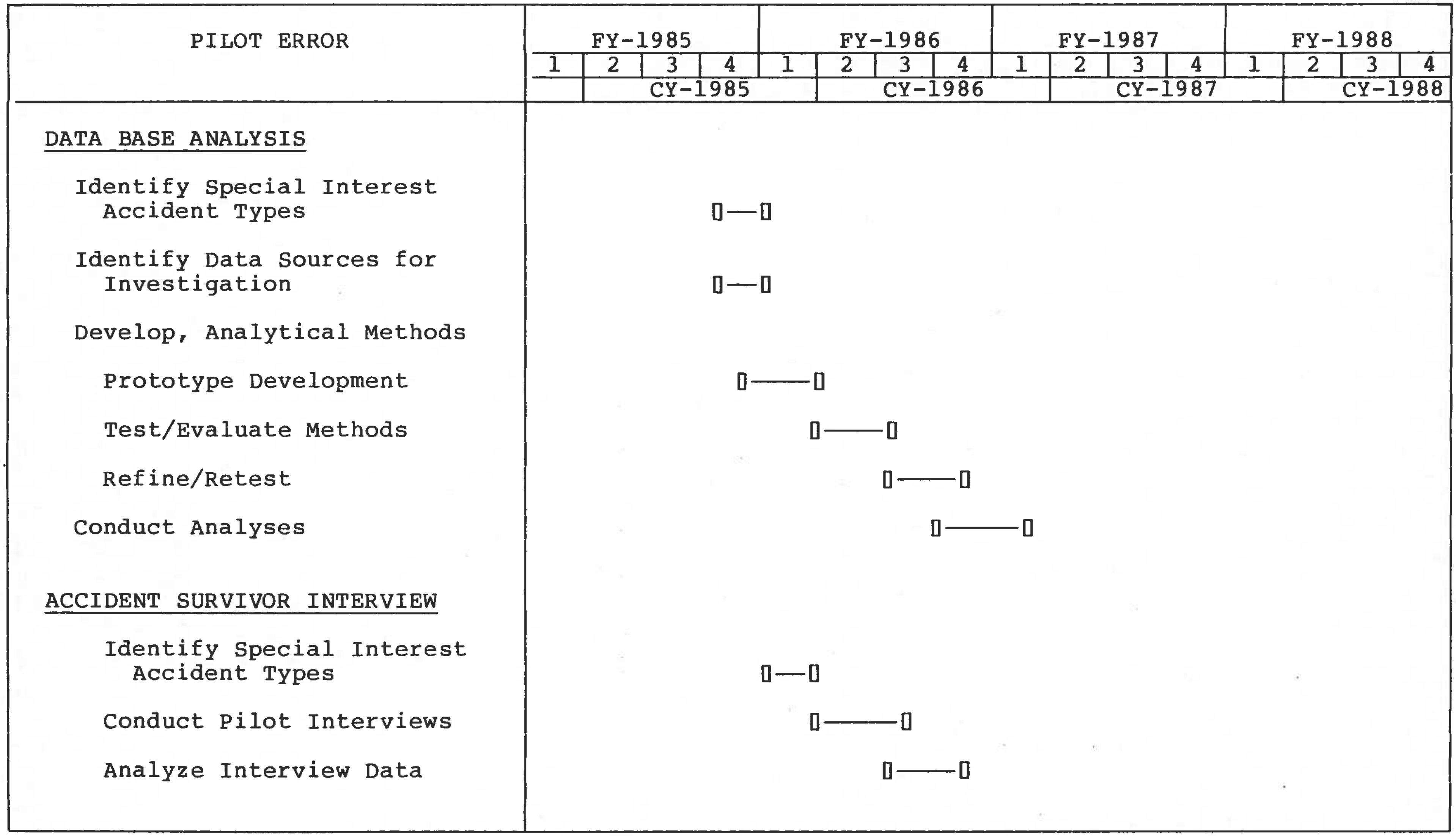
	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Identify areas of special interest	7/85		

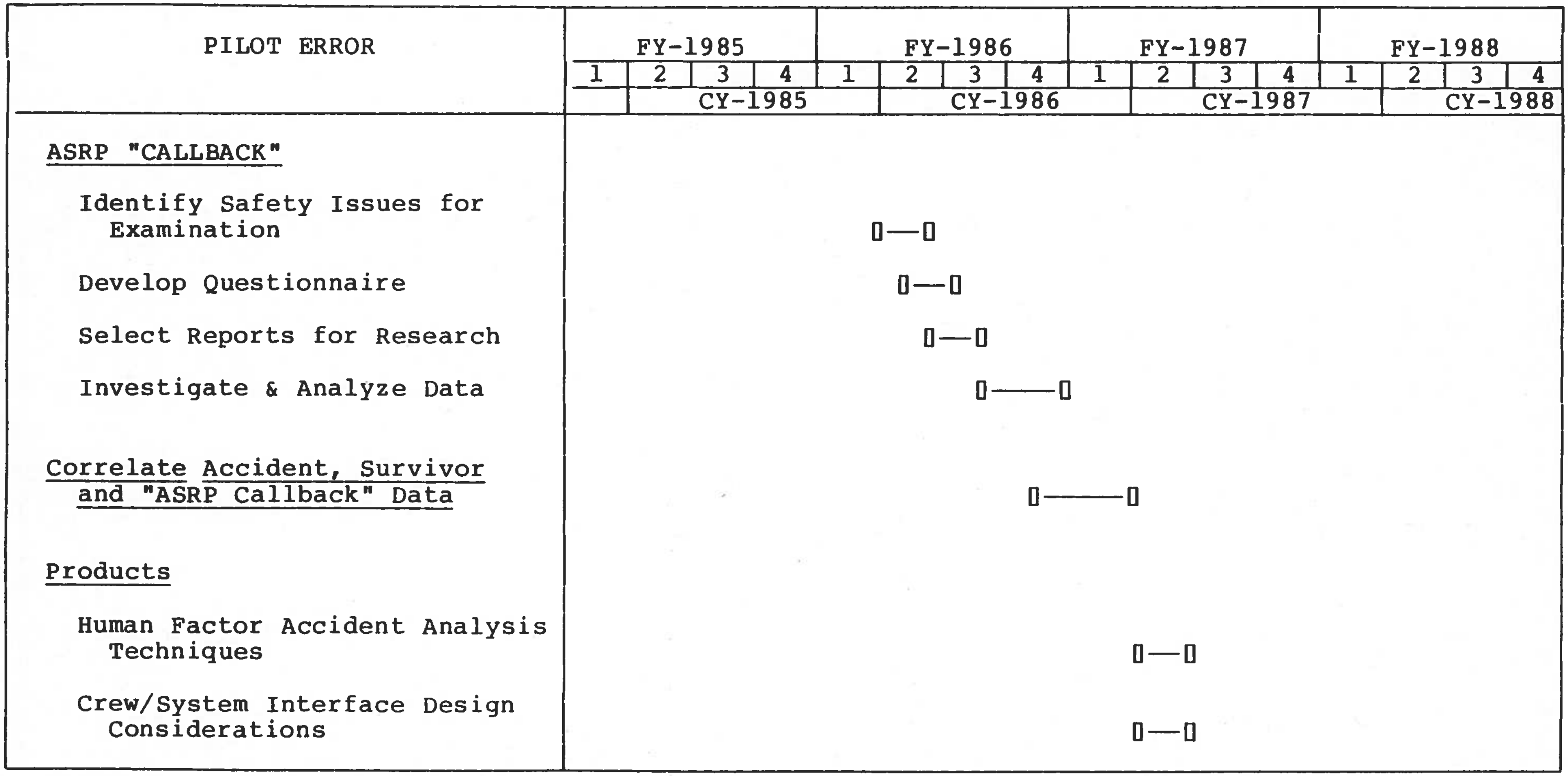
STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o ASRS;
- o ASAS; and
- o NTSB.


PILOT ERROR
FY-1985
FY-1986
FY-1987
FY-1988
1
2
3
4
CY-1985
CY-1986
CY-1987
CY-1988
DATA BASE ANALYSIS
Identify Special Interest Accident Types
Identify Data Sources for Investigation
Develop, Analytical Methods
Prototype Development
Test/Evaluate Methods
Refine/Retest
Conduct Analyses
ACCIDENT SURVIVOR INTERVIEW
Identify Special Interest Accident Types
Conduct Pilot Interviews
Analyze Interview Data



PILOT ERROR
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
ASRP "CALLBACK"
Identify Safety Issues for Examination
Develop Questionnaire
Select Reports for Research
Investigate & Analyze Data
Correlate Accident, Survivor and "ASRP Callback" Data
Products
Human Factor Accident Analysis Techniques
Crew/System Interface Design Considerations

3.2.2 IN-FLIGHT DATA COLLECTION

Objective:

Identify the characteristics of automated flight management systems that influence their compatibility with human operators.

Background and Requirement:

Currently, air crews operate some automated systems with virtually no errors, while the use of other systems is associated with frequent errors. Although each airline has its own policies on the use of automation in the cockpit, there is little documentation of how flight crews actually use the automated cockpit systems and the types of errors that they make with these systems. The absence of such information interferes with the development of design principles for advanced cockpit technology, and with the development of training programs which focus on the types of operational errors that crews actually make.

It cannot be assumed that performance measured during simulator training or during formal observations of actual flights will provide information sufficient to determine those characteristics of automated systems which affect the error rate. In the United Kingdom, such data is gathered through the use of flight recorders. The Royal Aircraft Establishment has initiated a cooperative agreement with commercial airlines under which they provide flight recorders to the airlines and the airlines provide data to the Authority. The data recorded include aircraft attitudes, airspeeds, rates of descent, and other indices of aircraft handling and operations. Such data could be used to evaluate the performance of automated flight management systems with regard to user compatibility.

Approach:

Initiate a cooperative demonstration program between DOT and an U.S. commercial airline for the collection of in-flight data on aircrew use of automated flight management systems. This program would be voluntary. The FAA would provide funding, and the confidentiality of the data would be assured through data analysis being the responsibility of an outside party (similar to ASRP).

Products:

Technical reports describing:

- o Factors influencing system/crew compatibility that should be addressed in the design of future systems;
- o Possible modifications of current automated systems; and
- o Possible modifications of company aircrew automation training programs.

AVS RESUME **RESUME NO.** 11
(8)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

IN-FLIGHT DATA COLLECTION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Identify the characteristics of automated flight management systems that influence their compatibility with human operators.

REQUIREMENT: (Brief description of why project is being undertaken)

Currently, air crews operate some automated systems without error, while the use of other systems is associated wtih frequent errors. There is little performance data to indicate how flight crews use, or misuse, automated cockpit systems during actual flight. Yet, such information is required to establish principles for automation systems design.

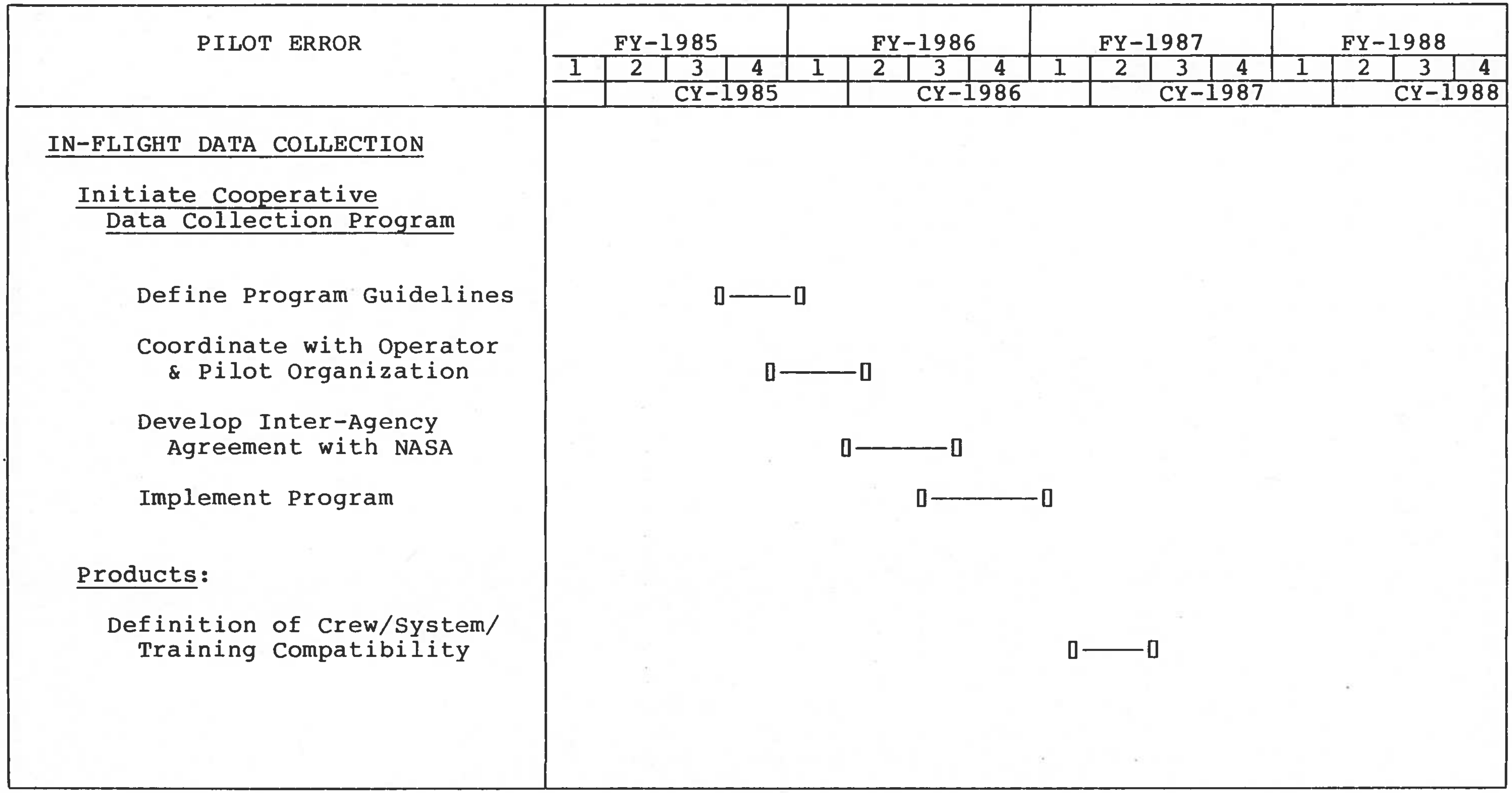
MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Develop guidelines	12/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work


PILOT ERROR
FY-1985
FY-1986
FY-1987
FY-1988
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
CY-1985
CY-1986
CY-1987
CY-1988
IN-FLIGHT DATA COLLECTION
Initiate Cooperative Data Collection Program
Define Program Guidelines
Coordinate with Operator & Pilot Organization
Develop Inter-Agency Agreement with NASA
Implement Program
Products:
Definition of Crew/System/ Training Compatibility

3.3 CREW TRAINING

This section includes eight proposals for research dealing with aircrew training. The first four are concerned with determining the need for additional training for aircrews. Such training may be required because of the impact of automation on pilot proficiency, apparent lack of coordination between cockpit and cabin crews, and the limited effectiveness of current line oriented flight training (LOFT). A fourth proposal is concerned with continuing an evaluation of materials developed by the FAA, GAMA, and Transport Canada for teaching pilot judgment to general aviation pilots. The remaining three proposals are concerned with expanding the role and usefulness of simulators in pilot training.

3.3.1 DATA ENTRY DEVICES AND HUMAN ERROR

Objective:

Develop standards and procedures for the use of currently available digital data input devices which minimize pilot error. Develop requirements for training flight crews in the use of these procedures.

Background and Requirement:

Currently, commercial and some business aircraft are equipped with inertial navigation systems and other flight management systems which require the crew to program the equipment manually under time stress conditions. Serious errors can occur during initial programming and reprogramming. It is inevitable that some level of data entry errors will occur. Data entry validation procedures must be developed to eliminate these errors.

Approach:

- o Assess the extent, frequency, and seriousness of problems resulting from data entry errors.
- o Survey current procedures and training to identify existing training and operations which result in the lowest level of data entry errors.
- o Identify equipment and conditions which result in particularly high or low levels of error.
- o Identify and/or develop methods which minimize errors.
- o Assess the methods.
- o Review methods with the civil aviation community.

Products:

Training guidelines and certification criteria for manual programming of digital data entry devices.

AVS RESUME **RESUME NO. 12 (6)**

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

DATA ENTRY DEVICES AND HUMAN ERROR

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Develop standards and procedures for use with currently available digital data input devices which minimize pilot error. Develop requirements for training flight crews in the use of these procedures.

REQUIREMENT: (Brief description of why project is being undertaken)

An in-depth assessment is needed to determine the type of errors that are occurring, the frequency of occurrence, and the operational procedures used to avoid errors. Using these data as a base, the need for changes in training procedures and design standards will be determined.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Operational error study	6/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o ARINC Standards.

3.3.2 PILOT PROFICIENCY AND AUTOMATED SYSTEMS

Objective:

Identify the extent to which the use of automated systems may degrade a pilot's ability to fly manually; if there is a potentially significant degradation of skills, determine what training is necessary to ensure maintenance of manual capability in the event of the failure of automated flight systems.

Background and Requirement:

The extensive use of automated systems in the conduct of flight has caused concern among pilots about the possible loss of manual piloting skills. Such proficiency is critical in cases where the pilot must revert to manual flight under emergency conditions, and may be a problem when pilots must transfer from automated to non-automated aircraft.

Approach:

Assess the extent and nature of the problem:

- o Survey pilots and professional organizations about the existence of this problem.
- o Survey the air carriers' policies and practices regarding the use of automation in aircraft.
- o Survey appropriate aviation safety data bases.

Products:

Documentation of the extent and seriousness of the problem. If warranted, appropriate recommendations regarding training and operational practices in the use of automation will be made.

AVS RESUME **RESUME NO.** 13
(12)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

PILOT PROFICIENCY AND AUTOMATED SYSTEMS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To identify the extent to which the use of automated systems may degrade the pilots' ability to fly manually, and if there is a potentially significant degradation of skills, determine what training is necessary to ensure maintenance of manual capability in the event of failure of automated flight systems.

REQUIREMENT: (Brief description of why project is being undertaken)

The extensive use of automated systems in the conduct of flight has caused concern about the possible loss of piloting skills needed in the event of automation failure. If significant skills are found to weaken with the use of automation, there will be a need to determine policies for using automation or the additional training required for the maintenance of pilot skills to ensure manual capabilities.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Evaluation plan	6/86		

STATUS: (Enter current information)

REMARKS/NOTES:

3.3.3 COCKPIT/CABIN CREW COORDINATION

Objective:

Improve the effectiveness of communication and coordination between cockpit and cabin crews to increase flight safety and passenger comfort during all phases of flight.

Background and Requirement:

Little effort is spent in training cockpit and cabin crews to operate in a cooperative and coordinated manner and to share responsibility for the aircraft and the well-being of its passengers. The resulting lack of crew coordination and shared responsibility during both normal and emergency flight operations has resulted in unnecessary risks to flight safety. Lack of coordination between the two crews has resulted in passenger injuries; e.g., injuries due to takeoffs that were unanticipated by the cabin crews. Lack of common terminology and understanding of critical aspects of flight impedes the effectiveness of communication between the two crews. The development and implementation of a program to train cockpit and cabin crews to work together more effectively is required.

Approach:

- Survey and document the problems which have occurred in the operation of commercial flights due to inadequate crew communication and coordination.
- Establish a set of training requirements to address the documented problems.
- In cooperation with a volunteer air carrier, develop and implement a prototype training program for their particular operational situation (e.g., the airline's financial status, crew size, route characteristics, and type of aircraft).
- Evaluate the program and, if warranted, identify the changes required to make it suitable for general application.

Products:

Guidelines for the development and utilization of training programs to increase the coordination and communication between cockpit and cabin crews.

AVS RESUME **RESUME NO.** 14
(new entry)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

COCKPIT/CABIN CREW COORDINATION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Improve the effectiveness of communication and coordination between cockpit and cabin crews to increase flight safety and passenger comfort during all phases of flight.

REQUIREMENT: (Brief description of why project is being undertaken)

Document and analyze crew coordination and communication problems that have occurred in emergency situations and develop operational procedures and training methods to solve these problems.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Problem analysis	12/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Recommendations for action, NTSB; and
- o LOFT and simulated emergency evacuation training, United Airlines.

3.3.4 LINE ORIENTED FLIGHT TRAINING ENHANCEMENT

Objective:

Increase the effectiveness of line oriented flight training (LOFT) for training crews in emergency procedures, for identifying shortcomings in training procedures, and for improving crew coordination.

Background and Requirement:

LOFT involves total mission simulation of a commercial revenue flight scenarios with a full cockpit crew complement. Approximately half of the "Part 121" air carriers use LOFT as an important part of their upgrade and recurrent training programs, and LOFT is used in lieu of semi-annual proficiency tests. Pilots have expressed concern that LOFT often is not used effectively: flight scenarios may be predictable and familiar to pilots, and training for emergency situations may be inadequate. Accident investigators have repeatedly reported inadequacies in cockpit resource management, and in the execution of procedures and control use during in-flight emergencies. The FAA has responsibility for the approval of such training programs.

Approach:

- LOFT and emergency procedures:
  - Evaluate the emergency procedures training requirements in FARs 121/135 to determine if they are sufficient to meet current flight safety requirements.
  - Survey the use and practices of various airlines with regard to the use of LOFT.
- LOFT enhancement:
  - Identify weaknesses in company training programs with regard to routine flight operations.
  - Capture and analyze the data from the LOFT sessions for use in identifying human performance safety issues.

Products:

Document the adequacy of LOFT emergency training requirements and practices. If warranted, recommended changes in approval requirements for the use of LOFT will be prepared.

Propose requirements and guidelines for the use of LOFT in identifying human performance safety issues.

AVS RESUME **RESUME NO.** 15 (16)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

LINE ORIENTED FLIGHT TRAINING ENHANCEMENT

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
D. Gilliom, AFO-260 (202) 426-3460

OBJECTIVE: (Brief description of what is to be accomplished)

Increase the effectiveness of line oriented flight training (LOFT) for training crews in emergency procedures, for identifying shortcomings in training procedures, and for improving crew coordination.

REQUIREMENT: (Brief description of why project is being undertaken)

Many of the Part 121 air carriers use LOFT as an important part of their upgrade and recurrent training programs, and LOFT is used in lieu of semi-annual proficiency checks. It has been reported that LOFT is often not used effectively. Flight scenarios may be predictable and familiar to pilots, and training for emergency situations may be inadequate. Accident investigators have repeatedly reported inadequacies in cockpit resource management and in the execution of procedures and motor responses to in-flight emergencies. Research must be conducted to identify the most effective uses of LOFT, and to develop guidelines and procedures for maximizing its use for increasing flight safety.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Detailed plan	9/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o LOFT Workshop 1981, NASA-Ames.

3.3.5 PILOT JUDGEMENT TRAINING AND EVALUATON

Objective:

Develop and evaluate training materials and evaluation techniques for improving pilot judgement.

Background and Requirement:

In 1976, the FAA sponsored research to investigate the extent of judgemental errors in civil aviation and to determine whether and how pilot judgement could be taught and evaluated. A review of the literature revealed that research in other fields such as medicine and business had determined that both the motivational and intellectual aspects of judgement can be taught. Analysis of five years of U.S. general aviation accident data indicated that approximately half of the total fatal accidents were related in part to poor judgement. Since that study, the FAA, in cooperation with the General Aviation Manufacturers Association (GAMA) and Transport Canada, has developed prototype training curricula. Field evaluations of these curricula have been initiated in both Canadian flying clubs and U.S. fixed-base operators (FBOs). Preliminary test results indicate that pilot judgement can be taught.

Approach:

- Refine prototype student and instructor manuals (completed).
- Evaluate refined manuals at selected FBOs, Canadian colleges, and in the FAA's Eastern Region.
- Develop a methodology for use by designated examiners to evaluate judgement during flight and written tests for private pilot licenses.
- Gather data using the methodology developed above.
- Develop draft manuals for instrument pilot training.

Products:

Improved manuals and procedures for judgement training in private pilots during primary and instrument training.

AVS RESUME **RESUME NO.** 16 (19)

Date of Resume:
Date of Revision: 5/27/83

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

PILOT JUDGEMENT TRAINING AND EVALUATION

PRINCIPAL SPECIALIST: Al Diehl, Ph.D., AAM-500 (202) 426-3433

OBJECTIVE: (Brief description of what is to be accomplished)

To develop and evaluate training materials and evaluation techniques for improving the judgement of pilots.

REQUIREMENT: (Brief description of why project is being undertaken)

NTSB accident data suggests that approximately half of all general aviation fatal accidents involve judgement errors by the pilot.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Refine prototype student and instructor pilot manuals, develop associate AV materials with GAMA assistance	12/82	2/83	7/83
Evaluate refined manuals, etc., at selected FBOs in Eastern Region.	6/83	12/84	
Evaluate refined manuals, etc, at Canadian Colleges.	8/83		10/83
- Develop methodology for use by designated examiner/inspector and to evaluate judgement during flight tests for private pilot license.	3/85		
- Gather data on private pilot flight test methodology.	9/85		
- Develop draft manuals for instrument pilot training;	6/85		

STATUS: (Enter current information)

Project underway.

REMARKS/NOTES:

Related Work

- o Eastern Region Student Pilots Demonstration Project done in conjunction with GAMA and AOPA; and
- o Instrument Pilot Manual being developed by R. Jensen at Ohio State University.

3.3.6 TRAINING SIMULATOR FIDELITY CRITERIA

Objective:

To determine the level of simulator fidelity that is necessary for training pilots in selected aviation tasks. Determine how much training is required at specific levels of simulator fidelity to qualify for credit toward regulated flight training.

Background and Requirement:

The amount of simulator training that is necessary to satisfy flight training requirements currently is determined by regulation. The regulations reflect the assumption that the more realistic the simulation, the greater is the value of the training. The level of fidelity required to satisfy these regulations is based on subjective judgements and has not been empirically determined.

Current simulators which are awarded full training credit are complex and expensive, thus limiting their effective availability to only the largest air carriers. This consequence is contrary to the FAA's goal of promoting simulator use, which is safer and more cost-effective than in-flight training, to enhance flight crew member training and checking. Research is required to empirically determine the level of simulator fidelity required to reach the training goals specified by the federal aviation training regulations.

Approach:

The FAA has developed a methodology called the Airman Certification System Development (ACSD), which is being used in the development of new simulator requirements. This method is a modification of an academic procedure used for instructional system development (ISD). The ACSD is a sophisticated analytical and evaluational tool that is incorporated in the following methodological sequence:

- o Identify the training and checking conditions within which the simulators will be deployed;
- o For each of these conditions, apply the ACSD methodology to determine the simulator characteristics required to reach the training goals;

- Develop simulators with varying levels of fidelity;
- Conduct the training on a representative group of pilots at selected levels of fidelity to determine the amount of simulator experience required to achieve training objectives at each level of fidelity; and
- Assess the differential effectiveness of the various levels of fidelity on pilot performance.

Products:

A developed, tested, and validated method for determining minimum fidelity requirements for simulators to be used in training, reviews, and checking.

AVS RESUME **RESUME NO.** 17 (22)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

TRAINING SIMULATOR FIDELITY CRITERIA

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
D. Gilliom, AFO-260 (202) 426-3460

OBJECTIVE: (Brief description of what is to be accomplished)

To determine the level of simulator fidelity that is necessary for training pilots in selected aviation tasks. Determine how much training is required at specific levels of simulator fidelity to qualify for credit toward regulated flight training.

REQUIREMENT: (Brief description of why project is being undertaken)

The high cost of operating aircraft and the crowding of many airport terminal areas make training of aviation tasks in flight equipment costly and hazardous. With the burgeoning costs of flight simulators, the historical approach of "more is better" needs to be evaluated on the basis of effectiveness of training and cost-effectiveness. Specific scientifically-based requirements for levels of simulator fidelity necessary to adequately train pilots in the performance of various mission segments and tasks, and to maintain their proficiency need to be developed.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Start concept validation	6/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Airplane Simulation Uses in Airman Certification, AFO-260.

3.3.7 SIMPLE SIMULATORS

Objective:

To identify the extent to which inexpensive simulators and part-task trainers can be utilized in the training of pilots.

Background and Requirement:

There has been constant improvement in the design of flight simulators. The emphasis has been on establishing simulator facilities which closely approximate the operation of specific types of aircraft. Flexibility and realism are important characteristics. The simulation of six degrees of motion, all-weather day/night visual scenes, and accurate flight control programs are considered essential for airline use. Without question, these devices are effective in training flight crews, and are safer and more economical than actual flight training. These complex simulators are limited in number because they are expensive, and therefore are not readily available for use by all pilots.

There are a number of desktop-type simulators, as well as simulation software for use in home computers, which allow the dynamic presentation of flight control information. Before qualification credit can be given for training on these devices, an assessment of these devices must be made. The assessment must address the simulator's level of sophistication and its limitations.

Approach:

- o Identify potential training applications for low-cost training devices.
- o Assess the capabilities of currently available devices.
- o Evaluate the utility of selected low-cost simulators with regard to the training applications identified above.

Products:

Recommendations and guidelines for the use of low-cost simulators.

AVS RESUME **RESUME NO.** 18 (23)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

SIMPLE SIMULATORS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080
P. Hwoschinsky, APM-430 (202) 426-3754

OBJECTIVE: (Brief description of what is to be accomplished)

To identify the extent to which inexpensive simulators and part-task trainers can be utilized in the training of pilots.

REQUIREMENT: (Brief description of why project is being undertaken)

The introduction of new "high technology" systems in existing aircraft requires additional training of the operators to adequately utilize these new systems. The purchase of complete flight simulators are necessary to meet the requirements of the regulations for the training of pilots in small airlines or air taxi operations is generally out of the question for economic reasons.

The development of truly low cost simulators may facilitate wider use of these devices and thereby, enhance safety.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Detailed test plan	7/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Use and requirements for Low Cost Simulators, APM-430.

3.3.8 PERFORMANCE FEEDBACK IN SIMULATORS

Objective:

Increase the effectiveness of simulation training for developing and maintaining flying proficiency.

Background and Requirement:

Traditionally, pilots in simulator training are subjectively evaluated based on a pass/fail grading system. The pass/fail system does not provide:

- Relative performance feedback;
- A detailed measure of training effectiveness;
- A sensitive indicator of training program needs; or
- An effective tool for targeting safety issues.

Providing quantitative parametric feedback to the trainee as to specific performance would serve to enhance learning through better motivation. Quantitative scoring would provide a measure of performance relative to an established baseline, and would help to evaluate training effectiveness and relative proficiency levels. Quantitative measures also would help to identify specific training needs and human performance safety issues related to flight operations.

Approach:

- Identify or develop critical flight scenarios.
- Identify performance measures to be quantified.
- Use the initial and recurring training programs in the B-727 simulator to establish a pilot performance data base using commercial airline pilots.
- Use the data base to develop parametric measures of performance in simulator training.
- Determine the quality and format of feedback that should be provided to the pilots, the training staff, and the air carriers.
- Perform a comparative evaluation of the relative effectiveness of pass/fail and parametric grading systems.

Products:

Guidelines for the establishment of a quantitative and parametric pilot performance feedback system for training in airline simulators.

AVS RESUME **RESUME NO.** 19 (18)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

PERFORMANCE FEEDBACK IN SIMULATORS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Increase the effectivenss of simulation training for developing and maintaining flying proficiency.

REQUIREMENT: (Brief description of why project is being undertaken)

With the use of computers to operate flight simulators and to monitor the performance of the operators (pilots), the traditional subjective feedback to pilots could be enhanced by more accurate, objective, and timely information that is more descriptive of what the pilots actually did with respect to that which was required rather than the traditional "pass-fail" grading system. It is necessary to determine what kind of feedback is optimal for the acquisition of piloting skills as well as the timing and extent of the feedback that should be provided.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Start data collection	2/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Occulometer sensing of pilot instrument scanning, NASA-Langley; and
- o Video recording of flight crew performance, United Airlines.

3.4 REGULATION

This section includes four proposals directed toward updating or expanding existing Federal Aviation Regulations. The proposals consider the following regulatory issues:

- Simplification and organization of Part 121 related to flight crew responsibilities to improve the interpretability and ease with which relevant regulations can be accessed and used during time-critical flight situations;

- Possibility of flight crew fatigue decreasing flight safety by disrupting the manner in which flight crews work together;

- Necessity for additional requirements for crew training to compensate for reductions in company emphasis on flight training during periods of negative economic conditions in the air carrier industry; and

- Updating of licensing and testing of aircraft mechanics to reflect advances in aviation technology.

3.4.1 INCREASE THE USEABILITY OF THE FARS

Objective:

Modify and clarify the federal aviation regulations in order to develop a regulation reference system or manual which can be used easily by aircrews to resolve uncertainties regarding their legal responsibilities.

Background and Requirement:

Pilot groups often complain that federal regulations are unnecessarily complex and difficult to understand. When pilots are faced with situations requiring them to consult the federal aviation regulations, the application of appropriate regulatory requirements may be difficult. They find that the regulations often are hard to locate and interpret.

The 1981 Report of the President's Task Force on Aircraft Crew Complement lists in its Summary of Conclusions and Recommendations the following recommendation: "Many of the Federal Aviation Regulations (FARs) relating to flight crew responsibilities appear to be unnecessarily complex. An effort should be made to simplify and clarify the FARs to make them more understandable and easier to use."

Important federal aviation regulations that require review and simplification are FARs Parts 91 and 121. An FAA project is underway to review and rewrite Part 91 to increase their understandability. The review and simplification of the sections of Part 121 relating to flight crew responsibility have not been initiated.

Approach:

- o Review the sections of FAR Part 121 relating to flight crew responsiblity with pilots and pilot organizations to identify problems associated with their use during flight.
- o Modify, clarify, and simplify objectionable sections, and have the changes reviewed to ensure that they meet all legal requirements.
- o Develop a simple and effective reference system for the regulations.

- o Test and evaluate the usability and clarity of the modified regulations under simulated flight conditions with a sample of flight crews provided by volunteer airlines.

Products:

- o Revisions of selected sections of Part 121 that are related to flight crew responsibilities.
- o An improved reference document of flight crew regulations designed for in-flight use.

AVS RESUME **RESUME NO.** 20
(29)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

INCREASE THE USEABILITY OF THE FARS

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Modify and clarify the federal aviation regulations in order to develop a regulation reference system or manual which can be used easily by aircrews to resolve uncertainties regarding their legal responsibilities.

REQUIREMENT: (Brief description of why project is being undertaken)

The Federal Aviation Regulations currently provide highly detailed determinations for conducting all aspects of civil aviation. A number of the regulations may be redundant and there may be conflicts between regulations that apply to the same categories of aviation. There is a need to review the FARs to determine if such redundancies and conflicts exist, to identify them if they do exist, and to suggest revisions of the FARs which would eliminate this problem.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
G-10 recommendations	6/86		

STATUS: (Enter current information)

REMARKS/NOTES:

3.4.2 FATIGUE AND CREW INTERACTION

Objective:

Background and Requirement:

Fatigue and fatigue management is a major problem in the cockpit. Industrial researchers have found that fatigue causes inattention, perseveration of ideas, confusion, and anxiety, all of which could degrade crew interaction in the cockpit. Pilots and researchers attending the FAA's human factors research workshops noted that the effects of fatigue on stress and on flight deck operations should be studied. ASRP pilot reports indicate that decrements in flight performance and in the effectiveness of crew interactions are related to the time of day and are more severe during the final phases of flight when fatigue would be expected to be greater.

Approach:

- Assessment:
  - Survey the literature on the influences of fatigue and sleep deprivation on social interaction, cooperative behavior, and leadership dynamics; and
  - Review crash investigation results to identify important flight crew and situational variables.
- Method:
  - Development of a test plan;
  - Development of flight test scenarios;
  - Selection of flight crew test subjects;
  - Data collection in full mission simulator;
  - Data analysis;
  - Development of prototype countermeasures; and
  - Evaluation of countermeasure effectiveness in full mission simulation.

Products:

A report documenting and summarizing the effects of fatigue on crew interaction, and describing potential techniques for alleviating fatigue-related problems, will be produced. The report will provide methodologies for evaluating the effectiveness of these techniques.

AVS RESUME **RESUME NO.** 21
(20)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

FATIGUE AND CREW INTERACTION

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To determine the effects of fatigue on crew interaction and develop countermeasures to neutralize the adverse effects.

REQUIREMENT: (Brief description of why project is being undertaken)

Inadequate fatigue and cockpit resource management is recognized as a major contributor to aircraft crashes. Reports from airline pilots indicate that fatigue affects crew interaction and that fatigue management is a major problem in the cockpit. ASRP data indicate that decrements in flight deck performance and in the effectiveness of crew interactions are related to the time of day and are more severe during the final phases of flight, when fatigue is greater.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
NASA short haul study	2/85		
NASA long haul study	12/85		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Effects of fatigue on flight crew interaction in the B-727, NASA-Ames; and
- o Effects of fatigue on flight crew interaction in corporate twins, Ohio State University.

3.4.3 ECONOMICS AND FLIGHT TRAINING

Objective:

Assess the impact of economic difficulties on the quality and quantity of recurrent training provided by the commercial airlines.

Background and Requirement:

There is a perception within the airline pilot community that the amount and quality of pilot training is tied directly to the economic health of individual airlines: the better the financial condition of the airline, the greater the investment in high-quality training. As a result of the competitive forces in the marketplace resulting from deregulation, pilots argue that the quality and quantity of training offered by financially pressed airlines is decreasing.

Approach:

Conduct an in-depth study to determine if airline pilot training fluctuates directly with an airline's economic status. This will involve:

- o Reviewing the types and amounts of training offered by the airlines over the past decade;
- o Examining the financial conditions of the airlines over the past decade; and
- o Determining if there is a correlation between these factors.

Products:

A report on the relationship between economics and flight training, with recommendations for ensuring that training does not fall below the minimum level required for safety, will be produced.

AVS RESUME | **RESUME NO.** 22 (30)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

ECONOMICS AND FLIGHT TRAINING

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

Assess the impact of economic difficulties on the quality and quantity of recurrent training provided by the commercial airlines.

REQUIREMENT: (Brief description of why project is being undertaken)

Deregulation has forced many airlines to adopt severe cost-cutting measures in order to stay competitive. Training may be one target of these cuts. To save money, airlines might stop renting simulators for crew training; simulator flight scenarios may not be upgraded, and there may be cuts in training staff. These cuts may result in reduction of flight safety. Study is needed to determine if there have been cuts resulting in deficiencies in training.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Impact assessment	10/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o Airplane Simulation Uses in Airman Certificaton, AFO-260; and
- o Uses and Requirements for Low Cost Simulators, APM-430.

3.4.4 SELECTION, TRAINING, AND LICENSING OF MAINTENANCE PERSONNEL

Objective:

To update the process of selection, training, and licensing of maintenance personnel to reflect the use of advanced technology in aircraft system design.

Background and Requirement:

The Sixth Human Factors Workshop on Aviation held at the Mike Moroney Aeronautical Center, Oklahoma City, Oklahoma, July 7-9, 1981, identified a number of issues which relate the training, testing, and qualification of newly FAA certified mechanics. The major issues identified by attendees at the Workshop are related to one of the following considerations: (1) the need to update FAR Part 147, Aviation Maintenance Technical Schools; (2) the adequacy of present procedures used in A & P licensing; and (3) the need to incorporate testing techniques that evaluate problem solving ability as well as the level of conceptual understanding of the maintenance functions and technical details.

The updated needs of the technical level of training provided candidates for an A & P license, as recommended by participants of the Workshop, included additional training in:

- Strength of materials;
- Electrical and electronic systems;
- Rotorcraft;
- Turbine engines; and
- New composite structural materials.

Concern for testing procedures produced recommendations that the testing techniques not be heavily weighted in favor of testing for strictly factual information that may be irrelevant or easily outdated. In addition, concern was expressed that tests should not be used which encourage the applicant to study testing format techniques and depend upon answering questions on the basis of what is perceived to be correct. Such testing techniques, it is argued, are inefficient, causing the student to study principally for the examination.

Another concern expressed in the Workshop related to the inability, or inadvisability, of placing a newly certified A & P rated mechanic in a position of responsibility without first determining the skills of the particular mechanic. The limited scope of training provided to qualify the A & P candidate for an industry with highly specialized maintenance needs was cited as one of the reasons for this situation.

Approach:

Establish a task group to:

- o Develop clear statements of requirements to update the qualification level of future candidates seeking A & P certification; and
- o Examine the validity of concerns expressed regarding the methodology of testing candidates for A & P certification.

Products:

The products of this activity will provide documentation with which the FAA can use to determine future action on maintenance selection, training and licensing.

AVS RESUME	RESUME NO. 23 (24, 26, 28)

Date of Resume: 1/15/85
Date of Revision:

Date Deferred/Cancelled:
Date of Final Completion:

PROJECT TITLE:

MAINTENANCE PERSONNEL

PRINCIPAL SPECIALIST: G. Tinsley, AFO-210 (202) 426-8080

OBJECTIVE: (Brief description of what is to be accomplished)

To update the process of selection, training, and licensing to reflect the advances in aviation technology.

REQUIREMENT: (Brief description of why project is being undertaken)

Resulted from the Sixth Human Factors Workshop on Aviation held at the Mike Monroney Aeronautical Center on July 7-9, 1981.

Update FAR 147 - Require training curricula which reflects the technological advances in aircraft design.

A & P Licensing - Assess adequacy of present procedures.

Testing Procedures - Testing should evaluate the applicant's problem solving ability as well as conceptual understanding. Testing should not be limited to measuring rote memory capability.

MILESTONE SCHEDULE: (List significant events and dates during project life)

	Scheduled Completion	Revised Scheduled Completion	Actual Completion
Establish task group	4/86		

STATUS: (Enter current information)

REMARKS/NOTES:

Related Work

- o NTSB study.

4.0 RESOURCES

This aviation research program is directed toward improving aviation system safety and effectiveness by focusing on the characteristics of flight crews. It is recognized that flight crews are critical elements in the design and use of flight system procedures and cockpit components. This work has a wide constituency in the aviation community.

Many of these constituents can contribute to the success of the proposed problem-solving efforts. Site visits to selected aviation safety research facilities throughout the country revealed many common research interests and the possibility of new cooperative research efforts with the FAA. Such cooperative activities can increase the cost effectiveness of FAA human factors work and increase the number of high-priority problem areas that can receive near-term attention. Described below are facilities that have research interests and capabilities which are directly related to the interests of the FAA.

4.1 NASA

NASA-Ames and NASA-Langley are the two NASA facilities currently doing work that is most directly applicable to the FAA's needs. Both are active in large-scale flight simulation systems, but there are differences between the simulators and the research orientations at the two facilities. The work at Ames is more basic and operator-oriented, while the work at Langley tends to be more display-and flight systems-oriented.

AMES

At Ames, most of the programmatic human factors work is done in the Man-Vehicle Systems Research Division. Important areas of direct relevance to the FAA include the following:

- Operator Automation Interaction: Survey of pilot experience with automation in 767 and DC9-80, and development of human factors principles in automation;
- Workload and Performance Assessment: Develop physiological and subjective measures of pilot workload; and

- o Flight Crew Fatigue: Identification of dimensions, correlates, and antecedents of crew reactions to fatigue during intercontinental flights.

Among its extensive fixed wing and rotorcraft simulator facilities is a 727 full mission simulator equipped for audio, video, and physiological recording of crew behavior under real time operational conditions. A summary of the major areas of human factors researach at Ames is presented in Table 1 in Appendix A of this report.

LANGLEY

The more equipment- and application-oriented work at Langley is directed toward developing and evaluating cockpit displays and systems from the pilot's point of view. The human factors work is concentrated in three branches, or offices, at Langley:

- o Flight Operations Research Branch;
- o Flight Management Branch; and
- o Advanced Transport Operating Systems Office (ATOPS).

The Flight Operations Branch does work which can be related to general or commercial aviation problems, but is oriented primarily towards single pilot IFR flight conditions. Problem areas being studied which are of particular interest to the FAA include the following:

- o Data link presentation of ATC information;
- o Workload and cockpit automation; and
- o Key issues in GA single pilot IFR operations.

The Flight Management Branch has done simulator evaluations of the use of the CDTI (Cockpit Display of Terminal Information) for monitoring in-trail separation during terminal area approach operations. The ATOPS office is primarily concerned with the automation of information transfer from the terminal area to the cockpit work of particular relevance to the potential impact of NAS modernizations on cockpit operations.

Langley's performance-measurement equipment and simulation facilities are extensive. The Langley occulometer is one of the best available in the industry.

It could be very useful in the development and testing of display formatting standards. The simulation facilities provide the capability for simulating general aviation, helicopter, and air carrier aircraft. Currently, voice and data links are being established between one of Langely's air carrier simulators and the air traffic control simulation facility at the FAA's Technical Center. This capability is being developed to investigate pilot-controller interactions during MLS approaches. A summary of the major factors research activities at Langley is presented in Table 2, Appendix A.

4.2 DOD

The Department of Defense's extensive experience in complex air operations provides a basis for significant contributions of relevant research facilities and expertise to civil aviation. In may cases, because of the normally high stress operational conditions involved, DOD's research on human performance and operator requirements is leading the state-of-the-art. A review of DOD-funded research in aviation through a search of the Defense Logistics Agency Manpower and Training Research Information System (MATRIS) data base revealed that DOD agencies are supporting contract research in over half of the 31 problem areas proposed for research in this plan. DOD agencies prominent in aviation-related research include the following:

Aerospace Medical Research Laboratory
Air Force Flight Dynamics Laboratory
Air Force Human Resources Laboratory
Air Force Office of Scientific Research
Army Research Institute
David W. Taylor Naval Ship R & D Center
Naval Air Systems Command
Naval Health Research Center
Naval Personnel Research and Development Center
Naval Surface Weapons Center
Naval Training Equipment Center

A site visit was conducted to the Aerospace Medical Research Laboratory (AMRL) and the Flight Dynamics Laboratory (FDL) at Wright Patterson Air

Force Base. AMRL and FDL were selected for site visits because of the direct relevance of their human factors research to human performance areas which have been identified by the FAA for special attention. AMRL has been aggressive in the development, refinement, and application of both subjective and objective measures of aircrew workloads. They are also developing new methods for allocation of flight control functions between the pilot and system automation. Scientists working in the area of flight function allocation at Wright Patterson appear particularly sensitive to the need for pilot-automation compatibility in their flight systems.

With continued advances in flight system technology, the human operator increasingly becomes the limiting element in system design and knowledge of his capabilities become more important to the system designs. Presently, there is no central repository of existing knowledge on human capabilities relevant to such design. AMRL is, with the aid of consultants, scientists, and academicians, assembling a vast compendium of such information. With the proper formatting, references, qualifications, and capability for updating, this document could be an important reference for developing flight systems design guidelines and certification criteria which are based upon human performance.

Among the responsibilities of the Flight Dynamics Laboratory is to anticipate the operational and technological requirements of the next generation of aircraft, develop control concepts to satisfy those requirements, and then to develop the hardware required to translate those concepts into cockpit reality. This approach to flight systems design keeps FDL at the state-of-the-art in their research and development activities. Work in three of their research areas is of particular relevance to civil aviation: pictoral situation displays presented on CRTs, voice recognition systems for use in cockpits, and the development and testing of variations in keyboard logic for display selection and control. The display work has direct application to the formatting and presentation of approach plates in the advanced technology cockpit of developing carrier aircraft; control of display data presentation by voice may provide a useful means of reducing head down time by pilots in high workload conditions; and the use of the new situation tailored keyboard logic being explored may reduce keyboard data entry errors.

Highlights of this human factors work are represented in Table 3 of Appendix A.

4.3 INDUSTRY

Both airframe manufacturers and air carriers maintain significant research capability in terms of facilities and researcher expertise.

The major aircraft manufacturers make simulators as well as civilian aircraft and conduct the research required to create aircraft which are compatible with the most demanding operational conditions. Accordingly, the most advanced expertise in the design and evaluation of flight system often resides with industry. Site visits were made to Sikorsky Aircraft and Douglas Aircraft Co. and special conversations were held with Boeing Commercial Aircraft Co. to determine the types of non-proprietary human factors work conducted by these compainies that was of particular relevance to the FAA.

Sikorsky Aircraft Company

Sikorsky is the largest manufacturer of military and of large helicopters in the world and has much of the human factors capability required to support this activity. However, in-house human factors research and development activities and facilities at Sikorsky Aircraft currently are limited. Presently, lab facilities are limited to a mock-up facility, a fixed-base developmental simulator, and a single laboratory room with a variety of more-or-less standard assortment of human factors equipment such as small computer/display systems, an eye position recorder, cameras, motion picture analyzers, and psycho-physiological measurement devices.

Sikorsky has plans to develop a major human factors research facility at their plant. These plans include a vast increase in floor space that can be dedicated to human factors research, advanced computer support, and the addition of a motion-base helicopter simulator with a 360^{o} dome visual system.

Douglas Aircraft Company

This airframe manufacturer has the design and human factors expertise required for designing and evaluating cockpit display and control systems. This capability is used for aviation-related research contracted from NASA, DOD, and the FAA.

As with other major airframe manufacturers, in-house and contract research activities often define the state-of-the-art in aviation systems. Current research activities of particular interest to the civil aviation community include work in workload measurement, problems encountered with flight crew and automation interaction, the formatting of CRT displays for aircraft cockpits, and the application of artificial intelligence to aircraft warning systems. Selected research activities and facilities are represented in Table 5 in Appendix.

Boeing Aircraft Company

Boeing is the largest airframe manufacturer in the world. They have complete facilities for the design, development, and fabrication of flight deck displays and controls, and for the measurement of pilot behavior as they use them. Boeing has the resident engineers, software modules, pilots, human factors specialists, and simulator system designers required for the research and evaluation of advanced flight deck concepts. Boeing's experience is well known in aviation and ranges from initial requirements determinations and task workload analysis through the hardware and software engineering and evaluation efforts required to develop and produce such FAA-certified aircraft as the 757 and 767 air carriers.

Their research laboratories include flight simulators, part-task training devices, information processing and display laboratories, and general and special purpose computers. The Flight Deck and Research and Preliminary Design Laboratory includes developmental and generic fixed-base simulators, advanced cockpit displays in flat panel configurations, programmable symbol generators, sophisticated eye view monitors, and prototype voice recognition systems.

The Boeing Aircrew Training Facility has motion-based simulators as well as part-task trainers for the 707, 727, 737, 757, 747, and 767. It has day/night/dusk visual systems for these simulators, and the in-house programming capability required to use the simulators.

Boeing regularly performs human factors research under contract and has done such contracted work for NASA, DOD, and the FAA. A summary of Boeing's research facilities relevant to the FAA's human factors interests is illustrated in Table 6 of Appendix A.

4.4 TRAINING CENTERS

A number of human factors research areas proposed for attention is this plan involve the examination of alternatives to the current design of air carrier crew training programs. The design and evaluation of such alternatives will require access to both aviation training experts, and training facilities. The Flight Safety International's Fairchild Learning Center in San Antonio, Texas and United Airlines' Training Center in Denver, Colorado were visited to identify training facilities and expertise potentially available for application to the study and resolution of training problems in civil aviation.

Flight Safety International

The Fairchild Learning Center is one of 24 Flight Safety International (FSI) centers "providing training to over 2,200 corporate and commuter aircraft operators and military clients."

Flight simulator facilities at the Fairchild Learning Center include:

- One SA 226 Merlin Metro with 4 degrees of motion and night-only computer generated visual system;
- One SA227 Merlin Metro with 4 degrees of motion and night/twilight computer generated visual system; and
- One SAAB Fairchild 340 with 4 degrees of motion and night/twilight computer generated visual system.

These simultors are supported by in-house maintenance and in-house and corporate programming capabilities.

Each of FSI's centers specialize in particular aircraft types, under contract to manufacturers of the aircraft, and in arrangement with aircraft operators. Aircraft manufacturers include: Fairchild, McDonnell Dougless, Gulfstream, Canadair, Lear Fan, Ltd, Cessna, Bell, Sikorsky, and others. The simulator and other procedures trainings, six computer-aided instruction stations, and audio-visual display outfitted classrooms are used for the corporate and commuter aircraft flight and maintenance training for the Merlin Metro and Fairchild 340 aircraft.

In addition to commuter and corporate aircraft simulators, the Fairchild Learning Center offers CAI (Computer Assisted Instruction) capabilities for flight procedures and maintenance training. Individualized instruction CAI programs enable pilots to practice simulated malfunction and emergency management procedures and to familiarize themselves with these procedures prior to flight simulator sessions. Currently, the software Fairchild Learning Center is developing CAI/videodisc integrated software for pilot training in flight problem identification and management, cockpit resource/crew interaction management, and fatigue/workload management. Maintenance trainees use FSI-developed CAI to practice problem identification procedures as a part of transition courses. A summary of the Fairchild Learning Center's facilities is presented in Appendix A of this document in Table 7.

United Airlines Training Center

The United Airlines Training Center, Stapleton Airport, Denver, Colorado, provides centralized training and personnel management for all United Airlines flight and cabin crew personnel. Training for flight crew includes initial, recurrent, transition, and upgrade programs. Cabin crew training includes initial and recurrent emergency management programs. Approxmately 6,000 pilots are served by this center's programs.

The training center provides classrooms equipped with video-tape recorders, television monitors, and other audio-visual training aid devices, procedures training mock-ups, conference rooms, offices for training, personnel and flight command staff, a cafeteria, and extensive flight simulator facilities.

Fourteen flight simulators used for initial, recurrent, and upgrade training, and for flight checks (under FAR exemptions) include:

- Two Link 2 degrees of motion DC-8;
- One Link 3 degrees of motion DC-8;
- One Conductron 3 degrees of motion DC-8;
- Three Link 3 degrees of motion B-727;
- One Redifon 3 degrees of motion B-727;

- o Two Conductron 3 degrees of motion B-737;
- o One Link 6 degrees of motion B-747;
- o Two Redifon 6 degrees of motion DC-10; and
- o One Redifon 6 degrees of motion B-757.

In addition to these fourteen flight simulators, United has one B-757 emergency procedures training device. This is used for training flight and cabin crews in emergency evacuation. Its capabilities include limited roll (tilt) and pitch, simulated fire and cabin smoke generation.

The flight simulators, one of which is rated as Phase III, have a variety of CPU memory and programming capabilities, motion systems, and visual display characteristics. Programming and maintenance support for the simulators is also housed at the center. The simulator scenarios are reprogrammed once each year to include a different mix of geographical variables in accordance with changes in United's route system, and to provide for the inclusion of line flight problems of current concern, such as wind shear.

In addition to simulators, United extensively uses CAI and audio-visual training devices. Procedures trainers of graded complexity are also used and are of particular importance in the transition training programs.

While the primary purpose of the Center is training, United Airlines is interested in conducting research related to its training objectives. The LOFT program has been research oriented for example. A summary of the Training Center's facilities is presented in Table 8 of Appendix A.

4.5 UNIVERSITIES: OHIO STATE (OSU)

A number of universities in this country are currently involved in aviation-related research. These include MIT, Princeton, Purdue, University of Illinois, Univeristy of Wisconsin, Univerisity of Massachusetts, University of Miami, Georgia Technical, Virginia Polytechnical Institute, and Ohio State University. Of these, the Ohio State University is currently the most active in applied aviation human factors.

The Ohio State University's (OSU) Department of Aviation has its own airport, flight school, and staff of aviation psychologists. Judging from the published human factors literature, OSU's Department of Aviation is currently the most active academic department in civil aviation human factors research today. The department is housed at the OSU Airport.

Staff members have military and civilian flight experience. They also have advanced degrees in engineering and human factors psychology, teach graduate level courses in the aviation sciences, and do contract work for NASA and the FAA.

Most of the department's work has been in general aviation, but new research capabilities are being established in commercial aviation. It has the following particular strengths and capabilities:

- Design and evaluation of cockpit displays;
- Research on general aviation instruction and training; and
- Research on pilot error and pilot judgement.

A summary of recent and current aviation research done at OSU is presented in Table 9 of Appendix A.

4.6 FAA

The Federal Aviation Administration currently has a variety of human factors programs underway. Work is done at headquarters both "in-house" and through contracts and interagency agreements with NASA, DOD, universities, and private firms.

The FAA also maintains two major field facilities for conducting aviation-related human performance research: The FAA Civil Aeromedical Institute (CAMI), located at the Mike Monroney Aeronautical Center in Oklahoma City, Oklahoma, and the FAA Technical Center at Atlantic City Airport, New Jersey. Both organizations are oriented primarily toward supporting the FAA air traffic control responsibilities, but they also do some "airside" work. CAMI's airside work is primarily concerned with the influence of personal and environmental stress upon operator performance, whereas the Technical Center's airside work is more oriented toward the pilot's interaction with flight control systems.

Headquarters

At headquarters, the FAA has a number of research and development programs concerned with pilot performance and the pilots interface with the aircraft and the National Airspace System. Some of the work is related to the high priority problems presented in this document for special attention. Most of the cockpit-related human performance work is administered through three offices:

- o Program Engineering and Maintenance Service (APM);
- o Office of Aviation Medicine (AAM); and
- o Office of Flight Operations.

The work is broad and varied and includess:

- o Development and evaluation of cockpit displays;
- o Development of pilot training methods and cirrucula;
- o Development and evaluation of cockpit alerting systems;
- o Development of methods and procedures of cockpit certification; and
- o Review of accident investigation procedures.

A brief summary of the cockpit-related human factors work administered from FAA headquarters is presented in Table 10 of Appendix A.

Civil Aeromedical Institute (CAMI)

CAMI's role is to provide the FAA with primary support for medical and behavioral research. Its activities are approved and directed by the Office of Aviation Medicine. The work actually conducted is based upon information requirements placed upon it by this office and upon the interest of the individual researchers as reflected in research proposals submitted to the office for approval.

The unique strengths of this facility are the broad range of research capabilities among its staff members, its toxicological facilities, and its facilities simulating environmental stressors. Although most of the work done here is application-oriented in that it provides data upon which to base FAA regulations or advisories, much of the work is also general enough and of the necessary quality for use by the aviation community at large and the scientific community as well.

Work which is done at CAMI is done almost entirely in-house--contractor support for research is rare. This limits CAMI's ability to satisfy all of the FAA's research needs, but also assures that the expertise developed through CAMI research remains with the FAA.

The CAMI research complex is divided into four laboratories that are identified according to the following four research disciplines:

- o Aviation Toxicology;
- o Aviation Physiology;
- o Aviation Psychology; and
- o Protection and Survival.

Each laboratory includes highly-trained researchers who maintain skills and do research in the areas of direct relevance to aviation safety.

A major advantage of CAMI is its substantial capability for testing human subjects and a variety of environmentally-, task-, and drug-induced conditions of stress. The following is a partial list of specialized equipment that can be used in studies of such stressors:

- o Multiple tasks (psychomoter) performance battery
- o Disorientation (middle ear) device
- o Simulated radar display in en-route console
- o Honeywell Mark II Vision Tester
- o Physiological measurement equipment
- o Electronically insulated test chamber
- o Environmental chamber
- o Altitude chamber
- o Lower body negative pressure device
- o Chamber for testing masks and other breathing equipment

- o Treadmill
- o Complete optics and vision laboratory
- o Microwave research laboratory
- o Indoor swimming pool 14' deep by 40' square
- o Liquid chromatograph
- o Gas chromatograph
- o ATC-S10 Personal Flight Simulators

A summary of the research to the Office of Aviation Medicine for initiation and continuance in 1984 is represented in Table 11 of Appendix A. Review of this table reveals the broad range of interest and capability at CAMI which include work in cabin safety and the influence of drugs on flight safety--two areas of which are probably not being addressed outside of government laboratories. Work in pilot error and display monitoring are areas of particular relevance to designers of cockpit automated systems. The investigative methods which would be used in the proposed research include data base reviews, collection and analysis of fluid and tissue samples from accident victims, and classical laboratory research. Products are primarily informational, being comprised of technical reports.

Table 11 also shows that most of the work done by the Psychology Laboratory is directed toward air traffic control. This work will be dealt with at a later date, as the present report is concerned with work more closely associated with activities inside of the aircraft.

FAA Technical Center

The FAA Technical Center is located near Altantic City, New Jersey. Organizationally, it is part of the FAA's Office of Development and Logistics. Presently, the Technical Center's research and development activities are directed primarily toward air traffic control. They are heavily involved in testing and evaluating systems and hardware that are developed by contractors for the 9020 replacement program. This heavy involvement in the ground side of the National Airspace System (NAS) is reflected in the activities listed in Tables included in Appendix A of this report.

Some pilot work has been and is being done at the Technical Center. It has managed several studies conducted through Embry Riddle Aeronautical University that were concerned with training the general aviation pilot. A subjective technique (POSWAT) for estimating pilot workload was developed here; and some evaluational work on the Cockpit Display of Terminal Information (CDTI) has been conducted. Current flight-related work is concerned with microwave landing systems (MLS). Some work is being done to obtain data for establishing technical instrument approach procedures (TERPS) for MLS approaches to heliports. Another study is concerned with the use of segmented MLS approaches by conventional aircraft. This study will use commercial pilots flying a DC-9 simulator at NASA Langely while talking to air traffic controllers at the ATC simulation facility at the Technical Center.

There is no single organizational concentration of human factors expertise in the Technical Center. Most of the people with human factors skills are distributed among the following three divisions:

- o Air Traffic Control Systems Division (ACT-200);
- o Systems Integration Division (ACT-500); and
- o Engineering Division (ACT-100).

The names, specialty areas and organizational assignments of these people are shown in Table 12 of Appendix A.

Although the Technical Center has recently deemphasized its human factors work and capability, it has the following unique facilities (some of which are currently being used) for studying pilot-air traffic control issues:

- o MLS equipped experimental heliport;
- o It will have the first operational and simulated example of an automated en route ATC and so may be in a good position to investigate the impact of this system on cockpit workload;
- o It has a cooperative working agreement with NASA-Langely linking their DC-9 flight simulator with the Technical Center's ATC simulation facilities.